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Estimation of Late Run Sockeye Salmon Spawning Distribution in the Chignik River Watershed, 2004

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Jeffry L. Anderson

Abstract

Sockeye salmon *Oncorhynchus nerka* in the Chignik River watershed are an important species for commercial and subsistence harvest. Recently, subsistence fishers in the Chignik area have expressed concern that late run sockeye salmon in Chignik Lake have declined and that they are having a difficult time harvesting their subsistence fish. They are concerned that not enough fish are reaching the spawning grounds and that overall productivity might be decreasing. A project was completed in 2002 using radio telemetry to determine the run timing and estimate the spawning distribution of sockeye salmon that passed the Chignik weir in August and early September. Local concern that the results of the monitoring in 2002 may have been influenced by high water conditions was the impetus for this project. Our objective in 2004 was to use radio telemetry to determine the spawning distribution of sockeye salmon that passed the Chignik weir in August and early September. In 2004, radio transmitters were deployed in 190 sockeye salmon that passed the Chignik weir in August and early September, and 152 were successfully tracked to final locations. Most sockeye salmon (69%) were located in Chignik Lake and its tributaries. Results from the 2004 study were similar to those in 2002, except more fish were located in Chignik Lake and Black River in 2002, and more fish were located in Clark River and Chignik River in 2004.

Introduction

The Chignik River watershed supports a viable commercial salmon fishery, primarily targeting sockeye salmon *Oncorhynchus nerka* (Pappas et al. 2003). Subsistence fishers from the villages of Chignik, Chignik Lagoon, and Chignik Lake also target late run sockeye salmon in Chignik Lake, and approximately 3,000 are harvested in the subsistence fishery each year (ADFG 2003). Although subsistence harvest is not allowed within Clark River, a tributary to Chignik Lake, late run sockeye salmon originating from this drainage are important to local subsistence users as the primary fish used for drying. Areas within Chignik Lake important to subsistence fishers include Hatchery Beach, and near the mouth of Clark River and Home Creek. Subsistence fishing for late run sockeye salmon in Chignik Lake begins in late September and continues until freeze up.

The Alaska Department of Fish and Game (ADFG) operates a weir on Chignik River 4.5 km upstream from the entrance of Chignik River into Chignik Lagoon. The Chignik weir is used to estimate escapement within the Chignik River watershed and to provide in-season management of the commercial fisheries (Pappas et al. 2003). Since the weir is removed in early September, it only provides a drainage-wide escapement estimate prior to that date. The ADFG also conducts aerial surveys of the tributaries to Chignik Lake until early September.

The ADFG currently manages the Chignik sockeye salmon fishery based on two different runs: an early run that primarily spawns in tributaries to Black Lake, and a later run that primarily spawns in Chignik Lake and its tributaries. Escapement objectives at the Chignik weir are 350,000 to 400,000 early run sockeye salmon destined for Black Lake past the weir by 4 July, and 200,000 to 250,000 sockeye salmon destined for Chignik Lake past the weir prior to 31

Author: Jeffry L. Anderson is a fishery biologist with the U. S. Fish and Wildlife Service. He can be contacted at King Salmon Fish and Wildlife Field Office, P.O. Box 277, King Salmon, AK 99613; or jeffry_anderson@fws.gov.

August (Nelson and Lloyd 2001). Since 1989, a supplemental escapement objective of 25,000 late run sockeye salmon past the weir after 31 August has been targeted to meet subsistence and commercial fishing needs.

Recently, subsistence fishers in the Chignik area have expressed concern that late run sockeye salmon in Chignik Lake have declined and that they are having a difficult time harvesting their subsistence fish. They are concerned that not enough fish are reaching the spawning grounds and that overall productivity might be decreasing. The U. S. Fish and Wildlife Service King Salmon Fish and Wildlife Field Office (KSFO) initiated a monitoring project in 2002 to address these subsistence concerns. Radio telemetry was used to determine the run timing and estimate the spawning distribution of sockeye salmon that passed the Chignik weir in August and early September (Anderson 2003). Local concern that the results of the monitoring in 2002 may have been influenced by high water conditions was the impetus for this project. A cooperative project with ADFG, KSFO, and the Village of Chignik Lagoon was initiated to determine the spawning distribution of sockeye salmon that passed the Chignik weir from 1 August through 4 September 2004. Primary funding for this project was provided by the Alaska Department of Community and Economic Development, through the Subsistence Restoration Grant Program. KSFO and ADFG also provided in-kind support for the project.

Study Area

The Chignik River watershed is located on the South Alaska Peninsula about 270 km southwest of Kodiak Island, and is within the boundaries of the Alaska Peninsula National Wildlife Refuge (Figure 1). The watershed comprises two interconnected lakes (Black Lake and Chignik Lake) that drain into Chignik River; Chignik River then empties into Chignik Lagoon, an estuary to the Pacific Ocean. Black Lake (the upper lake) has a maximum depth of 6 m, a surface area of 43 km^2, and an elevation of approximately 15 m above sea level (Narver 1968). The bottom is composed mainly of sand and silt, with organic detritus prevalent near the outlet of the lake and in the northeast corner (Narver 1968). Chignik Lake has a maximum depth of 64 m, a surface area of 24 km^2, and an elevation of 5 m above sea level (Narver 1968). The bottom is dominated by rubble and boulders interspersed with gravel, silt, and organic deposits (Narver 1968).

In addition to sockeye salmon, the Chignik River watershed supports runs of Chinook *O. tshawytscha*, coho *O. kisutch*, pink *O. gorbuscha*, and chum *O. keta* salmon. Dolly Varden *Salvelinus malma* also pass the Chignik weir in large numbers and are present throughout the system (Owen et al. 2000).

Methods

Tagging of sockeye salmon was accomplished at the Chignik weir facilities of the ADFG using a trap box installed in the center of the weir to capture migrant fish. Cylindrical esophageal radio transmitters with external whip antennas were implanted in sockeye salmon by ADFG personnel in proportion to the run past the Chignik weir. The previous day's weir passage estimate was used to determine the number of tags to deploy each day. A goal of one transmitter was scheduled for deployment for every 250 sockeye salmon that passed the Chignik weir from 1 August until the weir was removed on 4 September. Sockeye salmon were randomly netted from the trap box, and were handled in the water in a padded cradle; only ocean-bright fish were selected for tagging. Transmitters were dipped in a glycerin solution to provide lubrication, and

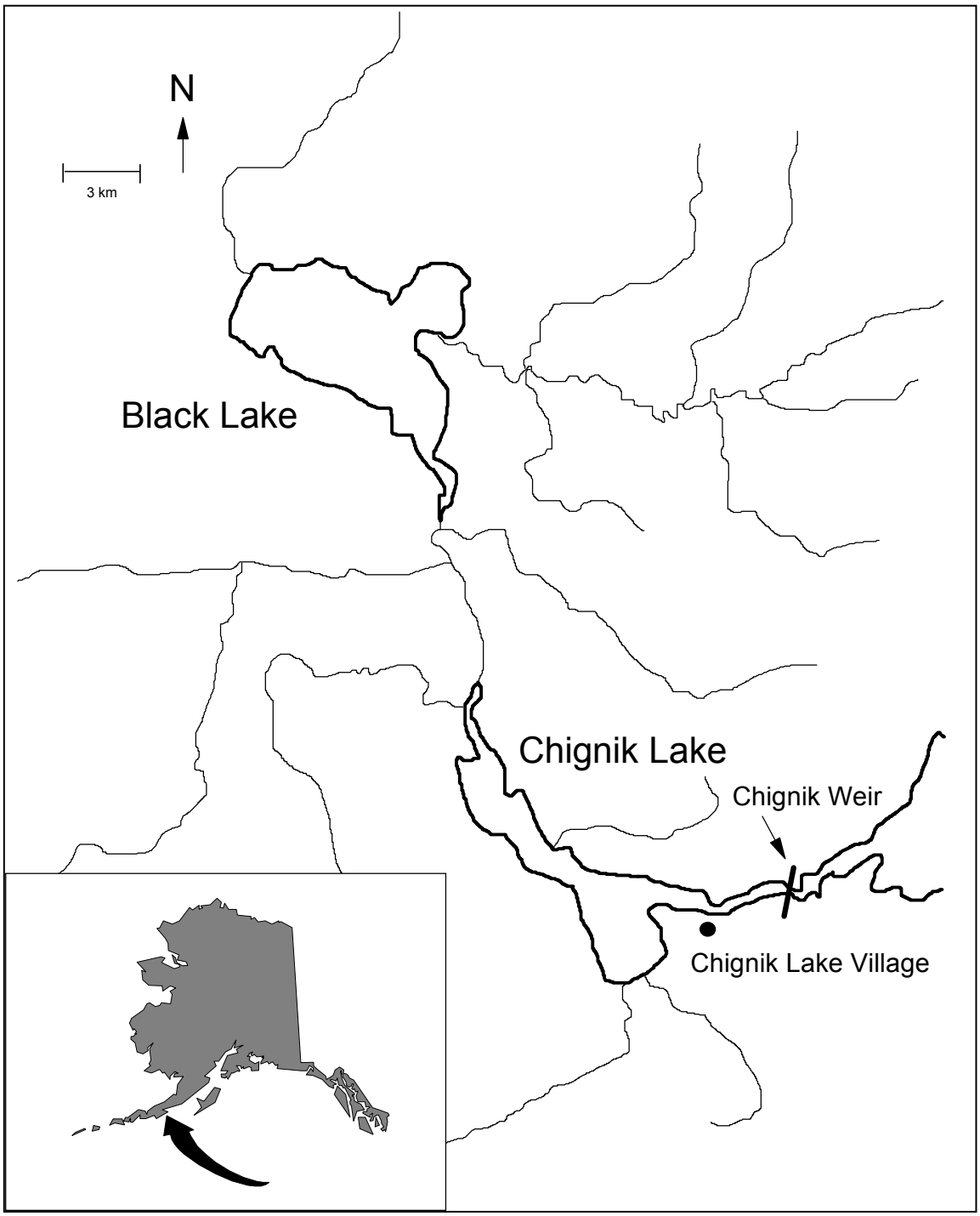

Figure 1. Chignik River watershed study area, Alaska Peninsula National Wildlife Refuge.

were gently forced down the throat of sockeye salmon to the stomach using a plunger. Care was taken to avoid puncturing the stomach. Tagged sockeye salmon were released above the weir and observed for any negative effects of handling.

Transmitters, manufactured by Advanced Telemetry Systems, Inc. (Model No. F1835), were encapsulated in a biologically inert polypropylene copolymer and weighed 14 g. Transmitters measured 42 mm in length with a diameter of 17 mm, and each had a 346-mm stainless steel nylon coated whip antenna. Two hundred unique pulse-coded tags were used, and were distributed equally over 10 frequencies between 164.147 and 164.366 MHz, with a minimum 20 KHz separation between frequencies. The combination of codes on each frequency allowed the identification of unique tags (fish). A matrix of tag frequency codes was developed to select individual tags to deploy to minimize the number of same-frequency tags being deployed on a single day.

Radio-tagged sockeye salmon were tracked throughout the Chignik River watershed using boat and aerial surveys throughout late summer and fall. During boat surveys, a portable receiver and four-element Yagi antenna were used, and at numerous sites throughout Chignik River and Chignik Lake, the receiver was allowed to scan through all transmitter frequencies for 4 s on each frequency. During aerial surveys, the entire Chignik River watershed was searched, and the receiver constantly scanned through all frequencies at 4-s intervals. Fixed-wing searches were conducted at a survey height of 100 m and a speed of 150 Km/h, and used a single four-element Yagi antenna mounted in a forward- and downward-looking aspect. Helicopter searches were conducted at a survey height of 30 m, and the speed varied from a hover to 160 Km/h depending on the number of transmitters detected in a given area. A two-element H-style antenna was mounted on each side of the helicopter in a forward- and downward-looking aspect. We were able to use the helicopter to hover and point the antennae in specific directions to identify individual transmitter locations. The transmitter frequency code combination, tag number, location, and other comments were recorded on pre-printed forms.

Only sockeye salmon that were successfully tracked were included in the spawning distribution analysis. Multiple detections in a single area, movement patterns of individual fish in Chignik Lake, and best professional judgment were used to determine the final location of transmitters. Confidence in final tag location was rated as low, medium, and high for the different escapement areas in the Chignik River watershed according to the following criteria. For sockeye salmon detected in terminal spawning tributaries, any detection in that tributary corresponded to a high degree of confidence that the fish actually spawned there. For fish detected in the main rivers (Chignik River and Black River), a single detection represented a low degree of confidence, two detections spaced throughout the season represented a medium degree of confidence, and multiple detections at different locations in the river represented a high degree of confidence that the fish spawned in the river or a nearby tributary. Sockeye salmon detected in Chignik Lake were assigned a low confidence if only one or two detections occurred in the lake over the entire survey period, but the fish was not detected anywhere else. A medium degree of confidence was assigned if two or more detections occurred in the same area, and detections were recorded in nearby areas. A high degree of confidence was assigned to sockeye salmon that were detected consistently in the same area in Chignik Lake throughout the season.

Sockeye salmon spawning distributions were analyzed by age and sex composition, and distribution patterns based on run timing past the weir were examined. Proportions ($\hat{p}$) of transmitters at different locations were estimated using standard estimators (Zar 1996) as

$$\hat{p} = \frac{X}{n},$$

where X is the number of transmitters located in each area and n is the number of fish successfully tracked to final locations. Sample variance (s^2) was calculated as

$$s^2 = \frac{\hat{p}(1-\hat{p})}{n-1}.$$

A finite population correction was not calculated, as the sample ($n < 200$) was small relative to the total weir passage ($N \approx 50{,}000$) during the period of sampling (Zar 1996).

All sockeye salmon implanted with radio transmitters were measured to the nearest mm (mid-eye to fork length) and the sex of the fish was determined from external characteristics when possible. One scale from each sockeye salmon was removed from the preferred area on the left side (Jearld 1983), cleaned, and mounted on gummed scale cards. Scales were pressed and aged on-site at the Chignik weir by ADFG personnel. Standards and guidelines of Mosher (1968) were used in aging scales. Salmon ages are reported according to the European method described by Jearld (1983) and Mosher (1968), where the number of winters the fish spent in fresh water and in the ocean are separated by a decimal.

Age, sex, and length characteristics of sockeye salmon implanted with radio transmitters were estimated using standard estimators (Zar 1996). Proportions by age and sex category were estimated as above, except X is the number of individuals in each age or sex category and n is the number of fish implanted with transmitters.

Results

An estimated 47,123 sockeye salmon migrated past the Chignik weir in 2004 from 1 August through 4 September (Bouwens 2004). Radio transmitters were deployed in 190 sockeye salmon during this period. However, transmitters were not deployed in proportion to the run, as no fish were tagged between 20 and 31 August due to the lack of available personnel (Figure 2). Of the 190 transmitters deployed, 152 were successfully tracked (Table 1, Appendix A). Thirteen transmitters were detected but not often enough to determine a spawning location, and 25 transmitters were never detected during any search; ten transmitters were not successfully deployed in 2004.

The Chignik River watershed was searched on seven occasions for tags during late summer and fall 2004 (Table 2). Aerial searches with a helicopter located the most transmitters, although boat surveys early in the season located the largest proportion of transmitters. One transmitter was returned to ADFG personnel from a fish captured in a subsistence net near the mouth of Clark River.

Most of the sockeye salmon that were successfully tracked were located in Chignik Lake (53%), followed by Chignik River (16%) and Clark River (15%; Table 3, Figure 3). Twenty-three sockeye salmon (15%) were located in Black River and its tributaries, and no transmitters were detected in Black Lake or its tributaries in 2004 (Table 3, Figure 3).

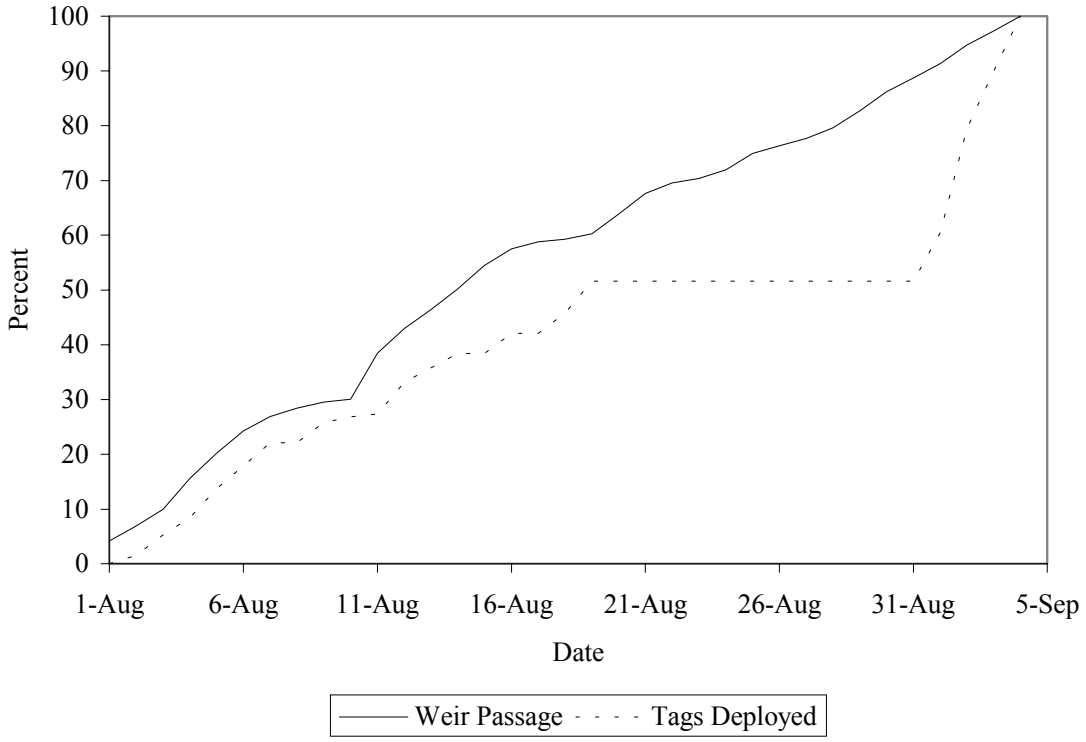

Figure 2. Cumulative percent sockeye salmon escapement at the Chignik weir (N = 47,123) and cumulative percent of tags deployed (n = 190), 1 August to 4 September 2004.

Table 1. Fate of sockeye salmon implanted with radio transmitters at the Chignik weir, 2004.

Fate	Number of Transmitters
Successfully tracked	152
Unknown final location	13
Never detected	25
Defective or dropped	5
No tagging record	4
Reference	1
Total	200

Table 2. Tracking effort in the Chignik River watershed for sockeye salmon implanted with radio transmitters, 2004.

Date	Method	Extent	Tags Located	Tags Deployed
11 Aug	Boat	Chignik River/Chignik Lake	36	52
15 Aug	Boat	Chignik River/Chignik Lake	53	73
1 Sep	Air[a]	Entire system	39	98
4 Sep	Boat	Chignik River/Chignik Lake	53	170
15 Sep	Air[a]	Entire system	35	190
7 Oct	Air[b]	Entire system	119	190
6 Nov	Air[b]	Entire system	121	190

[a] = Fixed wing aircraft
[b] = Helicopter

Table 3. Final transmitter locations for sockeye salmon tagged at the Chignik weir, 2004.

Final Location	*n*	Percent	SE (%)
Chignik Lake	81	53	4.1
Clark River	23	15	2.9
Home Creek	1	1	0.7
Chignik River	24	16	2.0
Black River	3	2	1.1
Bearskin Creek	2	1	0.9
Chiaktuak Creek	7	5	1.7
West Fork	11	7	2.1
Total	152	--	--

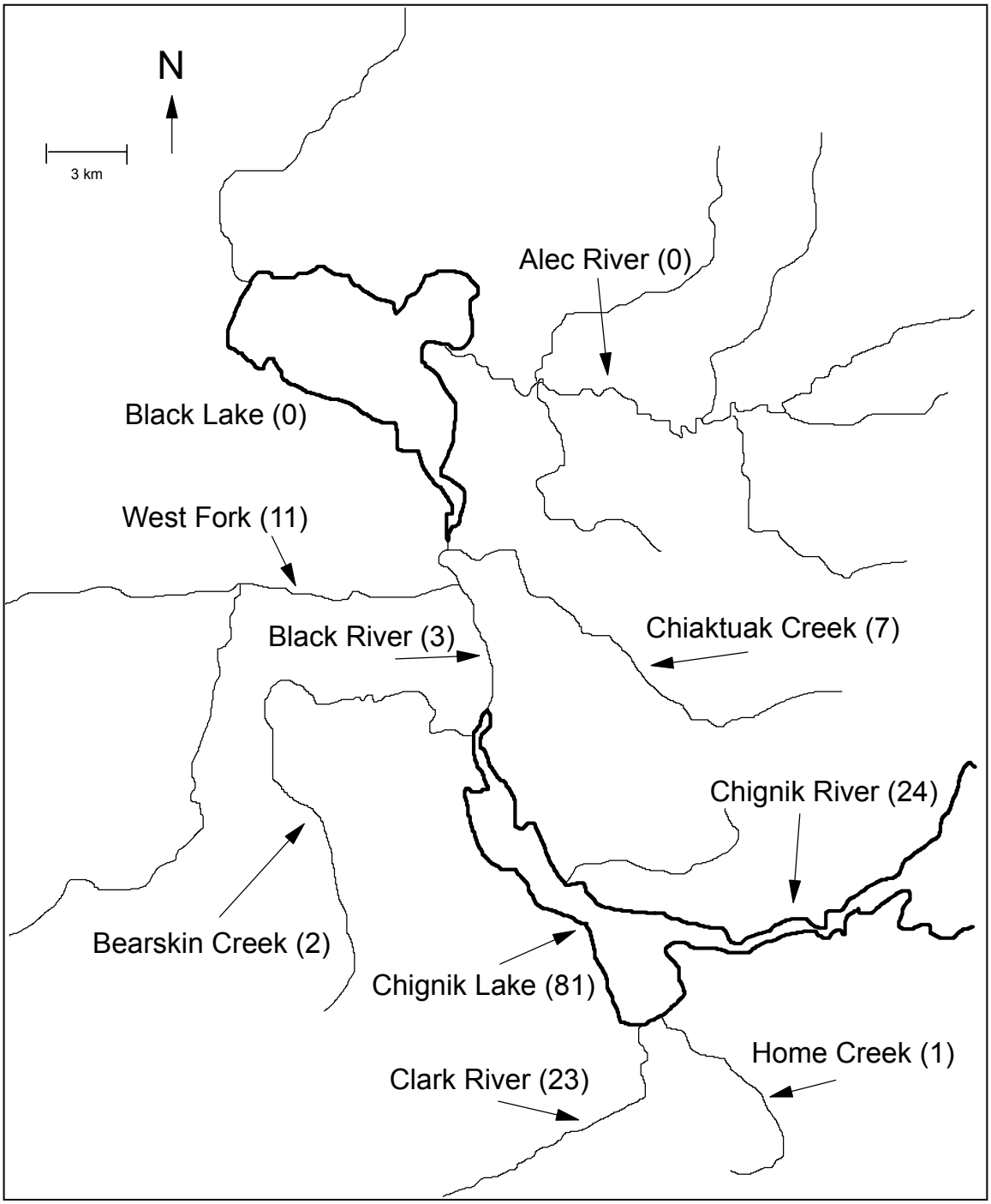

Figure 3. Final locations and numbers (in parentheses) of sockeye salmon implanted with radio transmitters at the Chignik weir, 2004.

Most sockeye salmon located in Black River and its tributaries and in Chignik River were tagged at the weir during the early tagging period (1 - 19 August; Tables 4 and 5). Sockeye salmon located in Chignik Lake and its tributaries were the largest component of both tagging periods, although they comprised a greater proportion of the late tagging period than the early tagging period (Tables 4 and 5). Most transmitters that were never located were implanted during the late tagging period (1 - 4 September), while most fish with unknown final locations were tagged during the early tagging period (1 - 19 August; Table 4).

Scale samples were collected from 191 sockeye salmon at the Chignik weir in 2004, and ages were determined from 139 fish; ages could not be determined from 52 scales. Eight ages were identified, and most fish (72%) were age 2.3 (Table 6). Fifty-seven percent of fish sampled in 2004 were males (Table 7). Lengths of sockeye salmon sampled at the Chignik weir in 2004 ranged from 432 to 655 mm, and males were generally larger than females at age, except age 1.3 females were larger than males (Table 8, Figure 4).

Age 2.3 sockeye salmon were the most widely distributed age class in 2004, and represented the majority of fish at all locations (Table 9). The male-dominated sex composition was also evident in the tag distribution, except most fish located in Chiaktuak Creek were female (Table 10).

Discussion

Twenty-five sockeye salmon were never located following their successful release above the weir in 2004, and most (n = 21) were tagged from 1 to 4 September (Table 4). The transmitters were functional when the fish were released, and it is unlikely that all 25 tags were defective as we only observed one (out of 200) defective transmitter prior to deployment. These sockeye salmon were probably in Chignik Lake, but were too deep in the lake during subsequent surveys and were not detected. We were confident in our coverage of tributary streams and rivers (Chignik and Black), and believe these fish could only have avoided detection in Chignik Lake. We do not believe that tagged fish avoided detection by moving below the weir, as there is no mechanism to allow downstream passage, and any dead fish that washed up on the weir were examined for transmitters. All 13 fish with unknown final locations were initially tracked in Chignik River, but were never located once they exited the river. As with the fish that were never located, we believe these fish were in Chignik Lake but not detected. If more effort had been allocated to tracking, we may have been able to locate more transmitters with confidence in 2004.

Distributions of sockeye salmon in the Chignik River watershed were similar in 2002 and 2004 (Table 11). However, more fish were located in Chignik Lake and Black River in 2002, and more fish were located in Clark River and Chignik River in 2004. Similar percentages of tags were successfully tracked in both years, although more transmitters were never located in 2004 compared to 2002 (Table 12). We do not know why more sockeye salmon were located in Chignik and Clark rivers in 2004, although run timing for Clark River fish was different in 2002 and 2004. Late run sockeye salmon located in Clark River migrated past the Chignik weir throughout the study period in 2004 (Table 4). In 2002, however, most (4 out of 5) Clark River fish migrated past the weir towards the end of the sampling period (after 29 August; Anderson 2003). The Clark River component of the late run also comprised a larger proportion of the overall sample in 2004 than in 2002 (Table 11).

Table 4. Final transmitter locations for sockeye salmon tagged at the Chignik weir by tagging period, 2004.

	Tagging Period	
Location	1 - 19 Aug	1 - 4 Sep
Chignik Lake	36	45
Clark River	9	14
Home Creek	1	--
Chignik River	18	6
Black River	2	1
Bearskin Creek	2	--
Chiaktuak Creek	6	1
West Fork	9	2
Never located	4	21
Unknown final location	11	2
Total	98	92

Table 5. Summary of transmitter locations for sockeye salmon tagged at the Chignik weir during early (1 to 19 August) and late (1 to 4 September) tagging periods in 2004.

	Tagging Period					
	Early (1 - 19 Aug)			Late (1 - 4 Sep)		
Location	*n*	%	SE (%)	*n*	%	SE (%)
Black River and Tributaries[a]	19	23	4.6	4	6	2.8
Chignik Lake and Tributaries[b]	46	55	5.5	59	86	4.3
Chignik River	18	22	4.6	6	9	3.4
Total	83	--	--	69	--	--

[a] Tributaries include Bearskin Creek, Chiaktuak Creek, and West Fork.
[b] Tributaries include Clark River and Home Creek.

Table 6. Age composition of sockeye salmon implanted with radio transmitters at the Chignik weir, 2004.

Age	*n*	%	SE (%)
0.3	1	< 1	0.7
1.2	5	4	1.6
1.3	12	9	2.4
1.4	2	1	1.0
2.2	5	4	1.6
2.3	100	72	3.8
2.4	11	8	2.3
3.3	3	2	1.2
Total	139	--	--

Table 7. Sex composition of sockeye salmon implanted with radio transmitters at the Chignik weir, 2004.

Sex	*n*	%	SE (%)
Female	83	43	4.0
Male	109	57	4.0
Total	192	--	--

Table 8. Mean, SE, range, and samples size of lengths (mm) by age and sex taken from sockeye salmon at the Chignik weir, 2004.

	Age							
	0.3	1.2	1.3	1.4	2.2	2.3	2.4	3.3
				Female				
Mean	--	--	578	--	--	561	558	--
SE	--	--	32	--	--	29	39	--
Min	--	516	544	577	--	464	508	573
Max	--	--	630	--	--	617	595	--
n	--	1	5	1	--	47	6	1
				Male				
Mean	--	516	571	--	506	589	593	600
SE	--	67	39	--	62	24	38	14
Min	553	433	487	608	432	503	542	590
Max	--	578	602	--	578	655	634	610
n	1	4	7	1	5	53	5	2
				Total				
Mean	--	516	574	592	506	575	574	591
SE	--	58	35	22	62	30	41	19
Min	553	433	487	577	432	464	508	573
Max	--	578	630	608	578	655	634	610
n	1	5	12	2	5	100	11	3

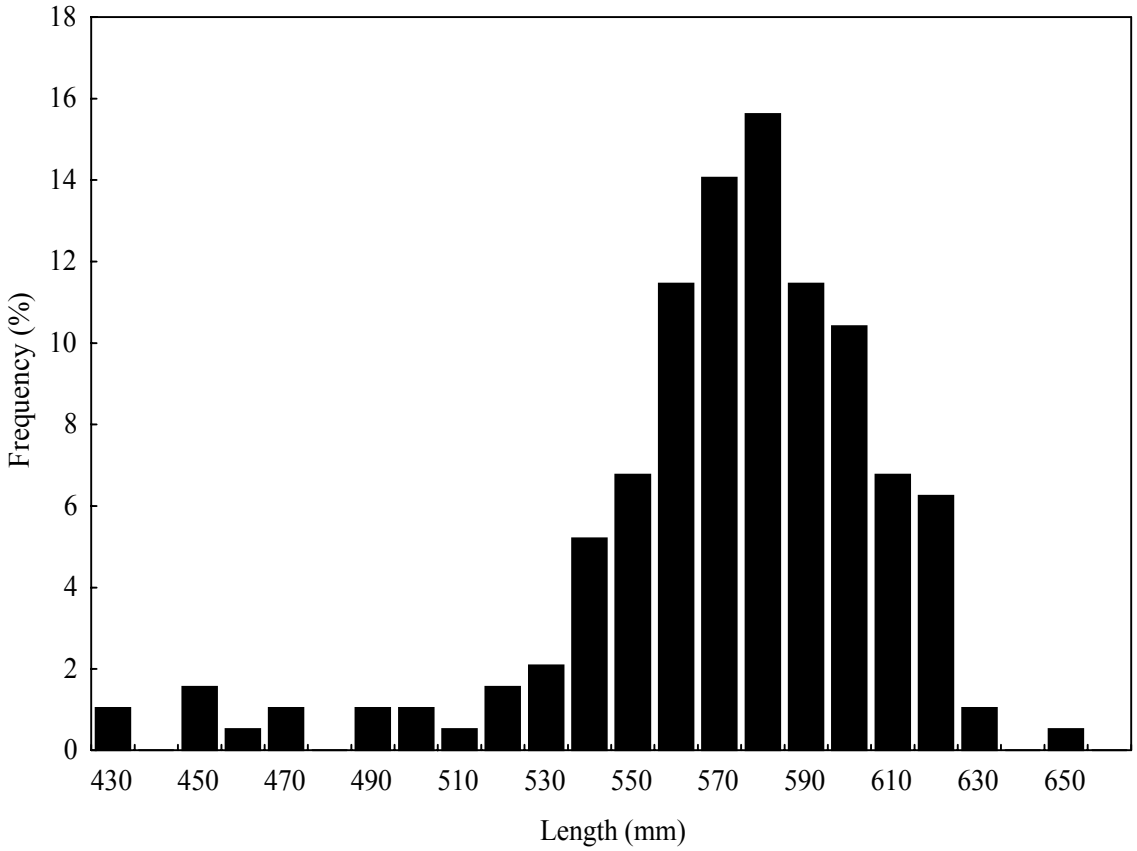

Figure 4. Length-frequency distribution of sockeye salmon implanted with radio transmitters at the Chignik weir, 2004.

Table 9. Age composition by location for sockeye salmon tagged at the Chignik weir, 2004.

	Age								
Location	0.3	1.2	1.3	1.4	2.2	2.3	2.4	3.3	Unreadable
Chignik Lake	--	4	4	1	1	42	7	--	22
Clark River	--	--	1	--	2	12	2	1	5
Home Creek	--	--	--	--	--	--	--	--	1
Chignik River	1	1	2	--	1	13	--	--	6
Black River	--	--	--	--	1	2	--	--	--
Bearskin Creek	--	--	--	--	--	1	--	--	1
Chiaktuak Creek	--	--	1	--	--	5	--	--	1
West Fork	--	--	1	1	--	4	1	--	4
Never detected	--	--	1	--	--	15	1	1	7
Unknown	--	--	2	--	--	5	--	1	5
Total	1	5	12	2	5	99	11	3	52

Table 10. Sex composition by location for sockeye salmon tagged at the Chignik weir, 2004.

	Sex	
Location	Female	Male
Chignik Lake	31	50
Clark River	10	13
Home Creek	--	1
Chignik River	12	12
Black River	1	2
Bearskin Creek	1	1
Chiaktuak Creek	6	1
West Fork	5	6
Never detected	9	16
Unknown	8	5
Total	83	107

Table 11. Final transmitter locations for sockeye salmon tagged at the Chignik weir in 2002 and 2004. 2002 data are from Anderson (2003).

	Percent of Transmitters	
Location	2002	2004
Chignik Lake	68	53
Clark River	6	15
Home Creek	--	1
Chignik River	1	16
Black River	11	2
Bearskin Creek	1	1
Chiaktuak Creek	4	5
West Fork	5	7
Alec River	3	--

Table 12. Fate of sockeye salmon implanted with radio transmitters at the Chignik weir, 2002 and 2004. 2002 data are from Anderson (2003).

	Percent of Transmitters	
Fate	2002	2004
Successfully tracked	78	76
Unknown final location	7	7
Never detected	6	12
Not deployed successfully	9	5

The sockeye salmon run past the Chignik weir in August and early September was considerably less in 2004 (47,123; Bouwens 2004) than in 2002 (102,838; Pappas 2002). Because of the smaller run and the availability of more transmitters, we deployed transmitters in a larger proportion of the overall run in 2004 (190 for 47,123 fish) compared to 2002 (96 for 102,838 fish; Anderson 2003). Regardless of these differences in run strength and tagging effort between years, tag distributions were similar: most fish passing the Chignik weir in August and early September are destined for Chignik Lake and its tributaries.

Local residents still express concerns that they have difficulty harvesting late run sockeye salmon for subsistence purposes (BBNA 2004). If the distribution patterns we observed in 2002 and 2004 are consistent from year to year, the fish that pass the weir after 31 July should be available for subsistence harvest in Chignik Lake, at least until early November (the extent of our surveys). However, lower returns, such as experienced in 2004, may result in local residents needing to expend more effort to harvest sufficient numbers of fish. Also, the telemetry efforts in 2002 and 2004 did not attempt to estimate escapement into the Chignik River watershed after the weir was removed in early September. To address this data gap, KSFO has proposed to monitor sockeye salmon abundance and escapement in Chignik Lake from September until freeze up using hydroacoustic techniques.

Acknowledgements

We would like to thank the Alaska Department of Fish and Game for their support of this project. The crew at the Chignik weir tagged and tracked fish throughout August and September, and provided logistical support throughout the project. Without their efforts, the project would not have succeeded. The Village of Chignik Lagoon provided the support and infrastructure to enable the project to receive funding consideration. Egli Air Haul in King Salmon provided the helicopter flight service for the October and November aerial searches. Finally, we thank the Alaska Department of Community and Economic Development for funding this project through the Subsistence Restoration Grant Program.

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Appendix A. Summary of sockeye salmon radio tagging and tracking, 2004. UR = unreadable scale.

Tag Date	Tag	Tag Freq.	Pulse Code	Sex	Length	Age	Location	Confidence	No. Detections at Location	Total No. Detections
2-Aug	1	164.147	22	M	546	--	Reference	--	--	--
2-Aug	2	164.167	6	M	573	2.3	Chignik River	Medium	4	4
2-Aug	3	164.194	17	F	565	2.3	West Fork	High	4	6
2-Aug	4	164.217	26	M	452	2.2	Clark River	High	4	5
3-Aug	5	164.245	11	M	608	1.4	West Fork	High	2	5
3-Aug	6	164.264	75	M	580	1.3	Chignik River	Medium	4	4
3-Aug	7	164.295	21	M	575	2.3	Black River	Medium	3	5
--	8	164.315	5	--	--	--	Bad/Expelled	--	--	--
3-Aug	9	164.345	11	M	573	UR	Chignik Lake	Medium	4	4
3-Aug	10	164.366	22	M	567	UR	Chiaktuak Creek	High	4	4
3-Aug	11	164.147	17	M	580	1.3	Unknown	--	--	--
3-Aug	12	164.167	26	M	610	UR	Home Creek	High	3	4
4-Aug	13	164.194	14	M	586	2.3	Chignik River	Medium	4	4
4-Aug	14	164.217	14	F	525	2.3	Chignik Lake	Medium	2	3
4-Aug	15	164.245	23	F	551	2.3	Chiaktuak Creek	High	3	4
4-Aug	16	164.264	13	M	449	UR	West Fork	High	4	5
4-Aug	17	164.295	12	M	487	1.3	Never Located	--	--	--
4-Aug	18	164.315	13	F	572	UR	Chignik Lake	Medium	3	3
5-Aug	19	164.345	75	F	540	2.3	Chignik Lake	Medium	3	4
5-Aug	20	164.366	21	F	585	1.3	Unknown	--	--	--
5-Aug	21	164.147	13	M	553	0.3	Chignik River	Medium	4	4
5-Aug	22	164.167	11	M	527	2.2	Clark River	High	1	4
5-Aug	23	164.194	75	M	603	2.3	Chignik River	Medium	5	5
5-Aug	24	164.217	6	M	580	2.3	Chignik Lake	High	7	7
5-Aug	25	164.245	18	M	565	2.3	Chignik River	Low	1	1
5-Aug	26	164.264	23	M	586	UR	West Fork	High	2	3
5-Aug	27	164.295	15	F	505	2.3	Chignik River	Low	1	1
5-Aug	28	164.315	8	F	570	2.3	Chignik Lake	Low	1	3
6-Aug	29	164.345	21	M	597	2.3	Chignik Lake	Medium	4	5
6-Aug	30	164.366	6	M	580	UR	Chignik River	Medium	4	4
6-Aug	31	164.147	9	F	563	2.3	Unknown	--	--	--
6-Aug	32	164.167	14	M	564	2.3	Chignik Lake	Low	2	3
6-Aug	33	164.194	12	M	569	UR	Chignik Lake	Medium	3	3
6-Aug	34	164.217	13	F	551	UR	Chignik River	Medium	4	4
6-Aug	35	164.245	20	F	569	UR	Clark River	High	1	2
6-Aug	36	164.264	18	M	578	2.2	Chignik River	High	5	5
7-Aug	37	164.295	11	M	579	UR	Chignik Lake	Medium	3	4
7-Aug	38	164.315	19	F	525	2.3	Bearskin Creek	High	1	2
7-Aug	39	164.345	12	F	554	2.3	Chignik River	Medium	4	4
7-Aug	40	164.366	24	M	604	2.3	Chignik Lake	Low	1	2

Appendix A. continued.

Tag Date	Tag	Tag Freq.	Pulse Code	Sex	Length	Age	Location	Confidence	No. Detections at Location	Total No. Detections
7-Aug	41	164.147	19	M	605	2.3	Chignik Lake	Low	2	2
7-Aug	42	164.167	5	F	565	2.3	Chiaktuak Creek	High	4	5
7-Aug	43	164.194	5	M	578	1.2	Chignik River	Low	3	3
7-Aug	44	164.217	23	F	580	UR	Never Located	--	--	--
9-Aug	45	164.245	16	M	564	2.3	Clark River	High	3	6
9-Aug	46	164.264	16	M	596	2.3	Unknown	--	--	--
9-Aug	47	164.295	16	M	491	1.2	Chignik Lake	Medium	3	5
9-Aug	48	164.315	24	M	602	2.3	West Fork	High	4	5
9-Aug	49	164.345	9	M	560	1.3	Chignik Lake	Medium	3	3
9-Aug	50	164.366	26	M	594	2.3	Chignik Lake	Medium	3	3
9-Aug	51	164.147	21	M	581	UR	Chignik Lake	Low	1	2
10-Aug	52	164.167	8	F	561	2.3	Chiaktuak Creek	High	1	4
10-Aug	53	164.194	6	F	590	UR	Chignik Lake	Low	1	2
11-Aug	54	164.217	11	F	574	2.3	Unknown	--	--	--
12-Aug	55	164.245	5	F	546	2.3	West Fork	High	4	5
12-Aug	56	164.264	11	M	590	3.3	Unknown	--	--	--
12-Aug	57	164.295	75	M	599	2.3	Chignik River	Low	2	3
12-Aug	58	164.315	14	M	634	2.4	Chignik Lake	Low	2	2
12-Aug	59	164.345	15	F	577	2.3	Chignik Lake	Medium	2	3
12-Aug	60	164.366	23	M	542	2.2	Black River	Low	1	2
12-Aug	61	164.147	5	F	565	UR	Chignik River	Medium	3	4
12-Aug	62	164.167	12	F	566	2.3	Clark River	High	3	5
12-Aug	63	164.194	13	M	577	UR	Bearskin Creek	High	2	5
12-Aug	64	164.217	8	F	578	UR	Chignik Lake	Medium	4	5
12-Aug	65	164.245	6	M	576	2.3	West Fork	High	2	4
13-Aug	66	164.264	22	M	565	2.3	Chignik Lake	Low	2	3
13-Aug	67	164.295	19	M	450	UR	Unknown	--	--	--
13-Aug	68	164.315	23	F	584	UR	Unknown	--	--	--
13-Aug	69	164.345	14	M	50	2.3	Clark River	High	2	5
13-Aug	70	164.366	18	F	559	UR	Unknown	--	--	--
14-Aug	71	164.147	14	M	433	1.2	Chignik Lake	Medium	3	3
14-Aug	72	164.167	9	M	552	UR	Chignik River	Low	1	1
14-Aug	73	164.194	20	F	568	2.3	Chignik River	Medium	4	4
14-Aug	74	164.217	19	F	516	1.2	Chignik Lake	Low	1	2
14-Aug	75	164.245	75	F	575	UR	Unknown	--	--	--
--	76	164.264	9	--	--	--	No Tag Record	--	--	--
16-Aug	77	164.295	9	M	597	1.3	Chignik Lake	Medium	4	4
16-Aug	78	164.315	9	M	590	1.3	Chignik Lake	Medium	2	2
16-Aug	79	164.345	5	F	547	2.3	Chignik Lake	High	4	5
16-Aug	80	164.366	17	M	586	2.3	Chignik Lake	Low	1	2

Appendix A. continued.

Tag Date	Tag	Tag Freq.	Pulse Code	Sex	Length	Age	Location	Confidence	No. Detections at Location	Total No. Detections
16-Aug	81	164.147	6	F	544	1.3	Chignik River	Low	1	2
16-Aug	82	164.167	23	M	602	2.3	Chignik Lake	Low	1	1
16-Aug	83	164.194	18	F	566	1.3	Clark River	High	1	3
18-Aug	84	164.217	21	M	605	UR	West Fork	High	4	4
18-Aug	85	164.245	21	F	575	2.3	Never Located	--	--	--
18-Aug	86	164.264	12	F	565	2.3	Chignik Lake	Low	1	1
18-Aug	87	164.295	23	F	540	2.3	Clark River	High	1	3
--	88	164.315	12	--	--	--	Bad/Expelled	--	--	--
18-Aug	89	164.345	6	F	566	1.3	Chiaktuak Creek	High	2	3
18-Aug	90	164.366	19	F	563	UR	Chignik Lake	Low	1	2
18-Aug	91	164.147	20	M	607	UR	Chignik Lake	Low	1	1
19-Aug	92	164.167	21	M	564	2.3	Chignik River	Low	2	2
19-Aug	93	164.194	11	M	595	2.3	Chignik Lake	Low	1	1
19-Aug	94	164.217	15	F	464	2.3	Never Located	--	--	--
19-Aug	95	164.245	14	M	590	UR	Chignik Lake	Medium	2	2
19-Aug	96	164.264	20	M	625	2.3	Clark River	High	3	4
19-Aug	97	164.295	22	F	630	1.3	West Fork	High	2	2
19-Aug	98	164.315	17	F	580	2.3	Chiaktuak Creek	High	4	4
19-Aug	99	164.345	26	M	581	2.3	Chignik Lake	Medium	2	2
19-Aug	100	164.366	15	F	562	2.3	Unknown	--	--	--
19-Aug	101	164.147	23	M	606	2.3	Chignik Lake	High	4	4
19-Aug	102	164.167	18	M	562	1.2	Chignik Lake	Medium	3	3
1-Sep	103	164.194	23	M	609	2.4	Chignik Lake	Low	1	1
1-Sep	104	164.217	17	M	527	UR	Clark River	High	1	1
1-Sep	105	164.245	22	M	596	2.3	Never Located	--	--	--
1-Sep	106	164.264	21	F	567	2.3	Chignik Lake	Medium	2	3
1-Sep	107	164.295	8	F	583	UR	Chignik Lake	Low	2	3
--	108	164.315	16	--	--	--	Bad/Expelled	--	--	--
1-Sep	109	164.345	24	M	574	2.3	Chignik Lake	Low	1	1
1-Sep	110	164.366	11	F	545	2.3	Clark River	High	1	2
1-Sep	111	164.147	75	F	580	UR	West Fork	High	2	3
1-Sep	112	164.167	16	F	540	2.3	Never Located	--	--	--
1-Sep	113	164.194	8	M	580	2.3	Never Located	--	--	--
1-Sep	114	164.217	24	F	557	UR	Unknown	--	--	--
1-Sep	115	164.245	15	F	575	2.3	Chignik Lake	Low	1	1
1-Sep	116	164.264	26	F	564	2.3	Clark River	High	2	3
1-Sep	117	164.295	14	F	548	2.3	Chignik River	Low	2	2
1-Sep	118	164.315	18	F	600	2.3	Never Located	--	--	--
1-Sep	119	164.345	17	M	623	2.3	Chignik Lake	Medium	2	3
1-Sep	120	164.366	5	M	604	UR	Chignik Lake	Medium	2	2

Appendix A. continued.

Tag Date	Tag	Tag Freq.	Pulse Code	Sex	Length	Age	Location	Confidence	No. Detections at Location	Total No. Detections
2-Sep	121	164.147	8	F	583	2.3	Clark River	High	1	3
2-Sep	122	164.167	17	F	593	UR	Chignik Lake	Medium	2	2
2-Sep	123	164.194	22	M	609	2.3	Bad/Expelled	--	--	--
2-Sep	124	164.217	16	F	595	2.4	Chignik Lake	Low	2	3
2-Sep	125	164.245	13	F	587	2.4	Chignik Lake	Medium	2	2
2-Sep	126	164.264	24	M	619	UR	Chignik Lake	Low	1	1
2-Sep	127	164.295	20	F	576	2.3	Chignik Lake	Low	2	2
2-Sep	128	164.315	15	M	622	2.3	Never Located	--	--	--
2-Sep	129	164.345	16	M	606	UR	Chignik Lake	Medium	3	3
2-Sep	130	164.366	13	F	526	2.4	West Fork	High	2	2
2-Sep	131	164.147	15	F	591	2.3	Chignik Lake	Low	2	2
2-Sep	132	164.167	19	F	474	2.3	Never Located	--	--	--
--	133	164.194	24	--	--	--	Bad/Expelled	--	--	--
2-Sep	134	164.217	20	M	620	2.3	Never Located	--	--	--
2-Sep	135	164.245	12	F	569	UR	Chignik Lake	Medium	3	3
2-Sep	136	164.264	6	F	571	UR	Chignik River	Low	2	2
2-Sep	137	164.295	18	F	572	UR	Chignik River	Low	2	2
2-Sep	138	164.315	21	M	593	UR	Clark River	High	2	2
2-Sep	139	164.345	22	M	564	2.4	Clark River	High	1	2
2-Sep	140	164.366	14	M	593	2.3	Chignik Lake	Low	2	2
2-Sep	141	164.147	18	F	621	UR	Clark River	High	1	3
2-Sep	142	164.167	13	M	608	UR	Chignik Lake	Low	2	2
2-Sep	143	164.194	19	F	592	2.3	Chignik Lake	Low	1	1
2-Sep	144	164.217	22	F	573	2.3	Chignik Lake	Low	1	1
2-Sep	145	164.245	17	M	601	2.3	Chignik Lake	Low	1	1
2-Sep	146	164.264	5	M	467	UR	Chignik Lake	Medium	2	2
2-Sep	147	164.295	24	M	528	UR	Clark River	High	2	2
2-Sep	148	164.315	26	F	562	UR	Chignik Lake	High	4	4
2-Sep	149	164.345	19	F	537	2.4	Chignik Lake	Medium	2	2
2-Sep	150	164.366	9	F	617	2.3	Black River	Low	1	3
2-Sep	151	164.147	24	F	594	2.4	Chignik Lake	Low	2	2
2-Sep	152	164.167	24	F	555	2.3	Clark River	High	1	2
2-Sep	153	164.194	26	M	606	2.3	Never Located	--	--	--
2-Sep	154	164.217	75	F	508	2.4	Never Located	--	--	--
2-Sep	155	164.245	24	F	588	2.3	Chignik River	Low	2	2
2-Sep	156	164.264	14	M	592	UR	Chignik Lake	Low	2	2
2-Sep	157	164.295	5	M	564	2.3	Chignik Lake	Low	2	2
2-Sep	158	164.315	22	M	542	2.4	Clark River	High	1	1
3-Sep	159	164.345	13	M	577	2.3	Clark River	High	1	3
3-Sep	160	164.366	8	F	547	UR	Never Located	--	--	--

Appendix A. continued.

Tag Date	Tag	Tag Freq.	Pulse Code	Sex	Length	Age	Location	Confidence	No. Detections at Location	Total No. Detections
3-Sep	161	164.147	11	M	570	2.3	Never Located	--	--	--
3-Sep	162	164.167	15	M	605	2.3	Chignik Lake	Medium	2	2
3-Sep	163	164.194	16	F	598	2.3	Chignik Lake	Medium	2	2
3-Sep	164	164.217	5	F	579	2.3	Chiaktuak Creek	High	1	2
3-Sep	165	164.245	9	M	586	2.3	Chignik Lake	Medium	3	3
3-Sep	166	164.264	8	M	610	UR	Never Located	--	--	--
3-Sep	167	164.295	6	M	577	2.3	Chignik Lake	Low	2	3
3-Sep	168	164.315	6	F	539	2.3	Chignik River	Low	2	2
3-Sep	169	164.345	8	M	555	2.3	Clark River	High	2	3
3-Sep	170	164.366	16	M	602	1.3	Chignik Lake	Low	1	2
3-Sep	171	164.147	26	M	604	2.3	Unknown	--	--	--
3-Sep	172	164.167	75	F	571	2.3	Chignik River	Low	2	2
3-Sep	173	164.194	21	F	599	2.3	Clark River	High	2	4
3-Sep	174	164.217	9	M	611	UR	Never Located	--	--	--
3-Sep	175	164.245	8	M	580	2.3	Chignik Lake	Low	1	2
3-Sep	176	164.264	17	M	610	3.3	Clark River	High	1	3
3-Sep	177	164.295	13	M	432	2.2	Chignik Lake	Medium	2	2
4-Sep	178	164.315	11	M	594	UR	Chignik Lake	Low	2	2
3-Sep	179	164.345	23	F	570	2.3	Chignik Lake	Medium	2	2
4-Sep	180	164.366	12	M	621	UR	Never Located	--	--	--
4-Sep	181	164.147	16	M	602	2.3	Never Located	--	--	--
--	182	164.167	20	--	--	--	No Tag Record	--	--	--
4-Sep	183	164.194	9	F	577	1.4	Chignik Lake	Low	2	2
--	184	164.217	18	--	--	--	No Tag Record	--	--	--
4-Sep	185	164.245	26	M	614	2.3	Chignik Lake	Low	2	2
4-Sep	186	164.264	19	M	577	2.3	Chignik Lake	Low	2	2
4-Sep	187	164.295	17	F	570	UR	Chignik Lake	Medium	2	2
4-Sep	188	164.315	20	M	565	2.3	Never Located	--	--	--
4-Sep	189	164.345	18	M	503	2.3	Never Located	--	--	--
4-Sep	190	164.366	75	M	594	2.3	Chignik Lake	Low	1	1
4-Sep	191	164.147	12	M	655	2.3	Chignik Lake	Low	1	1
4-Sep	192	164.167	22	F	573	3.3	Never Located	--	--	--
4-Sep	193	164.194	15	M	576	2.3	Chignik Lake	Low	1	1
4-Sep	194	164.217	12	M	616	2.3	Never Located	--	--	--
--	195	164.245	19	--	--	--	No Tag Record	--	--	--
4-Sep	196	164.264	15	M	623	UR	Never Located	--	--	--
4-Sep	197	164.295	26	M	619	UR	Never Located	--	--	--
4-Sep	198	164.315	75	F	538	2.3	Chignik Lake	Medium	2	2
4-Sep	199	164.345	20	F	581	2.3	Chignik Lake	Medium	2	2
4-Sep	200	164.366	20	M	616	2.4	Chignik Lake	Medium	3	3