

Annual Project Report No. 00-032
USFWS Office of Subsistence Management
Fishery Information Services Division

**Stock Assessment of Sockeye Salmon from the Buskin
River, Kodiak, Alaska, 2001**

by

Donn Tracy,
Len Schwarz,
and
Suzanne Schmidt

June 2002

Alaska Department of Fish and Game

Division of Sport Fish



Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used in Division of Sport Fish Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications without definition. All others must be defined in the text at first mention, as well as in the titles or footnotes of tables and in figures or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft ³ /s
foot	ft
gallon	gal
inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd
Spell out acre and ton.	

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s
Spell out year, month, and week.	

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
Compass directions:	
east	E
north	N
south	S
west	W
Copyright	©

Corporate suffixes:

Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
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
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™

United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

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	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
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.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H ₀
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
standard length	SL
total length	TL
variance	Var

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*Donn Tracy, Len Schwarz and Suzanne Schmidt
Alaska Department of Fish and Game, Division of Sport Fish
211 Mission Road, Kodiak, AK 99615-6399, USA*

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Annual Report Summary Page

Title: Stock assessment of sockeye salmon from the Buskin River, Kodiak, Alaska, 2001

Study Number: 00-032

Investigator(s)/Affiliation(s): Donn Tracy, Len Schwarz and Suzanne Schmidt, Alaska Department of Fish and Game, Division of Sport Fish, 211 Mission Road, Kodiak, AK 99615-6399, USA.

Management Regions: Kodiak Area, Bristol Bay/Alaska Peninsula/Kodiak Region

Information Type: Stock Status and Trends

Issue Addressed: Data collected from the project will be used to develop an escapement goal of this sockeye salmon stock and potentially be used for inseason management.

Study Cost: \$49,500

Study Duration: May 20, 2001– August 15, 2001

Key Words: Age composition, Buskin River, Kodiak Island, sockeye salmon, *Oncorhynchus nerka*, subsistence harvest, weir.

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TABLE OF CONTENTS

	Page
LIST OF TABLES.....	ii
LIST OF FIGURES	ii
LIST OF APPENDICES	ii
ABSTRACT	1
INTRODUCTION	1
METHODS.....	3
Buskin River Weir	3
Age-Sex-Length Sampling	3
Data Analysis.....	3
RESULTS.....	5
DISCUSSION.....	9
ACKNOWLEDGMENTS	9
LITERATURE CITED.....	10
APPENDIX A. SUPPORTING DATA.....	11

LIST OF TABLES

Table	Page
Table 1.-Immigration, by date, of sockeye salmon through the Buskin River weir, 2001.....	6
Table 2.-Estimates by age of the sockeye salmon escapement, Buskin River, 2001.....	8
Table 3.-Estimates, by age and temporal stratum, of the subsistence harvest of sockeye salmon to the Buskin River, 2001.....	8
Table 4.-Escapement of sockeye salmon into the Buskin River, 1985-2001.....	9
Table 5.-Subsistence harvests of sockeye salmon, Buskin Bay, 1980-2001.....	9

LIST OF FIGURES

Figure	Page
Figure 1.-Map of Kodiak Island.	2
Figure 2.-Location of the Buskin River weir, 2001.	5
Figure 3.-Daily counts of sockeye salmon passing the Buskin River weir, 2001.....	7
Figure 4.-Cumulative percent of sockeye salmon passing the Buskin River weir, 2001.....	7

LIST OF APPENDICES

Appendix	Page
Appendix A1.-Age composition, by temporal strata, for the sockeye salmon escapement, Buskin River, 2001.	12

ABSTRACT

A weir was operated on the Buskin River on Kodiak Island, Alaska, from May 20 - July 31, 2001 to enumerate sockeye salmon *Oncorhynchus nerka*. We counted 20,544 sockeye salmon, the largest recorded escapement, into the Buskin River. The midpoint of the run occurred on June 10. Most sockeye salmon in the escapement were ages 1.3 or 2.3. The subsistence harvest was 8,251 sockeye salmon, most of which were ages 1.3 or 2.3.

Key words: Buskin River, Kodiak Island, sockeye salmon, *Oncorhynchus nerka*, weir, subsistence harvest, age composition.

INTRODUCTION

The Buskin River (Figure 1), located approximately 2 miles from the city of Kodiak, is the most intensively fished river on Kodiak Island (Mills 1990-1994; Howe et al. 1995-2001a-d; Walker et al. *in prep*). A subsistence fishery in marine waters near the mouth of the Buskin River harvests large numbers of sockeye salmon *Oncorhynchus nerka*. Subsistence harvests averaged 4,837 sockeye salmon from 1990-1998 and increased to over 7,000 fish in 1999 and 2000 (Schwarz et al. 2002), making the Buskin River the largest contributor to subsistence harvests in federally managed waters within the Kodiak area.

Sockeye salmon from the Buskin River are also harvested by a recreational fishery which has been monitored since 1980. Sockeye salmon sport harvest averaged 1,725 fish from 1990-2000, and recreational fishing effort on the Buskin River represented an average of 35% of the annual freshwater recreational fishing effort in the Kodiak Management Area during the 1990s (Schwarz et al. 2002). This effort was also directed at other stocks harvested in subsistence fisheries, including Dolly Varden *Salvelinus malma*, coho salmon *O. kisutch*, and pink salmon *O. gorbuscha*.

To a much lesser degree, sockeye salmon from the Buskin River are harvested commercially. Commercial harvests of sockeye salmon have been small, at less than 100 fish annually during the 1990s.

Escapements of sockeye salmon returning to the Buskin River have been monitored since 1980. From 1980-1984, escapement was estimated using aerial survey counts. Beginning in 1985, a weir has been used to monitor escapement. From 1990-2000, annual sockeye salmon escapements into the Buskin River averaged 11,204 fish (Schwarz et al. 2002).

Although historically harvests and escapements have been monitored, age data from the subsistence harvest have been collected consistently since 1993 only (Schwarz and Clapsadl 2000), except for 1999 when age data from the escapement and subsistence harvest were not collected due to budget constraints. Consequently, there is very little information available to assess productivity of this salmon stock and to evaluate the biological escapement goal (BEG).

Estimates of total return by age from sampling the escapement and subsistence harvest are needed in order reconstruct the run and develop brood tables. Cumulative weir counts are needed for comparison to historic time of entry data in order to ensure fisheries are managed to meet the BEG annually. Results from this project will ensure that the Buskin River sockeye salmon stock is not negatively affected by subsistence, recreational, or commercial fisheries.

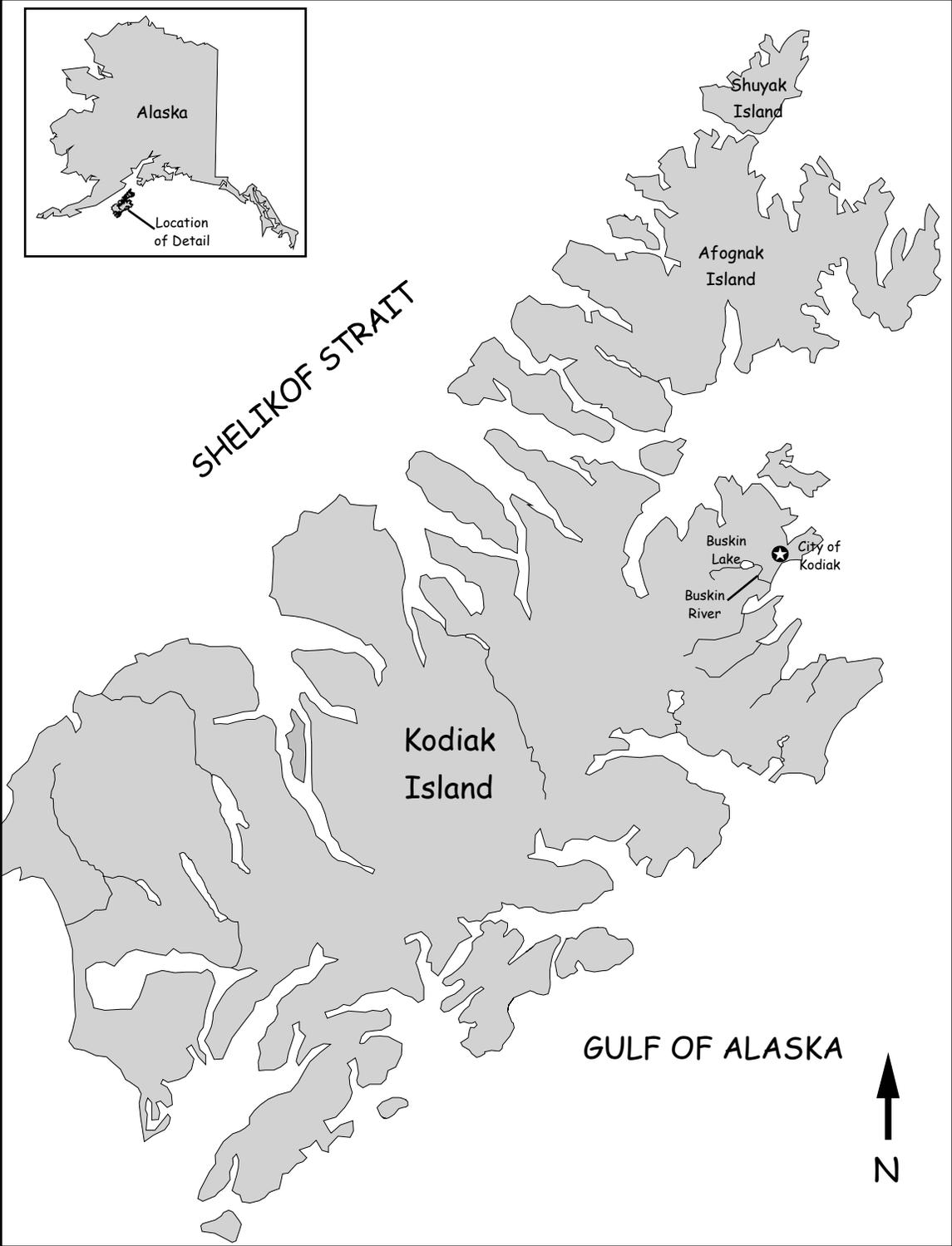


Figure 1.-Map of Kodiak Island.

Therefore, the objectives of this study were to census the sockeye salmon escapement into the Buskin River in 2001, and to estimate the age composition of the subsistence harvest and escapement of sockeye salmon returning to the Buskin River. This information, along with historic data and sport and commercial harvest estimates, will be used to begin development of a brood table to evaluate the sockeye salmon escapement goal for this system.

METHODS

BUSKIN RIVER WEIR

The spawning escapement of sockeye salmon was censused through a weir at the outlet of Buskin Lake (Figure 2) from May 20 - July 31, 2001. Fish present behind the weir were enumerated as they were allowed to migrate upstream. Daily counts of sockeye salmon were entered on salmon weir count forms. After July 31, the weir was moved to a downstream location to enumerate coho salmon.

AGE-SEX-LENGTH SAMPLING

We sampled sockeye salmon from the Buskin River weir sampling box during each of three temporal strata: May 20 – June 15, June 16-30, and July 1-31. Sampling was conducted on two days, one week apart, during each stratum. All fish entering the trap on selected days were sampled, even if the daily sample goal was exceeded. When large numbers (>100) of sockeye salmon were present behind the weir, fish were sampled during the early, middle and late portions of the time interval required for their passage upstream.

The subsistence harvest was sampled for age, sex, and length on the same schedule as escapement. Harvested fish were sampled from permit holders opportunistically within each time stratum. Sampling was conducted on the fishing grounds from a boat during good weather, or dockside at the local boat harbor.

Fish were measured from mid-eye to fork-of-tail and sex determined. Two scales were taken from each fish and mounted on a gum card. Scales were taken 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, two rows above the lateral line (Clutter and Whitesel 1956). Scales were taken proximal to the preferred region when necessary, although only within the area bounded dorsally by the fourth row of scales above the lateral line, ventrally by the lateral line, and between lines drawn vertically from the posterior insertion of the dorsal fin and the anterior insertion of the anal fin. If scales were not available in the preferred region on the left side of the fish, scales were collected from the preferred region on the right side. Age was interpreted from scales using the criteria of Clutter and Whitesel (1956).

DATA ANALYSIS

Chi-squared statistics were used to test for differences in age and sex composition among temporal strata within each source (i.e. escapement or subsistence harvests) and also between each source. If differences were detected, estimates were stratified to minimize bias. If differences were not detected, age data were pooled to improve precision. The proportion of sockeye salmon from source h (escapement or subsistence harvest) during stratum i ($i = 1,2,3$) in age/sex class j was estimated as a binomial proportion by:

$$\hat{p}_{hij} = \frac{n_{hij}}{n_{hi}} \quad (1)$$

and its variance by:

$$\hat{V}(\hat{p}_{hij}) = \left[\frac{N_{hi} - n_{hi}}{N_{hi}} \right] \frac{\hat{p}_{hij}(1 - \hat{p}_{hij})}{n_{hi} - 1}, \quad (2)$$

where:

n_{hij} = the number of sockeye salmon from source h during stratum i that were in age/sex class j,

n_{hi} = the number of sockeye salmon sampled from source h during stratum i, and

N_{hi} = the total number of sockeye salmon in source h during stratum i.

Weir counts and permit returns of subsistence harvests were treated as censuses with no variance. In the event that temporal stratification was required for the subsistence harvest, N_{Si} was calculated by multiplying the total subsistence harvest by the proportion of the sockeye salmon run passing through the weir in temporal stratum i.

The number of fish from source h during stratum i of age/sex class j was estimated by:

$$\hat{N}_{hij} = N_{hi} \hat{p}_{hij}, \quad (3)$$

where N_{hi} = the total number of sockeye salmon from source h during stratum i;

and its variance by:

$$\hat{V}(\hat{N}_{hij}) = N_{hi}^2 \hat{V}(\hat{p}_{hij}). \quad (4)$$

The total number of fish from source h of age/sex class j was estimated as:

$$\hat{N}_{hj} = \sum_{i=1}^t \hat{N}_{hij} \quad (5)$$

where t = the number of strata; and the variance was estimated as the sum of the variances as:

$$V(\hat{N}_{hj}) = \sum V(\hat{N}_{hij}). \quad (6)$$

The proportion of sockeye salmon age/sex class j for the total of source h was estimated as:

$$\hat{p}_{hj} = \frac{\hat{N}_{hj}}{N_h}, \quad (7)$$

where N_h = the total for source h.

The variance of the proportion was estimated by:

$$V(\hat{p}_{hj}) = \frac{V(\hat{N}_{hj})}{N_h^2}. \quad (8)$$

RESULTS

In 2001, we counted 20,544 sockeye salmon through the Buskin River weir (Table 1). The highest count, 2,238 sockeye salmon, occurred on June 10 (Figure 3), which was also the date of the midpoint of the run (Figure 4). We had age and sex data for 728 sockeye salmon, and sex and length data for 805 fish. Age compositions were significantly different by temporal strata ($\chi^2 = 62.64$, $df = 6$, $P < 0.01$), so they were stratified (Appendix A1). Most fish in the escapement were ages 1.3 or 2.3 (Table 2). Mean length of females in the escapement was 522 mm (SE = 1.61); mean length of males was 542 mm (SE = 2.79).

The subsistence harvest was 8,251 sockeye salmon in 2001. There was a significant difference in age compositions by temporal strata ($P < 0.05$). Most fish in the subsistence harvest were ages 1.3 or 2.3 (Table 3). Mean length of females in the subsistence harvest was 538 mm (SE = 2.16), and 566 mm (SE = 2.47) for males.

The age composition of the escapement was significantly different from the subsistence harvest ($\chi^2 = 8.35$, $df = 2$, $P = 0.02$).

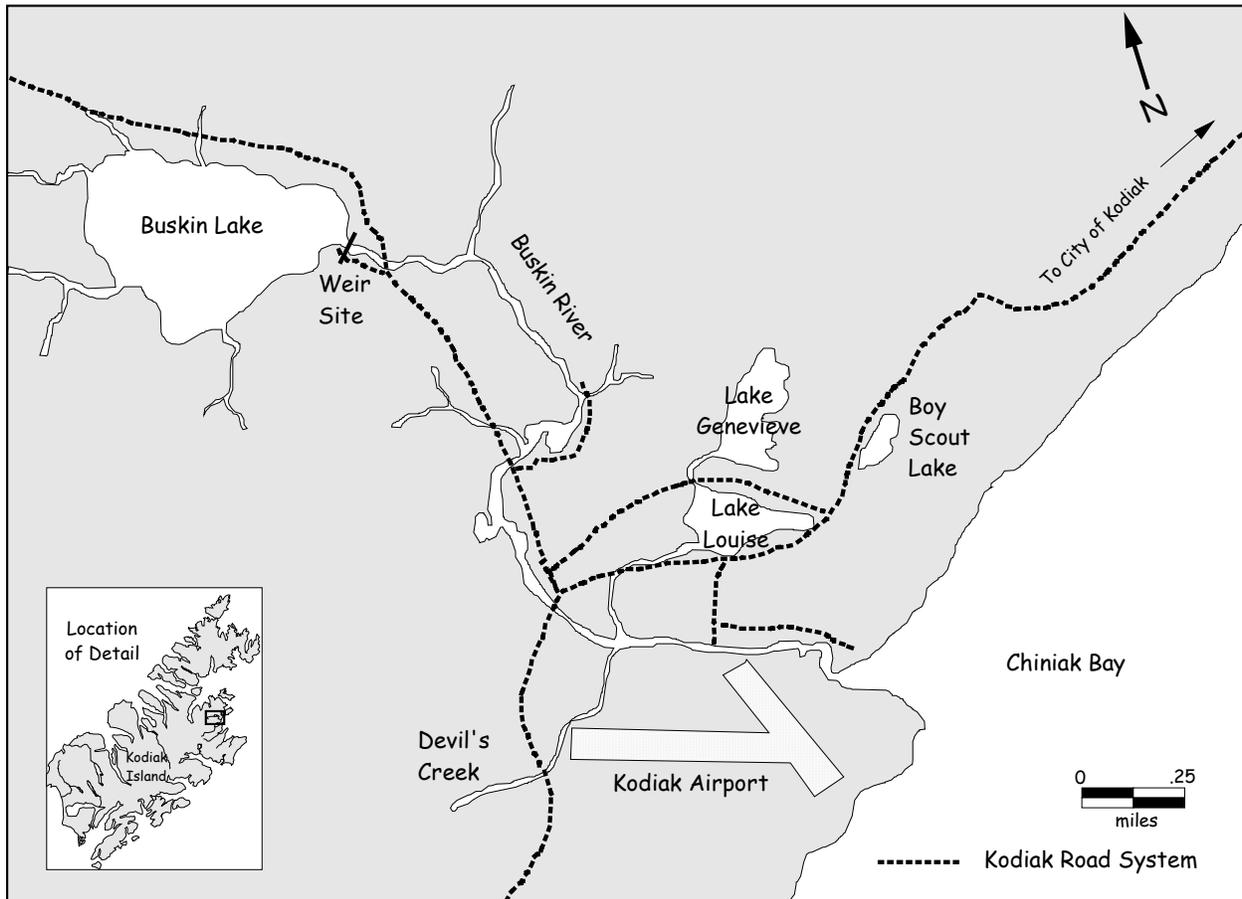


Figure 2.-Location of the Buskin River weir, 2001.

Table 1.-Immigration, by date, of sockeye salmon through the Buskin River weir, 2001.

Date	Number Counted	Cumulative %	Date	Number Counted	Cumulative %
5/20/01	0	0.0	7/1/01	20	92.5
5/21/01	0	0.0	7/2/01	50	92.8
5/22/01	0	0.0	7/3/01	405	94.7
5/23/01	0	0.0	7/4/01	64	95.0
5/24/01	0	0.0	7/5/01	331	96.7
5/25/01	12	0.1	7/6/01	20	96.8
5/26/01	44	0.3	7/7/01	6	96.8
5/27/01	77	0.6	7/8/01	37	97.0
5/28/01	178	1.5	7/9/01	49	97.2
5/29/01	156	2.3	7/10/01	1	97.2
5/30/01	472	4.6	7/11/01	16	97.3
5/31/01	718	8.1	7/12/01	39	97.5
6/1/01	298	9.5	7/13/01	22	97.6
6/2/01	497	11.9	7/14/01	49	97.8
6/3/01	271	13.2	7/15/01	15	97.9
6/4/01	600	16.2	7/16/01	60	98.2
6/5/01	1,501	23.5	7/17/01	0	98.2
6/6/01	616	26.5	7/18/01	19	98.3
6/7/01	500	28.9	7/19/01	267	99.6
6/8/01	1,368	35.6	7/20/01	7	99.6
6/9/01	519	38.1	7/21/01	19	99.7
6/10/01	2,238	49.0	7/22/01	2	99.7
6/11/01	1,108	54.4	7/23/01	28	99.8
6/12/01	642	57.5	7/24/01	2	99.9
6/13/01	1,208	63.4	7/25/01	21	100.0
6/14/01	1,014	68.3	7/26/01	0	100.0
6/15/01	279	69.7	7/27/01	0	100.0
6/16/01	692	73.0	7/28/01	0	100.0
6/17/01	475	75.3	7/29/01	0	100.0
6/18/01	146	76.0	7/30/01	0	100.0
6/19/01	317	77.6	7/31/01	0	100.0
6/20/01	556	80.3			
6/21/01	106	80.8	Total	20,544	
6/22/01	113	81.4			
6/23/01	625	84.4			
6/24/01	648	87.6			
6/25/01	84	88.0			
6/26/01	524	90.5			
6/27/01	295	91.9			
6/28/01	17	92.0			
6/29/01	62	92.3			
6/30/01	19	92.4			

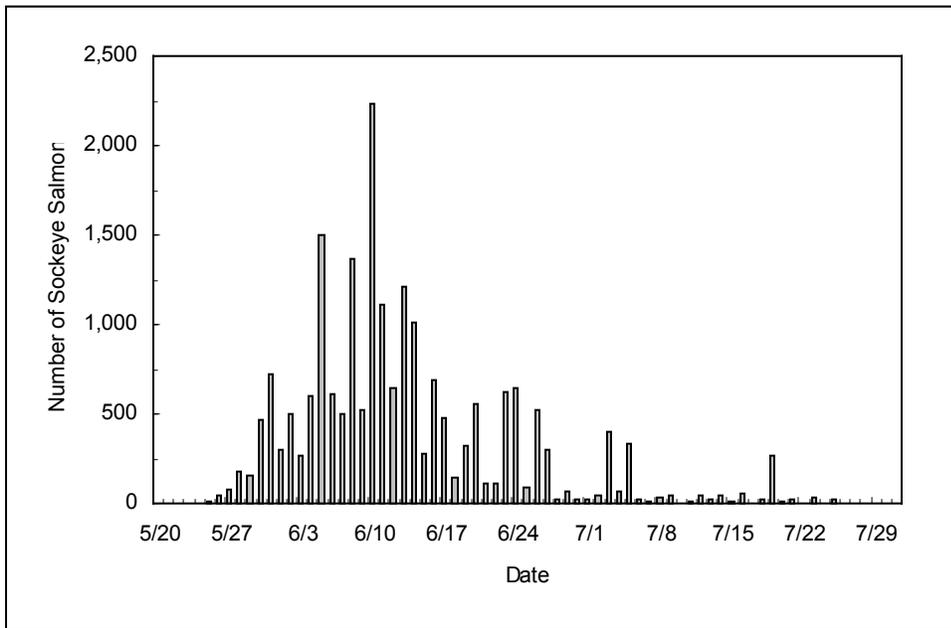


Figure 3.-Daily counts of sockeye salmon passing the Buskin River weir, 2001.

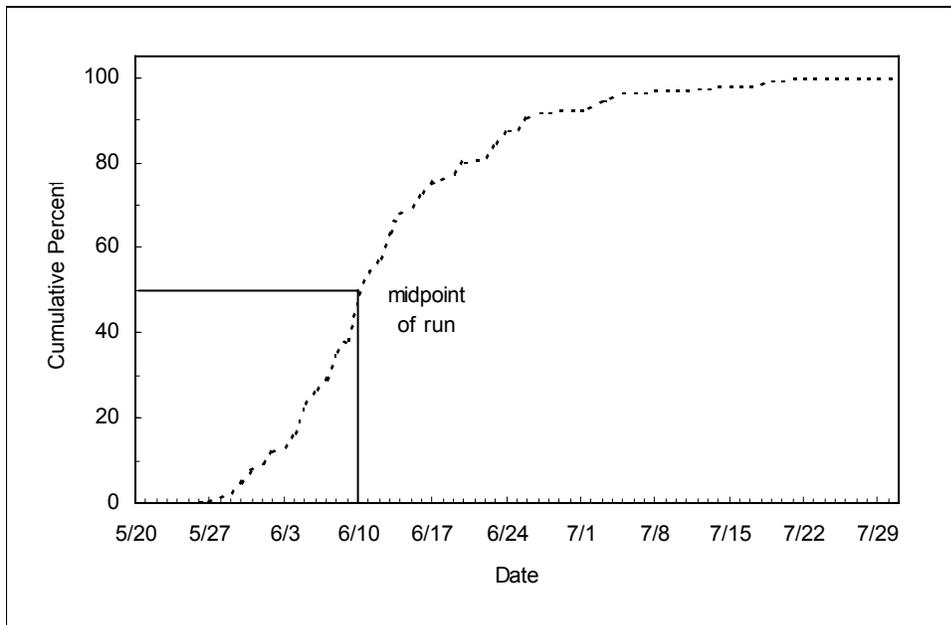


Figure 4.-Cumulative percent of sockeye salmon passing the Buskin River weir, 2001.

Table 2.-Estimates by age of the sockeye salmon escapement, Buskin River, 2001.

Sex	Age									Total
	0.2	0.3	1.2	1.3	1.4	2.1	2.2	2.3	2.4	
May 20 - July 31										
Females										
Estimated Run	0	0	591	7,363	413	0	810	2,556	0	11,732
SE Run	0	0	133	426	137	0	149	310	0	430
Proportion	0.00	0.00	0.03	0.36	0.02	0.00	0.04	0.12	0.00	0.57
SE Proportion	0.0000	0.0000	0.0065	0.0208	0.0067	0.0000	0.0073	0.0151	0.0000	0.0209
Males										
Estimated Run	19	19	649	5,468	344	73	697	1,377	167	8,812
SE Run	18	17	114	381	127	32	150	226	86	430
Proportion	0.00	0.00	0.03	0.27	0.02	0.00	0.03	0.07	0.01	0.43
SE Proportion	0.0009	0.0008	0.0055	0.0185	0.0062	0.0015	0.0073	0.0110	0.0042	0.0209
Total										
Estimated Run	19	19	1,240	12,830	757	73	1,507	3,933	167	20,544
SE Run	18	17	172	427	185	32	208	362	86	
Proportion	0.00	0.00	0.06	0.62	0.04	0.00	0.07	0.19	0.01	1.00
SE Proportion	0.0009	0.0008	0.0084	0.0208	0.0090	0.0015	0.0101	0.0176	0.0042	

Table 3.-Estimates, by age and temporal stratum, of the subsistence harvest of sockeye salmon to the Buskin River, 2001.

Stratum	Age										Total
	0.2	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	
20 May - 15 June	0	25	74	0	3,717	149	99	719	25	0	4,807
16 June - 30 June	0	0	50	0	1,660	223	0	297	0	25	2,255
1 July - 31 July	0	25	124	0	669	99	0	273	0	0	1,189
Total	0	50	248	0	6,046	471	99	1,288	25	25	8,251

Table 4.-Escapement of sockeye salmon into the Buskin River, 1985-2001.

Year	Escapement
1985	18,010
1986	8,939
1987	12,690
1988	12,144
1989	17,853
1990	10,528
1991	9,789
1992	9,782
1993	9,526
1994	11,783
1995	15,520
1996	9,661
1997	9,840
1998	14,767
1999	10,812
2000	11,233
2001	20,544

Notes: From 1985-1989 the weir was operated upstream of Bridge #1 from April through October. Beginning in 1990, the weir has been located at the outlet of Buskin Lake during the sockeye immigration (June and July) and then moved to upstream of Bridge #1 during the coho immigration (mid-July through September). From 1990-1992 the weir at the lake outlet was also operated during the spring Dolly Varden emigration. Sockeye entering the tributary lakes of Louise and Genevieve are not counted at the upriver location.

Sources: 1985-1998 data from Schwarz and Clapsadl 2000; 1999-2000 data from Schwarz et al. 2002.

Table 5.-Subsistence harvests of sockeye salmon, Buskin Bay, 1980-2001.

Year	Harvest
1980	4,279
1981	4,742
1982	6,748
1983	5,690
1984	565
1985	5,326
1986	5,303
1987	3,375
1988	3,099
1989	3,312
1990	3,448
1991	4,301
1992	3,295
1993	4,745
1994	4,899
1995	5,547
1996	5,403
1997	5,890
1998	6,011
1999	7,985
2000	7,281
2001	8,251

Source: data for 1980-2000 from Schwarz et al. 2002.

DISCUSSION

The 2001 escapement of sockeye salmon into the Buskin River was the highest on record since weir operations began in 1985. The subsistence harvest was also the largest since 1980. Escapements, subsistence harvests, and age estimates obtained from this project will be used with sport and commercial harvest data to construct brood tables. This information will then be used to evaluate and refine escapement goals for Buskin River sockeye salmon.

ACKNOWLEDGMENTS

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APPENDIX A. SUPPORTING DATA

Appendix A1.-Age composition, by temporal strata, for the sockeye salmon escapement, Buskin River, 2001.

Sex	Age									Total
	0.2	0.3	1.2	1.3	1.4	2.1	2.2	2.3	2.4	
May 20 – June 15										
Females										
Sample Size	0	0	6	112	8	0	7	46	0	179
Proportion	0.00	0.00	0.02	0.38	0.03	0.00	0.02	0.16	0.00	0.62
SE Proportion	0.0000	0.0000	0.0083	0.0283	0.0095	0.0000	0.0089	0.0212	0.0000	0.0283
Estimated Run	0	0	295	5,510	394	0	344	2,263	0	8,806
SE Run	0	0	118	405	136	0	127	304	0	405
Males										
Sample Size	0	0	3	70	7	0	8	21	3	112
Proportion	0.00	0.00	0.01	0.24	0.02	0.00	0.03	0.07	0.01	0.38
SE Proportion	0.0000	0.0000	0.0059	0.0248	0.0089	0.0000	0.0095	0.0150	0.0059	0.0283
Estimated Run	0	0	148	3,444	344	0	394	1,033	148	5,510
SE Run	0	0	84	356	127	0	136	215	84	405
Total										
Sample Size	0	0	9	182	15	0	15	67	3	291
Proportion	0.00	0.00	0.03	0.63	0.05	0.00	0.05	0.23	0.01	1.00
SE Proportion	0.0000	0.0000	0.0101	0.0281	0.0129	0.0000	0.0129	0.0245	0.0059	
Estimated Run	0	0	443	8,954	738	0	738	3,296	148	14,316
SE Run	0	0	144	403	184	0	184	350	84	
June 16 – June 30										
Females										
Sample Size	0	0	10	75	1	0	19	12	0	117
Proportion	0.00	0.00	0.04	0.30	0.00	0.00	0.08	0.05	0.00	0.47
SE Proportion	0.0000	0.0000	0.0115	0.0267	0.0037	0.0000	0.0155	0.0125	0.0000	0.0290
Estimated Run	0	0	189	1,421	19	0	360	227	0	2,216
SE Run	0	0	54	125	17	0	72	58	0	136
Males										
Sample Size	1	1	17	78	0	3	13	16	1	130
Proportion	0.00	0.00	0.07	0.32	0.00	0.01	0.05	0.06	0.00	0.53
SE Proportion	0.0039	0.0037	0.0147	0.0270	0.0000	0.0064	0.0130	0.0143	0.0037	0.0290
Estimated Run	19	19	322	1,478	0	57	246	303	19	2,463
SE Run	18	17	69	126	0	30	61	67	17	136
Total										
Sample Size	1	1	27	153	1	3	32	28	1	247
Proportion	0.00	0.00	0.11	0.62	0.00	0.01	0.13	0.11	0.00	1.00
SE Proportion	0.0039	0.0037	0.0181	0.0282	0.0037	0.0064	0.0195	0.0184	0.0037	
Estimated Run	19	19	511	2,898	19	57	606	530	19	4,679
SE Run	18	17	85	132	17	30	91	86	17	

continued

Appendix A1.-Page 2 of 2.

Sex	Age									Total
	0.2	0.3	1.2	1.3	1.4	2.1	2.2	2.3	2.4	
July 1 - July 31										
Females										
Sample Size	0	0	13	53	0	0	13	8	0	87
Proportion	0.00	0.00	0.07	0.28	0.00	0.00	0.07	0.04	0.00	0.46
SE Proportion	0.0000	0.0000	0.0172	0.0306	0.0000	0.0000	0.0172	0.0137	0.0000	0.0339
Estimated Run	0	0	106	432	0	0	106	65	0	709
SE Run	0	0	27	47	0	0	27	21	0	53
Males										
Sample Size	0	0	22	67	0	2	7	5	0	103
Proportion	0.00	0.00	0.12	0.35	0.00	0.01	0.04	0.03	0.00	0.54
SE Proportion	0.0000	0.0000	0.0218	0.0326	0.0000	0.0070	0.0128	0.0109	0.0000	0.0339
Estimated Run	0	0	179	546	0	16	57	41	0	840
SE Run	0	0	34	50	0	11	20	17	0	53
Total										
Sample Size	0	0	35	120	0	2	20	13	0	190
Proportion	0.00	0.00	0.18	0.63	0.00	0.01	0.11	0.07	0.00	1.00
SE Proportion	0.0000	0.0000	0.0264	0.0329	0.0000	0.0070	0.0209	0.0172	0.0000	
Estimated Run	0	0	285	978	0	16	163	106	0	1,549
SE Run	0	0	41	51	0	11	32	27	0	