Fishery Data Series No. 14-26

Stock Assessment of Sockeye Salmon in the Buskin River, 2010–2013

Final Report for Study 10-403

USFWS, Office of Subsistence Management

Fishery Information Service Division

by

Tyler B. Polum,

David Evans,

and

Tyler H. Dann

May 2014

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

FISHERY DATA SERIES NO. 14-26

STOCK ASSESSMENT OF SOCKEYE SALMON IN THE BUSKIN RIVER, 2010–2013

by
Tyler B. Polum
Alaska Department of Fish and Game, Division of Sport Fish, Kodiak

David Evans
Alaska Department of Fish and Game, Division of Sport Fish, Anchorage

and

Tyler H. Dann
Alaska Department of Fish and Game, Gene Conservation Laboratory, Anchorage

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

May 2014

This investigation was partially financed by the USFWS Office of Subsistence Management through the Fisheries Resource Monitoring Program, under agreement 70181AJ035.

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

Tyler B. Polum
Alaska Department of Fish and Game, Division of Sport Fish
351 Research Court, Kodiak, AK 99615-6399, USA

David Evans
Alaska Department of Fish and Game, Division of Sport Fish
333 Raspberry Road, Anchorage, AK 99518-1565, USA

and

Tyler H. Dann
Alaska Department of Fish and Game, Gene Conservation Laboratory
333 Raspberry Road, Anchorage, AK 99518-1565, USA

This document should be cited as:
Polum, T. B., D. Evans, and T. H. Dann. 2014. Stock assessment of sockeye salmon in the Buskin River, 2010–2013. Alaska Department of Fish and Game, Fishery Data Series No. 14-26, Anchorage.

The Alaska Department of Fish and Game (ADF&G) administers all programs and activities free from discrimination based on race, color, national origin, age, sex, religion, marital status, pregnancy, parenthood, or disability. The department administers all programs and activities in compliance with Title VI of the Civil Rights Act of 1964, Section 504 of the Rehabilitation Act of 1973, Title II of the Americans with Disabilities Act (ADA) of 1990, the Age Discrimination Act of 1975, and Title IX of the Education Amendments of 1972.

If you believe you have been discriminated against in any program, activity, or facility please write:
ADF&G ADA Coordinator, P.O. Box 115526, Juneau, AK 99811-5526
U.S. Fish and Wildlife Service, 4401 N. Fairfax Drive, MS 2042, Arlington, VA 22203
Office of Equal Opportunity, U.S. Department of the Interior, 1849 C Street NW MS 5230, Washington DC 20240

The department's ADA Coordinator can be reached via phone at the following numbers:
(VOICE) 907-465-6077, (Statewide Telecommunication Device for the Deaf) 1-800-478-3648,
(Juneau TDD) 907-465-3646, or (FAX) 907-465-6078

For information on alternative formats and questions on this publication, please contact:
ADF&G, Division of Sport Fish, Research and Technical Services, 333 Raspberry Rd, Anchorage AK 99518 (907) 267-2375

TABLE OF CONTENTS

Page

TABLE OF CONTENTS (Continued)

Page

LIST OF TABLES

LIST OF FIGURES

Figure **Page**

LIST OF APPENDICES

Appendix **Page**

ABSTRACT

Since 1990, the Alaska Department of Fish and Game, Division of Sport Fish, has assessed the annual run of Buskin River sockeye salmon (*Oncorhynchus nerka*) stock on Kodiak Island, Alaska. This report presents escapement, harvest, and age-sex-length data collected from 2010 through 2013, and a spawner-recruitment analysis using data collected from 1990 through 2013. The Buskin River sockeye salmon weir counts were 9,800, 11,982, 8,565, and 16,189 for 2010–2013, respectively. The sockeye salmon weir counts for Lake Louise were 421, 360, 301, and 903 for 2010–2013, respectively, and the reported annual subsistence harvests for the Buskin River Section were 1,514, 4,639, and 2,631 for 2010–2012, respectively, and not available for 2013. In 2010, age-1.3 and -2.3 sockeye salmon comprised 71% of the Buskin River escapement and 87% of the subsistence harvest but only 26% of the Lake Louise escapement. The male to female ratio was 1.05:1.0 for the Buskin River, 1.33:1.0 for Lake Louise, and 0.65:1.0 for the subsistence harvest. In 2011, age-1.3 and -2.3 sockeye salmon comprised 61% of the Buskin River escapement, 70% of the subsistence harvest, but only 4% of the Lake Louise escapement. The male to female ratio was 0.90:1.0 for the Buskin River, 1.15:1.0 for Lake Louise, and 0.88:1.0 for the subsistence harvest. In 2012, age-1.3 and -2.3 sockeye salmon comprised 64% of the Buskin River escapement and 85% of the subsistence harvest but only 24% of the Lake Louise escapement. The male to female ratio was 0.68:1.0 for the Buskin River, 0.80:1.0 for Lake Louise, and 0.78:1.0 for the subsistence harvest. In 2013, age-1.3 and -2.3 sockeye salmon comprised 48% of the Buskin River escapement and 82% of the subsistence harvest but only 13% of the Lake Louise escapement. The male to female ratio was 0.99:1.0 for the Buskin River, 1.30:1.0 for Lake Louise, and 0.99:1.0 for the subsistence harvest. Enumerated sockeye salmon spawning escapement for the entire drainage was 10,143, 12,342, 8,866, and 17,092 for 2010–2013, respectively. A Bayesian spawner-recruitment analysis estimated the spawning escapement that produces maximum sustained yield to be about 6,400 (95% credibility interval of 5,100 to 8,200). A traditional linear regression Ricker analysis yielded similar results. A sustained yield probability analysis suggests the current biological escapement goal (BEG) range for the Buskin Lake system of 5,000 to 8,000 sockeye salmon is reasonable. Mixed stock analysis of genetic samples from the Buskin River subsistence fishery shows that harvest of Buskin Lake origin sockeye salmon ranged from 75% to 97% of the harvest from 2010 to 2013. Harvest of sockeye salmon bound for Lake Louise ranged from 0.1% to 6.4% of the subsistence harvest. In interviews conducted from 2010 through 2013, 91% of subsistence fishers reported the Buskin River as a traditional fishing location, and 63% of those reported subsistence fishing in other areas.

Key words: sockeye salmon, *Oncorhynchus nerka*, escapement, escapement goal, Buskin River, Lake Louise, age-sex-length composition, sport harvest, spawner-recruitment, subsistence harvest, stock assessment.

INTRODUCTION

The Buskin River drainage, located on the northeast end of Kodiak Island (Figure 1), contains 1 of only 3 native populations of sockeye salmon (*Oncorhynchus nerka*) found on the Kodiak Island road system. The drainage supports one of the largest subsistence salmon fisheries in the Kodiak Archipelago and, historically, the single largest subsistence fishery within the Kodiak/Aleutian Islands Federal Subsistence Region. The subsistence fishery occurs in nearshore marine waters adjacent to the river mouth and targets several species of salmon. Sockeye salmon typically comprise more than 70% of the total subsistence salmon harvest, with reported harvests ranging from 1,514 to 11,151 fish for 2004–2013 (Table 1, Figure 2). Since 2004, the Buskin River subsistence harvest averaged 43% of the total sockeye salmon subsistence harvest reported on Kodiak Island. Harvest in this fishery is documented through subsistence permits issued by the Alaska Department of Fish and Game (ADF&G), Division of Commercial Fisheries (CF).

The Buskin River is also the most popular recreational fishing stream on Kodiak Island, recently representing approximately 33% of the total freshwater recreational fishing effort in the Kodiak Management Area (Jennings et al. 2004, 2006a-b, 2007, 2009a-b, 2010a-b, 2011a-b, *In prep*). Recreational fishing effort on the Buskin River is directed primarily toward sockeye salmon and coho salmon (*O. kisutch*) but also toward steelhead and rainbow trout (*O. mykiss*), pink salmon (*O.*

gorbuscha), and Dolly Varden (*Salvelinus malma*). From 2004 through 2013, sport harvest of sockeye salmon from the Buskin River ranged from 332 to 1,577 fish and averaged 1,216 (Table 1, Figure 2). Sport harvest of sockeye salmon and sport fishing effort on the Buskin River are estimated annually by the ADF&G, Division of Sport Fish (SF), Statewide Harvest Survey (SWHS).

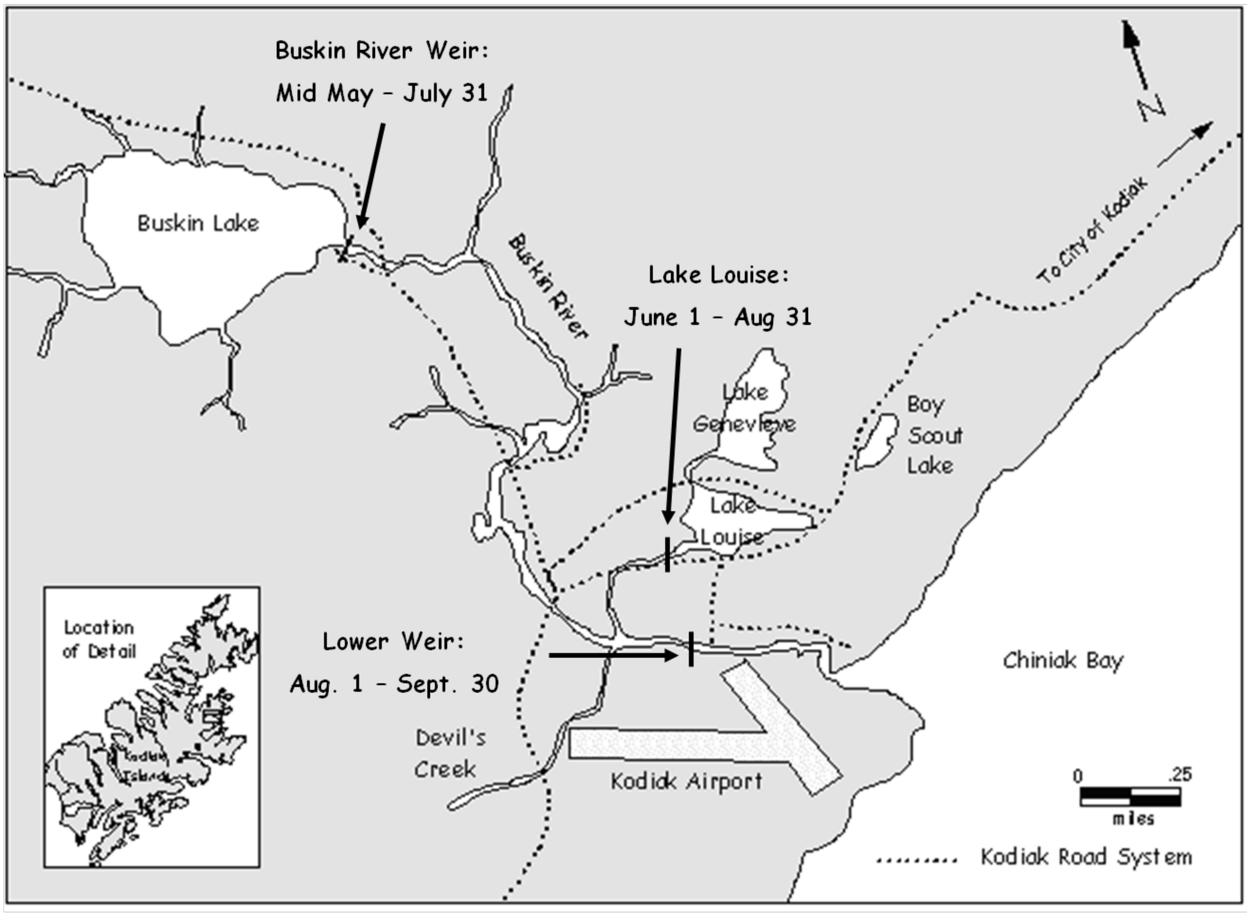


Figure 1.–Buskin River system weir locations, 2010–2013.

A relatively minor commercial harvest of Buskin River sockeye salmon occurs in adjacent marine waters of Chiniak Bay. These harvests are small or nonexistent during some years. Fish ticket harvest receipts available from the CF fish ticket database indicate that between 2004 and 2013, the harvest of Buskin River sockeye salmon was less than 50 in every year except 2004, when it reached 1,098 (Table 1).

Inriver returns of sockeye salmon are usually monitored at 2 salmon counting weirs (Figure 1) to ensure the sustainability and long-term health of the stock (Schmidt et al. 2005; Schmidt 2007). One weir is located about 100 yards downstream from the outlet of Buskin Lake and has been operated annually by ADF&G since the mid-1980s. Counts of adult salmon entering Buskin Lake via the Buskin River are usually obtained between late May and late July, with peak daily escapements typically occurring during the third week of June (Figure 3). The second weir is located on a tributary stream draining both Lake Louise and Lake Genevieve and has been operated annually by ADF&G since 2002. Counts of adult salmon entering this tributary stream are usually obtained between early June and late August, with peak daily escapements typically occurring during August and occasionally into September (Figure 3). The largest daily counts at this weir generally coincide with high water events.

Table 1.-Total weir counts and sources of harvest for Buskin River drainage sockeye salmon, 2004-2013.

Year	Commercial harvest [a]	Subsistence harvest [b]	Weir count [c]		Sport fishery estimates [d]		
			Buskin Lake	Louise Lake	Harvest	Catch	Effort [e]
2004	1,098	9,421	22,023	2,086	1,379	3,620	17,549
2005	0	8,239	15,468	2,028	1,540	2,851	17,575
2006	6	7,577	17,734	4,586	1,577	2,642	19,875
2007	30	11,151	16,502	1,610	1,509	3,143	17,124
2008	0	2,664	5,900	833	1,160	1,560	15,180
2009	45	1,883	7,757	992	687	1,417	18,695
2010	0	1,514	9,800	421	332	699	13,365
2011	38	4,639	11,982	360	1,277	2,285	13,879
2012	1	2,631	8,565	301	1,484	1,938	13,996
2013	3	NA[f]	16,189	903	NA	NA	NA
Average	122	5,524	13,192	1,404	1,216	2,239	16,360

[a] Source: ADF&G, Division of Commercial Fisheries (CF), fish ticket database system. Includes all sockeye salmon harvested annually at the mouth of Buskin River in Womens Bay, statistical areas 259-22 and 259-26.

[b] Source: Subsistence harvest records maintained by CF Westward Region; includes all reported harvest at the Buskin River.

[c] Source: Fuerst (2013); CF Westward Region database.

[d] Sources: Jennings et al. (2007, 2009a-b, 2010a-b, 2011a-b, *In prep*).

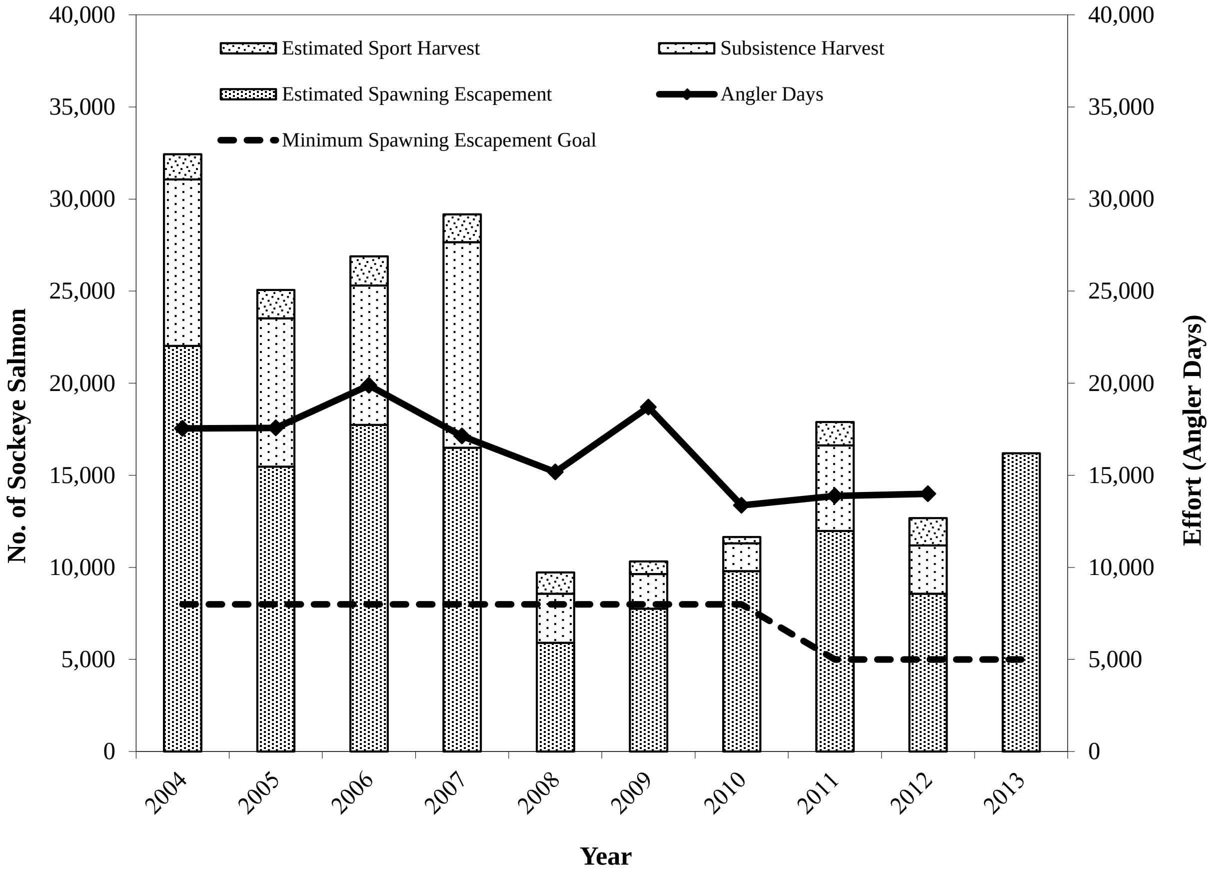
[e] Units are angler-days and include effort directed toward other species.

[f] NA = not available.

The current sockeye salmon biological escapement goal (BEG) for the Buskin River, established in 2011, is 5,000–8,000 fish. The previous escapement goal was 8,000 to 13,000 fish and was determined in 1996 based on weir counts from 1985 through 1989. The BEG, a range of escapements that provides the greatest potential for maximum sustained yield based on the best available biological information, is used to guide inseason management of subsistence, sport, and commercial fisheries. If inseason weir counts indicate the BEG will not be achieved, harvest restrictions are first enacted for sport and commercial fisheries. If these restrictions are not sufficient to ensure the BEG will be achieved, harvest restrictions may also be placed on the subsistence fishery.

To improve management of Buskin River sockeye salmon for the benefit of all users, it is essential to establish an escapement goal that accurately reflects the production capacity of the stock. Since 2000, ADF&G has obtained funding from the United States Fish and Wildlife Service (USFWS), Office of Subsistence Management, to collect data needed to evaluate the Buskin River sockeye salmon BEG. Escapement data from these efforts, along with harvest data from subsistence permits and commercial fish tickets (Jackson and Keyse 2013) and statewide sport harvest surveys (Jennings et al. 2004, 2006a-b, 2007, 2009a-b, 2010a-b, 2011a-b, *In prep*) are used with associated age composition estimates to construct a brood table, conduct spawner-recruitment analysis, and set escapement goals. The BEG is periodically reevaluated as new information becomes available to help ensure that the fisheries can be maintained while the sockeye salmon resource is sustained.

This report presents 2010-2013 study results, including daily sockeye salmon escapement counts; seasonal harvest estimates; stock composition estimates for age, sex, and mean length-at-age by sex; and a spawner-recruitment analysis.



Note: Subsistence and sport harvests are unavailable for 2013.

Figure 2.–Buskin Lake sockeye salmon spawning escapement, estimated sport and subsistence harvest of sockeye salmon, and sport fishing effort (angler-days) directed toward all fish species in the Buskin River drainage, 2004-2013.

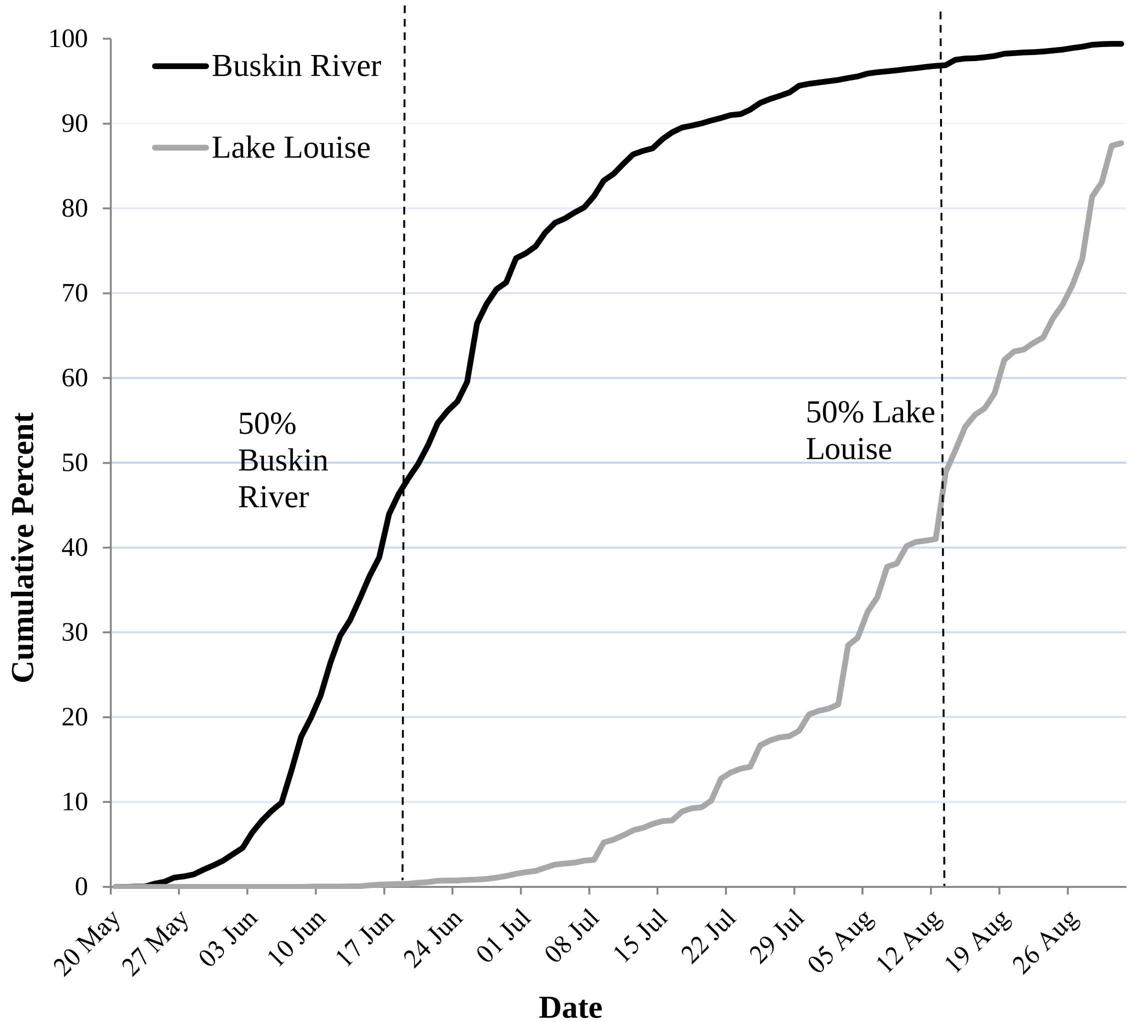


Figure 3.–Average run timing of sockeye salmon returning to the Buskin River and Lake Louise, 2004–2013.

STUDY OBJECTIVES

During 2010-2013, objectives for the stock assessment of Buskin River sockeye salmon consisted of the following:

1. Census the sockeye salmon escapement into Buskin Lake from approximately 1 June to 1 August, and the Louise and Catherine lakes tributary from approximately 1 June through 31 August.
2. Estimate the age composition of the sockeye salmon run (combined subsistence harvest in the Chiniak Bay section and escapement) to Buskin Lake such that the estimates are within 5 percentage points of the true value 95% of the time.
3. Estimate the age composition of the sockeye salmon run (escapement) to the Louise and Catherine lakes tributary such that the estimates are within 7.5 percentage points of the true value 95% of the time.
4. Estimate proportions (through DNA analysis) of Buskin and Louise/Catherine lakes run components in the sockeye salmon subsistence harvest in the Buskin River Section of Chiniak Bay, such that the estimates are within 7.5 percentage points of the true value 90% of the time.
5. Evaluate and, if necessary, refine the sockeye salmon BEG on a triennial basis concurrent with the Alaska Board of Fisheries meeting cycle for Kodiak area fin-fisheries.
6. Document local residency of Buskin River sockeye salmon subsistence users and user preferences for areas traditionally fished.

METHODS

DATA COLLECTION

Weir Counts

During the 4 years of this study, up to 3 weirs were operated each season: 1) just downstream from the outlet of Buskin Lake (referred to as the Buskin River weir), 2) on the tributary stream draining Louise and Genevieve lakes (referred to as the Lake Louise weir), and 3) 0.6 miles upstream of the Buskin River mouth (referred to as the lower weir) (Figure 1). The lower weir is operated during August and September but is funded by another project. During each year, the weirs were operated continuously and monitored daily. Fish passage was only allowed when counts were made, and all immigrant and emigrant anadromous fishes passing through the weirs were enumerated and identified by species.

From 2010 through 2013, ADF&G operated a picket weir (approximately 125 ft [38 m] long) about 100 yards (30 m) downstream of the outlet to Buskin Lake (Figure 1). The Buskin River weir was constructed with a superstructure framework of wooden tripods weighted with sandbags, aluminum cross stringers, and a boardwalk. Rigid aluminum panels (10 ft high and 2.5 ft wide [3 m × 0.8 m], constructed from 1-inch diameter schedule-40 pipe sections spaced 1 inch (2.5 cm) apart and welded into aluminum T-bars) provided structural continuity and created a barrier to uncontrolled fish passage. Four counting gates integrated into the panel array allowed for the controlled passage of fish over a submerged white-colored background to assist in species identification. A funnel entrance trap structure constructed of aluminum panels and attached to one of the counting gates was installed to capture fish migrating upstream for sampling.

From 2010 through 2013, the Buskin River weir was operated at the outlet of Buskin Lake from mid-May to late September, and an additional weir was operated at the lower site from early August to the end of September. Annual sockeye salmon counts obtained from the Buskin River weir were considered a close approximation of total spawning escapement because harvests do not typically occur within Buskin Lake or its tributaries.

During the years 2010–2013, a second weir was also operated on a major tributary stream flowing into the Buskin River from Lake Louise (Figure 1). The Lake Louise weir was similar in design to the one used at Buskin Lake. It was approximately 20 feet (6 m) long with a counting gate and funnel entrance trap structure constructed of aluminum panels. Dates of operation were somewhat flexible each year. Typically, the weir was operated between the first week of June and early September; however, the weir was put in earlier in 2010 and 2011 to accommodate enumeration of the sockeye salmon smolt emigration. It was also kept in later in September in all but 2013 to accommodate exceptionally late returns of sockeye salmon to this system. Annual sockeye salmon counts obtained from the weir provided a close approximation of total spawning escapement into Lake Louise because harvests do not typically occur upstream of the weir site.

Because sport fish harvests or other known removals of sockeye salmon typically do not occur upriver of the weirs at Buskin Lake and Lake Louise, the sum of counts taken at the weirs was considered a census of the spawning escapement (with zero variance). No adjustments were made to the weir counts for the Buskin River system to account for fish migrating before or after weir operation or for weir-leakage during high flow events. It is expected that very few fish were unaccounted for because there were virtually no high water estimates made in the 4 years of the study and the weir was kept in through September each year. No adjustment was made for the Lake Louise weir count because of its smaller run size and lack of weir leakage. A spawner-recruitment analysis was performed on the Buskin Lake stock but not the Lake Louise stock.

Fishery Harvests

Annual subsistence harvests of Buskin River drainage sockeye salmon were estimated from returns of completed permits received by the CF Kodiak office. From 2004 through 2012 (2013 unavailable), annual return rates of completed permits ranged between 85% and 93% and averaged 90% (Westward Region Commercial Fisheries Database). It was not possible to determine the proportion of permit holders who harvested Buskin River sockeye salmon but failed to return permits.

The sport fishery harvest of sockeye salmon was estimated by the SWHS (Jennings et al. 2004, 2006a-b, 2007, 2009a-b, 2010a-b, 2011a-b, *In prep*). Commercial harvests were obtained from the CF fish ticket database system and CF division area management reports (Jackson and Keyse 2013).

Age, Sex, and Length Sampling

During the years 2010–2013, sockeye salmon age, sex, and length (ASL) sampling was stratified into 5 temporal intervals for the Buskin Lake escapement. The intervals were 15–31 May, 1–15 June, 16–30 June, 1–15 July, and 16–31 July. Samples from inriver returns of sockeye salmon to Buskin Lake were obtained from weir traps or beach seines. Typically, sampling was conducted 3 days per week. Whenever possible, all sockeye salmon captured in the weir traps or seines were sampled for ASL.

For the Lake Louise escapement, sample intervals were 1 June–15 July, 16–31 July, 1–15 August, and 16–31 August. Sampling was typically conducted every other day. Whenever possible, all sockeye salmon captured in the weir trap were sampled.

From 2010 through 2013, ASL sampling of the subsistence harvest was stratified into two 2-week intervals: 1–15 June and 16–30 June. Sampling was conducted on the fishing grounds during good weather and also dockside at the local boat harbor. Samples were obtained opportunistically within each time interval. No ASL sampling was conducted for either the sport fish or commercial harvests. ASL statistics for these harvests were assumed to be the same as those estimated for escapement counted through the weirs.

Lengths from mid eye to tail fork (METF) were recorded to the nearest millimeter for each sockeye salmon sampled. Sex was determined through external morphology such as head shape and presence of the ovipositor. Whenever possible, 2 scales were removed from the left side of the body, at a point on a diagonal line from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin, 2 rows above the lateral line (Welander 1940). Scales not available from the preferred area were taken from the 3rd or 4th row above the lateral line in the same linear plane. Scales not available in either preferred area on the left side were collected from the same region on the right side of the body. Sampled scales were placed on a gummed card for subsequent analysis. Ages of sampled sockeye salmon were determined from scales using criteria described in Mosher (1969).

Subsistence User Survey

In response to a priority information need identified by the Kodiak/Aleutians Region Subsistence Advisory Council, technicians opportunistically surveyed sockeye salmon subsistence fishers on the fishing grounds adjacent to the Buskin River mouth while concurrently sampling the harvest for ASL. The survey was conducted over the duration of the subsistence fishery each year of the study. Although it probably provided a representative sample of people participating in the fishery, the user survey was not designed to account for bias or estimate precision. The survey provided residency and fishing effort data not currently available from the subsistence permit returns. Following a set of brief introductory remarks, all fishers who agreed to be interviewed were asked a short series of questions to determine their residency (Kodiak Island Borough or elsewhere in Alaska) and traditional subsistence fishing location(s) (Buskin River or elsewhere).

Genetic Tissue Sampling

Baseline Collections

Baseline samples were collected for genetic analyses from spawning populations of sockeye salmon on islands of the Kodiak archipelago. 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's genotyping platform.

Chiniak Bay Subsistence Harvests

The respective proportions of subsistence harvests originating from 4 reporting groups of interest (described below) were estimated from samples of adult sockeye salmon collected from the subsistence harvest in Chiniak Bay. These samples were collected concurrently with ASL samples taken on the fishing grounds or dockside at the local boat harbor. Occasionally, subsistence harvesters were pressed for time and only genetic samples were taken. The axillary process was clipped from the fish and placed into prelabeled, 1 ml vials filled with ethanol (ETOH). Labeled samples were shipped to the ADF&G Gene Conservation Laboratory for storage and processing. Sampling periods were concurrent with ASL sampling timelines and attempted to capture the entire fishery, which starts in late May or early June and is over by 4 July.

LABORATORY ANALYSIS

Assaying Genotypes

Baseline and subsistence harvest collections were genotyped for 96 single nucleotide polymorphisms (SNPs) following the methods of Dann et al. (2009). 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 the genotyping process. Genotypes were retrieved from LOKI and imported into R (R Development Core Team 2011). The quality of the data was confirmed by identifying and removing invariant SNP markers, individuals that were missing substantial genotypic data (80% rule; Dann et al. 2009), and duplicate individuals. Collections and SNPs were tested for conformance to Hardy-Weinberg equilibrium (HWE) and collections were pooled to obtain better estimates of allele frequencies when appropriate. The final marker set, defined by Dann et al. (2009), was based on results of tests for linkage disequilibrium and the results of HWE tests. The utility of the baseline for mixed stock analysis (MSA) was evaluated by assessing the "identifiability" of reporting groups; the reporting of this Kodiak archipelago baseline is still in preparation (Dann et al. *In prep*[1]). Reporting groups for this project were the two lake systems in the Buskin River drainage (Buskin Lake and Catherine and Louise lakes), Saltery, and Other Kodiak. "100% proof tests" were conducted following the methods of Dann et al. (2009). The stock composition of the 2010–2013 Chiniak Bay subsistence harvest samples were estimated following these same methods.

DATA ANALYSIS

Age and Sex Composition

Escapement

The proportion of sockeye salmon of age or sex class *j* in stratum *i* for the escapement was estimated as a binomial proportion (Cochran 1977) as follows:

$$\hat{p}_{ij} = \frac{n_{ij}}{n_i}, \tag{1}$$

and its variance was estimated by

$$\text{var}(\hat{p}_{ij}) = \left[\frac{N_i - n_i}{N_i}\right]\frac{\hat{p}_{ij}(1-\hat{p}_{ij})}{n_i - 1} \tag{2}$$

1 Dann, T.H., M.B. Foster, J. Olsen, and C. Habicht. *In prep*. Genetic baseline for sockeye salmon on the Kodiak Archipelago. Alaska Department of Fish and Game, Fishery Manuscript Series Anchorage.

where

n_{ij} = the number of sockeye salmon in age or sex class *j* during stratum *i*,

n_i = the total number of sockeye salmon sampled during stratum *i*, and

N_i = the number of sockeye salmon in the weir count during stratum *i*.

The number of fish by age or sex class *j* in stratum *i* was estimated as follows:

$$\hat{N}_{ij} = N_i \hat{p}_{ij}, \tag{3}$$

and its variance was estimated by

$$\mathrm{var}(\hat{N}_{ij}) = N_i^2 \,\mathrm{var}(\hat{p}_{ij}). \tag{4}$$

The estimated total number of sockeye salmon ($\hat{N}_j$) of each age or sex class *j* in the escapement and its variance [$\mathrm{var}(\hat{N}_j)$] were calculated as the sum of the individual stratum estimates. The overall proportion of sockeye salmon of age or sex class *j* was calculated as follows:

$$\hat{p}_j = \frac{\hat{N}_j}{N}, \tag{5}$$

and its variance was estimated as follows:

$$\mathrm{var}(\hat{p}_j) = \frac{\mathrm{var}(\hat{N}_j)}{N^2}. \tag{6}$$

Subsistence Harvest

Subsistence harvest estimates could not be stratified because subsistence harvest was only reported seasonally with no reliable method of stratification available. Pooled estimates of age and sex composition were therefore calculated using Equations 1–4 with deletion of subscript *i*, as was done for unstratified escapement estimates.

Sport Harvest

The number of sockeye salmon in the sport harvest by age or sex class *j* was estimated as follows:

$$\hat{H}_{SFj} = \hat{H}_{SF}\,\hat{p}_j \tag{7}$$

where

$\hat{H}_{SF}$ = the SWHS estimate of total sport harvest, and

$\hat{p}_j$ = the proportion of age or sex class *j* derived from escapement sampling (sport harvest was not sampled for age or sex).

The variance of the number of fish in the sport harvest of age or sex class *j* was estimated according to Goodman (1960):

$$\mathrm{var}(\hat{H}_{SFj}) = \hat{H}_{SF}^2 \,\mathrm{var}(\hat{p}_j) + \hat{p}_j^2 \,\mathrm{var}(\hat{H}_{SF}) - \mathrm{var}(\hat{p}_j)\,\mathrm{var}(\hat{H}_{SF}), \tag{8}$$

where

$\hat{V}\left(\hat{H}_{SF}\right)$ = estimated variance of harvest, estimated from the SWHS.

Assessment of Age-Sex–Sampling Period Interactions

Log-linear analysis (e.g., Agresti 1990, page 143) on the counts of fish in the 3-way age-sex–sampling period contingency table was used to examine interactions. Models were chosen based on likelihood ratio tests.

Run Size Estimation

To estimate sockeye salmon total run size, the weir counts, number of returned subsistence permits, and fish ticket tallies of commercial harvests were treated as censuses (total counts with zero variance). Harvest from unreturned subsistence permits ($\widetilde{H}_{SUB}$) was estimated by assuming a harvest rate that was 65% of the harvest rate for returned permits:

$$\widetilde{H}_{SUB} = H_{SUB} + \left[\frac{H_{SUB}}{p_{\mathrm{Re}t}} - H_{SUB} \right] * 0.65 \tag{9}$$

where

H_{SUB} = reported subsistence harvest, and

$p_{\mathrm{Re}t}$ = proportion of issued permits returned.

A value of 0.65 was assumed reasonable based on estimated harvest rates for unreturned permits in other fisheries in the state of Alaska (0.69 for the Kenai River sockeye salmon dip net fishery and 0.66 for the Chitina sockeye salmon dip net fishery [Patricia Hansen, biometrician, ADF&G, Anchorage, personal communication]). The adjustment is relatively small, and no variance component was calculated.

The number of sockeye salmon of age class *j* in the total run ($\hat{N}_j$) to the Buskin River system and its variance were estimated by summing the component estimates from the escapement, subsistence harvest, and sport harvest, with variance [$\mathrm{var}(\hat{N}_j)$] calculated by summing the respective variance estimates. A covariance will exist between the sport harvest estimate of the age class *j* and the escapement estimates of age class *j* (through $\hat{p}_j$). However, the covariances will be small because the sport harvest is always a relatively small component of the total run.

Exploitation Rate Estimation

Exploitation rates (*E*) for the subsistence and sport fisheries were estimated as follows:

$$\hat{E} = \frac{H}{\hat{T}} \tag{10}$$

where *H* is either the subsistence harvest or sport harvest estimate and *T* is the total run. The variance estimate of the subsistence exploitation rate was calculated as follows:

$$\mathrm{var}(\hat{E}) = H^2 \frac{1}{\hat{T}^4} \mathrm{var}(\hat{T}). \tag{11}$$

The variance of the sport fish exploitation rate was estimated as follows:

$$\text{var}(\hat{E}) = \left(\frac{\hat{H}}{\hat{T}}\right)^2 \left(\frac{\text{var}(\hat{H})}{\hat{H}^2} + \frac{\text{var}(\hat{H})}{\hat{T}^2}\right). \tag{12}$$

Spawner-Recruitment Analysis

Two different methods were used to model the spawner-recruitment relationship: a traditional, widely used method that provides an average relationship (Ricker 1975); and a more recently developed Bayesian Markov Chain Monte Carlo method, based on an underlying Ricker-type relationship, which is better able to incorporate the uncertainty associated with the various datasets into the estimated relationship (Fleischman et al. 2013).

Traditional Analysis

The first method is based on simple linear regression techniques to fit the linearized Ricker stock-recruitment function:

$$\ln(R_y / S_y) = \ln\alpha - \beta S_y + \varepsilon_y \tag{13}$$

where R_y and S_y are the returns and spawning abundance, respectively, relevant to brood year y; α and β describe the shape of the Ricker spawner-recruitment relationship (Ricker 1975); and ε_y represents process error that has approximately a normal distribution $N(0,\sigma^2)$, with variance σ^2. Spawning abundance yielding maximum sustained yield, S_{MSY}, was modeled using the approximation of Hilborn and Walters (1992):

$$S_{MSY} = \frac{\ln(\alpha)'}{\beta}(0.5 - 0.07\ln(\alpha)') , \tag{14}$$

where

$$\ln(\alpha)' = \ln(\alpha) + \sigma^2/2 . \tag{15}$$

Spawning abundance for which $R = S$ was modeled as follows:

$$S_{EQ} = \frac{\ln(\alpha)'}{\beta} . \tag{16}$$

Estimates of the quantities in Equations 14–16 were obtained by plugging in the simple linear regression estimates of $\ln(\alpha)$, β, and σ^2.

Confidence intervals for S_{MSY} were estimated using the bootstrap method (Efron 1982); each iteration of the bootstrap was conducted by resampling the residuals from the regression, creating a bootstrap dataset, and then refitting the regression model to the bootstrapped dataset. A sustained yield probability profile was also created that described the probability of attaining 90% of maximum sustained yield as a function of spawning escapement. A “horsetail” plot of the Ricker relationship was created from the first 20 bootstrap datasets.

Serial correlation was examined through inspection of the autocorrelation and partial autocorrelation functions of the residuals and by the Durbin-Watson statistic. It is noted that the assumption of zero error in the escapement measurement is largely met for this system because of reliable weir counts. The traditional Ricker analysis used data corresponding to the 1990–2007 brood years (18 years); imputed returns were used for the 1999 run year, when no effective age class sampling occurred, and "best guess" estimates of the subsistence and sport harvests that have not yet been finalized were used for the 2013 data. We have confidence that the estimated subsistence and sport harvests used here will be close to the final 2013 values.

Bayesian Analysis

The Bayesian analysis method, previously described by Fleischman et al. (2013), has several potential advantages over the traditional stock recruitment model described above. The method is capable of incorporating into parameter estimation the uncertainty associated with incomplete stock-recruitment datasets (such as the missing age composition data for the 1999 calendar year), error in spawning escapement measurements (not considered problematic for this analysis), sampling variability in age composition estimation, serial correlation in returns, and other ad hoc sources of variability. These additional sources include errors in sport harvest and subsistence harvest estimation and the notion that weir count at Buskin Lake represents minimum escapement. The Bayesian method also allows use of incomplete brood year data.

Markov Chain Monte Carlo (MCMC) methods, which are especially well-suited for modeling complex population and sampling processes, were used to obtain the Bayesian estimates. The MCMC algorithms were implemented in OpenBUGS (Lunn et al. 2009).

The Bayesian MCMC analysis considers all the data simultaneously in the context of the following "full-probability" statistical model. Returns of sockeye salmon originating from spawning escapement in brood years *y* from 1990 to 2009 are modeled as a Ricker stock-recruitment function with autoregressive lognormal errors:

$$\ln(R_y) = \ln(S_y) + \ln(\alpha) - \beta S_y + \phi \nu_{y-1} + \varepsilon_y \qquad (17)$$

where α and β are Ricker parameters, ϕ is the autoregressive coefficient, $\{\nu_y\}$ are the model residuals

$$\nu_y = \ln(R_y) - \ln(S_y) - \ln(\alpha) + \beta S_y\,, \qquad (18)$$

and the $\{\varepsilon_y\}$ are independently and normally distributed process errors with mean zero and variance σ^2_{SR}.

Age proportion vectors $\underline{\boldsymbol{p}}_{\boldsymbol{y}}$ = (p_{y4}, p_{y5}, p_{y6}) from brood year *y* returning at ages 4–6 are drawn from a common Dirichlet distribution (multivariate analogue of the beta). The Dirichlet is reparameterized such that the usual parameters in the following equation

$$D_a = \pi_a D \qquad (19)$$

are written in terms of location (overall age proportions π_a) and inverse scale (D, which governs the inverse dispersion of the $\underline{\boldsymbol{p}}_{y}$ age proportion vectors among brood years).

The abundance *N* of age-*a* sockeye salmon in calendar year *t* ($t \in$ 1990–2013) is the product of the age proportion scalar *p* and the total return *R* from brood year $y = t-a$:

$$N_{ta} = R_{t-a}\, p_{t-a,a}\,. \qquad (20)$$

Total run during calendar year *t* is the sum of abundance at age across ages:

$$N_{t\cdot} = \sum_a N_{ta} \,. \tag{21}$$

Spawning abundance is total abundance minus harvest,

$$S_t = N_{t\cdot} - HSF_t - HSub_t \tag{22}$$

where HSF_t is in turn the product of the annual exploitation rate μ_t and total run:

$$HSF_t = \mu_t N_t \,, \tag{23}$$

and $HSub_t$ is

$$HSub_t = HSub_{pt} + \left[\frac{HSub_{pt}}{p_{rt}} - HSub_{pt} \right] p_h \tag{24}$$

where $HSub_{pt}$ is the (known) harvest from returned permits in year *t*, p_{rt} is the proportion of issued permits returned, and p_h is a discounting proportion accounting for the reduction in harvest rate associated with unreturned permits. The prior distribution on p_h was set as beta (1.9,1), an informative prior with mean 0.65.

Although spawners were counted at a weir, it was usual for some fish to escape to Buskin Lake either before or after the weir was installed and removed. The spawning escapement available for counting was modeled as follows:

$$S_{wt} = \rho_t S_t \tag{25}$$

where ρ_t is the proportion of the escapement available for counting in year *t*; the prior distribution on ρ_t was set as beta (30,1), an informative prior with mean 0.97.

Spawning abundance yielding peak return S_{MAX} is the inverse of the Ricker β parameter. Equilibrium spawning abundance S_{EQ} and spawning abundance leading to maximum sustained yield S_{MSY} are obtained using equations 14 and 16, except that ln (α) is corrected for AR1 serial correlation as well as lognormal process error:

$$\ln(\alpha') = \ln(\alpha) + \frac{\sigma_{SR}^2}{2(1-\phi^2)} \,. \tag{26}$$

Expected sustained yield at a specified escapement *S* is calculated by subtracting spawning escapement from the expected return, again incorporating corrections for lognormal process error and AR1 serial correlation:

$$SY = E[R] - S = Se^{\ln(\alpha') - \beta S} - S \,. \tag{27}$$

Probability that a given level of escapement would produce average yields exceeding 90% of MSY was obtained by calculating the expected sustained yield (*SY*; Equation 27) at multiple incremental values of *S* (0 to 10,000) for each Monte Carlo sample, then comparing *SY* with 90% of the value of MSY for that sample. The proportion of samples in which *SY* exceeded 0.9 MSY is the desired probability.

Observed data include estimates of spawning abundance (weir counts), estimates of sport harvest, and scale age counts. Likelihood functions for the data follow.

Weir counts were modeled as follows:

$$\hat{S}_{wt} = S_{wt} e^{\varepsilon_{Swt}} \tag{28}$$

where the $\{\varepsilon_{Swt}\}$ are normal $(0,\sigma^2_{Swt})$ with measurement error variance σ^2_{Swt}; the weir counts were assumed to have a coefficient of variation of 2%.

Estimated sport harvest was modeled as

$$\hat{H}SF_t = HSF_t e^{\varepsilon_{Ht}} \tag{29}$$

where ε_{Ht} are normal $(0,\sigma^2_{Ht})$ with individual variances σ^2_{Ht} assumed known from the Statewide Harvest Survey.

Numbers of fish sampled for scales (*n*) that were classified as age-*a* in calendar year *t*, x_{ta}, are assumed multinomially (r_{ta},n) distributed, with proportion parameters as follows:

$$r_{ta} = \frac{N_{ta}}{N_{t\cdot}}. \tag{30}$$

Bayesian analyses require that prior probability distributions be specified for all unknowns in the model. Non-informative priors (chosen to have a minimal effect on the posterior) were used almost exclusively. Initial returns R_{1984}–R_{1989} (those with no linked spawner abundance) were modeled as drawn from a common lognormal distribution with median μ_{LOGR} and variance σ^2_{LOGR}. Normal priors that had mean zero and very large variances, and were constrained to be positive, were used for ln(α) and β (Millar 2002), as well as for μ_{LOGR}. The initial model residual v_0 was given a normal prior with mean zero and variance $\sigma^2_{SR} / (1-\phi^2)$. Diffuse conjugate inverse gamma priors were used for σ^2_{SR} and σ^2_{LOGR}. Annual exploitation rates $\{\mu_t\}$ were given beta (0.1, 0.1) prior distributions.

Markov-chain Monte Carlo samples were drawn from the joint posterior probability distribution of all unknowns in the model. For each of 2 Markov chains initialized, a 50,000-sample burn-in period was discarded. A total of 100,000 samples were used to estimate the marginal posterior means, standard deviations, and percentiles. The diagnostic tools of OpenBUGS assessed mixing and convergence, and no major problems were encountered. Interval estimates were obtained from the percentiles of the posterior distribution.

RESULTS

YEAR 2010

Buskin River Weir

The Buskin River weir was installed on 21 May and operated continuously, except for a span of 10 hours (7 hours on 3 July and 3 hours on 4 July, due to a member of the public opening a gate), through 26 July 2010; it was then relocated about 100 yards downstream and operated continuously through 7 October. The cumulative weir count through 31 July was 9,650 sockeye salmon, with 50% of the run passing the weir by 25 June (Appendix A1). The final sockeye salmon count at the weir was 9,800. Final sockeye salmon escapement was tallied only at Buskin Lake even though a second weir was operated about 2 miles from the mouth from 29 July through 29 September to count returning coho salmon. Sockeye salmon counted through this weir are usually less than 1% of the total escapement (Schmidt et al, *in prep*[2]).

Age was determined for 287 of 360 sockeye salmon sampled at the Buskin River weir (Table 2). Of those with determined ages, 71% had reared in the ocean for 3 years; 23.6% were age 1.3 and 47.7% were age 2.3 (Table 2). Most of the remaining escapement reared in the ocean for 2 years. Mean length of males (520 mm, SE 4.9) was not significantly different than that of females (510 mm, SE 2.5) (two-sample *z*-test; $|z| = 1.86$, $P = 0.06$).

Log-linear modeling of counts in the 3-way age-sex–sampling period (‘time’) analysis showed that the no-interaction model ($\chi^2 = 14.39$, df = 17, $P = 0.64$) was the best fit and indicates that neither age nor sex changed over time, and that age composition is the same for males and females. The sex ratio was 1.05 (males:females) and was not significantly different from 1.0 (large-sample *z*-test; $|z| = 0.40$, $P = 0.69$).

Lake Louise Weir

The Lake Louise weir operated from 27 April to 15 September 2010. The cumulative weir count through 31 July was 139, and it was not until 15 August that 50% of the return had passed the weir (Appendix A2). The final sockeye salmon count at the weir was 421.

Age was determined for 70 of 98 sockeye salmon sampled at the Lake Louise weir (Table 3). Of those with determined ages, about 26% had reared in the ocean for 3 years; 15.8% were age 1.3 and 10.6% were age 2.3 (Table 3). Mean length of males (505 mm, SE 6.3) was not significantly different than that of females (500 mm, SE 5.2) (two-sample z-test; $|z| = 0.63$, $P = 0.53$).

Log-linear modeling of counts in the 3-way age-sex-time analysis showed that the best fitting model was one in which sex is jointly independent of age and time ($\chi^2 = 13.65$, df = 7, $P = 0.06$). This model is slightly more complex than the no interaction model described above. The selected model implies age and sex are independent in the marginal table (i.e. collapsed over time), and that sex and time are independent when collapsed over age. The selected model implies that age composition does, however, change over time. The sex ratio was 1.12 (males:females) and was not significantly different from 1.0 (large-sample *z*-test; $|z| = 0.55$; $P = 0.58$).

---

[2] Schmidt, J., T. Polum, and D. Evans. *In prep*. Stock assessment of Buskin River coho salmon, 2008–2010. Alaska Department of Fish and Game, Fishery Data Series, Anchorage.

Table 2.–Estimated age and sex compositions and mean length-at-age of the sockeye salmon escapement at Buskin River weir, 2010.

	Age												
Run component	0.2	1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Total[a]
Females													
Number sampled	0	0	0	3	0	35	31	0	68	0	0	0	176
Percent	0.0	0.0	0.0	0.9	0.0	12.2	10.5	0.0	25.4	0.0	0.0	0.0	48.9
SE percent	0.0	0.0	0.0	0.5	0.0	2.1	1.9	0.0	2.8	0.0	0.0	0.0	2.8
Total escapement	0	0	0	87	0	1,199	1,030	0	2,494	0	0	0	4,789
SE escapement	0	0	0	49	0	203	188	0	278	0	0	0	277
Mean length	0	0	0	478	0	517	481	0	520	0	0	0	510
SE mean length	0.0	0.0	0.0	28.9	0.0	4.5	5.7	0.0	3.3	0.0	0.0	0.0	2.5
Minimum length	0	0	0	430	0	432	429	0	420	0	0	0	420
Maximum length	0	0	0	530	0	551	541	0	575	0	0	0	575
Males													
Number sampled	0	0	0	7	9	34	36	0	61	0	0	0	184
Percent	0.0	0.0	0.0	2.5	2.3	11.6	12.2	0.0	22.3	0.0	0.0	0.0	51.1
SE percent	0.0	0.0	0.0	1.0	0.9	2.0	2.0	0.0	2.7	0.0	0.0	0.0	2.8
Total escapement	0	0	0	247	222	1,138	1,196	0	2,188	0	0	0	5,011
SE escapement	0	0	0	97	84	195	198	0	265	0	0	0	277
Mean length	0	0	0	470	340	556	493	0	554	0	0	0	520
SE mean length	0.0	0.0	0.0	21.0	6.6	5.2	7.3	0.0	3.7	0.0	0.0	0.0	4.9
Minimum length	0	0	0	417	310	455	375	0	445	0	0	0	310
Maximum length	0	0	0	543	365	608	598	0	608	0	0	0	608
All													
Number sampled	0	0	0	10	10	69	67	0	131	0	0	0	360
Percent	0.0	0.0	0.0	3.4	2.9	23.6	22.5	0.0	47.7	0.0	0.0	0.0	
SE percent	0.0	0.0	0.0	1.1	1.1	2.6	2.6	0.0	3.1	0.0	0.0	0.0	
Total escapement	0	0	0	330	284	2,310	2,200	0	4,675	0	0	0	9,800
SE escapement	0	0	0	107	103	259	252	0	308	0	0	0	
Mean length	0	0	0	473	340	536	487	0	536	0	0	0	515
SE mean length	0.0	0.0	0.0	16.2	6.6	4.2	4.8	0.0	2.9	0.0	0.0	0.0	2.8
Minimum length	0	0	0	417	310	432	375	0	420	0	0	0	310
Maximum length	0	0	0	543	365	608	598	0	608	0	0	0	608

[a] Sex-age components do not necessarily sum to sex pooled over age or age pooled over sex due to missing sex for age data and missing age for sex data.

Table 3.–Estimated age and sex compositions and mean length-at-age of the sockeye salmon escapement at Lake Louise weir, 2010.

	Age												
Run component	0.2	1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Total[a]
Females													
Number sampled	0	0	0	3	0	8	12	0	8	0	0	0	42
percent	0.0	0.0	0.0	6.5	0.0	10.1	21.8	0.0	7.9	0.0	0.0	0.0	47.1
SE percent	0.0	0.0	0.0	3.9	0.0	4.1	6.2	0.0	3.1	0.0	0.0	0.0	5.2
Total escapement	0	0	0	28	0	43	92	0	33	0	0	0	198
SE escapement	0	0	0	16	0	17	26	0	13	0	0	0	22
Mean length	0	0	0	487	0	509	493	0	522	0	0	0	500
SE mean length	0.0	0.0	0.0	16.8	0.0	4.9	9.6	0.0	8.6	0.0	0.0	0.0	5.2
Minimum length	0	0	0	454	0	491	420	0	496	0	0	0	415
Maximum length	0	0	0	508	0	529	538	0	566	0	0	0	570
Males													
Number sampled	0	0	0	12	0	4	18	0	4	0	0	0	56
Percent	0.0	0.0	0.0	26.2	0.0	5.1	19.5	0.0	2.9	0.0	0.0	0.0	52.9
SE percent	0.0	0.0	0.0	6.6	0.0	3.0	5.0	0.0	1.1	0.0	0.0	0.0	5.2
Total escapement	0	0	0	110	0	21	82	0	12	0	0	0	223
SE escapement	0	0	0	28	0	12	21	0	5	0	0	0	22
Mean length	0	0	0	499	0	516	492	0	548	0	0	0	505
SE mean length	0.0	0.0	0.0	11.3	0.0	28.9	13.7	0.0	13.4	0.0	0.0	0.0	6.3
Minimum length	0	0	0	430	0	433	302	0	520	0	0	0	302
Maximum length	0	0	0	562	0	558	575	0	581	0	0	0	581
All													
Number sampled	0	0	0	15	0	13	30	0	12	0	0	0	98
Percent	0.0	0.0	0.0	32.6	0.0	15.8	41.0	0.0	10.6	0.0	0.0	0.0	
SE percent	0.0	0.0	0.0	6.9	0.0	4.9	7.0	0.0	3.3	0.0	0.0	0.0	
Total escapement	0	0	0	137	0	66	172	0	45	0	0	0	421
SE escapement	0	0	0	29	0	21	29	0	14	0	0	0	
Mean length	0	0	0	497	0	511	493	0	531	0	0	0	503
SE mean length	0.0	0.0	0.0	9.5	0.0	9.3	8.9	0.0	7.9	0.0	0.0	0.0	4.2
Minimum length	0	0	0	430	0	433	302	0	496	0	0	0	302
Maximum length	0	0	0	562	0	558	575	0	581	0	0	0	581

[a] Sex-age components do not necessarily sum to sex pooled over age or age pooled over sex due to missing sex for age data and missing age for sex data.

Age composition of the Lake Louise escapement differed significantly from that of the Buskin River escapement (chi-square test of independence; $\chi^2 = 48.35$, df = 4, $P < 0.001$). Sex composition between these run components was not significantly different (large two-sample *z*-test; $|z| = 0.29$, $P = 0.77$). The mean length of sockeye salmon passing the Buskin River weir (515 mm, SE 2.8) was significantly different (two-sample *z*-test; $|z| = 2.29$, $P = 0.022$) than that of sockeye salmon passing the Lake Louise weir (503 mm, SE 4.2).

Subsistence Harvest

The reported sockeye salmon subsistence harvest from the marine waters of the Buskin River drainage in 2010 was 1,514 (Table 1). About 93% of the permits were returned, resulting in an adjusted harvest of 1,594 (Table 4). Age was determined for 74 of 84 fish sampled from the harvest.

About 87% of sampled sockeye salmon harvested in the subsistence fishery reared in the ocean for 3 years. Ages 1.3 (41.9%) and 2.3 (44.6%) comprised the dominant age groups (Table 4). Mean length of males (537 mm, SE 7.8) was not significantly different (two-sample *z*-test; $|z| = 1.86$, $P = 0.06$) than that of females (521 mm, SE 4.3).

The subsistence harvest was sampled for less time in 2010 (31 May–9 June) than in other years, and only interactions between age and sex were assessed; a 2-factor (age, sex) Pearson chi-square test of independence detected no age-sex interaction ($\chi^2 = 0.51$, df = 1, $P = 0.48$). The sex ratio was 0.65 (males:females) and was significantly different from 1.0 (large-sample *z*-test; $|z| = 2.05$, $P = 0.04$).

The age composition of the subsistence harvest was significantly different ($\chi^2 = 12.04$, df = 3, $P = 0.007$) from that of the Buskin Lake escapement. Sex composition between run components was also significantly different (large-two-sample *z*-test; $|z| = 1.99$, $P = 0.046$). Sockeye salmon harvested by the subsistence fishery averaged 528 mm (SE 4.3) in length compared to fish sampled at the Buskin River weir, which averaged 515 mm (SE 2.8), and were significantly different (two-sample *z*-test; $|z| = 2.62$, $P < 0.001$).

Sport and Commercial Fisheries

In 2010, anglers fishing the Buskin River drainage caught an estimated 699 sockeye salmon and harvested 332 (SE 132) sockeye salmon, expending 13,365 (SE 2,844) angler-days of effort for all species during the entire year (Table 1). For sockeye salmon harvested in the sport fishery, 71.3% reared in the ocean for 3 years, and the predominant ages were 1.3 (23.6%), 2.2 (22.5%) and 2.3 (47.7%) (Table 5).

Fish ticket harvest receipts from CF indicate that 0 sockeye salmon were harvested at the mouth of the Buskin River in Womens Bay, statistical areas 259-22 and 259-26, during 2010.

YEAR 2011

Buskin River Weir

The Buskin River weir was installed on 28 May and operated continuously through 18 September 2011. The cumulative weir count through 31 July was 10,915 sockeye salmon, with 50% of the run passing the weir by 17 June (Appendix A1). The final count at the weir was 11,982 sockeye salmon.

Table 4.–Estimated age and sex composition and mean length-at-age of the reported sockeye salmon subsistence harvest for the Buskin River drainage, 2010.

	Age												
Run component	0.2	1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Total[a]
Females													
Number sampled	0	0	0	1	0	21	1	0	20	0	0	0	51
Percent	0.0	0.0	0.0	1.4	0.0	29.6	1.4	0.0	28.2	0.0	0.0	0.0	60.7
SE percent	0.0	0.0	0.0	1.3	0.0	5.2	1.3	0.0	5.1	0.0	0.0	0.0	5.2
Total harvest	0	0	0	22	0	472	22	0	449	0	0	0	968
SE harvest	0	0	0	21	0	83	21	0	82	0	0	0	83
Mean length	0	0	0	525	0	523	500	0	521	0	0	0	521
SE mean length	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	7.6	0.0	0.0	0.0	4.3
Minimum length	0	0	0	525	0	500	500	0	421	0	0	0	421
Maximum length	0	0	0	525	0	544	500	0	580	0	0	0	580
Males													
Number sampled	0	0	0	1	0	8	6	0	13	0	0	0	33
Percent	0.0	0.0	0.0	1.4	0.0	11.3	8.5	0.0	18.3	0.0	0.0	0.0	39.3
SE percent	0.0	0.0	0.0	1.3	0.0	3.6	3.2	0.0	4.4	0.0	0.0	0.0	5.2
Total harvest	0	0	0	22	0	180	135	0	292	0	0	0	626
SE harvest	0	0	0	21	0	58	51	0	70	0	0	0	83
Mean length	0	0	0	491	0	557	518	0	552	0	0	0	537
SE mean length	0.0	0.0	0.0	0.0	0.0	12.6	19.6	0.0	11.9	0.0	0.0	0.0	7.8
Minimum length	0	0	0	491	0	510	475	0	460	0	0	0	450
Maximum length	0	0	0	491	0	585	610	0	595	0	0	0	610
All													
Number sampled	0	0	0	3	0	31	7	0	33	0	0	0	84
Percent	0.0	0.0	0.0	4.1	0.0	41.9	9.5	0.0	44.6	0.0	0.0	0.0	
SE percent	0.0	0.0	0.0	2.3	0.0	5.6	3.3	0.0	5.7	0.0	0.0	0.0	
Total harvest	0	0	0	65	0	668	151	0	711	0	0	0	1,594
SE harvest	0	0	0	36	0	90	53	0	91	0	0	0	
Mean length	0	0	0	508	0	535	515	0	533	0	0	0	528
SE mean length	0.0	0.0	0.0	17.0	0.0	6.0	16.8	0.0	6.9	0.0	0.0	0.0	4.3
Minimum length	0	0	0	491	0	500	475	0	421	0	0	0	421
Maximum length	0	0	0	525	0	585	610	0	595	0	0	0	610

[a] Sex-age components do not necessarily sum to sex pooled over age or age pooled over sex due to missing sex for age data and missing age for sex data.

Table 5.–Estimated age and sex composition and mean length-at-age of the sockeye salmon sport and commercial harvest combined for the Buskin River drainage, 2010.

	Age												
Run component[a]	0.2	1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Total[b]
Females													
Percent	0.0	0.0	0.0	0.9	0.0	12.2	10.5	0.0	25.4	0.0	0.0	0.0	48.9
SE percent	0.0	0.0	0.0	0.5	0.0	2.1	1.9	0.0	2.8	0.0	0.0	0.0	2.8
Harvest	0	0	0	3	0	41	35	0	84	0	0	0	162
SE harvest	0	0	0	2	0	17	15	0	35	0	0	0	65
Males													
Percent	0.0	0.0	0.0	2.5	2.3	11.6	12.2	0.0	22.3	0.0	0.0	0.0	51.1
SE percent	0.0	0.0	0.0	1.0	0.9	2.0	2.0	0.0	2.7	0.0	0.0	0.0	2.8
Harvest	0	0	0	8	8	39	41	0	74	0	0	0	170
SE harvest	0	0	0	5	4	16	17	0	31	0	0	0	68
All													
Percent	0.0	0.0	0.0	3.4	2.9	23.6	22.5	0.0	47.7	0.0	0.0	0.0	
SE percent	0.0	0.0	0.0	1.1	1.1	2.6	2.6	0.0	3.1	0.0	0.0	0.0	
Harvest	0	0	0	11	10	78	75	0	158	0	0	0	332
SE harvest	0	0	0	6	5	32	31	0	64	0	0	0	

[a] Sport harvest estimates come from age-sex proportions of Buskin River escapement.

[b] Sex-age components do not necessarily sum to sex pooled over age or age pooled over sex due to missing sex for age data and missing age for sex data.

Age was determined for 275 of 327 sockeye salmon sampled at the Buskin River weir (Table 6). Of those with determined ages, about 61% had reared in the ocean for 3 years; 6.3% were age 1.3 and 54.4% were age 2.3. Over 37% had reared in the ocean for 2 years (0.7% age 1.2, 0.4% age 3.2, and 36.5% age 2.2) (Table 6). Mean length of males (535 mm, SE 4.6) was significantly different (two-sample *z*-test; $|z| = 4.09$, $P < 0.001$) from that of females (512 mm, SE 2.8).

Log-linear modeling of counts in the 3-way age-sex-time analysis showed that the best fitting model is a no-interaction model ($\chi^2 = 26.2$, df = 17, $P = 0.07$) where neither age nor sex changes over sampling period, and age composition is the same for males and females. The sex ratio was 0.88 (males:females) and was not significantly different from 1.0 (large-sample *z*-test; $P = 0.23$).

Lake Louise Weir

The Lake Louise weir was operated continuously from 25 April to 12 September 2011 except for a few hours that a panel was dislodged on 3 September. The cumulative count through 31 July was 10 sockeye salmon, with 50% of the run passing the weir by 26 August (Appendix A2). The final sockeye salmon count at the weir was 360. Similar to other years, daily peak counts coincided with high water events. More than 68% of the total weir count occurred from 25 to 29 August.

Age was determined for 27 of 71 sockeye salmon sampled at the Lake Louise weir (Table 7). Because of the late return and the maturity of the salmon, few age determinations were made due to scale reabsorption. Sockeye salmon returning to Lake Louise often hold in the Buskin River until significant rainfall raises the water level enough for fish passage. For sockeye salmon with determined ages, about 85% reared in the ocean for 2 years; 18.5% were age 1.2 and 66.7% were age 2.2. Only 3.7% reared in the ocean for 3 years; all were age 2.3 (Table 7). Mean length of males (506 mm, SE 10.8) was not significantly different (two-sample *z*-test; $P = 0.51$) than that of females (497 mm, SE 7.0).

Age composition of the Louise River escapement differed significantly from that of the Buskin River escapement (chi-square test of independence; $\chi^2 = 58.08$, df = 4, $P < 0.001$). Sex composition did not differ between the Louise and Buskin rivers escapements (large two-sample *z*-test; $|z| = 1.13$, $P = 0.26$). Mean length of sockeye salmon passing the Buskin Lake weir (523 mm, SE 2.7) was significantly different (two-sample *z*-test; $|z| = 2.91$, $P = 0.004$) than that of sockeye salmon passing the Lake Louise weir (502 mm, SE 6.6).

Subsistence Harvest

The reported sockeye salmon subsistence harvest from marine waters of the Buskin River system in 2011 was 4,639 fish (Table 1). About 90% of the permits were returned; the adjusted harvest was 4,885 (Table 8). Age was determined for 115 of 141 sockeye salmon sampled from the harvest, and about 70% reared in the ocean for 3 years: 15.7% age 1.3 and 53.9% age 2.3 (Table 8). The remaining salmon sampled reared in the ocean for 2 years. Mean length of males (549 mm, SE 3.1) differed significantly (two-sample *z* test; $|z| = 3.71$, $P < 0.001$) from females (530 mm, SE 4.0).

Table 6.-Estimated age and sex compositions and mean length-at-age of the sockeye salmon escapement at Buskin River weir, 2011.

	Age												
Run component	0.2	1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Total[a]
Females													
Number sampled	0	0	0	2	0	7	61	0	78	1	0	0	172
Percent	0.0	0.0	0.0	0.7	0.0	2.7	21.9	0.0	28.8	0.4	0.0	0.0	53.3
SE percent	0.0	0.0	0.0	0.5	0.0	1.0	2.5	0.0	2.7	0.4	0.0	0.0	2.8
Total escapement	0	0	0	81	0	326	2,626	0	3,448	44	0	0	6,386
SE escapement	0	0	0	59	0	121	297	0	327	43	0	0	331
Mean length	0	0	0	471	0	541	488	0	530	472	0	0	512
SE mean length	0.0	0.0	0.0	1.0	0.0	11.5	4.8	0.0	3.1	0.0	0.0	0.0	2.8
Minimum length	0	0	0	470	0	500	425	0	435	472	0	0	425
Maximum length	0	0	0	472	0	576	598	0	582	472	0	0	598
Males													
Number sampled	0	1	0	0	5	9	40	0	71	0	0	0	155
Percent	0.0	0.4	0.0	0.0	1.4	3.6	14.6	0.0	25.6	0.0	0.0	0.0	46.7
SE percent	0.0	0.4	0.0	0.0	0.6	1.1	2.1	0.0	2.6	0.0	0.0	0.0	2.8
Total escapement	0	50	0	0	167	426	1,748	0	3,066	0	0	0	5,596
SE escapement	0	50	0	0	73	138	256	0	315	0	0	0	331
Mean length	0	340	0	0	359	571	507	0	562	0	0	0	535
SE mean length	0.0	0.0	0.0	0.0	7.1	6.2	7.2	0.0	2.9	0.0	0.0	0.0	4.6
Minimum length	0	340	0	0	339	543	413	0	487	0	0	0	339
Maximum length	0	340	0	0	374	600	587	0	621	0	0	0	621
All													
Number sampled	0	1	0	2	5	16	101	0	149	1	0	0	327
Percent	0.0	0.4	0.0	0.7	1.4	6.3	36.5	0.0	54.4	0.4	0.0	0.0	
SE percent	0.0	0.4	0.0	0.5	0.6	1.5	2.9	0.0	3.0	0.4	0.0	0.0	
Total escapement	0	50	0	81	167	752	4,374	0	6,514	44	0	0	11,982
SE escapement	0	50	0	58	72	179	345	0	357	43	0	0	
Mean length	0	340	0	471	359	558	496	0	545	472	0	0	523
SE mean length	0.0	0.0	0.0	1.0	7.1	7.0	4.1	0.0	2.5	0.0	0.0	0.0	2.7
Minimum length	0	340	0	470	339	500	413	0	435	472	0	0	339
Maximum length	0	340	0	472	374	600	598	0	621	472	0	0	621

[a] Sex-age components do not necessarily sum to sex pooled over age or age pooled over sex due to missing sex for age data and missing age for sex data.

Table 7.-Estimated age and sex compositions and mean length-at-age of the sockeye salmon escapement at Lake Louise weir, 2011.

	Age												
Run component	0.2	1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Total[a]
Females													
Number sampled	0	0	0	5	0	0	9	0	1	0	0	0	33
Percent	0.0	0.0	0.0	18.5	0.0	0.0	33.3	0.0	3.7	0.0	0.0	0.0	46.5
SE percent	0.0	0.0	0.0	7.3	0.0	0.0	8.9	0.0	3.6	0.0	0.0	0.0	5.3
Total escapement	0	0	0	67	0	0	120	0	13	0	0	0	167
SE escapement	0	0	0	26	0	0	32	0	13	0	0	0	19
Mean length	0	0	0	486	0	0	505	0	520	0	0	0	497
SE mean length	0.0	0.0	0.0	9.1	0.0	0.0	17.5	0.0	0.0	0.0	0.0	0.0	7.0
Minimum length	0	0	0	450	0	0	425	0	520	0	0	0	425
Maximum length	0	0	0	500	0	0	560	0	520	0	0	0	575
Males													
Number sampled	0	1	0	0	2	0	9	0	0	0	0	0	38
Percent	0.0	3.7	0.0	0.0	7.4	0.0	33.3	0.0	0.0	0.0	0.0	0.0	53.5
SE percent	0.0	3.6	0.0	0.0	4.9	0.0	8.9	0.0	0.0	0.0	0.0	0.0	5.3
Total escapement	0	13	0	0	27	0	120	0	0	0	0	0	193
SE escapement	0	13	0	0	18	0	32	0	0	0	0	0	19
Mean length	0	350	0	0	442	0	503	0	0	0	0	0	506
SE mean length	0.0	0.0	0.0	0.0	101.5	0.0	13.8	0.0	0.0	0.0	0.0	0.0	10.8
Minimum length	0	350	0	0	340	0	445	0	0	0	0	0	340
Maximum length	0	350	0	0	543	0	570	0	0	0	0	0	590
All													
Number sampled	0	1	0	5	2	0	18	0	1	0	0	0	71
Percent	0.0	3.7	0.0	18.5	7.4	0.0	66.7	0.0	3.7	0.0	0.0	0.0	
SE percent	0.0	3.6	0.0	7.3	4.9	0.0	8.9	0.0	3.6	0.0	0.0	0.0	
Total escapement	0	13	0	67	27	0	240	0	13	0	0	0	360
SE escapement	0	13	0	26	18	0	32	0	13	0	0	0	
Mean length	0	350	0	486	442	0	504	0	520	0	0	0	502
SE mean length	0.0	0.0	0.0	9.1	101.5	0.0	10.8	0.0	0.0	0.0	0.0	0.0	6.6
Minimum length	0	350	0	450	340	0	425	0	520	0	0	0	340
Maximum length	0	350	0	500	543	0	570	0	520	0	0	0	590

[a] Sex-age components do not necessarily sum to sex pooled over age or age pooled over sex due to missing sex for age data and missing age for sex data.

Log-linear modeling of counts in a 3-way age-sex-time analysis showed that the best-fitting model is a no-interaction model (χ^2 = 13.5, df = 10, P = 0.20) where neither age nor sex change over sampling periods, and where age composition is the same for males and females. The sex ratio was 0.88 (males:females) and was not significantly different from 1.0 (large-sample *z*-test; $|z|$ = 0.8, P = 0.44).

Age composition of sockeye salmon harvested in the subsistence fishery was significantly different (chi-square test of independence; χ^2 = 42.85, df = 3, P < 0.001) from that of the Buskin Lake escapement. Sex composition between run components was not significantly different (large-two-sample *z*-test; $|z|$ = 0.02, P = 0.98). The mean length of sockeye salmon harvested by subsistence fishers (539 mm, SE 2.7) was significantly different (two-sample *z*-test; $|z|$ = 4.24, P < 0.001) from that of the Buskin Lake escapement (523 mm, SE 2.7).

Sport and Commercial Fisheries

In 2011, anglers fishing the Buskin River drainage caught an estimated 2,285 sockeye salmon and harvested 1,277 (SE 439), expending 13,879 (SE 1,954) angler-days of effort for all species during the year (Table 1). About 61% of sampled sockeye salmon harvested by the sport and commercial fisheries reared in the ocean for 3 years: 6.3% age 1.3 and 54.4% age 2.3 (Table 9).

Fish ticket harvest receipts available from CF indicate that 38 sockeye salmon were harvested adjacent to the Buskin River in Womens Bay, statistical areas 259-22 and 259-26, during 2011.

YEAR 2012

Buskin River Weir

The Buskin River weir was installed on 21 May and operated continually through 27 September 2012. The cumulative count at the weir through 31 July was 8,049 sockeye salmon, with 50% passing the weir by 17 June (Appendix A1). The final sockeye salmon weir count was 8,565.

Age was determined for 292 of 370 sockeye salmon sampled (Table 10). About 64% of sampled sockeye salmon reared in the ocean for 3 years; 4.1% were age 1.3, and 59.8% were age 2.3 (Table 10). Most of the remaining sockeye salmon (32.2%) reared in the ocean for 2 years. Mean METF length of males (537 mm, SE 6.2) was not significantly different from that of females (523 mm, SE 2.8) (two-sample *z* test; $|z|$ = 1.92, P = 0.055).

Log-linear modeling of counts in the 3-way age-sex-time analysis showed the best fitting model is one in which time is jointly independent of age and sex (χ^2 = 17.58, df = 14, P = 0.23). The selected model implies that age and time are independent in the marginal table (i.e., collapsed over sex), and that sex and time are independent when collapsed over age. The selected model implies that sex composition changes over age. The sex ratio was 0.67 (males:females) and was significantly different from 1.0 (large-sample *z*-test; $|z|$ = 3.8, P < 0.001).

Table 8.-Estimated age and sex compositions and mean length-at-age of the reported sockeye salmon subsistence harvest for the Buskin River drainage, 2011.

	Age												
Run component	0.2	1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Total[a]
Females													
Number sampled	0	0	0	4	0	12	12	0	32	0	0	0	75
Percent	0.0	0.0	0.0	3.5	0.0	10.5	10.5	0.0	28.1	0.0	0.0	0.0	53.2
SE percent	0.0	0.0	0.0	1.7	0.0	2.8	2.8	0.0	4.2	0.0	0.0	0.0	4.2
Total harvest	0	0	0	171	0	514	514	0	1,371	0	0	0	2,598
SE harvest	0	0	0	83	0	139	139	0	203	0	0	0	203
Mean length	0	0	0	503	0	545	500	0	540	0	0	0	530
SE mean length	0.0	0.0	0.0	8.1	0.0	6.9	10.8	0.0	5.3	0.0	0.0	0.0	4.0
Minimum length	0	0	0	484	0	508	449	0	450	0	0	0	449
Maximum length	0	0	0	519	0	580	559	0	610	0	0	0	610
Males													
Number sampled	0	0	0	7	0	6	12	0	29	0	0	0	66
Percent	0.0	0.0	0.0	6.1	0.0	5.3	10.5	0.0	25.4	0.0	0.0	0.0	46.8
SE percent	0.0	0.0	0.0	2.2	0.0	2.1	2.8	0.0	4.0	0.0	0.0	0.0	4.2
Total harvest	0	0	0	300	0	257	514	0	1,243	0	0	0	2,287
SE harvest	0	0	0	109	0	101	139	0	197	0	0	0	203
Mean length	0	0	0	525	0	565	525	0	560	0	0	0	549
SE mean length	0.0	0.0	0.0	8.9	0.0	8.9	5.9	0.0	3.6	0.0	0.0	0.0	3.1
Minimum length	0	0	0	485	0	528	498	0	494	0	0	0	485
Maximum length	0	0	0	557	0	588	558	0	590	0	0	0	590
All													
Number sampled	0	0	0	11	0	18	24	0	62	0	0	0	141
Percent	0.0	0.0	0.0	9.6	0.0	15.7	20.9	0.0	53.9	0.0	0.0	0.0	
SE percent	0.0	0.0	0.0	2.7	0.0	3.4	3.8	0.0	4.6	0.0	0.0	0.0	
Total harvest	0	0	0	467	0	765	1,019	0	2,634	0	0	0	4,885
SE harvest	0	0	0	133	0	164	184	0	225	0	0	0	
Mean length	0	0	0	517	0	552	513	0	549	0	0	0	539
SE mean length	0.0	0.0	0.0	7.0	0.0	5.8	6.5	0.0	3.5	0.0	0.0	0.0	2.7
Minimum length	0	0	0	484	0	508	449	0	450	0	0	0	449
Maximum length	0	0	0	557	0	588	559	0	610	0	0	0	610

[a] Sex-age components do not necessarily sum to sex pooled over age or age pooled over sex due to missing sex for age data and missing age for sex data.

Table 9.-Estimated age and sex compositions and mean length-at-age of the sockeye salmon sport and commercial harvests combined for the Buskin River drainage, 2011.

	Age												
Run component[a]	0.2	1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Total[b]
Females													
Percent	0.0	0.0	0.0	0.7	0.0	2.7	21.9	0.0	28.8	0.4	0.0	0.0	53.3
SE percent	0.0	0.0	0.0	0.5	0.0	1.0	2.5	0.0	2.7	0.4	0.0	0.0	2.8
Harvest	0	0	0	9	0	36	288	0	378	5	0	0	701
SE harvest	0	0	0	7	0	17	101	0	131	5	0	0	236
Males													
Percent	0.0	0.4	0.0	0.0	1.4	3.6	14.6	0.0	25.6	0.0	0.0	0.0	46.7
SE percent	0.0	0.4	0.0	0.0	0.6	1.1	2.1	0.0	2.6	0.0	0.0	0.0	2.8
Harvest	0	6	0	0	18	47	192	0	336	0	0	0	614
SE harvest	0	5	0	0	10	21	69	0	117	0	0	0	208
All													
Percent	0.0	0.4	0.0	0.7	1.4	6.3	36.5	0.0	54.4	0.4	0.0	0.0	
SE percent	0.0	0.4	0.0	0.5	0.6	1.5	2.9	0.0	3.0	0.4	0.0	0.0	
Harvest	0	6	0	9	18	83	480	0	715	5	0	0	1,315
SE harvest	0	5	0	7	10	33	164	0	241	5	0	0	

[a] Sex-age components do not necessarily sum to sex pooled over age or age pooled over sex due to missing sex for age data and missing age for sex data.

[b] Sport harvest: estimates from age-sex proportions of Buskin River escapement.

Table 10.-Estimated age and sex compositions and mean length-at-age of the sockeye salmon escapement at Buskin River weir, 2012.

	Age												
Run component	0.2	1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Total[a]
Females													
Number sampled	0	0	0	3	0	2	150	0	17	0	0	0	220
Percent	0.0	0.0	0.0	1.3	0.0	0.7	52.5	0.0	6.0	0.0	0.0	0.0	59.7
SE percent	0.0	0.0	0.0	0.7	0.0	0.5	3.0	0.0	1.4	0.0	0.0	0.0	2.6
Total escapement	0	0	0	109	0	56	4,499	0	513	0	0	0	5,118
SE escapement	0	0	0	63	0	39	259	0	123	0	0	0	221
Mean length	0	0	0	480	0	543	508	0	540	508	0	0	523
SE mean length	0.0	0.0	0.0	9.6	0.0	16.4	5.6	0.0	2.5	0.0	0.0	0.0	2.8
Minimum length	0	0	0	415	0	486	448	0	469	508	0	0	336
Maximum length	0	0	0	540	0	594	581	0	612	508	0	0	612
Males													
Number sampled	0	0	0	16	7	7	18	0	65	0	0	0	150
Percent	0.0	0.0	0.0	5.9	2.7	2.2	6.1	0.0	22.7	0.0	0.0	0.0	40.3
SE percent	0.0	0.0	0.0	1.5	1.0	0.8	1.4	0.0	2.5	0.0	0.0	0.0	2.6
Total escapement	0	0	0	506	235	189	520	0	1,942	0	0	0	3,451
SE escapement	0	0	0	125	88	71	120	0	216	0	0	0	221
Mean length	0	361	0	483	327	567	535	0	570	538	573	0	537
SE mean length	0.0	48.5	0.0	12.7	7.5	22.6	11.1	0.0	5.1	15.9	0.0	0.0	6.2
Minimum length	0	312	0	405	300	454	426	0	453	511	573	0	300
Maximum length	0	409	0	584	362	615	607	0	663	566	573	0	663
All													
Number sampled	0	2	0	33	7	14	55	0	176	4	1	0	370
Percent	0.0	0.9	0.0	11.8	2.7	4.1	18.8	0.0	59.8	1.6	0.3	0.0	
SE percent	0.0	0.6	0.0	1.9	1.0	1.1	2.3	0.0	2.9	0.8	0.3	0.0	
Total escapement	0	78	0	1,007	229	354	1,610	0	5,127	141	22	0	8,569
SE escapement	0	53	0	167	86	93	197	0	249	70	22	0	
Mean length	0	361	0	481	327	555	516	0	551	531	573	0	529
SE mean length	0.0	48.5	0.0	7.8	7.5	13.8	5.4	0.0	2.7	13.5	0.0	0.0	3.0
Minimum length	0	312	0	405	300	454	426	0	453	508	573	0	300
Maximum length	0	409	0	584	362	615	607	0	663	566	573	0	663

[a] Sex-age components do not necessarily sum to sex pooled over age or age pooled over sex due to missing sex for age data and missing age for sex data.

Lake Louise Weir

The Lake Louise weir was operated continuously from 25 May to 21 September 2012. The cumulative count at the weir through 31 July was 5 sockeye salmon, with over 50% passing the weir by 18 September; the final sockeye salmon weir count was 301 (Appendix A2).

Age was determined for 33 of 135 sockeye salmon sampled (Table 11). Nearly the entire escapement was counted after 1 September but because the salmon had matured, there were fewer scales that could be aged because of scale reabsorption. For sockeye salmon with determined ages, about 24% reared in the ocean for 3 years, and all were age 1.3. There were 48.5% that reared in the ocean for 2 years; 27.3% were age 1.2 and 21.2% were age 2.2 (Table 11). The remaining sockeye salmon reared in the ocean for 1 year and returned as jacks. Mean length of males (469 mm, SE 10.4) was not significantly different (two-sample z-test; $|z| = 1.88$, $P = 0.06$) from that of females (490 mm, SE 3.8).

Age composition of the Louise River escapement differed significantly from that of the Buskin River escapement ($\chi^2 = 50.4$, df = 4, $P < 0.001$). Sex composition did not differ between the Louise and Buskin rivers escapements (large two-sample z-test; $|z| = 1.03$, $P = 0.30$). The mean length of Buskin Lake sockeye salmon (529 mm, SE 3.0) was significantly different (two-sample z-test; $|z| = 7.99$, $P < 0.001$) from that of Lake Louise sockeye salmon (481 mm, SE 5.2).

Subsistence Harvest

The reported sockeye salmon subsistence harvest from marine waters of the Buskin River system in 2012 was 2,631 fish (Table 1). About 88% of the permits were returned, resulting in an adjusted harvest of 2,771 (Table 12). Age was determined for 132 of 153 sockeye salmon sampled from the 2012 harvest (Table 12). Of those with determined ages, about 86% reared in the ocean for 3 years; 8.3% were age 1.3, 0.8% were age 3.3, and 76.5% were age 2.3 (Table 12). Most of the remaining sockeye salmon reared in the ocean for 2 years. Mean length of males (592 mm, SE 4.8) was significantly different (two-sample z-test; $|z| = 7.62$, $P < 0.001$) from that of females (550 mm, SE 2.8).

Log-linear modeling of counts in the 3-way age-sex-time analysis showed that the best-fitting model is a no-interaction model ($\chi^2 = 16.48$, df = 10, $P = 0.09$) where neither age nor sex change over the sampling period, and age composition is the same for males and females. The sex ratio was 0.78 (males:females) and was not significantly different from 1.0 (large-sample z-test; $|z| = 1.6$, $P = 0.11$).

The age composition of the subsistence harvest was significantly different (chi-square test of independence; $\chi^2 = 17.08$, df = 3, $P < 0.001$) from that of the Buskin Lake escapement, but sex composition was not significantly different (large two-sample z test; $|z| = 0.75$, $P = 0.45$). The mean length of sockeye salmon harvested by subsistence fishers (568 mm, SE 3.1) was significantly different (two-sample z-test; $|z| = 9.02$, $P < 0.001$) from that of Buskin Lake sockeye salmon (529 mm, SE 3.0).

Table 11.-Estimated age and sex compositions, and mean length-at-age of the sockeye salmon escapement at Lake Louise weir, 2012.

	Age												
Run component	0.2	1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Total[a]
Females													
Number sampled	0	0	0	6	0	4	7	0	0	0	0	0	75
Percent	0.0	0.0	0.0	18.2	0.0	12.1	21.2	0.0	0.0	0.0	0.0	0.0	55.6
SE percent	0.0	0.0	0.0	6.4	0.0	5.4	6.8	0.0	0.0	0.0	0.0	0.0	3.2
Total escapement	0	0	0	55	0	36	64	0	0	0	0	0	167
SE escapement	0	0	0	19	0	16	21	0	0	0	0	0	10
Mean length	0	0	0	471	0	524	465	0	0	0	0	0	490
SE mean length	0.0	0.0	0.0	8.4	0.0	13.3	9.5	0.0	0.0	0.0	0.0	0.0	3.8
Minimum length	0	0	0	450	0	494	426	0	0	0	0	0	426
Maximum length	0	0	0	498	0	550	508	0	0	0	0	0	594
Males													
Number sampled	0	8	0	3	1	4	0	0	0	0	0	0	60
Percent	0.0	24.2	0.0	9.1	3.0	12.1	0.0	0.0	0.0	0.0	0.0	0.0	44.4
SE percent	0.0	7.1	0.0	4.8	2.9	5.4	0.0	0.0	0.0	0.0	0.0	0.0	3.2
Total escapement	0	73	0	27	9	36	0	0	0	0	0	0	134
SE escapement	0	22	0	14	9	16	0	0	0	0	0	0	10
Mean length	0	339	0	501	354	539	0	0	0	0	0	0	469
SE mean length	0.0	11.0	0.0	12.8	0.0	17.3	0.0	0.0	0.0	0.0	0.0	0.0	10.4
Minimum length	0	272	0	484	354	510	0	0	0	0	0	0	272
Maximum length	0	370	0	526	354	589	0	0	0	0	0	0	589
All													
Number sampled	0	8	0	9	1	8	7	0	0	0	0	0	135
Percent	0.0	24.2	0.0	27.3	3.0	24.2	21.2	0.0	0.0	0.0	0.0	0.0	
SE percent	0.0	7.1	0.0	7.4	2.9	7.1	6.8	0.0	0.0	0.0	0.0	0.0	
Total escapement	0	73	0	82	9	73	64	0	0	0	0	0	301
SE escapement	0	22	0	22	9	22	21	0	0	0	0	0	
Mean length	0	339	0	481	354	532	465	0	0	0	0	0	481
SE mean length	0.0	11.0	0.0	8.2	0.0	10.5	9.5	0.0	0.0	0.0	0.0	0.0	5.2
Minimum length	0	272	0	450	354	494	426	0	0	0	0	0	272
Maximum length	0	370	0	526	354	589	508	0	0	0	0	0	594

[a] Sex-age components do not necessarily sum to sex pooled over age or age pooled over sex due to missing sex for age data and missing age for sex data.

Table 12.-Estimated age and sex compositions, and mean length-at-age of the reported sockeye salmon subsistence harvest for the Buskin River drainage, 2012.

	Age												
Run component	0.2	1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Total[a]
Females													
Number sampled	0	0	0	1	0	6	6	0	63	0	0	0	86
Percent	0.0	0.0	0.0	0.8	0.0	4.5	4.5	0.0	47.7	0.0	0.0	0.0	56.2
SE percent	0.0	0.0	0.0	0.7	0.0	1.8	1.8	0.0	4.3	0.0	0.0	0.0	3.9
Total harvest	0	0	0	21	0	126	126	0	1,322	0	0	0	1,557
SE harvest	0	0	0	20	0	49	49	0	118	0	0	0	108
Mean length	0	0	0	505	0	543	515	0	555	0	0	0	550
SE mean length	0.0	0.0	0.0	#N/A	0.0	11.6	16.1	0.0	2.8	0.0	0.0	0.0	2.8
Minimum length	0	0	0	505	0	500	456	0	503	0	0	0	456
Maximum length	0	0	0	505	0	580	569	0	603	0	0	0	603
Males													
Number sampled	0	0	0	3	0	5	7	0	38	0	2	1	67
Percent	0.0	0.0	0.0	2.3	0.0	3.8	5.3	0.0	28.8	0.0	1.5	0.8	43.8
SE percent	0.0	0.0	0.0	1.3	0.0	1.6	1.9	0.0	3.9	0.0	1.0	0.7	3.9
Total harvest	0	0	0	63	0	105	147	0	798	0	42	21	1,213
SE harvest	0	0	0	35	0	45	53	0	107	0	29	20	108
Mean length	0	0	0	514	0	598	537	0	604	0	603	0	592
SE mean length	0.0	0.0	0.0	1.7	0.0	17.2	12.8	0.0	4.7	0.0	22.5	0.0	4.8
Minimum length	0	0	0	511	0	552	472	0	543	0	580	0	472
Maximum length	0	0	0	517	0	641	575	0	660	0	625	0	660
All													
Number sampled	0	0	0	4	0	11	13	0	101	0	2	1	153
Percent	0.0	0.0	0.0	3.0	0.0	8.3	9.8	0.0	76.5	0.0	1.5	0.8	
SE percent	0.0	0.0	0.0	1.5	0.0	2.4	2.5	0.0	3.6	0.0	1.0	0.7	
Total harvest	0	0	0	84	0	231	273	0	2,120	0	42	21	2,771
SE harvest	0	0	0	40	0	65	70	0	100	0	29	20	
Mean length	0	0	0	512	0	568	526	0	573	0	603	634	568
SE mean length	0.0	0.0	0.0	2.6	0.0	12.8	10.2	0.0	3.4	0.0	22.5	0.0	3.1
Minimum length	0	0	0	505	0	500	456	0	503	0	580	634	456
Maximum length	0	0	0	517	0	641	575	0	660	0	625	634	660

[a] Sex-age components do not necessarily sum to sex pooled over age or age pooled over sex due to missing sex for age data and missing age for sex data.

Sport and Commercial Fisheries

In 2012, anglers fishing the Buskin River drainage caught an estimated 1,938 sockeye salmon and harvested 1,484 (SE 545), expending 13,996 (SE 1,926) angler-days of effort for all species during the year (Table 1). About 64% of sockeye salmon harvested by the sport fishery reared in the ocean for 3 years, and the predominant ages were 1.3 (4.1%) and 2.3 (59.8%) (Table 13).

Fish ticket harvest receipts available from CF indicate that 1 sockeye salmon was harvested adjacent to the Buskin River in Womens Bay, statistical areas 259-22 and 259-26, during 2012.

YEAR 2013

Buskin River Weir

The Buskin River weir was installed on 20 May and operated continuously through 30 September 2013. The cumulative count at the weir through 31 July was 15,448 sockeye salmon, with 50% passing the weir by 17 June (Appendix A1). The final weir count was 16,189 sockeye salmon when the weir was removed for the season.

Age was determined for 321 of 390 sockeye salmon sampled, and about 48% of these reared in the ocean for 3 years: 12.6 % age 1.3 and 35.3 % age 2.3 (Table 14). Most of the remaining (43%) reared in the ocean for 2 years. Mean lengths of males (490 mm, SE 6.1) and females (501 mm, SE 2.6) were not significantly different (two-sample *z*-test; $|z| = 1.59$, $P = 0.11$).

Log-linear modeling of counts in the 3-way age-sex-time analysis showed the best-fitting model is the saturated one with a 3-way interaction between age, sex, and time. This model is the most complex model possible; it indicates that age composition changes over time and that this change is different between sexes. Strictly, no pooling of data over factors is warranted. However, we present age and sex compositions separately because our sampling program was designed to give a pseudo-representative sample of the whole escapement; we believe introduced bias is minimal (see Agresti [1990, page 145] for a discussion on collapsing contingency tables).

Lake Louise Weir

The Lake Louise weir was operated continuously from 29 May to 31 August 2013. The cumulative count at the weir through 31 July was 9 sockeye salmon, with over 50% passing the weir by 7 August (Appendix A2). The final sockeye salmon weir count was 903.

Age was determined for 40 of 62 sockeye salmon sampled (Table 15). About 12.5% of the sockeye salmon harvested reared in the ocean for 3 years (7.5% age 1.3 and 5.0% age 2.3), and 60% reared in the ocean for 2 years (57.5% age 1.2 and 2.5% age 2.2) (Table 15). Mean lengths of males (451 mm, SE 11.8) and females (481 mm, SE 5.4) were significantly different (two-sample *z*-test; $|z| = 2.28$, $P = 0.023$).

Samples sizes were too small and the sampling window too narrow to investigate age-sex-time interactions for data collected in 2013. The sex ratio was 1.29 (males:females) and was not significantly different from 1.0 (large two-sample *z*-test; $|z| = 1.05$, $P = 0.29$).

Age composition of Lake Louise sockeye salmon was significantly different (chi-square test of independence; $\chi^2 = 45.01$, df = 4, $P < 0.001$) from Buskin Lake sockeye salmon. Sex composition did not differ between the Louise and Buskin rivers escapements (large two-sample *z*-test; $|z| = 1.46$, $P = 0.15$). Mean lengths of Buskin Lake (496 mm, SE 3.3) and Lake Louise (464 mm, SE 7.3) salmon were significantly different (two-sample *z*-test; $|z| = 3.92$, $P < 0.001$).

Table 13.-Estimated age and sex compositions and mean length-at-age of the sockeye salmon sport and commercial harvest combined for the Buskin River drainage, 2012.

	Age												
Run component[a]	0.2	1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Total[b]
Females													
Percent	0.0	0.0	0.0	1.3	0.0	0.7	52.5	0.0	6.0	0.0	0.0	0.0	59.7
SE percent	0.0	0.0	0.0	0.7	0.0	0.5	3.0	0.0	1.4	0.0	0.0	0.0	2.6
Harvest	0	0	0	19	0	10	780	0	89	0	0	0	887
SE harvest	0	0	0	12	0	7	289	0	38	0	0	0	327
Males													
Percent	0.0	0.0	0.0	5.9	2.7	2.2	6.1	0.0	22.7	0.0	0.0	0.0	40.3
SE percent	0.0	0.0	0.0	1.5	1.0	0.8	1.4	0.0	2.5	0.0	0.0	0.0	2.6
Harvest	0	0	0	88	41	33	90	0	337	0	0	0	598
SE harvest	0	0	0	38	21	17	38	0	128	0	0	0	222
All													
Percent	0.0	0.9	0.0	11.8	2.7	4.1	18.8	0.0	59.8	1.6	0.3	0.0	
SE percent	0.0	0.6	0.0	1.9	1.0	1.1	2.3	0.0	2.9	0.8	0.3	0.0	
Harvest	0	13	0	175	40	61	279	0	889	24	4	0	1,485
SE harvest	0	10	0	69	20	27	107	0	329	14	4	0	

[a] Sport harvest: estimates from age-sex proportions of Buskin River escapement.

[b] Sex-age components do not necessarily sum to sex pooled over age or age pooled over sex due to missing sex for age data and missing age for sex data.

Table 14.-Estimated age and sex compositions and mean length-at-age of the sockeye salmon escapement at Buskin River weir, 2013.

	Age												
Run component	0.2	1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Total[a]
Females													
Number sampled	0	0	0	24	0	22	50	0	68	0	1	0	196
Percent	0.0	0.0	0.0	7.3	0.0	7.7	14.9	0.0	21.5	0.0	0.2	0.0	50.4
SE percent	0.0	0.0	0.0	1.5	0.0	1.6	2.0	0.0	2.3	0.0	0.2	0.0	2.6
Total escapement	0	0	0	1,188	0	1,240	2,406	0	3,488	0	28	0	8,152
SE escapement	0	0	0	238	0	251	320	0	380	0	28	0	420
Mean length	0	0	0	474	0	521	476	0	522	0	506	0	501
SE mean length	0.0	0.0	0.0	5.1	0.0	4.6	3.4	0.0	2.8	0.0	0.0	0.0	2.6
Minimum length	0	0	0	428	0	450	426	0	442	0	506	0	320
Maximum length	0	0	0	531	0	548	521	0	580	0	506	0	580
Males													
Number sampled	0	4	0	38	28	16	29	0	40	0	0	1	194
Percent	0.0	1.1	0.0	12.4	7.2	5.0	8.6	0.0	13.8	0.0	0.0	0.3	49.7
SE percent	0.0	0.6	0.0	1.9	1.3	1.2	1.6	0.0	2.0	0.0	0.0	0.3	2.8
Total escapement	0	176	0	2,015	1,169	802	1,385	0	2,234	0	0	56	1,901
SE escapement	0	91	0	307	218	200	252	0	321	0	0	56	106
Mean length	0	323	0	469	347	568	495	0	562	0	0	581	490
SE mean length	0.0	14.3	0.0	6.6	4.3	5.6	6.9	0.0	3.6	0.0	0.0	0.0	6.1
Minimum length	0	286	0	398	310	522	405	0	514	0	0	581	286
Maximum length	0	350	0	561	404	600	550	0	615	0	0	581	615
All													
Number sampled	0	4	0	62	28	38	79	0	108	0	1	1	390
Percent	0.0	1.1	0.0	19.8	7.2	12.6	23.4	0.0	35.3	0.0	0.2	0.3	
SE percent	0.0	0.6	0.0	2.3	1.3	1.9	2.3	0.0	2.7	0.0	0.2	0.3	
Total escapement	0	176	0	3,203	1,169	2,043	3,792	0	5,722	0	28	56	16,189
SE escapement	0	90	0	367	217	310	379	0	437	0	28	56	
Mean length	0	323	0	471	347	541	483	0	536	0	506	581	496
SE mean length	0.0	14.3	0.0	4.5	4.3	5.2	3.5	0.0	2.9	0.0	0.0	0.0	3.3
Minimum length	0	286	0	398	310	450	405	0	442	0	506	581	286
Maximum length	0	350	0	561	404	600	550	0	615	0	506	581	615

[a] Sex-age components do not necessarily sum to sex pooled over age or age pooled over sex due to missing sex for age data and missing age for sex data.

Table 15.-Estimated age and sex compositions, and mean length-at-age of the sockeye salmon escapement at Lake Louise weir, 2013.

	Age												
Run component	0.2	1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Total[a]
Females													
Number sampled	0	0	0	14	0	3	1	0	1	0	0	0	27
Percent	0.0	0.0	0.0	35.0	0.0	7.5	2.5	0.0	2.5	0.0	0.0	0.0	43.5
SE percent	0.0	0.0	0.0	7.5	0.0	4.1	2.4	0.0	2.4	0.0	0.0	0.0	6.1
Total escapement	0	0	0	316	0	68	23	0	23	0	0	0	393
SE escapement	0	0	0	67	0	37	22	0	22	0	0	0	55
Mean length	0	0	0	470	0	523	485	0	503	0	0	0	481
SE mean length	0.0	0.0	0.0	5.0	0.0	19.1	0.0	0.0	0.0	0.0	0.0	0.0	5.4
Minimum length	0	0	0	446	0	499	485	0	503	0	0	0	446
Maximum length	0	0	0	511	0	561	485	0	503	0	0	0	561
Males													
Number sampled	0	5	0	9	6	0	0	0	1	0	0	0	35
Percent	0.0	12.5	0.0	22.5	15.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	56.5
SE percent	0.0	5.2	0.0	6.5	5.6	0.0	0.0	0.0	2.4	0.0	0.0	0.0	6.1
Total escapement	0	113	0	203	135	0	0	0	23	0	0	0	510
SE escapement	0	47	0	59	50	0	0	0	22	0	0	0	55
Mean length	0	363	0	493	361	0	0	0	534	0	0	0	451
SE mean length	0.0	3.1	0.0	8.2	6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.8
Minimum length	0	354	0	447	345	0	0	0	534	0	0	0	345
Maximum length	0	372	0	539	380	0	0	0	534	0	0	0	554
All													
Number sampled	0	5	0	23	6	3	1	0	2	0	0	0	62
Percent	0.0	12.5	0.0	57.5	15.0	7.5	2.5	0.0	5.0	0.0	0.0	0.0	
SE percent	0.0	5.2	0.0	7.7	5.6	4.1	2.4	0.0	3.4	0.0	0.0	0.0	
Total escapement	0	113	0	519	135	68	23	0	45	0	0	0	903
SE escapement	0	47	0	70	50	37	22	0	31	0	0	0	
Mean length	0	363	0	479	361	523	485	0	519	0	0	0	464
SE mean length	0.0	3.1	0.0	4.9	6.3	19.1	#N/A	0.0	15.5	0.0	0.0	0.0	7.3
Minimum length	0	354	0	446	345	499	485	0	503	0	0	0	345
Maximum length	0	372	0	539	380	561	485	0	534	0	0	0	561

[a] Sex-age components do not necessarily sum to sex pooled over age or age pooled over sex due to missing sex for age data and missing age for sex data.

Subsistence Harvest

A complete estimate of the sockeye salmon subsistence harvest from the marine waters of the Buskin River system was not yet available for 2013. Final subsistence harvest estimates will be available in the Westward Region CF database in fall 2014 as well as in subsequent reports regarding the subsistence harvest of Buskin River sockeye salmon. The 2013 return was larger than the 2012 return, and the 2013 harvest is anticipated to be greater than the 2012 harvest. Age was determined for 255 of 302 fish sampled (Table 16), and of these about 84% reared in the ocean for 3 years; 1.2% were age 0.3, 25.5% were age 1.3, 56.5% were age 2.3, and 0.8% were age 3.3 (Table 16). All of the remaining salmon reared in the ocean for 2 years. Mean lengths of males (543 mm, SE 2.7) and females (521 mm, SE 2.1) were significantly different (two-sample *z*-test; $|z| = 6.33$, $P < 0.001$).

The best-fitting model for the subsistence harvest age-sex-time data is the saturated one, with a 3-way interaction between age, sex, and time. This model is the most complex model possible, and it indicates that age composition changes over time and that this change is different between sexes. Strictly, no pooling of data over factors is warranted in this case, but we do present age and sex compositions separately because our sampling program was designed to give a pseudo-representative sample of the whole subsistence harvest, and we believe any introduced bias is minimal.

The age composition of sockeye salmon harvested in the subsistence fishery was significantly different (chi-square test of independence; $\chi^2 = 65.4$, df = 3, $P < 0.001$) than that of the Buskin Lake escapement. Sex composition between run components was not significantly different (large two-sample *z*-test; $|z| = 0.0006$, $P = 0.99$). The mean length of sockeye salmon harvested by subsistence fishers (532 mm, SE 1.8) was significantly different (two-sample *z*-test; $|z| = 9.72$, $P < 0.001$) from that of Buskin Lake sockeye salmon (496 mm, SE 3.3).

Sport and Commercial Fisheries

The 2013 harvest estimate of sockeye salmon from the Buskin River drainage is not yet available from the SWHS. The 2013 return of sockeye salmon to the Buskin River was larger than 2012, and the 2013 harvest is anticipated to be greater than the 2012 harvest with respect to fishing effort.

Fish ticket harvest receipts available from CF indicate that 3 sockeye salmon were harvested near the Buskin River mouth in Womens Bay, statistical areas 259-22 and 259-26, during 2013 (Table 1).

About 48% of sockeye salmon harvested by the sport and commercial fisheries reared in the ocean for 3 years, and the predominant ages were 1.3 (12.6%) and 2.3 (35.3%) (Table 17).

Table 16.-Estimated age and sex compositions and mean length-at-age of the reported sockeye salmon subsistence harvest for the Buskin River drainage, 2013.

	Age												
Run component	0.2	1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Total[a]
Females													
Number sampled	0	0	3	4	0	40	7	0	69	0	0	1	152
Percent	0.0	0.0	1.2	1.6	0.0	15.7	2.7	0.0	27.1	0.0	0.0	0.4	50.3
SE Percent	0.0	0.0	0.7	0.8	0.0	2.2	1.0	0.0	2.7	0.0	0.0	0.4	2.8
Total Harvest	0	0	45	60	0	600	105	0	1,036	0	0	15	1,927
SE harvest	0	0	25	29	0	84	38	0	103	0	0	15	106
Mean Length	0	0	545	468	0	529	488	0	524	0	0	502	521
SE Mean Length	0.0	0.0	12.5	13.6	0.0	3.3	11.7	0.0	3.1	0.0	0.0	0.0	2.1
Minimum Length	0	0	530	435	0	477	441	0	443	0	0	502	435
Maximum Length	0	0	570	493	0	577	520	0	579	0	0	502	579
Males													
Number sampled	0	0	0	11	0	25	19	0	75	0	0	1	150
Percent	0.0	0.0	0.0	4.3	0.0	9.8	7.5	0.0	29.4	0.0	0.0	0.4	49.7
SE percent	0.0	0.0	0.0	1.2	0.0	1.8	1.6	0.0	2.8	0.0	0.0	0.4	2.8
Total harvest	0	0	0	165	0	375	285	0	1,126	0	0	15	1,901
SE harvest	0	0	0	47	0	69	61	0	106	0	0	15	106
Mean length	0	0	0	482	0	550	520	0	558	0	0	522	543
SE mean length	0.0	0.0	0.0	11.0	0.0	2.3	5.1	0.0	2.5	0.0	0.0	0.0	2.7
Minimum length	0	0	0	431	0	526	491	0	500	0	0	522	431
Maximum length	0	0	0	550	0	574	589	0	607	0	0	522	607
All													
Number sampled	0	0	3	15	0	65	26	0	144	0	0	2	302
Percent	0.0	0.0	1.2	5.9	0.0	25.5	10.2	0.0	56.5	0.0	0.0	0.8	
SE percent	0.0	0.0	0.7	1.4	0.0	2.6	1.8	0.0	3.0	0.0	0.0	0.5	
Total harvest	0	0	45	225	0	976	390	0	2,162	0	0	30	3,828
SE harvest	0	0	25	55	0	101	70	0	115	0	0	20	
Mean length	0	0	545	478	0	537	511	0	542	0	0	512	532
SE mean length	0.0	0.0	12.5	8.8	0.0	2.5	5.5	0.0	2.4	0.0	0.0	10.0	1.8
Minimum length	0	0	530	431	0	477	441	0	443	0	0	502	431
Maximum length	0	0	570	550	0	577	589	0	607	0	0	522	607

[a] Sex-age components do not necessarily sum to sex pooled over age or age pooled over sex due to missing sex for age data and missing age for sex data.

Table 17.-Estimated age and sex compositions and mean length-at-age of the sockeye salmon sport and commercial harvest combined for the Buskin River drainage, 2013.

	Age												
Run component[a]	0.2	1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Total[b]
Females													
Percent	0.0	0.0	0.0	7.3	0.0	7.7	14.9	0.0	21.5	0.0	0.2	0.0	50.4
SE percent	0.0	0.0	0.0	1.5	0.0	1.6	2.0	0.0	2.3	0.0	0.2	0.0	2.6
Harvest	0	0	0	102	0	106	206	0	298	0	2	0	697
SE harvest	0	0	0	41	0	43	77	0	110	0	2	0	276
Males													
Percent	0.0	1.1	0.0	12.4	7.2	5.0	8.6	0.0	13.8	0.0	0.0	0.3	49.7
SE percent	0.0	0.6	0.0	1.9	1.3	1.2	1.6	0.0	2.0	0.0	0.0	0.3	2.8
Harvest	0	15	0	172	100	69	118	0	191	0	0	5	687
SE harvest	0	9	0	66	40	29	47	0	73	0	0	5	273
All													
Percent	0.0	1.1	0.0	19.8	7.2	12.6	23.4	0.0	35.3	0.0	0.2	0.3	
SE percent	0.0	0.6	0.0	2.3	1.3	1.9	2.3	0.0	2.7	0.0	0.2	0.3	
Harvest	0	15	0	274	100	175	324	0	489	0	2	5	1,384
SE harvest	0	9	0	102	40	67	119	0	177	0	2	5	

[a] Sport harvest: estimates from age-sex proportions of Buskin River escapement.

[b] Sex-age components do not necessarily sum to sex pooled over age or age pooled over sex due to missing sex for age data and missing age for sex data.

TOTAL RUN, EXPLOITATION RATES, AND BROOD TABLE

The estimated total sockeye salmon runs, incorporating subsistence harvest and escapement adjustments, were 11,726 in 2010, 18,182 in 2011, 12,825 in 2012, and an estimated 21,400 in 2013 (including estimates of anticipated subsistence and sport harvests, which were 3,635 and 1,381, respectively) (Table 18). Ocean-age-3 sockeye salmon (ages 2.3 and 1.3) were consistently predominant in the returns, followed by ocean-age-2 fish (ages 2.2 and 1.2).

Table 18.-Estimated total run of sockeye salmon to Buskin Lake by age class, 2010-2013.

		Age Class												
Year		0.2	1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Total
2010	Number	0	0	0	406	294	3,056	2,426	0	5,545	0	0	0	11,726
	SE	0	0	0	113	103	276	259	0	327	0	0	0	
2011	Number	0	56	0	558	185	1,599	5,873	0	9,862	49	0	0	18,182
	SE	0	50	0	145	73	245	424	0	486	44	0	0	
2012	Number	0	91	0	1,265	269	646	2,162	0	8,136	166	68	21	12,825
	SE	0	54	0	185	88	117	235	0	424	71	36	20	
2013[a]	Number	0	191	45	3,702	1,269	3,193	4,506	0	8,372	0	31	91	21,400
	SE	0	91	25	384	221	333	403	0	486	0	28	60	

[a] Anticipated subsistence (3,635) and sport harvests (1,381) included based on average of 2011 and 2012 harvests.

Annual subsistence fishery exploitation rates were 13.6% in 2010, 26.9% in 2011, and 21.6% in 2012, while annual sport and commercial fishery exploitation rates combined were 2.8% in 2010, 7.0% in 2011, and 11.6% in 2012 (Table 19). Estimates of removals by subsistence and sport users in 2013 are not available at this time but are expected to be higher than in 2012 because of larger returns of sockeye salmon in 2013. Standard errors of total exploitation rates were low (about 1–5%) and were driven by variability in SWHS harvest estimates.

Table 19.-Estimated exploitation rates (%) of sockeye salmon migrating to Buskin Lake by fishery, 2010-2013.

	Subsistence fishery		Sport and commercial fisheries		Total	
Year	%	SE	%	SE	%	SE
2010	13.6	0.15	2.8	1.1	16.4	1.1
2011	26.9	0.3	7.0	2.4	33.9	2.4
2012	21.6	0.39	11.6	4.28	33.2	4.30
2013	NA		NA		NA	

The brood table for Buskin River sockeye salmon, which was developed using all available Buskin River weir data through 2013, showed that the predominant age classes within most brood years were age 5 (52% of the 1990–2007 year class mean) and age 6 (36% of the 1990–2007 year class mean) sockeye salmon (Table 20). Historically, age-5 fish were the majority of sockeye salmon sampled until 2005–2007, when the majority of fish were age 6. Lake Louise data are not included in exploitation rates or the construction of the brood table.

Table 20.-Brood table for sockeye salmon migrating to Buskin Lake, 1990–2009 brood years.

Brood year	Spawner escapement	Recruitment parameter	Age at return: Age 3 (0.2, 1.1)	Age 4 (0.3, 1.2, 2.1)	Age 5 (1.3, 2.2,)	Age 6 (1.4, 2.3, 3.2)	Age 7 (2.4, 3.3)	Return totals
1990	10,528	Sample year	1993	1994	1995	1996	1997	
		Return (no.)	12	2,544	11,674	8,611	204	23,045
		Proportion by age	0.00	0.11	0.51	0.37	0.01	1.00
1991	9,789	Sample year	1994	1995	1996	1997	1998	
		Return (no.)	182	2,464	8,512	11,998	468	23,624
		Proportion by age	0.01	0.10	0.36	0.51	0.02	1.00
1992	9,782	Sample year	1995	1996	1997	1998	1999	
		Return (no.)	20	611	3,597	5,732	204	10,164
		Proportion by age	0.00	0.06	0.35	0.56	0.02	1.00
1993	9,526	Sample year	1996	1997	1998	1999	2000	
		Return (no.)	12	2,820	17,260	9,368	50	29,510
		Proportion by age	0.00	0.10	0.58	0.32	0.00	1.00
1994	13,146	Sample year	1997	1998	1999	2000	2001	
		Return (no.)	0	1,586	9,173	6,965	208	17,932
		Proportion by age	0.00	0.09	0.51	0.39	0.01	1.00
1995	15,520	Sample year	1998	1999	2000	2001	2002	
		Return (no.)	91	2,779	11,258	6,836	0	20,964
		Proportion by age	0.00	0.13	0.54	0.33	0.00	1.00
1996	10,277	Sample year	1999	2000	2001	2002	2003	
		Return (no.)	60	2,407	23,955	12,338	259	39,018
		Proportion by age	0.00	0.06	0.61	0.32	0.01	1.00
1997	9,840	Sample year	2000	2001	2002	2003	2004	
		Return (no.)	0	1,850	17,698	9,795	346	29,689
		Proportion by age	0.00	0.06	0.60	0.33	0.01	1.00

-continued-

Table 20.–Page 2 of 3.

Brood year	Spawner escapement	Recruitment parameter	Age at return: Age 3 (0.2, 1.1)	Age 4 (0.3, 1.2, 2.1)	Age 5 (1.3, 2.2,)	Age 6 (1.4, 2.3, 3.2)	Age 7 (2.4, 3.3)	Return totals
1998	14,767	Sample year	2001	2002	2003	2004	2005	
		Return (no.)	20	3,475	20,088	12,921	54	36,558
		Proportion by age	0.00	0.10	0.55	0.35	0.00	1.00
1999	10,812	Sample year	2002	2003	2004	2005	2006	
		Return (no.)	115	7,892	18,481	10,975	184	37,648
		Proportion by age	0.00	0.21	0.49	0.29	0.00	1.00
2000	11,233	Sample year	2003	2004	2005	2006	2007	
		Return (no.)	238	2,704	12,896	10,991	104	26,933
		Proportion by age	0.01	0.10	0.48	0.41	0.00	1.00
2001	20,556	Sample year	2004	2005	2006	2007	2008	
		Return (no.)	0	1,971	8,454	4,196	237	14,858
		Proportion by age	0.00	0.13	0.57	0.28	0.02	1.00
2002	17,174	Sample year	2005	2006	2007	2008	2009	
		Return (no.)	275	8,114	24,785	3,375	47	36,597
		Proportion by age	0.01	0.22	0.68	0.09	0.00	1.00
2003	23,870	Sample year	2006	2007	2008	2009	2010	
		Return (no.)	0	719	4,087	2,866	0	7,671
		Proportion by age	0.00	0.09	0.53	0.37	0.00	1.00
2004	22,023	Sample year	2007	2008	2009	2010	2011	
		Return (no.)	0	2,236	6,474	5,545	0	14,255
		Proportion by age	0.00	0.16	0.45	0.39	0.00	1.00
2005	15,468	Sample year	2008	2009	2010	2011	2012	
		Return (no.)	78	1,037	5,481	9,911	89	16,597
		Proportion by age	0.00	0.06	0.33	0.60	0.01	1.00

-continued-

Table 20.–Page 3 of 3.

Brood year	Spawner escapement	Recruitment parameter	Age at return: Age 3 (0.2, 1.1)	Age 4 (0.3, 1.2, 2.1)	Age 5 (1.3, 2.2,)	Age 6 (1.4, 2.3, 3.2)	Age 7 (2.4, 3.3)	Return totals
2006	17,734	Sample year	2009	2010	2011	2012	2013	
		Return (no.)	47	700	7,473	8,301	122	16,643
		Proportion by age	0.00	0.04	0.45	0.50	0.01	1.00
2007	16,502	Sample year	2010	2011	2012	2013	2014	
		Return (no.)	0	743	2,809	8,372	273	12,197
		Proportion by age	0.00	0.06	0.23	0.69	0.02	1.00
2008	5,900	Sample year	2011	2012	2013	2014	2015	
		Return (no.)	56	1,534	7,699	NA	NA	
		Proportion by age						
2009	7,757	Sample year	2012	2013	2014	2015	2016	
		Return (no.)	91	1,534	NA	NA	NA	
		Proportion by age						

Note: All highlighted entries in this table are substituted (imputed) values.

SUBSISTENCE USER SURVEY

The number of subsistence users who agreed to be interviewed ranged from 18 to 32 between 2010 and 2013 (Table 21). Most of the subsistence fishermen interviewed on marine waters adjacent to the Buskin River were residents of Kodiak Island and listed the area as their traditional sockeye salmon subsistence fishing location. An average of 63% of those interviewed indicated they also fished for sockeye salmon in other locations, with the 2 most popular locations being Pasagshak and Litnik.

Table 21.–Comparison of interviews of Buskin River sockeye salmon subsistence users, 2010–2013.

		Year			
Parameter	Detail	2010	2011	2012	2013
Interview date range		30 May–10	27 May–30	1 June–25	28 May–26
Number of interviews		20	28	18	32
Number of responses					
	Kodiak	20	26	18	32
	Unknown	0	0	0	0
Location of effort[a]					
	Buskin	18	27	16	28
	Pasagshak	1	1	2	2
	Southend	0	0	0	0
	Litnik	1	0	4	6
	Port Lions	0	0	2	5
Subsistence fish elsewhere?					
	Yes	12	17	16	17
	No	8	11	2	14
Location of additional effort					
	Pasagshak	6	8	7	5
	Litnik	6	9	5	6
	Port Lions-Ouzinkie	0	3	3	7
	Buskin	2	1	2	4
	Southend	0	1	0	0
	Westside	0	0	0	3
	Bristol Bay	0	0	0	0
	Chignik	0	0	0	0
	Kalsin Bay	2	0	3	0
	Sharatin Bay	1	0	0	0
	Saltery	1	1	1	0
Number of years subsistence fishing at Buskin River					
	Mean	17.7	18.3	20.1	20
	SE	3	3.1	3.7	2.2
	Median	20	13.5	33	21
	Minimum	0	1	1	1
	Maximum	35	50	50	49

[a] Location of traditional subsistence fishing location.

STOCK RECRUITMENT MODEL ESTIMATION

Traditional Analysis

The traditional analysis using data from brood years 1990 through 2007 (Table 20) generated an estimated value for ln(α) of 2.23 (95% bootstrapped confidence intervals [BCI] of 1.63 to 2.80) and an estimated value for β of 0.00013 (95% BCI of 0.00008 to 0.00017) (Figure 4).

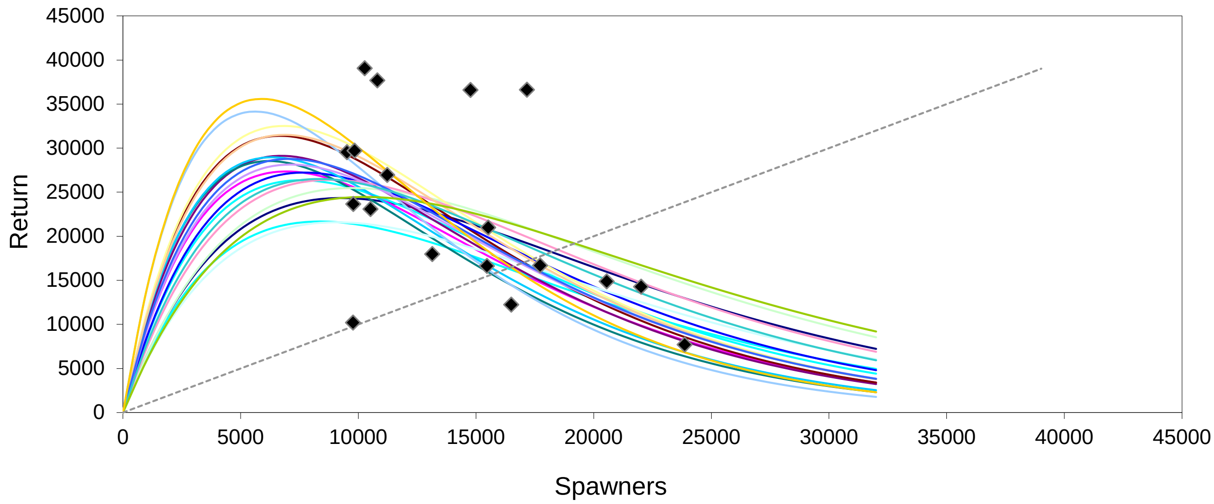


Figure 4.–Horsetail plot of the first 20 bootstrap Ricker model fits; the dotted line is S = R and diamonds are (observed) data (traditional analysis).

The estimated number of spawners required for maximum sustained yield (S_{MSY}) was 6,192 sockeye salmon (95% BCI of 5,073 to 7,955). The estimated exploitation at maximum sustained yield (MSY) was 0.78 (95% BCI of 0.65 to 0.86). The estimated spawning escapement at replacement (S_{EQ}) was 18,281 sockeye salmon (95% BCI of 16,384 to 21,430). The sustained yield probability calculations suggest an escapement goal range of 5,000 to 8,000 sockeye salmon would provide a sustained yield that would be 90% of MSY.

The Durbin-Watson test indicated there was no significant serial correlation among the residuals (Durbin Watson test statistic = 1.85, $P > 0.05$). Plots of the residuals against brood year also showed little evidence of autocorrelation (Figure 5).

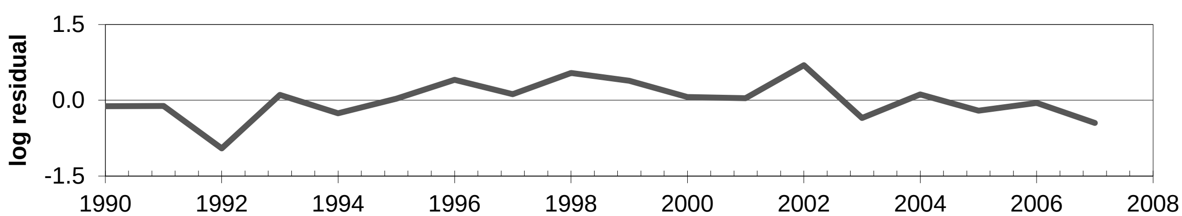


Figure 5.–Plot of residuals from the regression of ln(R/S) on S (traditional analysis).

Bayesian Analysis

The median of the posterior distribution of S_{MSY} is 6,415 sockeye salmon (Figure 6). The value of S_{MSY} lies between 5,104 and 8,199 with 95% certainty.

The Bayesian analysis suggests there may be some positive autocorrelation (ϕ), although the 95% interval extends into the negative (Table 22).

The spawner-recruitment relationship determined by the median values of $\ln(\alpha)$ and β from the Bayesian analysis was not very different from that estimated by the traditional Ricker model fit to the spawner-recruitment data (Figure 7).

GENETICS

Tissue Collections

The number of genetic samples collected from the subsistence fishery varied from 77 to 314 samples from 2010 to 2013. Samples were collected concurrently with ASL samples collected from the subsistence fishery and opportunistically at the local boat harbors. Sampling efforts are highly reflective of fishing effort and run strength.

Laboratory Analysis

Assaying Genotypes

We genotyped all individuals selected from baseline and smolt samples for 96 SNPs (Table 23; Dann et al. 2009). A majority of these genotypes were produced on the Biomark platform.

Quality Control

Quality control (QC) demonstrated a low overall discrepancy rate of 0.16% for 2010–2013 subsistence harvest samples; all discrepancies were between homozygotes and heterozygotes (total of 10 out of 6,144 genotypes compared). The 2010–2013 collections of subsistence harvest samples were genotyped with a process that produced genotypes with an error rate of 0.08% if equal error rates in the original and QC genotyping processes are assumed (Table 24).

GENETIC STATISTICAL ANALYSIS

Data Retrieval and Quality Control

A total of 126 individuals from baseline collections (1993–2012 average = 2 per year) and 9 individuals from the subsistence harvest samples (5–time strata average = 1.8 per time stratum) were missing genotypes from greater than 20% of the loci (19 SNPs) and were removed from further analyses (Dann et al. *In prep*; Table 25). No individuals were identified as non-target species. Thirty-six baseline individuals (1993–2012 average = 0.57 per year) and 2 subsistence harvest individuals (5–time strata average = 0.4 per time stratum) were identified as duplicate individuals and removed from further analyses (Dann et al. *In prep*; Table 23 and 25).

Hardy-Weinberg Equilibrium

All baseline collections conformed to HWE, but one marker did not and was dropped from further analyses (*One*_ACBP-79; probability of Fisher's Summary = 0.000003; 9 collections with $P < 0.05$; Dann et al. *In prep*).

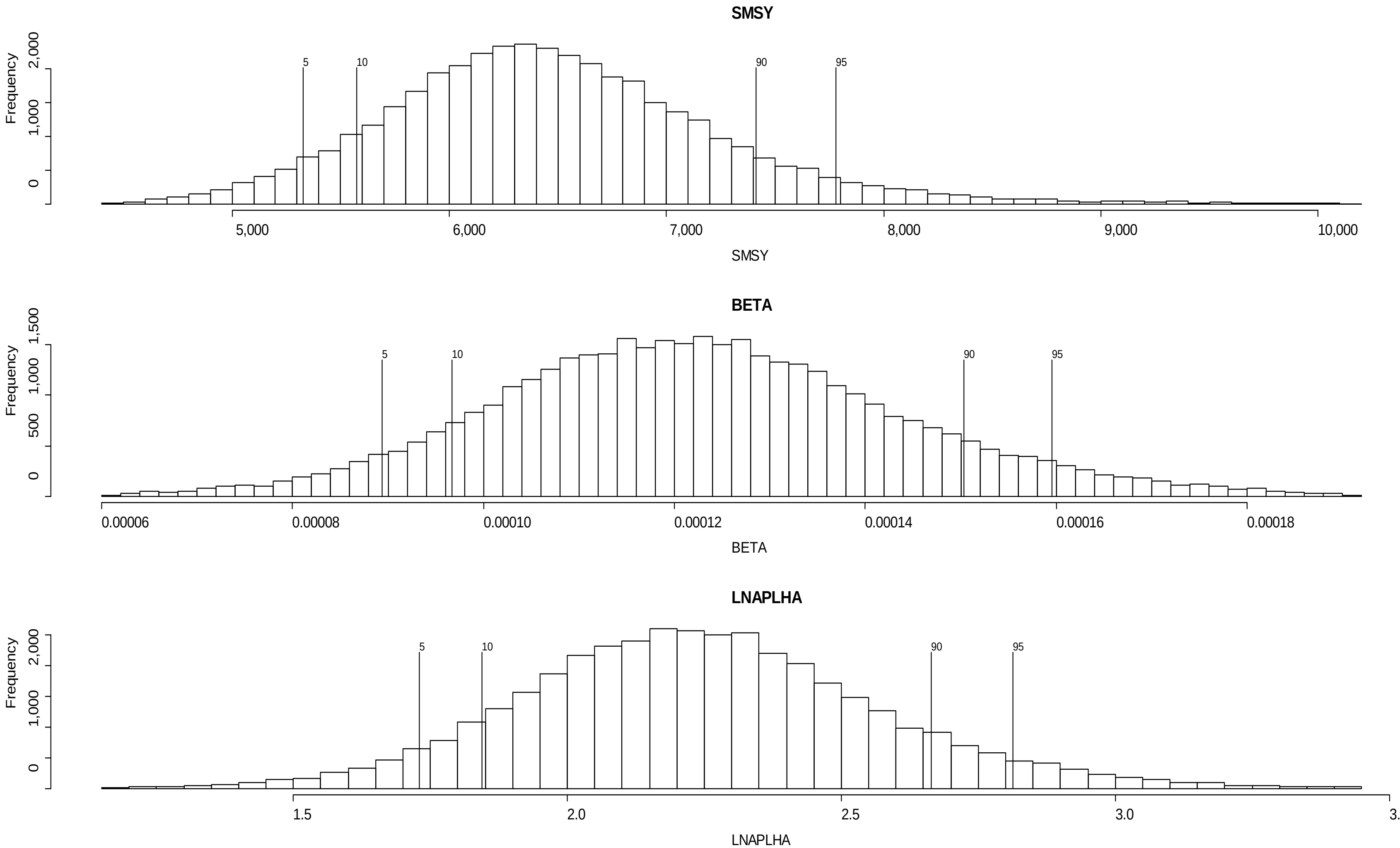


Figure 6.–Posterior distributions of S_{msy} (top), β (middle), and ln(α) (bottom); vertical lines depict 5th, 10th, 90th, and 95th percentiles of the distributions (Bayesian analysis).

Table 22.-Posterior percentiles for important nodes of the Bayesian analysis.

	Percentile		
Parameter	2.5	Median (50)	97.5
$\ln(\alpha)$	1.61	2.23	2.96
β	0.00	0.00	0.00
σ_{RS}	0.28	0.39	0.58
S_{MSY}	5,104	6,415	8,199
π_1	0.08	0.11	0.14
π_2	0.42	0.47	0.51
π_3	0.38	0.43	0.47
φ	-0.40	0.13	0.75

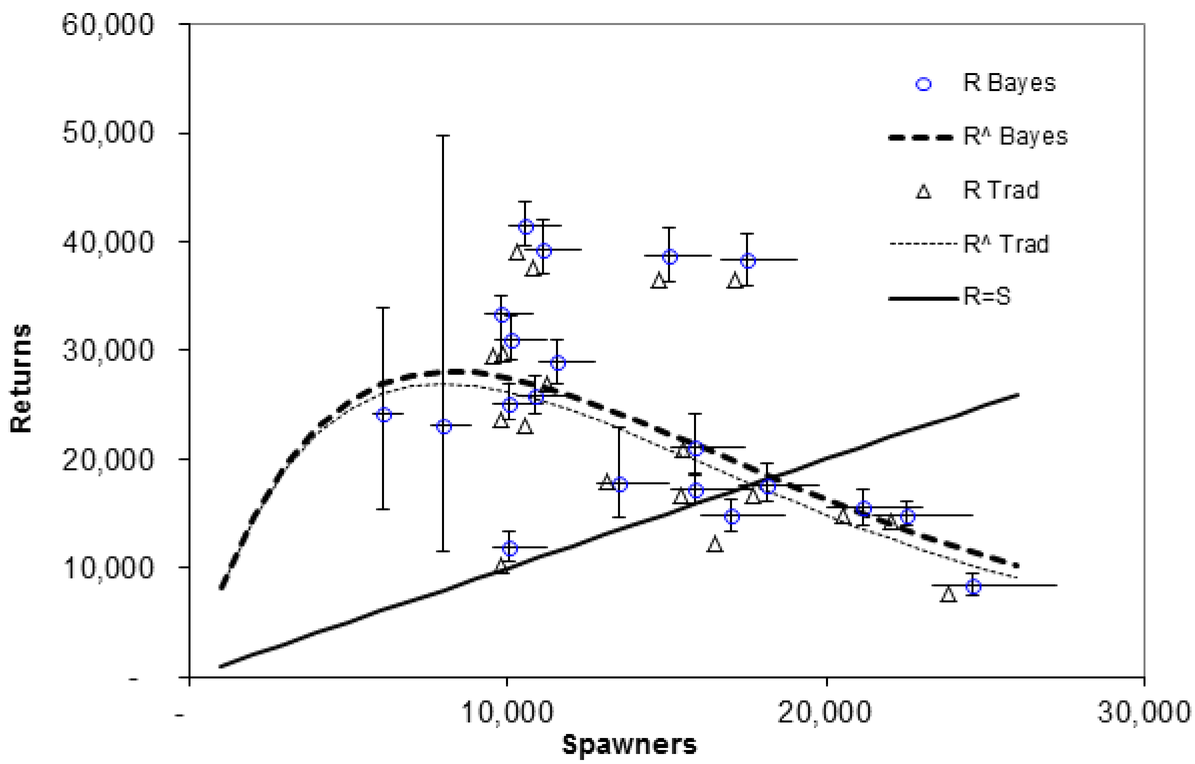


Figure 7.–Bayesian, traditional, and $R = S$ relationships; error bars are 95% credibility intervals.

Table 23.-Reporting group, ADF&G collection code, location, collection and population number, collection date, and the numbers of sockeye salmon used to estimate the stock composition of Chiniak Bay subsistence harvests of sockeye salmon. The number of individuals includes the number of individuals initially genotyped for the set of 96 SNPs (Initial), the numbers removed because of missing loci (Missing) and duplicate individuals (Duplicate), and the number of individuals incorporated into the baseline (Final).

						No. of individuals			
Reporting Group	ADF&G Code	Location	Collection	Population	Date	Initial	Missing	Duplicate	Final
Other Kodiak	SOCEAB06	Ocean Beach	1	1	29 Aug 2006	95	0	0	95
Other Kodiak	SHORS05	Horse Marine Lake	2	2	2 Sep 2005	95	0	0	95
Other Kodiak	SPINNM08	Frazer Lake - Pinnell Creek (Mouth)	3	3	21 Aug 2008	78	0	0	78
Other Kodiak	SSTUM08	Frazer Lake - Stumble Creek - Mouth	4	4	21 Aug 2008	95	1	0	94
Other Kodiak	SCOUR08	Frazer Lake - Courts Shoreline	5	5	21 Aug 2008	95	7	0	88
Other Kodiak	SMIDWM08	Frazer Lake - Midway Creek (Mouth)	6	6	21 Aug 2008	93	1	0	92
Other Kodiak	SMIDWS08	Frazer Lake - Midway Shoreline	7	5	21 Aug 2008	95	4	0	91
Other Kodiak	SLINDM08	Frazer Lake - Linda Creek (Mouth)	8	7	22 Aug 2008	95	5	0	90
Other Kodiak	SHOLFS08	Frazer Lake - Hollow Fox Shoreline	9	5	22 Aug 2008	95	1	0	94
Other Kodiak	SVALA08	Frazer Lake - Valarian Creek	10	8	21 Aug 2008	95	0	0	95
Other Kodiak	SOUTS08	Frazer Lake - Outlet Shoreline	11	9	20 Aug 2008	95	10	0	85
Other Kodiak	SDOGSC08	Frazer Lake - Dog Salmon Creek	12	10	22 Aug 2008	95	3	0	92
Other Kodiak	SAKALNE01L	Akalura Lake - NE shore late	13	11	25 Sep 2001	96	6	2	88
Other Kodiak	SAKALNE11	Akalura - NE Shoals	14	11	16 Sep 2011	95	0	0	95
Other Kodiak	SAKAL05L	Akalura Lagoon - late	15	12	2 Sep 2005	95	0	0	95
Other Kodiak	SOLGB01E	Olga Lakes, Upper Lake - Trib B early	16	13	24 Jul 2001	96	0	0	96
Other Kodiak	SOLGA01E	Olga Lakes, Upper Lake - Trib A early	17	14	23 Jul 2001	96	0	1	95
Other Kodiak	SOLGC01E	Olga Lakes, Upper Lake - Trib C early	18	15	23 Jul 2001	96	1	0	95
Other Kodiak	SUPPSW01L	Upper Lake, SW shoal - late	19	16	26 Sep 2001	96	4	3	89
Other Kodiak	SUPS00E	Upper Station Weir - early	20	17	14 Jun 2000	95	0	0	95
Other Kodiak	SUPUP93	Upper Station (up)	21	18	1 Sep 1993	95	0	0	95
Other Kodiak	SLUPS93	Upper Station (lower) 93	22	19	1 Jan 1993	95	1	0	94
Other Kodiak	SREDSS11	Red Lake - South Shoals	23	20	16 Sep 2011	95	0	0	95
Other Kodiak	SREDCRY11	Red Lake - Crystal Creek (Mouth)	24	21	18 Jul 2011	95	1	0	94
Other Kodiak	SREDSWS11	Red Lake - SW Shoals	25	20	17 Oct 2011	95	2	0	93
Other Kodiak	SREDWS12	Red Lake - West Shoals	26	20	11 Sep 2012	95	1	0	94
Other Kodiak	SREDNWS11	Red Lake - NW Shoals	27	20	17 Oct 2011	95	1	0	94
Other Kodiak	SREDCON11	Red Lake - Connecticut Creek (Mouth)	28	22	18 Jul 2011	95	0	0	95
Other Kodiak	SREDNES11	Red Lake - NE Shoals	29	20	16 Sep 2011	95	0	0	95

-continued-

Table 23.–Page 2 of 2.

Reporting Group	ADF&G Code	Location	Collection	Population	Date	No. of individuals Initial	Missing	Duplicate	Final
Other Kodiak	SAYAK00	Ayakulik River weir	30	23	26 Jul 2000	96	1	2	93
Other Kodiak	SAYAK08L	Ayakulik River weir - Late	31	24	14 Aug 2008	95	3	1	91
Other Kodiak	SFAL99E	Falls Creek - early	32	25	5 Aug 1999	66	0	0	66
Other Kodiak	SCAN99E	Canyon Creek - early	33	25	31 Jul 1999	96	10	1	85
Other Kodiak	SOMALL99	O'Malley River - Karluk Lake	34	26	30 Sep 1999	95	1	2	92
Other Kodiak	SKARLSE11	Karluk Lake - SE Shoals	35	27	16 Sep 2011	95	0	0	95
Other Kodiak	SCAS99E	Cascade Creek - early	36	28	28 Jul 1999	96	6	3	87
Other Kodiak	SKARLSE99L	Karluk Lake SE shoal area - late	37	27	28 Sep 1999	96	0	1	95
Other Kodiak	SUTHU99E	Upper Thumb River - early	38	29	29 Jul 1999	64	3	2	59
Other Kodiak	SUTHU00E	Upper Thumb Lake	39	30	24 Jul 2000	95	0	0	95
Other Kodiak	SSAL99E	Salmon Creek - early	40	31	29 Jul 1999	96	3	2	91
Other Kodiak	SLTHUM99	Lower Thumb River - Karluk Lake	41	32	30 Sep 1999	95	19	0	76
Other Kodiak	STHUS99L	Shoal area by Thumb River - late	42	33	1 Oct 1999	96	1	1	94
Other Kodiak	SHAL01E	Halfway Creek - early	43	34	19 Jul 2001	96	0	1	95
Other Kodiak	SGRA99E	Grassy Point Creek - early	44	35	27 Jul 1999	96	5	5	86
Other Kodiak	SKARLW99L	Karluk Lake West shoal area - late	45	36	27 Sep 1999	96	1	1	94
Other Kodiak	SKARLE99L	Karluk Lake East shoal area - late	46	37	27 Sep 1999	96	0	0	96
Other Kodiak	SCOT99E	Cottonwood Creek - early	47	38	27 Jul 1999	96	7	0	89
Other Kodiak	SMOR99E	Moraine Creek - early	48	39	26 Jul 1999	96	4	2	90
Other Kodiak	SKARL01L	Karluk River - late	49	40	14 Oct 2001	62	6	0	56
Other Kodiak	SLRIV97	Little River Lake	50	41	15 Jul 1997	96	1	0	95
Other Kodiak	SUGAN97	Uganik Lake	51	42	15 Jul 1997	95	0	0	95
Buskin Lake	SBUSK05	Buskin Lake	52	43	26 Jun 2005	95	1	0	94
Buskin Lake	SBUSKL10	Buskin Lake	53	43	13 Jun 2010	95	0	1	94
Lake Louise	SLKLOU05	Lake Louise - Buskin River	54	44	3 Aug 2005	95	0	0	95
Lake Louise	SLKLOU10	Lake Louise - Buskin River	55	44	19 Jul 2010	95	0	2	93
Other Kodiak	SPASA05	Pasagshak Lake	56	45	15 Jul 2005	95	0	0	95
Other Kodiak	SLMIA05	Lake Miam	57	46	2 Sep 2005	95	0	1	94
Saltery	SSALT94	Saltery	58	47	1 Jan 1994	95	2	0	93
Saltery	SSALT99	Saltery Lake	59	47	26 Aug 1999	95	1	0	94
Other Kodiak	SAFOG93	Afognak Lake	60	48	17 Aug 1993	80	1	1	78
Other Kodiak	SMALI93	Malina Lake - Lower	61	49	19 Aug 1993	80	1	1	78
Other Kodiak	STHOR06	Thorsheim Lake	62	50	23 Aug 2006	83	0	0	83
Other Kodiak	SPORT98	Portage Lake, Afognak Island	63	51	1 Jan 1998	96	0	0	96
					Total	5,850	126	36	5,688

Table 24.-Quality control (QC) results including the number genotyped in the original sample, the number of individuals included in the QC analysis, failure rates in the original sample, and the number of genotypes compared in the QC for each year. Discrepancy rates include the rate due to differences of alternate homozygote genotypes (Homo-homo), of homozygotes and heterozygote genotypes (Homo-het), and the overall discrepancy rate. Error rates assume that differences are the result of errors that are equally likely to have occurred in the production and QC genotyping process.

					Discrepancy rate					
					Homo-het		Homo-homo			
Year	Original *n*	QC *n*	Failure (%)	QC genotypes	*n*	%	*n*	%	Overall (%)	Error rate (%)
2010	78	6	2	576	0	0.00	0	0.00	0.00	0.00
2011	162	15	2	1,440	2	0.14	0	0.00	0.14	0.07
2012	198	17	3	1,632	5	0.31	0	0.00	0.31	0.15
2013	318	26	2	2,496	3	0.12	0	0.00	0.12	0.06
Total	756	64	1.97	6,144	10	0.16	0	0.00	0.16	0.08

Table 25.-Numbers of sockeye salmon samples from the subsistence harvest of the Buskin River section of Chiniak Bay that were genotyped and either removed due to missing genotypes (Missing), non-target species (Alternate), or duplicate individuals (Duplicate); or used in final mixed stock analyses (Final) for each temporal stratum.

Stratum	Genotyped	Missing	Alternate	Duplicate	Final
2010	78	0	0	1	77
2011	162	1	0	1	160
2012	198	4	0	0	194
2013 early	219	3	0	0	216
2013 late	99	1	0	0	98
Total		9	0	2	745
Strata average		1.8	0.0	0.4	149.0

Pooling Collections Into Populations

There were 63 baseline collections tested for differences in allele frequency from geographically and temporally proximate collections. These 63 collections pooled into 51 populations used in further analyses (Table 23; Dann et al. *In prep*).

Baseline Evaluation for MSA

Proof tests indicated that the two Buskin River reporting groups (Buskin and Louise-Catherine lakes), Saltery, and Other Kodiak were highly identifiable (Dann et al. *In prep*).

Subsistence Harvest Stock Composition Estimates

A total of 691 samples from the subsistence harvest were used in Mixed Stock Analysis (MSA; average per stratum = 138). Stock composition estimates of the subsistence harvest samples indicated that a majority of harvests originated from Buskin Lake (medians 74.8–97.2%; Table 26). For the year when sample sizes allowed for stratifying individuals into temporal strata (2013, before 16 June and after 15 June), the Buskin Lake estimate decreased in the later portion of the season (medians 97.2% in the early stratum and 84.3% in the late stratum). The Lake Louise median estimate ranged from 0.1–6.4% while the Saltery reporting group estimate was zero in all strata. The Other Kodiak estimate comprised the remainder of all strata.

DISCUSSION

The Buskin River drainage has consistently productive returns of sockeye salmon that are heavily utilized by subsistence and sport users. Historically, escapements have remained well above the current BEG and are expected to continue to meet or exceed escapement objectives. Subsistence and sport users can expect a predictable and orderly fishery on the Buskin River with few restrictions to their traditional fishing efforts for sockeye salmon. Since weir operation began, restrictions were placed on the subsistence or sport fisheries during only 2 years: 2008 and 2009. During 2008–2009, weir counts fell below the lower-end BEG at the time (8,000 fish), but not below the current goal of 5,000 fish. It is possible that the record high escapements occurring in the parent years of these returns resulted in low productivity due to poor lake rearing conditions. Whatever the cause, the Buskin River sockeye salmon run has rebounded since then and has been strong enough to warrant liberalization of both the subsistence and sport fisheries in recent years.

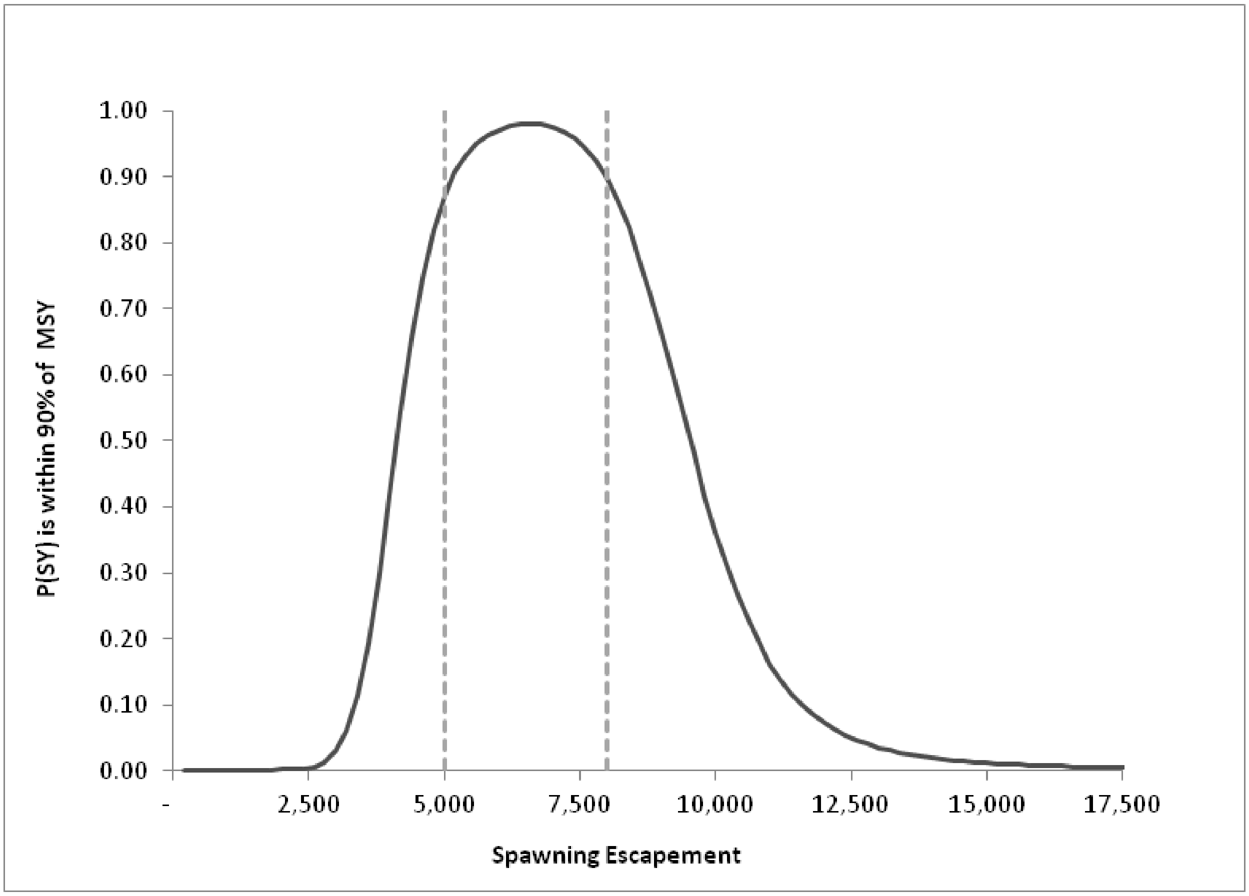
The Buskin Lake BEG was lowered from 8,000–13,000 to 5,000–8,000 in 2011, and the current spawner-recruitment analysis using data collected during the 4 years of this project supports this change. This recent spawner-recruitment analysis, illustrated in Figure 8, suggests that the current BEG range of 5,000 to 8,000 fish will provide for sustained yields within 90% of MSY with 90% or greater probability. Buskin River sockeye salmon fisheries will continue to be managed to achieve this goal, with priority being given to the subsistence fishery if restrictions are warranted in the future.

Table 26.-Stock composition estimates of the sockeye salmon subsistence harvest in the Buskin River Section of Chiniak Bay, 2010–2013.

			Stock composition estimates[a] (%)					
				90% CI				
Year	Sample size	Reporting group	Median	5%	95%	*P* = 0	Mean	SD
2010	77	Buskin Lake	74.8	66.1	82.4	0.00	74.6	5.0
		Lake Louise	0.1	0.0	2.1	0.04	0.5	0.8
		Saltery	0.0	0.0	0.0	0.93	0.0	0.1
		Other Kodiak	24.7	17.2	33.4	0.00	24.9	4.9
2011	106	Buskin Lake	83.5	78.3	88.0	0.00	83.4	3.0
		Lake Louise	2.0	0.6	4.6	0.00	2.2	1.3
		Saltery	0.0	0.0	0.0	0.94	0.0	0.1
		Other Kodiak	14.2	10.1	19.2	0.00	14.4	2.8
2012	194	Buskin Lake	86.8	82.1	90.8	0.00	86.7	2.6
		Lake Louise	1.6	0.1	4.2	0.00	1.8	1.3
		Saltery	0.0	0.0	0.0	0.94	0.0	0.1
		Other Kodiak	11.3	7.7	15.8	0.00	11.5	2.5
2013, early	216	Buskin Lake	97.2	94.1	99.4	0.00	97.0	1.6
(before 16 June)		Lake Louise	0.1	0.0	1.0	0.04	0.2	0.4
		Saltery	0.0	0.0	0.0	0.94	0.0	0.1
		Other Kodiak	2.5	0.4	5.5	0.00	2.7	1.6
2013, late	98	Buskin Lake	84.3	77.0	90.3	0.00	84.1	4.0
(after 15 June)		Lake Louise	6.4	3.0	11.5	0.00	6.8	2.6
		Saltery	0.0	0.0	2.9	0.70	0.5	1.1
		Other Kodiak	8.4	3.9	14.6	0.00	8.7	3.3

Note: Stock composition estimates may not sum to 100% due to rounding error.

[a] Estimates include median, 90% credibility interval (CI), the probability that the group estimate is equal to zero (*P* = 0), mean, and standard deviation (SD).



Note: Current BEG range shown as gray dashed lines.

Figure 8.–Probability that sustained yield (SY) is greater than 90% of maximum sustained yield (MSY) (Bayesian analysis).

The Buskin River drainage appears to have 2 distinct sockeye salmon runs. ADF&G Gene Conservation Laboratory analysis of samples from fish bound for Buskin Lake and Lake Louise showed genetic differences distinct enough to consider these run components as separate populations (C. Habicht, Fisheries Geneticist, ADF&G Gene Conservation Laboratory, Anchorage, personal communication). The allele frequencies are very different between the two populations, and the 100% simulations show that at least 99.8% of the mixtures allocate to the correct populations. These genetic differences have allowed us to examine whether the subsistence fishery harvests Lake Louise fish. From 2010 through 2013, sockeye salmon were sampled from the Buskin River Section subsistence harvest for genetic analysis. It was found that Buskin Lake sockeye salmon have made up at least 75% of the subsistence harvest over this period, while harvest of Lake Louise sockeye salmon made up less than 7% (Figure 10), supporting a long-held assumption that Lake Louise fish composed a small portion of the harvest. Further analysis will determine which stocks make up the remainder of the harvest.

The main reason for the low incidence of Lake Louise fish in the subsistence harvest during 2010–2013 is probably that the Lake Louise run during this period has been low, comprising an average of 3.7% of the total annual weir counts (Table 1). Other possible reasons that Lake Louise fish would not be caught by the subsistence fishery are that the run is consistently 6 weeks later (occurring after the subsistence fishery is over) than that of the main Buskin River run, as suggested by weir count timing at the Lake Louise weir (Figure 3); and that the known difference in size composition of the Lake Louise and Buskin Lake runs (Buskin Lake fish are larger), combined with size selectivity of subsistence fishery gillnets, causes lower harvest rates of Lake Louise fish because many may be small enough to escape the gillnets. There is also anecdotal evidence of greater numbers of net-marked fish at the Buskin River weir than at the Lake Louise weir, indicating greater harvest pressure on Buskin Lake fish. Interestingly, in 2013 (the only year sample sizes were large enough to temporally stratify the analysis), the proportion of Lake Louise and other stocks in the harvest increased over the sampling period, from 0.1% and 2.5% in the early sample to 6.4% and 8.4% in the late sample, respectively (Table 26). These data support the hypothesis that the Lake Louise run is later than the Buskin Lake run and therefore less subject to harvest.

Sockeye salmon returning to Buskin Lake and Lake Louise have distinct age and size structures characteristic of their respective runs. The Buskin Lake run is historically dominated by fish rearing in the marine environment for 3 years, mostly age-1.3 and -2.3 fish (Schmidt 2007). We found that the majority of fish sampled at the Buskin Lake weir in the years 2010–2013 were age 1.3 or 2.3 (Tables 2, 6, 10, and 14). Conversely, the Lake Louise run has been historically dominated by fish rearing in the marine environment for 2 years, typically age-1.2 and -2.2 fish (Schmidt 2007). We also found this generally to be the case as well (Tables 3, 7, and 15; only 46% of the 2012 run reared in the ocean for 2 years). From 2010 to 2013, we found that Buskin Lake sockeye salmon were, on average, 33 mm longer than Lake Louise sockeye salmon. This is probably due to the age composition of the two runs; younger fish of Lake Louise are expected to be smaller than older Buskin Lake fish. Age and size characteristics of Lake Louise salmon may also be linked by adaptation to the physical characteristics of the Lake Louise drainage. The creek flowing out of Lake Louise is shallow and narrow, and smaller sockeye salmon may be able to navigate the creek more easily than larger sockeye salmon, rendering them more fit to spawn in this drainage. This question would need a separate research project to answer fully.

This stock assessment project is expected to continue through at least 2017, and spawner-recruitment analyses will continue as data from these years are collected.

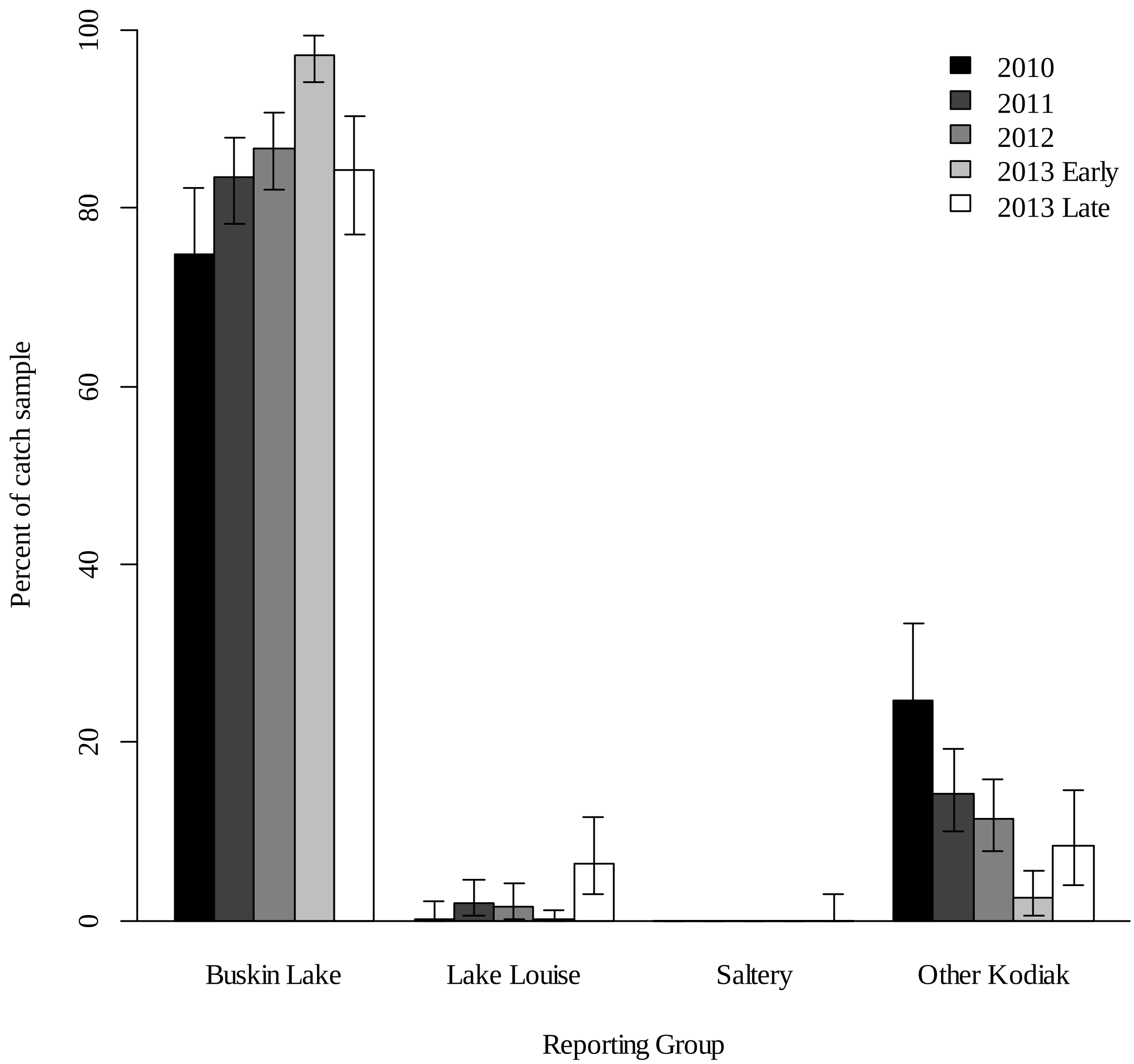


Figure 9.–Median estimate and 90% credibility interval of the contribution of 4 reporting groups to samples of the subsistence harvest in the Buskin River Section of Chiniak Bay, 2010–2013.

ACKNOWLEDGEMENTS

The authors would like to thank Suzanne Schmidt, Myra Scholze, Kate Kimmel, Connor Murphy, Katrina DelCarmen, Chris Polum, Sonya Sorto, and Patrick Chenoweth for their contributions in the field. We thank Gene Conservation Laboratory members Heather Liller, Zac Grauvogel, Serena Rogers Olive, Christina Cupp, Eric Lardizabal, and Chris Habicht for producing quality genotypic data in a timely fashion. Donn Tracy has contributed to all stages of this project since its inception. The United States Fish and Wildlife Service, Office of Subsistence Management, provided $396,625 in funding for this project through the Fisheries Resource Monitoring Program, under agreement 70181AJ035.

REFERENCES CITED

Agresti, A. 1990. Categorical data analysis. John Wiley and Sons, New York.

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.

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

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.adfg.alaska.gov/FedAidPDFs/FMS09-06.pdf

Efron, B. 1982. The jackknife, the bootstrap and other resampling plans. Society of Industrial and Applied Mathematics, Philadelphia CBMS-NSF Monograph 38, Philadelphia.

Fleischman, S. J., M. J. Catalano, R. A. Clark, and D. R. Bernard. 2013. An age-structured state-space stock-recruit model for Pacific salmon *Oncorhynchus* spp. Canadian Journal of Fisheries and Aquatic Sciences 70(3):401-414. http://www.nrcresearchpress.com/journal/cjfas

Fuerst, B. A. 2013. Kodiak Management Area weir descriptions and salmon escapement report, 2012. Alaska Department of Fish and Game, Fishery Management Report No. 13-25, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/FMR13-25.pdf

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

Hilborn, R., and C. J. Walters. 1992. Quantitative fisheries stock assessment: choice, dynamics and uncertainty. Chapman and Hall, New York.

Jackson, J., and M. Keyse. 2013. Kodiak Management Area commercial salmon fishery annual management report, 2013. Alaska Department of Fish and Game, Fishery Management Report No. 13-44, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/FMR13-44.pdf

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.adfg.alaska.gov/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.adfg.alaska.gov/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.adfg.alaska.gov/FedAidPDFs/FDS09-54.pdf

REFERENCES CITED (Continued)

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.adfg.alaska.gov/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.adfg.alaska.gov/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, and A. E. Bingham. *In prep*. Estimates of participation, catch, and harvest in Alaska sport fisheries during 2011. Alaska Department of Fish and Game, Fishery Data Series, Anchorage.

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.adfg.alaska.gov/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.adfg.alaska.gov/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.adfg.alaska.gov/FedAidpdfs/fds06-44.pdf

Lunn, D., D. Spiegelhalter, A. Thomas, and N. Best. 2009. The BUGS project: Evolution, critique and future directions. Statistics in Medicine 28(25):3049-3067.

Millar, R. B. 2002. Reference priors for Bayesian fisheries models. Canadian Journal of Fisheries and Aquatic Sciences 59:1492-1502.

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.

R Development Core Team. 2011. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/ (Accessed October 6, 2011).

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada 191:382.

Schmidt, J., D. Evans, and D. Tracy. 2005. Stock assessment of sockeye salmon of the Buskin River, 2000-2003. Alaska Department of Fish and Game, Fishery Data Series No. 05-69, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/fds05-69.pdf

Schmidt, J. S. 2007. Age composition and total run of Buskin River sockeye salmon, 2004-2006. Alaska Department of Fish and Game, Fishery Data Series No. 07-50, Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/fds07-50.pdf

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

Welander, A. D. 1940. A study of the development of the scale of Chinook salmon *Oncorhynchus tshawytscha*. Master's thesis. University of Washington, Seattle.

APPENDIX A: SOCKEYE SALMON COUNTS AT THE BUSKIN RIVER AND LAKE LOUISE WEIRS, 2004-2013

Appendix A1.–Daily cumulative counts (*N*) of sockeye salmon passage through Buskin River weir, 20 May–31 August 2004-2013.

	2004		2005		2006[a]		2007[b]		2008		2009		2010[c]		2011		2012		2013		2004–2013	
Date	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	Avg %
20 May	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21 May	2	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
22 May	2	0	0	0	20	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2	0
23 May	48	0	0	0	20	0	10	0	0	0	2	0	0	0	0	0	0	0	0	0	8	0
24 May	396	2	181	1	20	0	48	0	0	0	2	0	0	0	0	0	7	0	2	0	66	0
25 May	604	3	218	1	20	0	57	0	0	0	2	0	0	0	0	0	80	1	2	1	98	1
26 May	976	4	424	3	20	0	61	0	0	0	2	0	0	0	0	0	225	3	89	1	180	1
27 May	979	4	491	3	20	0	61	0	0	0	2	0	0	0	0	0	311	4	116	1	198	1
28 May	1,040	5	661	4	20	0	61	0	0	0	2	0	0	0	40	0	313	4	179	1	232	1
29 May	1,252	6	676	4	20	0	61	0	0	0	102	1	3	0	323	3	336	4	251	2	302	2
30 May	1,498	7	851	6	20	0	61	0	0	0	116	1	3	0	495	4	337	4	425	3	381	2
31 May	1,580	7	1,114	7	20	0	63	0	0	0	116	1	3	0	677	6	402	5	676	4	465	3
1 Jun	2,250	10	1,136	7	20	0	64	0	4	0	116	1	6	0	835	7	544	6	844	5	582	4
2 Jun	2,562	12	1,136	7	20	0	112	1	4	0	116	1	7	0	960	8	870	10	1,004	6	679	5
3 Jun	3,790	17	2,003	13	148	1	380	2	4	0	183	2	7	0	1,161	10	870	10	1,325	8	987	6
4 Jun	4,405	20	2,774	18	406	2	487	3	13	0	183	2	10	0	1,313	11	983	11	1,612	10	1,219	8
5 Jun	4,922	22	2,779	18	431	2	927	6	13	0	428	6	10	0	1,479	12	1,014	12	1,827	11	1,383	9
6 Jun	5,209	24	2,930	19	434	2	1,319	8	79	1	431	6	10	0	1,541	13	1,179	14	2,050	13	1,518	10
7 Jun	6,171	28	4,795	31	723	4	2,072	13	81	1	444	6	11	0	2,340	20	1,569	18	2,696	17	2,090	14
8 Jun	8,296	38	5,380	35	3,004	17	2,403	15	106	2	448	6	13	0	2,840	24	1,780	21	3,382	21	2,765	18
9 Jun	8,627	39	6,240	40	4,104	23	2,707	16	231	4	458	6	16	0	2,982	25	1,870	22	3,836	24	3,107	20
10 Jun	8,893	40	6,652	43	4,607	26	3,002	18	289	5	1,258	16	18	0	3,360	28	2,027	24	4,057	25	3,416	23
11 Jun	10,419	47	6,748	44	5,188	29	5,250	32	467	8	1,268	16	20	0	3,540	30	2,489	29	4,790	30	4,018	26
12 Jun	11,646	53	7,268	47	5,976	34	6,351	38	680	12	1,268	16	22	0	3,895	33	2,592	30	5,379	33	4,508	30
13 Jun	12,263	56	7,406	48	6,268	35	6,679	40	764	13	1,324	17	26	0	4,256	36	2,813	33	5,933	37	4,773	31
14 Jun	12,790	58	7,691	50	7,091	40	6,792	41	805	14	1,805	23	28	0	4,522	38	2,923	34	6,663	41	5,111	34
15 Jun	13,257	60	8,089	52	7,512	42	7,399	45	964	16	1,835	24	31	0	5,310	44	3,080	36	7,450	46	5,493	37
16 Jun	13,939	63	8,334	54	7,812	44	8,423	51	1,020	17	1,860	24	31	0	5,659	47	3,344	39	7,813	48	5,824	39
17 Jun	14,151	64	8,838	57	8,665	49	8,868	54	1,036	18	2,937	38	33	0	6,381	53	4,286	50	9,125	56	6,432	44
18 Jun	14,539	66	8,974	58	9,116	51	9,221	56	1,242	21	3,107	40	39	0	6,972	58	4,395	51	9,880	61	6,748	46
19 Jun	14,713	67	9,767	63	9,337	53	9,328	57	1,385	23	3,143	41	40	0	7,537	63	4,472	52	10,278	64	7,000	48
20 Jun	14,758	67	9,921	64	9,635	54	9,657	59	1,430	24	3,556	46	43	0	7,752	65	4,494	52	10,841	67	7,209	50
21 Jun	15,101	69	9,933	64	11,091	63	10,015	61	1,517	26	3,821	49	46	0	8,064	67	4,666	54	10,969	68	7,522	52

-continued-

Appendix A1.–Page 2 of 4.

	2004		2005		2006[a]		2007[b]		2008		2009		2010[c]		2011		2012		2013		2004–2013	
Date	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	Avg %
22 Jun	15,236	69	10,336	67	11,148	63	10,346	63	1,783	30	4,129	53	47	0	8,383	70	5,317	62	11,240	69	7,796	55
23 Jun	15,562	71	10,419	67	11,154	63	10,507	64	1,859	32	4,237	55	48	0	8,517	71	5,624	66	11,883	73	7,981	56
24 Jun	15,729	71	10,505	68	11,388	64	10,595	64	1,945	33	4,352	56	49	0	8,806	73	5,632	66	12,270	76	8,127	57
25 Jun	15,905	72	10,509	68	11,626	66	10,904	66	2,583	44	4,476	58	54	1	9,055	76	5,885	69	12,509	77	8,351	60
26 Jun	15,964	72	10,825	70	11,779	66	11,100	67	2,608	44	4,640	60	5,797	59	9,183	77	5,938	69	12,797	79	9,063	66
27 Jun	16,013	73	10,974	71	11,939	67	11,914	72	2,830	48	4,979	64	6,006	61	9,273	77	6,215	73	13,064	81	9,321	69
28 Jun	16,238	74	11,210	72	12,225	69	11,914	72	3,008	51	5,242	68	6,074	62	9,562	80	6,236	73	13,629	84	9,534	70
29 Jun	16,261	74	11,211	72	12,375	70	12,039	73	3,069	52	5,370	69	6,126	63	9,619	80	6,357	74	13,792	85	9,622	71
30 Jun	18,167	82	11,274	73	12,405	70	12,145	74	3,648	62	5,642	73	6,174	63	9,773	82	6,624	77	13,925	86	9,978	74
1 Jul	18,194	83	11,362	73	12,442	70	12,243	74	3,745	63	5,666	73	6,201	63	9,791	82	6,699	78	14,039	87	10,038	75
2 Jul	18,223	83	11,416	74	12,467	70	12,319	75	3,802	64	5,746	74	6,582	67	9,810	82	6,753	79	14,124	87	10,124	76
3 Jul	18,336	83	11,667	75	12,671	71	12,720	77	4,150	70	5,753	74	6,856	70	9,822	82	6,836	80	14,224	88	10,304	77
4 Jul	18,362	83	11,693	76	13,108	74	12,951	78	4,235	72	5,756	74	7,131	73	10,059	84	6,910	81	14,272	88	10,448	78
5 Jul	18,422	84	12,087	78	13,123	74	13,069	79	4,235	72	5,807	75	7,140	73	10,085	84	6,933	81	14,289	88	10,519	79
6 Jul	18,438	84	12,190	79	13,136	74	13,620	83	4,244	72	5,825	75	7,310	75	10,180	85	6,947	81	14,318	88	10,621	80
7 Jul	18,526	84	12,437	80	13,142	74	13,659	83	4,281	73	5,903	76	7,379	75	10,221	85	6,992	82	14,404	89	10,694	80
8 Jul	18,721	85	12,470	81	13,239	75	13,669	83	4,302	73	6,255	81	7,754	79	10,270	86	7,169	84	14,475	89	10,832	81
9 Jul	18,974	86	12,512	81	14,201	80	13,887	84	4,401	75	6,297	81	8,362	85	10,328	86	7,224	84	14,546	90	11,073	83
10 Jul	19,085	87	12,550	81	14,368	81	14,150	86	4,402	75	6,313	81	8,429	86	10,460	87	7,225	84	14,978	93	11,196	84
11 Jul	19,242	87	12,685	82	14,938	84	14,213	86	4,403	75	6,375	82	8,495	87	10,477	87	7,622	89	15,070	93	11,352	85
12 Jul	19,278	88	13,420	87	15,019	85	14,258	86	4,587	78	6,376	82	8,575	88	10,530	88	7,690	90	15,089	93	11,482	86
13 Jul	19,357	88	13,444	87	15,032	85	14,462	88	4,658	79	6,385	82	8,625	88	10,539	88	7,700	90	15,113	93	11,532	87
14 Jul	19,360	88	13,457	87	15,059	85	14,465	88	4,658	79	6,435	83	8,643	88	10,771	90	7,709	90	15,145	94	11,570	87
15 Jul	20,002	91	13,498	87	15,061	85	14,466	88	4,664	79	6,527	84	9,196	94	10,774	90	7,713	90	15,256	94	11,716	88
16 Jul	20,223	92	13,500	87	15,218	86	14,578	88	4,680	79	6,887	89	9,197	94	10,779	90	7,717	90	15,264	94	11,804	89
17 Jul	20,231	92	14,109	91	15,221	86	14,579	88	4,770	81	6,889	89	9,197	94	10,780	90	7,729	90	15,281	94	11,879	90
18 Jul	20,233	92	14,125	91	15,224	86	14,641	89	4,777	81	6,910	89	9,261	95	10,782	90	7,784	91	15,295	95	11,903	90
19 Jul	20,234	92	14,125	91	15,489	87	14,662	89	4,777	81	6,911	89	9,327	95	10,782	90	7,801	91	15,301	95	11,941	90
20 Jul	20,557	93	14,126	91	15,531	88	14,698	89	4,777	81	6,921	89	9,396	96	10,783	90	7,859	92	15,307	95	11,996	90
21 Jul	20,564	93	14,199	92	15,631	88	14,776	90	4,785	81	7,007	90	9,409	96	10,786	90	7,867	92	15,320	95	12,034	91
22 Jul	20,913	95	14,203	92	15,637	88	14,829	90	4,787	81	7,060	91	9,416	96	10,851	91	7,877	92	15,322	95	12,090	91
23 Jul	20,942	95	14,204	92	15,637	88	14,872	90	4,787	81	7,067	91	9,428	96	10,856	91	7,900	92	15,341	95	12,103	91
24 Jul	20,946	95	14,204	92	15,637	88	15,135	92	4,990	85	7,068	91	9,428	96	10,865	91	7,906	92	15,345	95	12,152	92
25 Jul	20,964	95	14,361	93	15,940	90	15,335	93	5,043	85	7,289	94	9,430	96	10,871	91	7,911	92	15,363	95	12,251	92

-continued-

Appendix A1.–Page 3 of 4.

	2004		2005		2006[a]		2007[b]		2008		2009		2010[c]		2011		2012		2013		2004–2013	
Date	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	Avg %
26 Jul	21,071	96	14,457	93	15,951	90	15,335	93	5,044	85	7,395	95	9,608	98	10,872	91	7,917	92	15,387	95	12,304	93
27 Jul	21,076	96	14,885	96	15,972	90	15,335	93	5,045	86	7,399	95	9,617	98	10,878	91	7,947	93	15,390	95	12,354	93
28 Jul	21,185	96	14,910	96	16,031	90	15,685	95	5,050	86	7,421	96	9,617	98	10,887	91	7,990	93	15,392	95	12,417	94
29 Jul	21,218	96	14,935	97	16,078	91	15,774	96	5,412	92	7,461	96	9,617	98	10,914	91	7,991	93	15,413	95	12,481	94
30 Jul	21,247	96	14,976	97	16,079	91	15,811	96	5,441	92	7,480	96	9,638	98	10,915	91	8,033	94	15,440	95	12,506	95
31 Jul	21,273	97	15,031	97	16,081	91	15,822	96	5,466	93	7,502	97	9,650	98	10,915	91	8,049	94	15,448	95	12,524	95
1 Aug	21,286	97	15,033	97	16,094	91	15,827	96	5,486	93	7,516	97	9,652	98	10,916	91	8,049	94	15,530	96	12,539	95
2 Aug	21,320	97	15,035	97	16,146	91	15,879	96	5,503	93	7,516	97	9,653	99	10,933	91	8,049	94	15,587	96	12,562	95
3 Aug	21,404	97	15,035	97	16,207	91	15,948	97	5,521	94	7,519	97	9,656	99	10,935	91	8,057	94	15,691	97	12,597	95
4 Aug	21,432	97	15,035	97	16,264	92	15,979	97	5,538	94	7,572	98	9,656	99	10,935	91	8,077	94	15,732	97	12,622	96
5 Aug	21,462	97	15,035	97	16,380	92	16,013	97	5,562	94	7,579	98	9,661	99	10,965	92	8,195	96	15,746	97	12,660	96
6 Aug	21,498	98	15,035	97	16,479	93	16,047	97	5,570	94	7,580	98	9,665	99	10,965	92	8,199	96	15,789	98	12,683	96
7 Aug	21,523	98	15,045	97	16,606	94	16,073	97	5,578	95	7,581	98	9,666	99	10,965	92	8,199	96	15,789	98	12,703	96
8 Aug	21,589	98	15,055	97	16,663	94	16,085	97	5,589	95	7,581	98	9,680	99	10,965	92	8,200	96	15,789	98	12,720	96
9 Aug	21,630	98	15,067	97	16,776	95	16,104	98	5,592	95	7,586	98	9,680	99	10,965	92	8,207	96	15,809	98	12,742	96
10 Aug	21,685	98	15,086	98	16,818	95	16,132	98	5,608	95	7,589	98	9,682	99	10,985	92	8,208	96	15,833	98	12,763	97
11 Aug	21,692	98	15,114	98	16,876	95	16,146	98	5,639	96	7,592	98	9,682	99	10,987	92	8,211	96	15,837	98	12,778	97
12 Aug	21,705	99	15,136	98	16,918	95	16,162	98	5,660	96	7,594	98	9,682	99	10,987	92	8,240	96	15,844	98	12,793	97
13 Aug	21,751	99	15,164	98	16,963	96	16,175	98	5,661	96	7,601	98	9,683	99	10,988	92	8,242	96	15,848	98	12,808	97
14 Aug	21,774	99	15,185	98	17,017	96	16,197	98	5,858	99	7,603	98	9,698	99	10,993	92	8,414	98	15,851	98	12,859	98
15 Aug	21,803	99	15,214	98	17,059	96	16,217	98	5,862	99	7,604	98	9,709	99	10,993	92	8,452	99	15,858	98	12,877	98
16 Aug	21,824	99	15,238	99	17,077	96	16,219	98	5,875	100	7,605	98	9,710	99	10,994	92	8,453	99	15,859	98	12,885	98
17 Aug	21,841	99	15,269	99	17,109	96	16,226	98	5,878	100	7,612	98	9,720	99	10,995	92	8,453	99	15,893	98	12,900	98
18 Aug	21,890	99	15,285	99	17,150	97	16,269	99	5,882	100	7,613	98	9,739	99	11,024	92	8,454	99	15,936	98	12,924	98
19 Aug	21,923	100	15,303	99	17,186	97	16,285	99	5,882	100	7,615	98	9,751	100	11,251	94	8,455	99	15,947	99	12,960	98
20 Aug	21,939	100	15,323	99	17,238	97	16,286	99	5,882	100	7,620	98	9,755	100	11,254	94	8,455	99	15,955	99	12,971	98
21 Aug	21,954	100	15,338	99	17,281	97	16,295	99	5,883	100	7,620	98	9,761	100	11,263	94	8,460	99	15,957	99	12,981	98
22 Aug	21,961	100	15,354	99	17,304	98	16,303	99	5,883	100	7,620	98	9,761	100	11,274	94	8,460	99	15,962	99	12,988	98
23 Aug	21,968	100	15,366	99	17,332	98	16,314	99	5,886	100	7,622	98	9,764	100	11,290	94	8,464	99	15,972	99	12,998	99
24 Aug	21,977	100	15,379	99	17,457	98	16,329	99	5,887	100	7,622	98	9,766	100	11,292	94	8,465	99	15,998	99	13,017	99
25 Aug	21,978	100	15,390	99	17,495	99	16,340	99	5,889	100	7,623	98	9,766	100	11,369	95	8,465	99	16,001	99	13,032	99
26 Aug	21,993	100	15,393	100	17,522	99	16,348	99	5,889	100	7,623	98	9,769	100	11,561	96	8,465	99	16,003	99	13,057	99
27 Aug	21,997	100	15,397	100	17,571	99	16,381	99	5,890	100	7,625	98	9,769	100	11,684	98	8,466	99	16,013	99	13,079	99

-continued-

	2004		2005		2006[a]		2007[b]		2008		2009		2010[c]		2011		2012		2013		2004–2013	
Date	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	Avg %
28 Aug	22,003	100	15,403	100	17,586	99	16,381	99	5,890	100	7,698	99	9,771	100	11,795	98	8,466	99	16,013	99	13,101	99
29 Aug	22,005	100	15,404	100	17,607	99	16,381	99	5,890	100	7,728	100	9,771	100	11,801	98	8,466	99	16,023	99	13,108	99
30 Aug	22,006	100	15,404	100	17,656	100	16,394	99	5,890	100	7,731	100	9,771	100	11,806	99	8,466	99	16,024	99	13,115	99
31 Aug	22,008	100	15,408	100	17,668	100	16,400	99	5,892	100	7,731	100	9,772	100	11,816	99	8,467	99	16,024	99	13,119	99
Total	22,023		15,468		17,734		16,502		5,900		7,757		9,800		11,982		8,565		16,189		13,192	

[a] Weir breached on 8 June and 21 July 2006 due to high water events.

[b] Weir breached 25–26 July 2007 due to high water event.

[c] Weir gate opened while unattended on 3–4 July.

Appendix A2.–Daily cumulative count (*N*) of sockeye salmon passage through the Lake Louise weir, 1 June–31 August 2004-2013.

	2003		2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		2004–2013	
Date	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	Avg %
1 Jun	0	0													0	0	0	0	0	0	0	0	0	0
2 Jun	0	0	0	0									0	0	0	0	0	0	0	0	0	0	0	0
3 Jun	0	0	0	0			0	0	0	0			0	0	0	0	0	0	0	0	0	0	0	0
4 Jun	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0
5 Jun	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0
6 Jun	0	0	1	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0
7 Jun	0	0	1	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0
8 Jun	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9 Jun	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 Jun	2	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 Jun	4	0	4	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
12 Jun	5	0	5	0	3	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
13 Jun	5	0	5	0	3	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
14 Jun	7	0	11	1	3	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
15 Jun	14	0	32	2	5	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
16 Jun	18	0	47	2	5	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
17 Jun	18	0	51	2	5	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
18 Jun	18	0	54	3	7	0	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	7	0
19 Jun	20	0	63	3	8	0	5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	8	0
20 Jun	21	0	68	3	9	0	8	0	0	0	1	0	0	0	0	0	3	1	0	0	0	0	9	0
21 Jun	26	1	72	3	10	0	8	0	0	0	1	0	0	0	0	0	5	1	0	0	0	0	10	1
22 Jun	29	1	82	4	10	0	9	0	0	0	1	0	0	0	0	0	8	2	0	0	0	0	11	1
23 Jun	35	1	92	4	10	0	10	0	0	0	1	0	0	0	0	0	8	2	0	0	0	0	12	1
24 Jun	46	1	92	4	10	0	10	0	0	0	1	0	0	0	0	0	8	2	0	0	0	0	12	1
25 Jun	55	1	93	4	21	1	10	0	0	0	1	0	0	0	0	0	8	2	0	0	0	0	13	1
26 Jun	56	1	98	5	26	1	10	0	0	0	1	0	0	0	0	0	8	2	0	0	0	0	14	1
27 Jun	57	1	102	5	37	2	13	0	0	0	1	0	0	0	0	0	8	2	0	0	0	0	16	1
28 Jun	58	1	108	5	45	2	20	0	0	0	5	1	0	0	0	0	8	2	0	0	0	0	19	1
29 Jun	61	1	128	6	47	2	20	0	0	0	13	2	0	0	0	0	8	2	0	0	0	0	22	1
30 Jun	71	2	149	7	69	3	22	0	0	0	13	2	0	0	0	0	10	3	0	0	0	0	26	2
1 Jul	84	2	171	8	83	4	24	1	0	0	13	2	0	0	0	0	10	3	0	0	0	0	30	2

-continued-

Appendix A2.–Page 2 of 3.

	2003		2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		2004–2013	
Date	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	Avg %
2 Jul	86	2	184	9	96	5	24	1	0	0	13	2	0	0	0	0	10	3	0	0	1	0	33	2
3 Jul	109	2	210	10	98	5	26	1	0	0	32	4	0	0	0	0	10	3	0	0	3	0	38	2
4 Jul	166	4	234	11	107	5	28	1	0	0	51	6	0	0	0	0	10	3	0	0	3	0	43	3
5 Jul	207	5	247	12	113	6	28	1	0	0	51	6	0	0	0	0	10	3	0	0	3	0	45	3
6 Jul	237	5	260	12	126	6	28	1	0	0	51	6	0	0	0	0	10	3	0	0	3	0	48	3
7 Jul	258	6	290	14	138	7	28	1	0	0	52	6	0	0	0	0	10	3	0	0	3	0	52	3
8 Jul	307	7	301	14	142	7	28	1	0	0	56	7	0	0	0	0	10	3	0	0	3	0	54	3
9 Jul	360	8	352	17	142	7	29	1	0	0	56	7	0	0	75	18	10	3	0	0	3	0	67	5
10 Jul	374	8	418	20	143	7	32	1	0	0	56	7	0	0	76	18	10	3	0	0	3	0	74	6
11 Jul	408	9	461	22	146	7	154	3	0	0	56	7	0	0	76	18	10	3	0	0	5	1	91	6
12 Jul	621	14	483	23	146	7	155	3	41	2	56	7	0	0	78	19	10	3	5	2	5	1	98	7
13 Jul	639	14	509	24	151	7	155	3	65	4	56	7	0	0	78	19	10	3	5	2	5	1	103	7
14 Jul	657	15	590	28	157	8	171	4	65	4	56	7	0	0	78	19	10	3	5	2	6	1	114	7
15 Jul	689	15	654	31	160	8	175	4	66	4	56	7	0	0	78	19	10	3	5	2	6	1	121	8
16 Jul	709	16	660	32	167	8	177	4	66	4	56	7	0	0	78	19	10	3	5	2	6	1	123	8
17 Jul	737	16	671	32	207	10	177	4	206	12	56	7	0	0	78	19	10	3	5	2	6	1	142	9
18 Jul	758	17	740	35	212	10	179	4	206	12	56	7	0	0	78	19	10	3	5	2	6	1	149	9
19 Jul	760	17	752	36	212	10	196	4	206	12	56	7	0	0	78	19	10	3	5	2	8	1	152	9
20 Jul	835	19	774	37	216	11	453	10	206	12	56	7	9	1	78	19	10	3	5	2	8	1	182	10
21 Jul	837	19	784	38	219	11	794	17	206	12	56	7	188	19	78	19	10	3	5	2	8	1	235	13
22 Jul	858	19	910	44	226	11	828	18	206	12	56	7	190	19	78	19	10	3	5	2	8	1	252	13
23 Jul	898	20	944	45	226	11	953	21	206	12	56	7	190	19	78	19	10	3	5	2	8	1	268	14
24 Jul	917	20	958	46	226	11	1,024	22	206	12	56	7	190	19	78	19	10	3	5	2	8	1	276	14
25 Jul	926	21	985	47	251	12	1,085	24	284	17	90	11	314	32	78	19	10	3	5	2	9	1	311	17
26 Jul	928	21	1,012	49	274	14	1,135	25	284	17	90	11	337	34	78	19	10	3	5	2	9	1	323	17
27 Jul	929	21	1,012	49	279	14	1,223	27	287	17	90	11	350	35	78	19	10	3	5	2	9	1	334	18
28 Jul	930	21	1,012	49	283	14	1,287	28	287	17	90	11	350	35	78	19	10	3	5	2	9	1	341	18
29 Jul	930	21	1,039	50	298	15	1,315	29	319	19	90	11	368	37	78	19	10	3	5	2	9	1	353	18
30 Jul	930	21	1,072	51	312	15	1,339	29	340	20	90	11	401	40	128	30	10	3	5	2	9	1	371	20
31 Jul	932	21	1,074	51	314	15	1,351	29	350	21	90	11	404	41	139	33	10	3	5	2	9	1	375	21
1 Aug	932	21	1,075	52	323	16	1,353	30	386	23	90	11	404	41	139	33	10	3	5	2	9	1	379	21
2 Aug	932	21	1,082	52	399	20	1,355	30	399	24	90	11	404	41	139	33	10	3	5	2	9	1	389	21

-continued-

Appendix A2.–Page 3 of 3.

	2003		2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		2004–2013	
Date	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	Avg %
3 Aug	932	21	1,083	52	1,444	71	1,717	37	399	24	90	11	405	41	139	33	10	3	5	2	100	11	539	28
4 Aug	932	21	1,087	52	1,605	79	1,754	38	399	24	90	11	405	41	139	33	10	3	5	2	102	11	560	29
5 Aug	932	21	1,087	52	1,654	82	1,763	38	399	24	90	11	577	58	139	33	10	3	37	12	102	11	586	32
6 Aug	932	21	1,088	52	1,682	83	1,775	39	399	24	90	11	600	60	139	33	10	3	37	12	219	24	604	34
7 Aug	932	21	1,088	52	1,693	83	1,788	39	400	24	90	11	600	60	139	33	10	3	37	12	538	60	638	38
8 Aug	932	21	1,095	52	1,705	84	1,797	39	400	24	90	11	600	60	139	33	10	3	37	12	561	62	643	38
9 Aug	932	21	1,513	73	1,715	85	1,802	39	400	24	90	11	600	60	140	33	10	3	37	12	561	62	687	40
10 Aug	1,117	25	1,582	76	1,737	86	1,806	39	400	24	90	11	600	60	140	33	10	3	37	12	562	62	696	41
11 Aug	1,152	26	1,588	76	1,755	87	1,820	40	400	24	90	11	600	60	140	33	10	3	37	12	562	62	700	41
12 Aug	1,168	26	1,588	76	1,775	88	1,825	40	400	24	99	12	600	60	140	33	10	3	37	12	562	62	704	41
13 Aug	1,173	26	1,597	77	1,789	88	1,827	40	400	24	743	89	600	60	140	33	10	3	37	12	562	62	771	49
14 Aug	1,679	37	1,601	77	1,794	88	2,131	46	403	24	761	91	600	60	184	44	10	3	55	18	562	62	810	51
15 Aug	1,810	40	1,602	77	1,808	89	2,192	48	403	24	762	91	600	60	269	64	10	3	72	24	562	62	828	54
16 Aug	1,832	41	1,603	77	1,817	90	2,192	48	403	24	762	91	600	60	269	64	10	3	75	25	677	75	841	56
17 Aug	1,832	41	1,608	77	1,894	93	2,193	48	403	24	762	91	600	60	273	65	10	3	75	25	701	78	852	56
18 Aug	1,834	41	1,613	77	1,917	95	2,227	49	500	30	766	92	600	60	273	65	15	4	75	25	772	86	876	58
19 Aug	2,074	46	1,743	84	1,930	95	2,245	49	710	42	787	94	600	60	273	65	65	18	75	25	796	88	922	62
20 Aug	3,027	67	1,743	84	1,940	96	2,376	52	718	43	789	95	600	60	273	65	87	24	75	25	798	88	940	63
21 Aug	3,268	73	1,748	84	1,950	96	2,386	52	718	43	791	95	601	61	275	65	88	24	75	25	801	89	943	63
22 Aug	3,408	76	1,755	84	1,964	97	2,396	52	723	43	794	95	601	61	284	68	89	25	80	27	815	90	950	64
23 Aug	3,445	77	1,773	85	1,980	98	2,412	53	776	46	797	96	601	61	285	68	90	25	80	27	821	91	962	65
24 Aug	3,467	77	2,040	98	1,990	98	2,827	62	778	46	797	96	602	61	285	68	90	25	80	27	824	91	1,031	67
25 Aug	3,470	77	2,063	99	1,999	99	2,906	63	778	46	798	96	603	61	286	68	132	37	80	27	827	92	1,047	69
26 Aug	3,483	78	2,073	99	2,004	99	3,028	66	778	46	798	96	604	61	286	68	204	57	80	27	827	92	1,068	71
27 Aug	3,486	78	2,077	100	2,004	99	3,168	69	795	47	798	96	624	63	286	68	287	80	82	27	827	92	1,095	74
28 Aug	3,488	78	2,086	100	2,013	99	3,196	70	1,326	79	798	96	898	91	286	68	334	93	82	27	829	92	1,185	81
29 Aug	4,488	100	2,086	100	2,021	100	3,206	70	1,467	88	798	96	955	96	288	68	338	94	82	27	829	92	1,207	83
30 Aug	4,488	100	2,086	100	2,023	100	4,586	100	1,500	89	798	96	987	99	288	68	338	94	82	27	903	100	1,359	87
31 Aug	4,488	100	2,086	100	2,028	100	4,586	100	1,511	90	806	97	990	100	289	69	338	94	83	28	903	100	1,362	88
Total	4,488		2,086		2,028		4,586		1,676		833		992		421		360		301		903		1,419	

[a] Weir panel dislodged on 3 September.