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A Summary of Harvest and Escapement Information and Recommendations for Improved Data Collection and Escapement Goals for Unalakleet River Chinook Salmon

by

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and

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October 2006

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

Symbols and Abbreviations

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

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

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

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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ABSTRACT

This report provides a description of the Chinook salmon *Oncorhynchus tshawytscha* fisheries in the Unalakleet Area, summarizes available harvest, escapement, age and sex information for returns to the Unalakleet River, and provides recommendations for improved data collection and escapement goals. This information was compiled and analyzed as part of a triennial review of escapement goals for the Arctic-Yukon-Kuskokwim area. This population is formally listed as a stock of concern as a result of low returns and harvests in recent years. Escapement data include tower-count estimates for the North River (a large tributary) and aerial survey counts of different sections within the drainage. Total harvest is estimated annually for all fisheries, but the fraction of the harvest in the marine subsistence and commercial fisheries that is of Unalakleet River origin is unknown. Age and sex composition are estimated annually from samples collected from the commercial and test fisheries, but due to gear selectivity, it is likely that both samples provide biased estimates of composition of the escapement. Escapement and harvest data were used to complete four separate run reconstructions (escapement and subsequent returns by age class) for years when a counting tower was operated on the North River. Each reconstruction used a different combination of age composition data (from either the commercial harvest only or a combination of the commercial harvest and test fishery) and a different assumption regarding stock-specific harvest in the marine fisheries in the terminal fishing district (either 100% or 75%). The proportion of the total escapement counted at the North River tower was estimated from a radiotelemetry study conducted in 1997 and 1998, and the average proportion from those 2 years was used to expand all available tower counts to estimate total drainage escapement. Run reconstructions yielded only four paired estimates of escapement and subsequent brood year returns and were thus insufficient to fit to a spawner-recruit model. For all four scenarios, estimates of return-per-spawner were below or only slightly above replacement. Estimated average total exploitation rates for 1996–2005 ranged from 46% to 52% depending on the assumption regarding stock-specific harvest in the marine fisheries. Average exploitation in recent years (2001–2005) has been lower, averaging 40%–46% as a result of direct management actions in the commercial fishery to reduce harvest. Recommendations for improving the quality of data for escapement goal determination include continuing operation of existing escapement and harvest monitoring projects, developing a sampling strategy to estimate age, sex, and length composition of the escapement, operation of a weir enumeration project on the mainstem Unalakleet River, and conducting additional radiotelemetry studies to estimate the proportional contribution of the North River escapement to the total drainage escapement. Recommendations for escapement goals were to retain the existing sustainable escapement goals for the North River and Unalakleet and Old Woman rivers, but to continue efforts toward developing a biological escapement goal.

Key words: Norton Sound, Unalakleet River, Chinook salmon, *Oncorhynchus tshawytscha,* escapement, harvest, run reconstruction, brood table, exploitation, escapement goal, stock of concern.

INTRODUCTION

The Unalakleet River drainage is located in western Alaska on the eastern shore of Norton Sound (Figure 1), and drains an area of approximately 5,400 square kilometers. The Unalakleet River originates in the Nulato Hills and flows southwesterly for approximately 160 km until emptying into Norton Sound at the village of Unalakleet (Figure 2). The upper 130 km of the Unalakleet River has been designated a federal National Wild and Scenic River, and its adjacent lands are managed by the U.S. Bureau of Land Management. The Unalakleet River lies within management Subdistrict 6 (Unalakleet) of the Norton Sound district, which consists of all waters from a point located 7 miles north of Egavik to the tip of Black Point. Chinook salmon *Oncorhynchus tshawytscha* bound for the Unalakleet River are also harvested in Subdistrict 5 (Shaktoolik), which consists of waters from the tip of Cape Denbigh to a point located 7 miles north of Egavik (mutual border with Subdistrict 6; Figure 2).

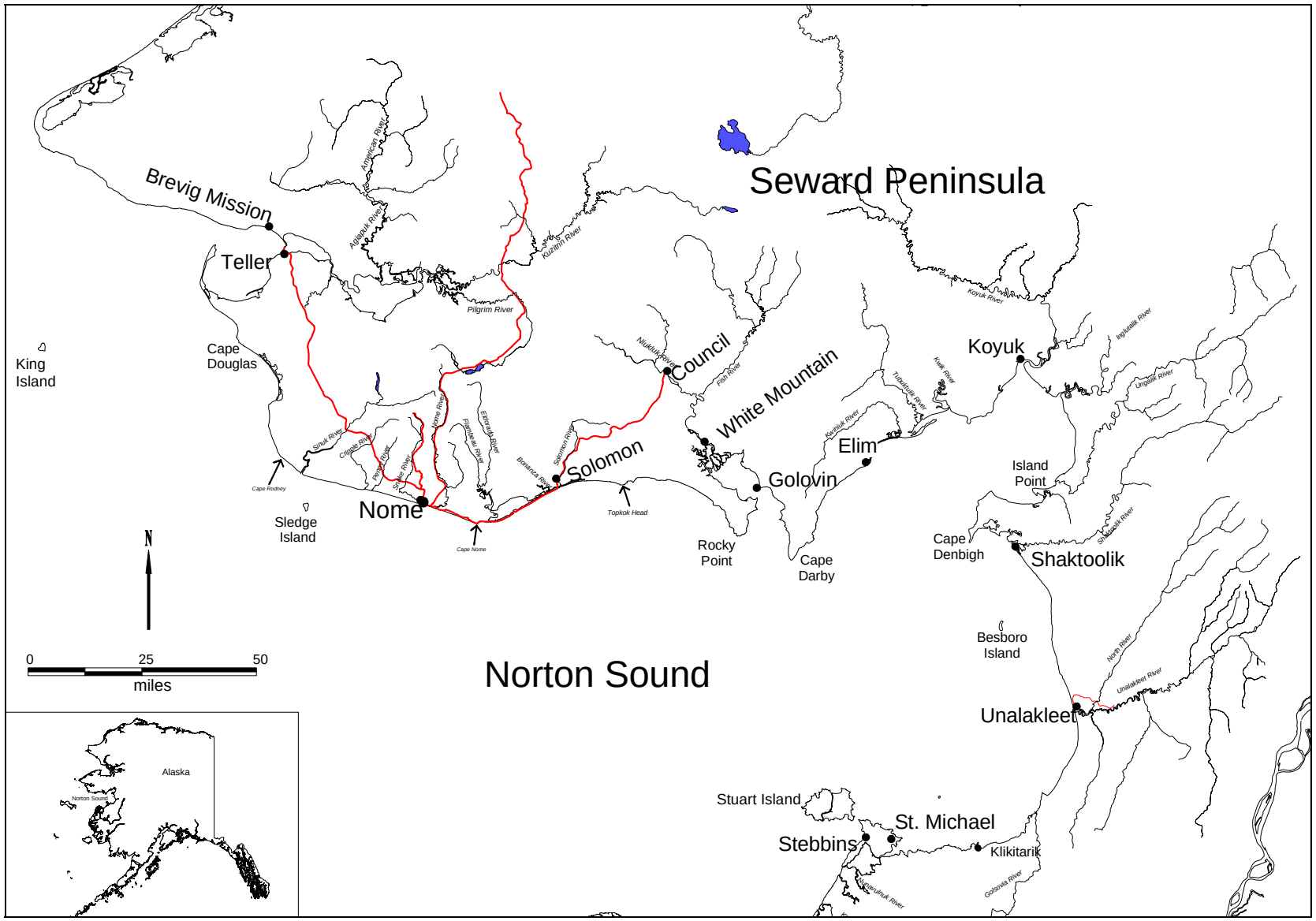


Figure 1.–Norton Sound Area showing the location of the Unalakleet River drainage.

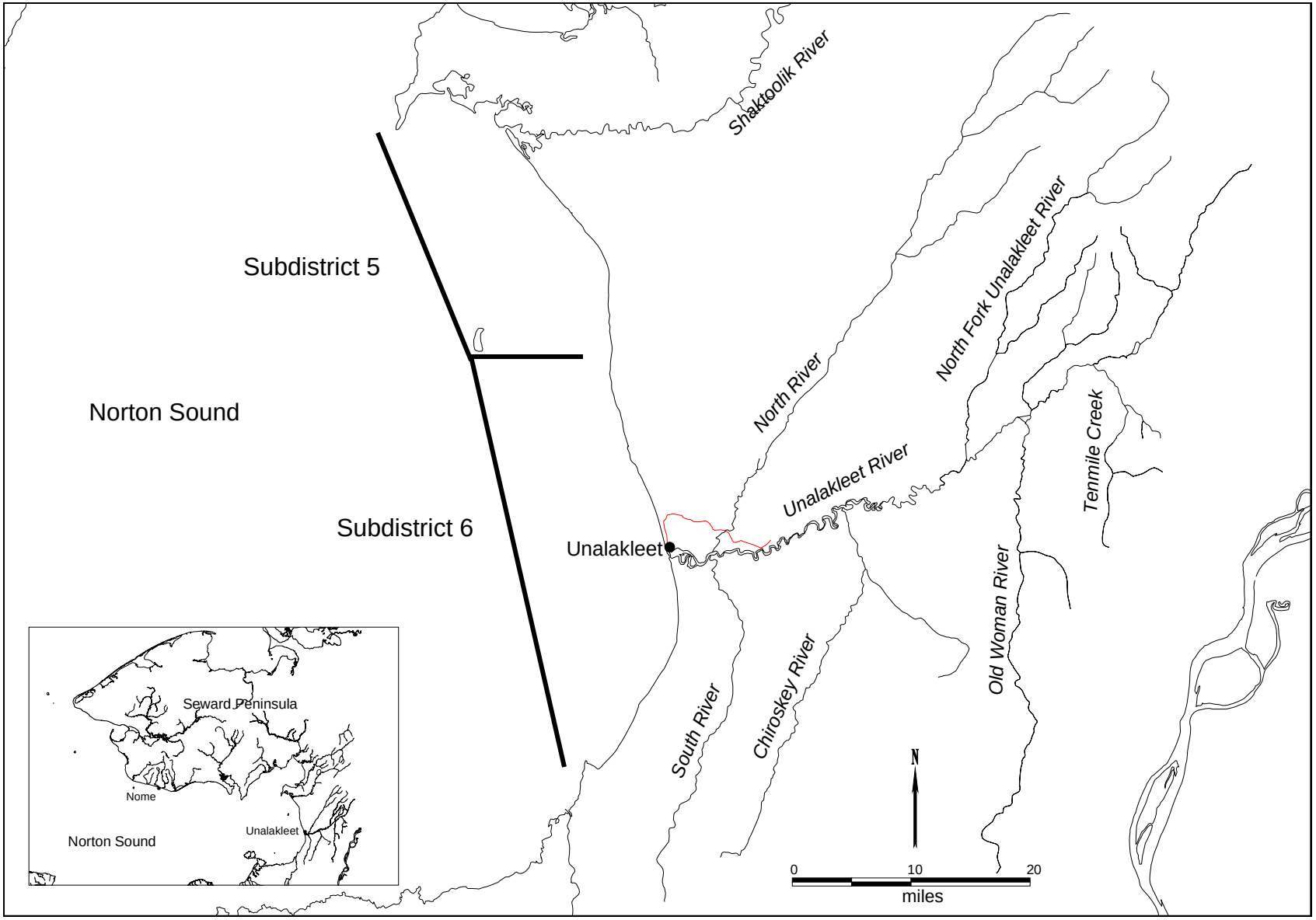


Figure 2.–Unalakleet River drainage showing management Subdistricts 5 and 6.

Unalakleet River Chinook salmon are harvested in subsistence, commercial, and sport fisheries. Subsistence fishers operate gillnets in the coastal marine waters near the mouth, and to a lesser extent, in the main river. Since 1964, subsistence harvests of Chinook salmon in Subdistrict 6 have ranged from 90 to 5,294 fish, averaging 1,612 fish (Table 1; Kohler et al. 2005). The most recent 5-year (2000–2004) average harvest is 2,489 fish. Commercial fishing in the Norton Sound area, by regulation, is conducted with set gillnets. Commercial harvests of Chinook salmon originating in the Unalakleet River drainage occur primarily in management Subdistrict 6 (Figure 2), although some are harvested in Subdistrict 5 (Gaudet and Schaefer 1982). Also, Chinook salmon bound for the Yukon River and other drainages are likely harvested in the Subdistrict 6 commercial and subsistence fisheries. Both subdistricts by regulation are managed concurrently for Chinook, chum *O. keta*, and coho *O. kisutch* salmon. However, since 2000, there has only been one Chinook salmon commercial opening (2005) because of continued weak returns of Chinook salmon (Kohler et al. 2005). In 2004, the Alaska Department of Fish and Game (ADF&G) recommended and the Alaska Board of Fisheries determined that Unalakleet River and Shaktoolik River Chinook salmon be classified a stock of yield concern[1]. Since 1961, commercial harvests of Chinook salmon in Subdistrict 6 have ranged from 0 to 12,621 fish, averaging 3,616 fish (Table 1; Kohler et al. 2005). The most recent 5-year (2001–2005) average is 46 fish. The Unalakleet River is the most popular sport fishing river in the Norton Sound area. Several guide services operate inriver, mainly targeting Chinook and coho salmon. Sport harvests (1990–2004) have ranged from 39 to 842, and averaged 333 Chinook salmon (Table 1; DeCicco 2004). The most recent 5-year (2000–2004) average harvest is 318 Chinook salmon.

Management of Chinook salmon in the Unalakleet River is based on information from subsistence harvests, an inriver test fishery (Kohler 2002), aerial surveys, and a counting tower located on the North River (a lower-river tributary of Unalakleet River; Kohler and Knuepfer 2002). Previous ground-based escapement project attempts, such as fixed-picket enumeration weirs, counting towers, and sonar (Lean 1985a), were hindered by high water level and increased turbidity associated with seasonal precipitation events. There are currently two escapement goals in place for Unalakleet River Chinook salmon. The first is a combined Old Woman River/Unalakleet River aerial survey sustainable escapement goal (SEG) of 550–1,100 fish, and the second is an SEG of 1,200 to 2,600 fish at the North River counting tower (ADF&G 2004).

This report was prepared as part of a triennial escapement goal review for salmon stocks in the Arctic-Yukon-Kuskokwim Region. The objective of this report is to summarize existing escapement, harvest, and age-sex composition information for Unalakleet River Chinook salmon for the purpose of evaluating existing escapement goals, recommending new goals if warranted, and identifying data gaps or information needs to develop new or refined goals in the future. Escapement goals are evaluated and recommendations are based on the *Policy for the Management of Sustainable Salmon Fisheries* (5 AAC 39.222, 2002) and the *Policy for Statewide Salmon Escapement Goals* (5 AAC 39.223, 2002). An ADF&G interdivisional team was assigned to review escapement and other data and make escapement goal recommendations when appropriate. In addition to the departmental team, representatives from other agencies were

[1] A salmon stock of yield concern is defined in the *Policy for the Management of Sustainable Salmon Fisheries* (5 AAC 39.222, 2002) as "a concern arising from a chronic inability, despite the use of specific management measures, to maintain expected yields, or harvestable surpluses, above a stock's escapement needs."

Table 1.–Chinook salmon commercial and subsistence harvests, Subdistricts 5 and 6, and Unalakleet River sport fish harvests, 1961–2005.

	Combined		Subdistrict 5		Subdistrict 6		Unalakleet River	
	Subdistricts 5 & 6		(Shaktoolik)		(Unalakleet)		Sport Fish Harvest	
Year	Commercial [a]	Subsistence [b]	Commercial [a]	Subsistence [b]	Commercial [a]	Subsistence [b]	Year	Harvest [c]
1961	5,300	0	140		5,160		1961	
1962	6,827	0	1,738		5,089		1962	
1963	6,421	0	480		5,941		1963	
1964	1,904	565	631	77	1,273	488	1964	
1965	1,448	552	127	31	1,321	521	1965	
1966	1,518	232	310	142	1,208	90	1966	
1967	1,794	752	43	262	1,751	490	1967	
1968	1,021	196	61	10	960	186	1968	
1969	2,309	364	33	40	2,276	324	1969	
1970	1,801	538	197	43	1,604	495	1970	
1971	2,450	998	284	87	2,166	911	1971	
1972	2,654	707	419	64	2,235	643	1972	
1973	1,686	374	289	51	1,397	323	1973	
1974	2,683	406	583	93	2,100	313	1974	
1975	2,289	181	651	18	1,638	163	1975	
1976	2,103	166	892	24	1,211	142	1976	
1977	4,212	772	1,521	49	2,691	723	1977	
1978	8,864	1,125	1,339	81	7,525	1,044	1978	
1979	8,731	702	2,377	62	6,354	640	1979	
1980	5,425	1,103	1,086	57	4,339	1,046	1980	
1981	7,641	877	1,484	8	6,157	869	1981	
1982	5,445	981	1,677	68	3,768	913	1982	
1983	9,764	N/A	2,742	N/A	7,022	1,868	1983	93
1984	8,417	N/A	1,613	N/A	6,804	1,650	1984	39
1985	17,933	1,695	5,312	298	12,621	1,397	1985	179
1986	5,569	N/A	1,075	N/A	4,494	N/A	1986	850
1987	5,460	N/A	2,214	N/A	3,246	N/A	1987	N/A
1988	2,889	N/A	671	N/A	2,218	N/A	1988	N/A
1989	5,643	N/A	1,241	N/A	4,402	N/A	1989	49
1990	8,642	N/A	2,644	N/A	5,998	2,476	1990	276
1991	5,858	N/A	1,324	N/A	4,534	N/A	1991	296
1992	4,507	N/A	1,098	N/A	3,409	N/A	1992	117
1993	8,700	N/A	2,756	N/A	5,944	N/A	1993	382
1994	5,285	6,469	885	1,175	4,400	5,294	1994	379
1995	8,856	6,324	1,239	1,275	7,617	5,049	1995	259
1996	4,984	4,008	1,340	1,114	3,644	2,894	1996	384
1997	11,516	5,337	2,449	1,146	9,067	4,191	1997	842
1998	7,323	4,945	910	982	6,413	3,963	1998	513

-continued-

Table 1.–Page 2 of 2.

	Combined Subdistricts 5 & 6		Subdistrict 5 (Shaktoolik)		Subdistrict 6 (Unalakleet)		Unalakleet River Sport Fish Harvest	
Year	Commercial [a]	Subsistence [b]	Commercial [a]	Subsistence [b]	Commercial [a]	Subsistence [b]	Year	Harvest [c]
1999	2,508	3,509	581	818	1,927	2,691	1999	415
2000	742	2,869	160	440	582	2,429	2000	345
2001	206	3,746	90	936	116	2,810	2001	250
2002	5	3,597	1	1,230	4	2,367	2002	544
2003	12	3,466	2	881	10	2,585	2003	97
2004	0	3,589	0	786	0	2,803	2004	354
2005	151	N/A	50	N/A	101	N/A	2005	N/A
Historical Average (all years)	4,655	1,782	1,039	398	3,616	1,612		333
Most Recent 5-Year Avg. (2001–2005)	75	3,343[d]	29	854[d]	46	2,489[d]		318[d]

N/A=Information not available.

[a] From Kohler et al. (2005) and Wes Jones, Commercial Fisheries Biologist, ADF&G, Nome; personal communication.

[b] Subsistence harvest data are incomplete prior to 1979. Subsistence surveys not conducted in all communities between 1986 and 1993. Data from Kohler et al. (2005) and Wes Jones, Commercial Fisheries Biologist, ADF&G, Nome; personal communication.

[c] From DeCicco (2004) and Fred DeCicco, Sport Fish Biologist, ADF&G, Fairbanks; personal communication.

[d] 2005 data not yet available, most recent 5-year average is 2000–2004.

invited to attend and participate in an advisory capacity. Invited advisors included one or more representatives from Bering Sea Fishermen's Association, Tanana Chiefs Conference, Kuskokwim Native Association, Association of Village Council Presidents, Kawerak, Inc., U.S. Fish and Wildlife Service (field offices, refuges, and Office of Subsistence Management), and U.S. National Park Service. Finally, this report was reviewed by the escapement goal team and escapement goal recommendations included in this report were supported by the team.

DATA REVIEW

NORTH RIVER COUNTING TOWER

A counting tower on the North River was operational from 1972–1974 (Regnart and Trasky 1973; Cunningham 1974, 1975), 1984–1986 (Lean 1987), and 1996–2005 (Kohler and Knuepher 2002; Kohler et al. 2005; Table 2). From 1972 through 1986 the tower was located near the North River Bridge (Lean 1987; Figure 3). Operation of the counting tower was discontinued after 1974 because of small chum salmon runs and a lack of market for those fish (Lean 1985b). In response to increased Chinook and chum salmon runs and renewed market interest, the operation of the counting tower resumed in 1984 (Lean 1985b). However, the project again ceased operation after 1986 due to lack of funding. Operation of the counting tower resumed again in 1996 at its present site downstream from the North River Bridge (Figure 3). In all years, Chinook salmon counts past the tower have ranged from 196 to 2,844 fish, averaging 1,510 fish. The most recent 5-year (2001–2005) average is 1,287 fish. Daily expanded counts for all years can be found in Appendix A.

Table 2.–North River counting tower historical dates of operation and Chinook salmon escapement count and expanded count.

Year	Operating Period	North River Tower Chinook Salmon Count	Estimated Unalakleet River Drainage Chinook Salmon Escp.[a]
1972	July 7-July 28 [b]	561	1,453
1973	June 29-July 23	298	772
1974	June 25-July 17	196	508
1984	June 25-July 28	2,844	7,368
1985	June 27-Aug 31	1,426	3,694
1986	June 25-July 18	1,613	4,179
1996	June 16-July 25	1,197	3,101
1997	June 16-Aug 21	4,185	10,842
1998	June 15-Aug 12	2,100	5,440
1999	June 30-Aug 31 [b]	2,648	6,860
2000	June 17-Aug 12	1,046	2,710
2001	July 05-Sept 15 [b]	1,791	4,640
2002	June-19-Aug 30	1,505	3,899
2003	June 15-Sept 13	1,452	3,762
2004	June 15-Sept 14	1,125	2,915
2005	June 17-Sept 5	1,015	2,630

[a] Drainage wide escapement estimate calculated by expanding tower count by 0.386, the average proportion of Chinook salmon migrating into the North River, 1997 and 1998 (Wuttig, 1999).

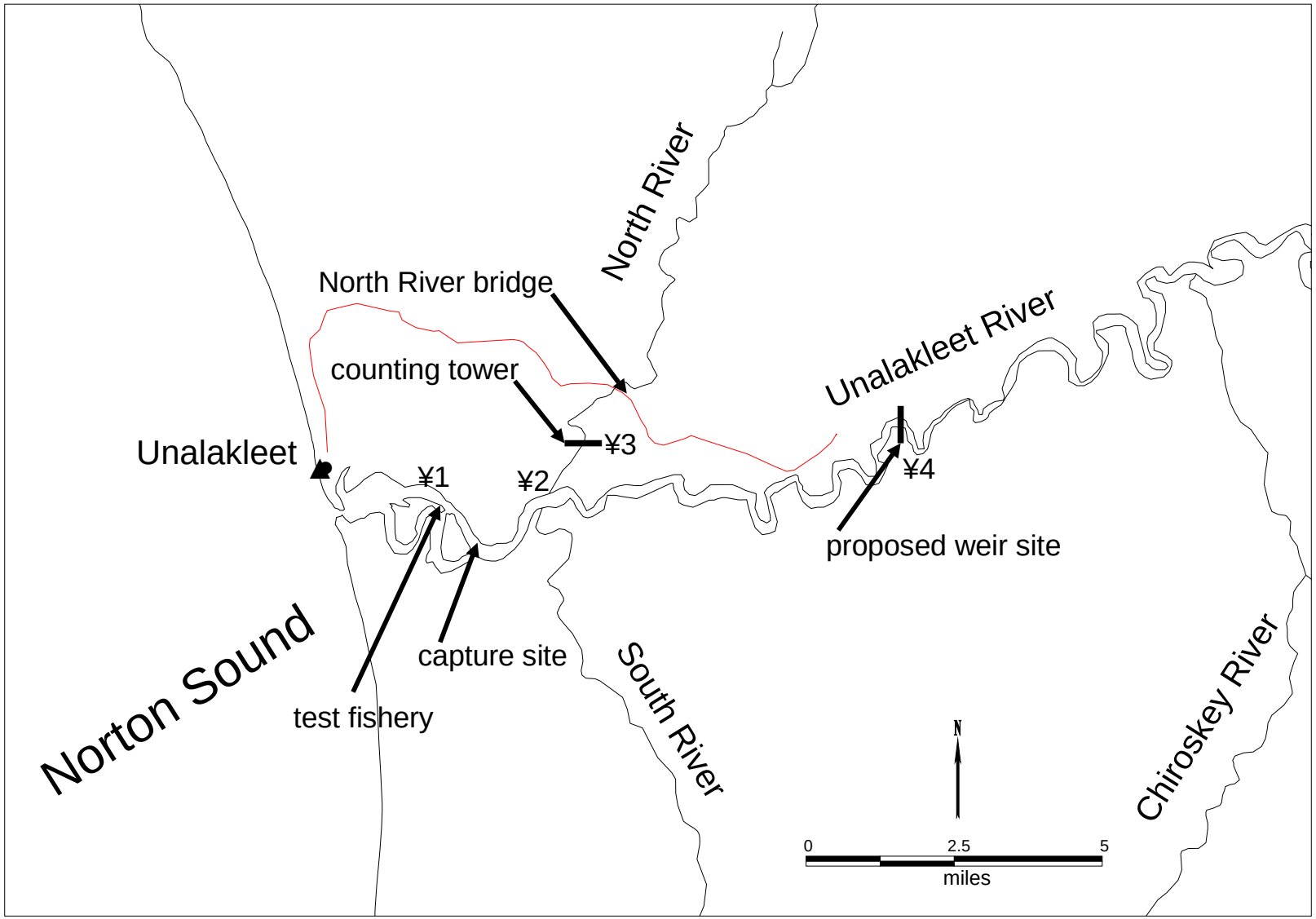
[b] Incomplete counts as a result of late start (1972, 1999, 2001) or early completion of the project (1973, 1974, 1986, 1996).

Escapement counts from 1972, 1999, and 2001 are incomplete because of late starting dates, and counts from 1973, 1974, 1984, 1986, and 1996 are incomplete because of early stop dates (Table 2). The portions of the escapement prior to project start date for 1999 and 2001 were estimated by expanding the counted escapement by the average cumulative proportion of passage (calculated from years 1996–1998, 2000, 2002–2005) of the day prior to start up (June 29, 1999; July 4, 2001). This resulted in 13% (1999) and 34% (2001) of the escapement being estimated.

AERIAL SURVEYS

Aerial surveys are rated in two categories by the observer conducting the survey: the overall rating of the survey that takes into account variables affecting the ability to observe fish (i.e., sun glare, wind, cloud cover), and a spawning stage rating that assesses the timing of the survey. Ratings for the overall quality of a survey are good (1), fair (2), and poor (3), and spawning state ratings are before peak (1); at peak (2), and after peak (3). Only surveys with an overall rating of fair or good (1 or 2), and surveys flown during peak spawning periods (or, if spawning stage was not rated, survey was flown between July 8 and July 29) were considered acceptable for run size assessment and escapement goal analysis.

The first Chinook salmon aerial survey of the Unalakleet River was flown in 1958, the first survey of the Old Woman River was in 1962 (Table 3). Since then, a total of 29 surveys have been flown for the Unalakleet River and 18 for the Old Woman River. A total of 18 combined Unalakleet River and Old Woman River surveys have been flown. Of those, only 8 were rated as acceptable. Aerial surveys of the North River for Chinook salmon were first flown in 1962. Since then, a total of 34 surveys have been flown, and of those, 20 were rated as acceptable (Table 4).



Note: ¥ 1 = Lower site SRS; ¥ 2 = North and Unalakleet rivers confluence SRS; ¥ 3 = North River counting tower SRS; ¥ 4 = proposed weir site SRS.

Figure 3.–Lower Unalakleet River drainage showing locations of the test fishery, North River counting tower, proposed weir site, North River bridge, and stationary receiver sites (SRS).

Table 3.–Aerial survey counts for Chinook salmon including overall and spawning stage ratings for Unalakleet and Old Woman rivers, separately and combined, 1958–2005.

	Unalakleet River Aerial Survey				Old Woman River Aerial Survey				Unalakleet and
Year	Count	Date Flown	Rating [a]	Stage [b]	Count	Date Flown	Rating [a]	Stage [b]	Old Woman Combined
1958	0	7/05	NR						
1959	100	8/04	NR	NR					
1960									
1961	1,329	7/15	1	NR					
1962	689	7/18	2	NR	169	7/18	1	NR	858
1963									
1964	9	7/11	1	NR					
1965									
1966	102	7/20	2	NR	81	7/20	1	3	183
1967									
1968									
1969									
1970									
1971									
1972	50	8/06	3	2					
1973	945	7/27	3						
1974									
1975	133	7/20	2	NR					
1976	297	7/16	2	NR					
1977	1,477	7/29							
1978	823	7/21	1	2	78	7/10	1	1	901
1979	54	7/20	3	1					
1980	29	7/18	2	1	25	7/18	1	1	54
1981	3	6/24	2	1	26	7/10	1	1	29
1982									
1983									
1984									
1985	400	7/18	3	2	202	7/22	1	2	602
1986	373	7/28	2	2					
1987	344	7/27	1	2	132	7/27	1	3	476
1988	923	7/19	1	2	311	7/19	1	3	1,234
1989									
1990	464	7/24	2	2	211	7/24	2	2	675
1991	1,253	7/25	1	2	403	7/25	1	2	1,656
1992									
1993	253	7/23	1	2	407	7/23	1	2	660
1994									
1995	532	7/25	1	2	424	7/25	1	2	956

-continued-

Table 3.–Page 2 of 2.

	Unalakleet River Aerial Survey				Old Woman River Aerial Survey				Unalakleet and Old Woman
Year	Count	Date Flown	Old Woman Rating [a]	Stage [b]	Count	Date Flown	Rating [a]	Stage [b]	Combined
1996					55	7/10	1	1	55
1997	991	7/29	2	2	246	7/29	2	2	1,237
1998	739	7/20	1	2	312	7/20	1	2	1,051
1999									
2000									
2001									
2002	28	7/11	2	2	33	7/11	2	2	61
2003	168	7/12	1	1					
2004	309	7/13	1	2	89	7/13	1	2	398
2005	306	7/23	3	2	204	7/23	2	2	510

Note: Highlighted numbers represent acceptable data = surveys where survey rating was either 1 (good) or 2 (fair), and spawning stage was rated as 2 (at peak), or if spawning stage is not rated (NR), the survey was flown between 7/8 and 7/29. In years where no data is entered, surveys were not flown or recorded.

[a] Survey Rating: good (1); fair (2) or poor (3).

[b] Spawning stage: before peak (1), at peak (2), or after peak (3).

Table 4.–North River aerial survey counts for Chinook salmon, including overall and spawning stage ratings, 1958–2005.

	North River Aerial Survey				
Year	Aerial Survey Count	Aerial Count Above Tower	Date Survey Flown	Survey Rating [a]	Spawning Stage [b]
1958					
1959					
1960					
1961					
1962	162		7/18	1	NR
1963	287		7/20	2	NR
1964	23		7/13	1	NR
1965					
1966	153		7/20	1	1
1967					
1968					
1969					
1970	1		7/17	2	NR
1971	256		8/10	2	2
1972					
1973	267	[c]	UNKNOWN	1	2
1974					
1975	60		7/20	1	2
1976	66		7/26	3	NR
1977	1,275		7/29	NR	1
1978	321		7/10	1	1
1979	735		7/20	1	1
1980	61		7/18	1	1
1981	68		8/08	1	1
1982	8		8/10	2	3
1983	347		7/08	2	1
1984	51	[c]	7/03	1	1
1985	873	703	7/22	2	1
1986					
1987	445		7/28	1	2
1988	202		7/18	1	NR
1989					
1990	255		7/24	2	2
1991	661		7/25	1	2
1992	329		7/23	2	2
1993	900		7/23	1	2
1994					
1995	622		7/25	1	2
1996	106	104	7/10	1	1
1997	1,605	1,600	7/29	2	2
1998	591	591	7/20	1	2

-continued-

Table 4.–Page 2 of 2.

	North River Aerial Survey				
Year	Aerial Survey Count	Aerial Count Above Tower	Date Survey Flown	Survey Rating [a]	Spawning Stage [b]
1999	18	18	7/23	1	3
2000					NR
2001	367	366	7/31	1	2
2002	122	121	7/11	2	2
2003	131	128	7/12	1	1
2004	189	189	7/13	1	2
2005	156	156	7/23	2	2

Note: Highlighted numbers represent acceptable data = surveys where survey rating was either good (1) or fair (2), and spawning stage was rated as at peak (2), or, if spawning stage is not rated (NR), the survey was flown between 7/8 and 7/29. In years where no data is entered, surveys were not flown or recorded.

[a] Survey Rating: 1, good; 2, fair; 3, poor.

[b] Spawning stage: 1, before peak; 2, at peak, 3, after peak.

[c] Above tower counts not conducted.

AGE AND SEX COMPOSITION

Chinook salmon commercially harvested in Subdistrict 6 have been sampled for age and sex determination in all years since 1981, except 1999 and 2002–2004 (Table 5). Commercial fishermen in Subdistrict 6 primarily use 20.3 cm (8 in) stretched mesh gear to harvest Chinook salmon, although smaller 14.9 cm (5 7/8 in) gear is also used (Wes Jones, Commercial Fisheries Biologist, ADF&G, Nome; personal communication). Chinook salmon captured in the test fishery have been sampled for age and sex determination in all years since 1980, except 1981, 1983, 1988, and 1999 (Table 6). The test fishery uses 14.9 cm (5 7/8 in) stretched mesh gear to capture fish (Kohler 2002). In addition, age and sex data were collected from various radiotelemetry studies conducted on the Unalakleet River in 1997 and 1998 (Wuttig 1999), and 2005 (Jeff Estensen, Commercial Fisheries Biologist, ADF&G, Nome; unpublished data[2]).

RUN RECONSTRUCTION

Run reconstructions, or brood tables (escapement and subsequent return of adults by age class), were developed using available escapement, harvest, and age composition information. Total drainage escapements were estimated by expanding escapement counts from the counting tower by the average proportion of the total escapement counted by the North River tower in 1997 and 1998 (0.386) as determined from radiotelemetry studies (Wuttig 1998, 1999). Because tower count estimates were discontinuous between 1972 and 1996, only escapement and harvest estimates from 1996–2005 were used to construct brood tables. A total of 4 brood tables were constructed, each using a different combination of age composition estimates and assumption of stock-specific harvest in the marine fisheries. Tables 7 and 9 were constructed by applying age composition estimates from Subdistrict 6 commercial harvest samples to the entire return. In years when fish were not sampled (1999, 2002–2004), the average age class composition for years when fish were sampled was used.

[2] Alaska Department of Fish and Game, Unalakleet chum radiotelemetry project; information supplied by project leader Jeff Estensen.

Table 5.–Age and sex composition of Chinook salmon sampled from the Subdistrict 6 commercial fishery, 1981–2005.

Year	Dates	Sample No.	Males (%)	Females (%)	Age Class (%)										
					1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3	2.4	2.5
1981	6/4-9/12	58	78	22	2	24	33	33	2	0		2	3	0	0
1982	6/27	2	50	50	0	50	0	50	0	0		0	0	0	0
1983	5/31-8/26	37	76	24	0	35	22	32	3	0		8	0	0	0
1984	6/26-7/20	446	49	51	<1	6	31	56	3	0	<1	0	<1	1	0
1985	6/28-7/6	442	51	49	0	1	8	69	21	1	0	0	0	0	0
1986	6/24-7/1	468	50	50	0	2	19	50	29	0	0	0	<1	<1	0
1987	6/26-7/28	161	43	57	0	4	12	71	13	0	0	0	0	0	0
1988	6/21-7/27	298	54	46	0	8	30	57	5	0	0	0	0	0	0
1989	6/19-6/24	138	58	42	0	13	38	45	4	0	0	0	0	0	0
1990	6/15-6/19	140	56	44	0	9	29	58	1	0	0	1	2	0	0
1991	6/18-6/25	160	53	47	0	27	34	37	1	0	0	0	0	<1	<1
1992	7/7-7/15	28	50	50	0	46	32	18	0	0	0	0	0	4	0
1993	6/15-6/22	139	60	40	0	27	27	41	3	0	0	0	1	1	0
1994	6/21-7/1	240	50	50	0	1	61	36	<1	0	0	0	<1	0	0
1995	6/13-6/30	230	52	48	1	14	13	70	1	0	1	0	0	0	0
1996	6/15-6/21	127	61	39	3	3	46	41	6	0	0	0	<1	<1	0
1997	6/17-6/24	149	53	47	0	31	14	54	<1	0	0	0	0	<1	0
1998	6/19-6/26	136	62	38	0	0	27	51	7	0	0	0	7	7	0
2000	6/23-6/27	100	66	34	0	0	48	39	6	0	0	0	1	5	1
2001	7/6-7/10	57	47	53	0	32	4	58	5	0	0	0	1	0	0
2005	6/28-6/29	43	unknown	unknown		0	9	14	60	0	0	0	0	12	5	0

Note: Data not available in 1999 and 2002–2004.

Tables 8 and 10 were constructed using a combination of age class information from the inriver test fishery and the Subdistrict 6 commercial harvest. In these tables, age class compositions from the commercial harvests were used to apportion the commercial and subsistence harvests, while the age class compositions from the inriver test fishery were used to apportion escapement and sport fish harvest. For both cases, in years when fish were not sampled (commercial harvest; 1999, 2002–2004, inriver test fishery; 1981, 1983, 1988, 1999), the average age class composition for the years when fish were sampled were used. A salmon-tagging study conducted in Norton Sound during 1978 and 1979 (Gaudet and Schaefer 1982) revealed that Chinook salmon originating in the Unalakleet River drainage are harvested in other districts. Also, it is widely believed that Yukon River and Shaktoolik River Chinook salmon are harvested in the Subdistrict 6 commercial and marine-water subsistence fisheries. Results from the study could not determine what percentages of the commercial and subsistence harvests were mixed stocks. Managers, however, assume that 25% of the Subdistrict 6 Chinook salmon commercial and marine-water subsistence harvests are comprised of stocks not indigenous to the Unalakleet River drainage. To examine the sensitivity of this assumption, Tables 7 and 8 were constructed assuming that 100% of Chinook salmon harvested in the Subdistrict 6 commercial and marine-water subsistence fisheries originated in the Unalakleet River drainage, and Tables 9 and 10 were constructed assuming that 75% of Chinook salmon harvested in the commercial and marine-water subsistence fisheries originated in the Unalakleet River.

Due to the limited length of the data set, only 4 years (1996–1999) of paired spawner and return estimates are available (the return from the 1999 escapement is lacking returns of age-7 fish which typically represent a small fraction of annual returns). The four return-per-spawner estimates in all four scenarios examined were below or only slightly above replacement (Tables 7–10). The source of the age class composition (commercial harvest; Tables 7 and 9; combination of commercial harvest and test fishery; Tables 8 and 10) accounted for the largest differences of recruit-per-spawner ratios between constructed brood tables. For the 1996 and 1999 brood years, recruit-per-spawner ratios were higher in brood tables constructed using age class data from the commercial harvest only. In contrast, in 1997 and 1998, recruit-per-spawner ratios were greater in tables constructed using combined age class data. The observed disparity between tables and years could be the result of a potential size (hence age) bias of the gear used to capture the fish for age and sex sampling, or because of large differences in average annual sample size between commercially and test fish age and sex information (171 and 55, respectively).

PAIRED ESCAPEMENT DATA ANALYSIS

Correlation between Old Woman/Unalakleet rivers aerial survey counts and escapement at the North River counting tower was tested using the correlation coefficient (r) for the variables y=tower counts and x=aerial survey counts (Figure 4a and b). The purpose of this analysis was to evaluate whether the North River escapement estimates provide a reasonable index of total drainage escapement, and to investigate potential methods for deriving total drainage escapements for years when the counting tower was not operational to aid in run reconstruction (described below). One analysis used all aerial surveys conducted from 1996–2005 (n=5; Table 3) and corresponding year tower counts (Table 2), and the other used only acceptable aerial survey counts (n=4) and corresponding year tower counts.

Correlation between tower counts and aerial survey counts were weak in both cases (all surveys r=0.62; acceptable surveys only, r=0.64; Figure 4a and b). Because of this and the small number of paired observations, this relationship was not used to supplement the run reconstructions developed below.

EXPLOITATION RATES

Exploitation rates were estimated using one of two assumptions: 1) that all Chinook salmon commercially and subsistence harvested in Subdistrict 6 originated in the Unalakleet River drainage (Table 11a), and 2) that 75% of the commercial and subsistence harvests originated in the Unalakleet River drainage (Table 11b). For assumption 1, total exploitation (1996 through 2004) ranged from 41% to 69%, averaging 54%. For assumption 2 (1996–2004) total exploitation ranged from 35% to 63%, averaging 46%. In both cases, the subsistence fishery has been the largest exploiter of Unalakleet River Chinook salmon since 2001, averaging 40% using assumption 1 and 33% using assumption 2.

Table 6.–Age and sex composition of Chinook salmon sampled from (a) Unalakleet inriver test fishery, 1980–2005, and (b) telemetry projects conducted in the Unalakleet River drainage.

a. Unalakleet inriver test fishery, 1980–2005.

Year [a]	Dates	Sample No.	Males (%)	Females (%)	Age Class (%)								
					1.1	1.2	1.3	2.2	1.4	1.5	1.6	2.3	2.4
1980	06/19-07/01	137	55	45	0	7	29	0	55	9	0	0	0
1982	05/22-06/23	5	40	60	0	0	0	0	0	100	0	0	0
1984	06/24-07/26	111	59	41	0	4	54	0	38	<1	0	1	3
1985	07/02-07/17	16	38	62	0	16	25	0	49	10	0	0	0
1986	06/19-07/14	47	49	51	0	2	38	0	32	28	0	0	0
1987	06/20-07/17	36	58	42	0	17	22	0	58	3	0	0	0
1989	06/20-08/01	14	93	7	0	36	57	0	7	0	0	0	0
1990	06/15-08/27	40	58	42	0	28	40	0	17	5	0	5	5
1991	06/10-08/30	32	28	72	0	47	19	0	25	6	0	3	0
1992	06/27-08/31	24	58	42	0	71	21	0	8	0	0	0	0
1993	06/08-07/13	83	69	31	0	53	27	0	20	0	0	0	0
1994	06/16-07/13	32	47	53	0	6	72	0	19	3	0	0	0
1995	06/05-07/11	75	71	29	0	44	13	0	41	2	0	0	0
1996	06/06-07/06	117	40	60	<1	9	79	0	12	<1	0	0	0
1997	06/12-07/18	111	49	51	0	35	12	0	52	1	0	0	0
1998	06/10-07/27	72	33	67	0	0	22	0	70	8	0	0	0
2000	06/13-07/14	44	61	39	0	5	48	0	34	7	0	4	2
2001	06/16-07/17	63	63	37	0	36	10	0	54	0	0	0	0
2002	06/03-07/13	41	93	7	0	19	68	0	7	3	0	0	3
2003	06/02-07/28	23	74	26	0	4	74	0	9	0	0	9	4
2004	06/09-09/09	23	61	39	0	9	35	13	26	0	0	4	13
2005	06/21-07/09	68	unknown	unknown	0	75	9	1	12	0	0	3	0

b. Telemetry projects conducted in the Unalakleet River drainage.

Year	Sample No.	Males (%)	Females (%)	Age Class (%)										
				1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3	2.4	2.5
1997 [b]	329	86	14	0	59	8	31	1	0	0	1	<1	<1	0
1998 [c]	164	52	48	0	3	60	27	1	0	0	0	3	6	0
2005 [d]	26	19	81	8	69	4	11	4	0	0	4	0	0	0

[a] Data not available in 1981, 1983, 1988, 1999.

[b] Wuttig 1998.

[c] Wuttig 1999.

[d] Alaska Department of Fish and Game, Unalakleet chum radiotelemetry project; information supplied by project leader Jeff Estensen.

Table 7.–Brood table constructed using age compositions determined from Subdistrict 6 commercial harvests, assuming 100% of the total Subdistrict 6 commercial and subsistence Chinook salmon harvests are indigenous to the Unalakleet River drainage.

Run Component	Return Year									
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Commercial harvest	3,644	9,067	6,413	1,927	582	116	4	10	0	101
Subsistence harvest	2,894	4,191	3,963	2,961	2,429	2,810	2,367	2,585	2,803	2,599 [a]
Sport harvest	384	842	513	415	345	250	544	97	354	318 [b]
Escapement	3,101	10,842	5,440	6,860	2,710	4,640	3,899	3,762	2,915	2,630
Total run	10,023	24,942	16,329	12,163	6,066	7,816	6,814	6,454	6,072	5,648 [c]

		Return by Age					Total	Brood	Return/
Brood Year	Escapement	3	4	5	6	7	Return	Return	Spawner
1989						458	10,023	458	
1990					3,099	249	24,942	3,348	
1991				5,761	13,235	1,929	16,329	20,925	
1992			510	3,258	10,289	1,038	12,163	15,095	
1993		196	8,199	4,111	4,760	606	6,066	17,873	
1994		0	0	3,841	2,365	146	7,816	6,353	
1995		0	2,499	2,942	4,367	435	6,814	10,243	
1996	3,101	24	153	606	1,494	339	6,454	2,616	0.84
1997	10,842	0	2,697	3,642	1,989	624	6,072	8,952	0.83
1998	5,440	0	1,231	3,535	2,379	135	5,648	7,280	1.34
1999	6,860	12	577	2,303	2,386			5,279	0.77
2000	2,710	13	751	614				1,378	
2001	4,640	14	2,277					2,291	
2002	3,899	236						236	
2003	3,762								
2004	2,915								
2005	2,630								

Note: Salmon ages are combined freshwater and saltwater ages.

[a] Number estimated from most recent (2000–2004) 5-year subsistence average.

[b] Number estimated from most recent (2000–2004) 5-year sport harvest.

[c] Calculated using estimated subsistence and sport harvests.

[d] Incomplete returns from brood year escapements.

Table 8.–Brood table constructed using age composition from the Subdistrict 6 commercial fishery and the Unalakleet inriver test fishery, assuming 100% of the total Subdistrict 6 commercial and subsistence Chinook salmon harvests are indigenous to the Unalakleet River drainage.

Run	Return Year									
Component	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Commercial harvest	3,644	9,067	6,413	1,927	582	116	4	10	0	101
Subsistence harvest	2,894	4,191	3,963	2,961	2,429	2,810	2,367	2,585	2,803	2,599 [a]
Sport harvest	384	842	513	415	345	250	544	97	354	318 [a]
Escapement	3,101	10,842	5,440	6,860	2,710	4,640	3,899	3,762	2,915	2,630
Total run	10,023	24,942	16,329	12,163	6,066	7,816	6,814	6,454	6,072	5,648 [c]

		Return by Age					Total	Brood	Return/
Brood Year	**Escapement**	**3**	**4**	**5**	**6**	**7**	**Return**	**Return**	**Spawner**
1989						702	10,023	702	
1990					4,109	249	24,942	4,359	
1991				4,611	13,469	2,286	16,329	20,365	
1992			301	3,492	9,634	864	12,163	14,291	
1993		301	7,732	4,409	6,069	667	6,066	19,178	
1994		0	0	3,187	2,426	391	7,816	6,004	
1995		0	1,983	2,972	4,611	484	6,814	10,050	
1996	3,101	61	0	313	3,400	458	6,454	4,232	1.36
1997	10,842	0	2,501	1,785	3,220	431	6,072	7,938	0.73
1998	5,440	0	1,111	1,691	3,030	282	5,648	6,114	1.12
1999	6,860	34	1,052	1,591	4,066			6,743	0.98
2000	2,710	32	990	791				1,813	
2001	4,640	30	508					539	
2002	3,899	0						0	
2003	3,762								
2004	2,915								
2005	2,630								

Note: Age class information from the commercial harvests was used to apportion the commercial and subsistence harvests; age class information from the test fishery was used to apportion the escapement and sport fish harvest. Salmon ages are combined freshwater and saltwater ages.

[a] Number estimated from most recent (2000–2004) 5-year subsistence average.

[b] Number estimated from most recent (2000–2004) 5-year sport harvest.

[c] Calculated using estimated subsistence and sport harvests.

[d] Incomplete returns from brood year escapements.

Table 9.–Brood table constructed using age compositions determined from Subdistrict 6 commercial harvests, assuming 75% of the total Subdistrict 6 commercial and subsistence Chinook salmon harvests are indigenous to the Unalakleet River drainage.

Run	Return Year									
Component	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Commercial harvest	2,733	6,800	4,810	1,445	436	87	3	7	0	75
Subsistence harvest	2,170	3,143	2,972	2,018	1,822	2,107	1,775	1,939	2,102	1,949[a]
Sport harvest	384	842	513	415	345	250	544	97	354	318[b]
Escapement	3,101	10,842	5,440	6,860	2,710	4,640	3,899	3,762	2,915	2,630
Total run	8,388	21,627	13,735	10,738	5,313	7,084	6,221	5,805	5,371	4,972[c]

		Return by Age					Total	Brood	Return/
Brood Year	**Escapement**	**3**	**4**	**5**	**6**	**7**	**Return**	**Return**	**Spawner**
1989						587	8,388	587	
1990					3,439	216	21,627	3,655	
1991				3,858	11,679	1,923	13,736	17,460	
1992			252	3,028	8,104	762	10,738	12,146	
1993		252	6,704	3,709	5,358	584	5,313	16,607	
1994		0	0	2,813	2,125	354	7,083	5,293	
1995		0	1,750	2,603	4,179	442	6,221	8,975	
1996	3,101	54	0	283	3,104	412	5,805	3,853	1.24
1997	10,842	0	2,267	1,630	2,897	381	5,371	7,175	0.66
1998	5,440	0	1,014	1,521	2,680	249	4,972	5,463	1.00
1999	6,860	31	946	1,407	3,580			5,964	0.87
2000	2,710	29	875	696				1,600	
2001	4,640	269	447					716	
2002	3,899	0						0	
2003	3,762								
2004	2,915								
2005	2,630								

Note: Salmon ages are combined freshwater and saltwater ages.

[a] Number estimated from most recent (2000–2004) 5-year subsistence average.

[b] Number estimated from most recent (2000–2004) 5-year sport harvest.

[c] Calculated using estimated subsistence and sport harvests.

[d] Incomplete returns from brood year escapements.

Table 10.–Brood table constructed using age compositions determined from the Subdistrict 6 commercial fishery and Unalakleet inriver test fishery, assuming 75% of the total Subdistrict 6 commercial and subsistence Chinook salmon harvests are indigenous to the Unalakleet river drainage.

Run	Return Year									
Component	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Commercial harvest	2,733	6,800	4,810	1,445	436	87	3	7	0	75
Subsistence harvest	2,170	3,143	2,972	2,018	1,822	2,107	1,775	1,939	2,102	1,949[a]
Sport harvest	384	842	513	415	345	250	544	97	354	318[b]
Escapement	3,101	10,842	5,440	6,860	2,710	4,640	3,899	3,762	2,915	2,630
Total run	8,388	21,627	13,735	10,738	5,313	7,084	6,221	5,805	5,371	4,972[c]

		Return by Age					Brood	Return/
Brood Year	**Escapement**	**3**	**4**	**5**	**6**	**7**	**Return**	**Spawner**
1989						343	343	
1990					2,428	216	2,645	
1991				5,009	11,445	1,566	18,019	
1992			461	2,794	8,759	937	12,951	
1993		147	7,172	3,411	4,049	523	15,302	
1994		0	0	3,468	2,064	110	5,642	
1995		0	2,267	2,573	3,935	393	9,167	
1996	3,101	17	153	577	1,198	293	2,238	0.72
1997	10,842	0	2,462	3,487	1,666	574	8,189	0.76
1998	5,440	0	1,134	3,365	2,029	101	6,630	1.22
1999	6,860	9	472	2,120	1,899		4,499	0.66
2000	2,710	10	637	519			1,166	
2001	4,640	11	2,216				2,226	
2002	3,899	236					236	
2003	3,762							
2004	2,915							
2005	2,630							

Note: Age class information from the commercial harvests was used to apportion the commercial and subsistence harvests**;** age class information from the test fishery was used to apportion the escapement and sport fish harvest**.** Salmon ages are combined freshwater and saltwater ages.

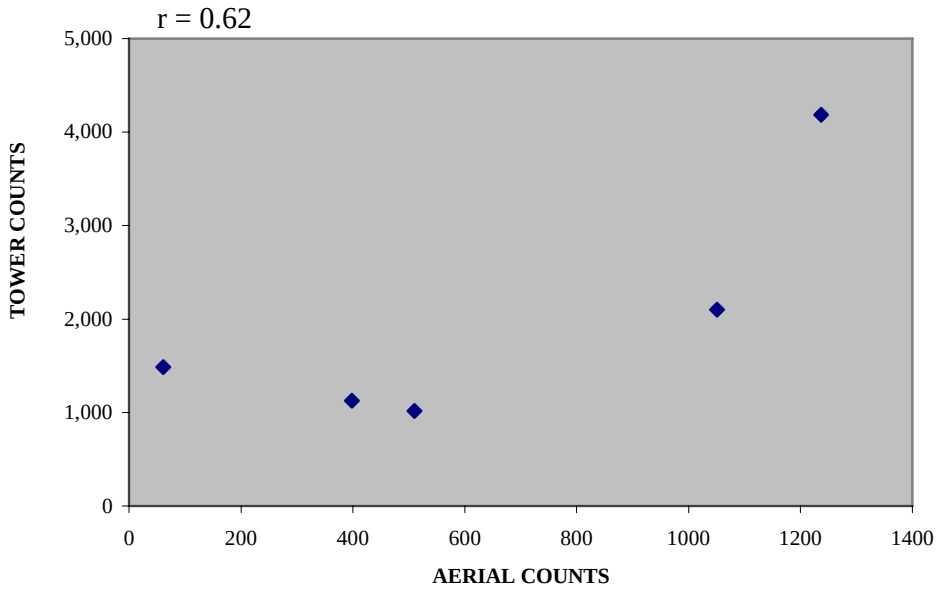
[a] Number estimated from most recent (2000–2004) 5-year subsistence average.

[b] Number estimated from most recent (2000–2004) 5-year sport harvest.

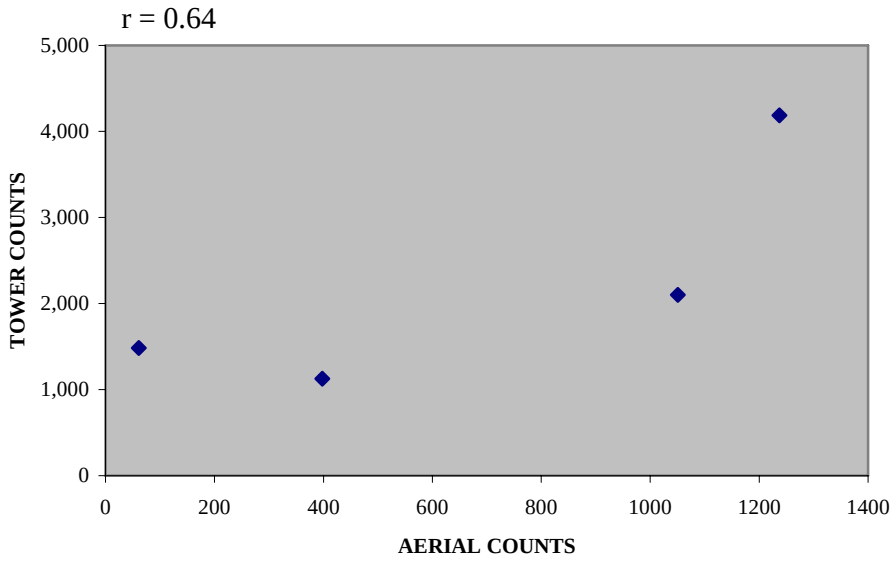
[c] Calculated using estimated subsistence and sport harvests.

[d] Incomplete returns from brood year escapements.

a. All Old Woman/Unalakleet River aerial surveys between 1996–2005 versus corresponding year escapement at the North River counting tower.



b. Acceptable aerial surveys only.



Note: Plots include the correlation coefficient (r) for each plot.

Figure 4.–Scatterplot of (a) all Old Woman/Unalakleet River aerial surveys between 1996–2005 versus corresponding year escapement at the North River counting tower, and (b) acceptable aerial surveys only.

Table 11.–Exploitation of Unalakleet River Chinook salmon (a) assuming 100% of fish harvested in the Subdistrict 6 commercial and subsistence fisheries are indigenous to the Unalakleet River drainage, and (b) only 75% of the combined harvest is indigenous.

a. Assuming 100% of fish harvested are indigenous.

Year	North River count	Estimated total Unk escapement[a]	Estimated total run (esc+harvest)	Proportion exploited commercial	Proportion exploited subsistence	Proportion exploited sport	Total exploitation (com+sub)	Total exploitation (com+sub+sp)
1996	1,197	3,101	10,023	0.364	0.289	0.038	0.652	0.691
1997	4,185	10,842	24,942	0.364	0.168	0.034	0.532	0.565
1998	2,100	5,440	16,329	0.393	0.243	0.031	0.635	0.667
1999	2,263	5,863	10,896	0.177	0.247	0.038	0.424	0.462
2000	1,046	2,710	6,066	0.096	0.400	0.057	0.496	0.553
2001	1,337	3,464	6,640	0.017	0.423	0.038	0.441	0.478
2002	1,505	3,899	6,814	0.001	0.347	0.080	0.348	0.428
2003	1,452	3,762	6,454	0.002	0.401	0.015	0.402	0.417
2004	1,125	2,915	6,072	0.000	0.462	0.058	0.462	0.520
2005	1,015	2,630	5,648[b]	0.018[b]	0.460[b]	0.056[b]	0.478[b]	0.534[b]
1996–2005 Average	1,723	4,462	10,410[c]	0.157[c]	0.325[c]	0.044[c]	0.482[c]	0.539[c]
2001–2005 Average	1,287	3,334	6,300[d]	0.023[d]	0.396[d]	0.051[d]	0.419[d]	0.470[d]

b. Assuming 75% of all fish harvested are indigenous.

Year	North River count	Estimated total Unk escapementa	Estimated total run (esc+harvest)	Proportion exploited commercial	Proportion exploited subsistence	Proportion exploited sport	Total exploitation (com+sub)	Total exploitation (com+sub+sp)
1996	1,197	3,101	8,388	0.326	0.259	0.046	0.585	0.630
1997	4,185	10,842	21,627	0.314	0.145	0.039	0.460	0.499
1998	2,100	5,440	13,735	0.350	0.216	0.037	0.567	0.604
1999	2,263	5,863	9,741	0.148	0.207	0.043	0.356	0.398
2000	1,046	2,710	5,313	0.082	0.343	0.065	0.425	0.490
2001	1,337	3,464	5,908	0.015	0.357	0.042	0.371	0.414
2002	1,505	3,899	6,221	0.000	0.285	0.087	0.286	0.373
2003	1,452	3,762	5,805	0.001	0.334	0.017	0.335	0.352
2004	1,125	2,915	5,371	0.000	0.391	0.066	0.391	0.457
2005	1,015	2,630	4,972	0.015[b]	0.392[b]	0.064[b]	0.407[b]	0.471[b]
1996–2005 Average	1,723	4,462	9077[c]	0.137[c]	0.276[c]	0.05[c]	0.414[c]	0.464[c]
2001–2005 Average	1,287	3,334	5,641[d]	0.020[d]	0.332[d]	0.057[d]	0.352[d]	0.408[d]

[a] Drainage-wide escapement estimate calculated by expanding tower count by 0.386, the average proportion of Chinook salmon migrating into the North River, 1997 and 1998 (Wuttig, 1999).

[b] Subsistence and sport fish harvests for 2005 were unavailable at the time of writing. As a result, the most recent 5-year averages (2000–2004) of the subsistence and sport harvests were used to estimate total run size and exploitation for 2005.

[c] Average 1996–2004.

[d] Average 2000–2004.

WATERSHED MODEL TO ESTIMATE OPTIMAL PRODUCTION

A watershed model utilizing power functions[3] that link watershed area (A) of the Unalakleet River drainage to carrying capacity (S_{EQ}) and optimal escapement (S_{MSY}) to numbers of stream-type Chinook salmon age 1.1 and older was used as a means of evaluating escapement goals. The power functions are:

$$\ln(S_{EQ}) = 0.693 \times \ln(A) + 3.894 \quad (1)$$

$$\ln(S_{MSY}) = 0.692 \times \ln(A) + 2.917 \quad (2)$$

The watershed area of the Unalakleet River drainage was determined to be 5,390 square kilometers. Watershed area was computed using GIS software (ESRI ArcMap 9.1 with the Spatial Analyst extension and ArcHydro toolset)[4]. Input data sources included: (1) Geographic coordinates of the river mouth; (2) National Elevation Dataset (http://ned.usgs.gov/); and, (3) National Hydrography Dataset (http://nhd.usgs.gov/index.html). Digitized USGS topo maps (1:63,360 and 1:250,000-scale) were used to plot points at river mouths, and for quality control of watershed boundaries. Applying this area calculation to the power functions above yields drainage-wide estimates of S_{MSY}=7,065 and S_{EQ}=18,929 Chinook salmon.

DISCUSSION AND RECOMMENDATIONS

The following section reviews the quality of the available data, identifies information gaps, and presents alternative methods and possible solutions to improve the accuracy and reliability of the data for the purpose of refining escapement goals.

ESCAPEMENT MONITORING

The North River counting tower generally provides reliable escapement counts for the North River, a tributary that supports a large proportion of the total drainage Chinook salmon escapement. Radiotelemetry methodologies estimated relatively consistent proportions of Unalakleet River Chinook salmon migrating up the North River: 37.2% in 1997 and 40.1% in 1998 (Wuttig 1998, 1999). This information suggests the North River escapement counts likely provide a good index of total drainage escapement and can be expanded to estimate total drainage escapement with reasonable accuracy. However, caution should be taken using an expansion factor based solely on 2 years of proportional data, because it is likely not sufficient to observe the full extent of annual variations in proportions over varying levels of total abundance.

Aerial surveys of the Unalakleet and Old Woman rivers are difficult to conduct because of frequent inclement weather conditions, lack of aircraft availability, poor water clarity (turbidity), masking by large pink salmon escapements, and variable channel morphometry. It is unlikely that the frequency or quality of aerial surveys can be improved. Also, correlation between aerial survey counts of the Unalakleet and Old Woman rivers combined and escapement at the North River counting tower is

[3] Estimated parameters for this model along with analysis of the efficacy of this model were taken from a working paper presented and accepted before the Pacific Stock Assessment and Research Committee of the Canadian Department of Fisheries and Oceans in 2005. This working paper is, by their request, uncitable at this time.

[4] Product names used in this report are included for scientific completeness but do not constitute a product endorsement.

weak, suggesting there may be more variability in the relationship between North River tower counts and total drainage escapement than was indicated from the radiotelemetry study.

HARVEST MONITORING

Total harvest from commercial, subsistence, and sport fisheries are estimated annually through fish tickets, household subsistence surveys, and a statewide sport fishing harvest survey, respectively, and are considered reasonably accurate. However, the biggest unknown relative to harvest assessment is quantifying the fraction of the marine harvest that is of Unalakleet River origin. This information is necessary for accurately determining total returns of Unalakleet River Chinook salmon. The run reconstructions presented in this report (Tables 7–10) assumed either 75% or 100% of the marine harvest in Subdistrict 6 were of Unalakleet River origin. However, it is unknown whether this range includes the true harvest of Unalakleet River fish or the extent to which the harvest rate may vary from year to year.

AGE AND SEX COMPOSITION

Accurate assessment of returns from a particular escapement requires that the age and sex composition of the harvest and the escapement be estimated. Current methods for assessing age and sex compositions include sampling the commercial fishery and the inriver return with the test net project. Both commercial and subsistence fishermen in Subdistrict 6 primarily use 20.3 cm (8 in) stretched mesh gillnets to harvest Chinook salmon, although smaller 14.9 cm (5 7/8 in) gear is occasionally used. Thus, samples from the commercial fishery have provided adequate estimates of age and sex compositions of the majority of the harvest. However, with the severe restrictions on the commercial fishery since 2000, age composition information has been obtained primarily from the inriver test fishery which uses a 14.9 cm (5 7/8 in) stretched mesh gillnet to capture fish. It is unlikely that either the commercial fishery or test fishery samples provide accurate composition estimates of the escapement. Given the gear used, the commercial fishery samples are likely biased for large, hence older, fish, while the test fishery likely selects for small, younger fish. In addition, annual sample sizes from the inriver test fishery are typically small (average=53) compared to average sample size from the commercial fishery (average=171). Although no composition sampling is conducted for the sport fishery, it represents a relatively small fraction of the total harvest (Tables 7–10).

RECOMMENDATIONS FOR IMPROVED DATA COLLECTION

Based on the review of existing information for Unalakleet River Chinook salmon, the following recommendations are made for improving the quality and quantity of data necessary for a rigorous evaluation of escapement goals in future years:

1. Continue operation of the North River counting tower, fishery harvest monitoring, and age, sex, and length (ASL) sampling of the commercial and test fisheries.
2. Develop a strategy to identify the origin of Chinook salmon stocks harvested in the Subdistrict 5 (Shaktoolik) and Subdistrict 6 (Unalakleet) commercial and marine subsistence harvests. Our recommendation is to develop a genetic stock identification (GSI) program which would begin with developing a baseline of unique genetic markers from the spawning stocks that are likely harvested in the Norton Sound marine fisheries (especially for Unalakleet, Shaktoolik, and Yukon River stocks), and then collecting samples from the mixed stock marine fisheries (primarily Subdistricts 5 and 6) to estimate stock composition of the harvest.

3. Develop a sampling strategy to collect accurate ASL information from both the escapement and the subsistence harvest.
4. Develop a strategy to improve the accuracy of subsistence harvest estimates of Unalakleet River Chinook salmon in both the inriver and marine fisheries.
5. Consider operation of a resistance board floating weir on the Unalakleet River. The long term operation of such a weir, along with the North River counting tower, would provide accurate estimates of total drainage escapement, and provide a platform for sampling the escapement for age and sex determination.
6. In the absence of a mainstem weir project, conduct additional radiotelemetry studies to estimate the proportional contribution of the North River escapement to the total drainage escapement.

ESCAPEMENT GOAL REVIEW AND RECOMMENDATIONS

In 2004, an SEG of 1,200–2,600 Chinook salmon was established for the North River (ADF&G 2004) based on observed tower count estimates through 2003 using the percentile algorithm of Bue and Hasbrouck (2001). In addition, there is a Chinook salmon aerial survey SEG of 550–1,100 for index sections of the upper Unalakleet and Old Woman rivers established in 2004 (ADF&G 2004), also developed using the percentile algorithm. Because of the importance of the fisheries on this stock, and the current classification as a stock of concern, a greater understanding of the productivity of this stock at differing levels of escapement is desired in order to refine escapement goals to ensure sustained yields. Toward this end, this report compiled available escapement and harvest data in an attempt to describe spawner-recruit relationships. However, there were a number of data issues that prevented accomplishing this. First, the length of the data set of escapement and subsequent return estimates was short. With the run reconstruction procedures used in this report, the three complete and one nearly complete, paired spawner and return estimates were too few to fit to a spawner-recruit model. Second, there is uncertainty in both the estimates of total drainage escapement and stock-specific harvest. Lastly, there is uncertainty regarding the estimates of age and sex composition of the escapement.

The paired spawner-return estimates that were calculated were of limited value for assessing escapement goals. Total escapements from these 4 years ranged from 3,101–10,842 (corresponds to North River escapements of 1,197–4,185) and return-per-spawner estimates were all either below or only slightly above replacement, and there were no apparent increasing or decreasing trends in returns as escapements increased. The return-per-spawner estimates were likely biased low. This is apparent from the disconnect arising from return-per-spawner estimates near or below one, along with average harvests of more than 2,000 fish from 1996–2005 (Table 1).

The watershed model indicated that a total drainage escapement of 7,065 Chinook salmon produces maximum sustained yield (S_{MSY}). Applying the average proportion of the total escapement enumerated by the North River counting tower (0.386 determined from the radiotelemetry studies) to this estimate yields a tower-count index of S_{MSY} of 2,727 Chinook salmon. During discussions at ADF&G escapement goal review meetings, there was reluctance to use the watershed model to establish escapement goals until the method has gone through peer review and been published, especially in the absence of other supporting information. In this case, the model suggests the current escapement goal (1,200–2,600) may be too low. However, of the 16 years of tower count estimates

that are available, only two have exceeded 2,727 (Table 2). Observed escapements along with the four relatively low estimates of return-per-spawner suggest the model may be overestimating S_{MSY}.

Estimated average total exploitation rates for 1996–2005 ranged from 46% to 52% depending on the assumption regarding stock-specific harvest in the marine fisheries (Table 11). Average estimates for recent years (2001–2005) were lower, ranging from 40%–46%. The lower exploitation rates are attributed to directed management actions restricting harvest in the commercial fishery as a result of the low returns in recent years. Given the relatively low estimates of return per spawner for 1996–1999, the harvest reductions are warranted.

During discussions of the escapement goal review committee, it was generally agreed that there should be an escapement goal for North River Chinook salmon based on estimates from the counting tower project. However, the utility of the SEG based on aerial survey counts in the upper Unalakleet and Old Woman rivers was questioned. There is evidence that supports the idea that escapement counts of Chinook salmon in the North River adequately reflect total drainage escapement. Estimates of proportional escapement and run timing from the radiotelemetry studies (Wuttig 1998, 1999) were relatively similar in both years of the study during which North River escapement ranged from 2,100–4,185 (Table 2). Other studies of relative contributions of Chinook salmon from significant tributary systems have shown that the relative escapement in such tributaries remain relatively static (e.g., ±5%) over time regardless of the magnitude of the total escapement; for example, in the Holitna River (Stroka and Reed 2005) and Stikine River (Der Hovanisian et al. 2005). However, there was poor correlation between North River tower estimates and aerial survey counts of the upper Unalakleet drainage. The poor correlation, although based on very limited paired observations, suggests that the proportional contribution of the North River escapement may be more variable than indicated from the radiotelemetry studies or that aerial survey counts are not a good indicator of run magnitude in this drainage. A serious drawback of an sustainable escapement goal (SEG), based on aerial survey counts, is that acceptable surveys are rarely completed.

Based on the review of existing data and the analyses conducted in this report, the following escapement goal recommendations are made:

1. Retain the existing SEG of 1,200–2,600 Chinook salmon estimated with expanded tower counts for the North River.
2. Retain the existing SEG of 550–1,100 Chinook salmon counted by aerial survey for the index sections in the upper Unalakleet and Old Woman rivers, but focus research in the upcoming 3–6 years on further evaluating whether the North River escapement estimate provides an adequate index of total drainage escapement and/or developing new methods of assessing escapement in the Unalakleet River upstream of the North River.
3. Continue updates and refinements of brood tables for the next review cycle (2010); however, efforts to conduct a spawner-recruit analysis are not warranted until at least the 2013 review cycle (when 10 paired spawner-recruit estimates are available).

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APPENDIX A

Appendix A1.–Daily expanded counts of Chinook salmon, North River counting tower, 1972–1974, 1984–1986, and 1996–2005.

	Year															
Date	**1972**	**1973**	**1974**	**1984**	**1985**	**1986**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
6/15									0					0	0	
6/16							8	2	0					2	0	
6/17							-2	3	2		0			0	0	0
6/18							-2	20	2		2			4	0	0
6/19							-4	0	3		0		8	4	0	0
6/20							0	0	4		12		6	12	4	0
6/21							-6	2	4		4		0	7	0	0
6/22							-3	4	7		4		4	6	0	2
6/23							0	14	22		8		14	14	4	-6
6/24							4	25	20		2		18	-2	2	4
6/25			0	0		0	-4	80	26		12		8	6	6	46
6/26			0	0		2	-3	101	26		2		16	0	40	4
6/27			1	0	0	2	-1	116	11		6		28	10	64	8
6/28			3	0	0	2	-1	326	5		-2		80	10	76	66
6/29		1	6	55	0	8	0	398	8		24		76	11	82	90
6/30		1	42	101	0	42	2	639	0	6	78		48	6	14	72
7/01		1	48	513	0	116	10	388	20	8	56		38	152	-6	24
7/02		6	53	642	0	158	8	170	12	3	50		66	81	30	22
7/03		10	88	745	0	198	38	255	5	2	70		184	76	4	30
7/04		16	125	984	0	326	101	213	13	0	40		40	8	30	118
7/05		19	151	1,038	1	338	161	213	13	0	24	10	86	12	10	8
7/06		2	173	1,207	35	438	110	181	12	0	40	65	34	14	96	82
7/07	11	22	184	1,274	34	609	112	70	88	2	82	99	4	18	86	40
7/08	15	26	191	1,341	34	731	78	84	56	6	52	106	34	58	20	18
7/09	30	33	191	1,367	34	827	46	20	71	30	228	100	52	78	32	21
7/10	50	43	192	1,418	34	953	56	34	80	35	28	24	66	42	31	38
7/11	126	71	192	1,648	32	1,167	30	21	259	52	8	42	118	60	154	52
7/12	172	82	192	1,957	33	1,230	55	37	242	48	8	60	38	34	58	8
7/13	194	83	193	2,126	39	1,294	76	44	50	24	16	97	76	100	60	12
7/14	245	87	196	2,242	71	1,364	58	48	72	56	0	72	10	56	78	46
7/15	309	94	196	2,358	126	1,446	78	76	60	36	45	36	42	34	42	52
7/16	376	97	196	2,481	213	1,518	28	106	92	54	23	131	66	0	10	35
7/17	406	119	196	2,602	260	1,557	26	140	114	123	23	92	36	54	7	8
7/18	458	150		2,674	314	1,613	18	49	56	85	23	92	38	96	8	12
7/19	466	150		2,706	366		36	60	39	60	23	92	36	78	16	2
7/20	475	216		2,784	563		40	59	82	424	26	53	20	56	24	8
7/21	492	231		2,803	635		26	50	92	221	23	29	22	48	12	20
7/22	508	262		2,825	748		8	30	90	221	23	11	14	48	6	16
7/23	521	298		2,847	824		6	38	106	221	13	0	2	20	2	8
7/24	535			2,845	958		4	15	43	221	2	22	8	16	2	12
7/25	544			2,840	1,093		0	19	39	221	7	14	6	47	2	2
7/26	551			2,844	1,168			8	43	16	-8	10	8	15	4	2
7/27	556			2,848	1,213			2	20	20	-14	8	8	15	4	2
7/28	561			2,844	1,266			9	2	20	2	15	10	14	0	2
7/29					1,300			11	14	22	0	23	4	10	4	4
7/30					1,322			6	12	2	0	27	6	2	2	1

-continued-

Appendix A.–Page 2 of 2.

	Year															
Date	**1972**	**1973**	**1974**	**1984**	**1985**	**1986**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
7/31					1,328			0	14	5	-10	7	4	2	3	6
8/01					1,341			0	10	5	-9	0	2	6	2	2
8/02					1,356			-1	7	4	-2	0	0	0	0	4
8/03					1,366			0	6	3	0	0	0	0	0	2
8/04					1,381			0	5	2	0	0	0	-2	2	4
8/05					1,382			0	5	2	0	0	0	0	-4	0
8/06					1,392			0	5	4	0	0	0	4	0	0
8/07					1,397			0	5	0	0	0	0	4	0	0
8/08					1,414			0	2	0	0	0	0	0	4	4
8/09					1,418			0	-2	0	0	0	0	0	0	2
8/10					1,423			0	2	-2	0	0	0	0	0	0
8/11					1,427			0	4	-2	0	0	0	2	-2	0
8/12					1,429			0	0	2	2	0	0	2	0	0
8/13					1,429			0		-2		0	0	0	0	0
8/14					1,432			0		-1		0	0	0	0	0
8/15					1,428			0		0		0	0	0	0	0
8/16					1,428			0		-4		0	0	0	0	0
8/17					1,425			0		0		0	0	0	0	0
8/18					1,424			0		0		0	0	0	0	0
8/19					1,424			0		0		0	0	0	0	0
8/20					1,425			0		2		0	0	2	0	0
8/21					1,426			0		1		0	0	0	0	0
8/22								0		1		0	0	0	0	0
8/23								0		1		0	0	0	0	0
8/24								0		1		0	0	0	0	0
8/25								0		1		0	0	0	0	0
8/26								0		1		0	0	0	0	0
8/27										0		0	0	0	0	0
8/28										0		0	0	0	0	0
8/29										0		0		0	0	0
8/30										0		0		0	0	0
8/31										0		0		0	0	0
9/01												0		0	0	0
9/02												0		0	0	0
9/03												0		0	0	0
9/04												0		0	0	0
9/05												0		0	0	0
9/06												0		0	0	
9/07												0		0	0	
9/08												0		0	0	
9/09												0		0	0	
9/10												0		0	0	
9/11												0		0	0	
9/12												0		0	0	
9/13												0			0	
9/14												0			0	
9/15																
Totals	**561**	**298**	**196**	**2,844**	**1,426**	**1,613**	**1,197**	**4,185**	**2,100**	**2,263**	**1,046**	**1,337**	**1,484**	**1,452**	**1,125**	**1,015**

Note: Days with no data indicate days when the project was not operational.