U.S. Fish & Wildlife Service

Estimation of Coho Salmon Escapement in Streams Adjacent to Perryville and Sockeye Salmon Escapement in Chignik Lake Tributaries, Alaska Peninsula National Wildlife Refuge, 2007

Alaska Fisheries Data Series Number 2007–12

Anchorage Fish and Wildlife Field Office
Anchorage, Alaska
December 2007

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Jeffry L. Anderson

Abstract

Runs of coho salmon *Oncorhynchus kisutch* in the Kametolook, Three Star, and Long Beach rivers near Perryville have declined, and residents can no longer meet their subsistence needs in those rivers. Local residents are now taking coho salmon from streams outside the immediate vicinity of Perryville. With fishing effort spread out to other streams, we need to ensure escapement is maintained to meet the subsistence needs of the Native Village of Perryville. In order to prevent over harvest of these small stocks, escapement in those other streams needs to be monitored. Monitoring of sockeye salmon escapement in Clark River, a tributary to Chignik Lake, is also necessary to ensure escapement is maintained to meet subsistence needs for residents of the Chignik villages. In 2007, two aerial surveys were conducted to count adult coho salmon in streams near Perryville and sockeye salmon in Clark River using low-level helicopter flights. Overall numbers of coho salmon counted in 2007 and run timing were similar to previous years. The survey in mid September preceded the coho salmon run in most streams, but a peak count was probably obtained for most major streams during the October survey. Local water conditions prevented us from obtaining complete counts in some streams.

Introduction

The residents of Perryville depend on fish and wildlife resources for subsistence, and salmon (primarily coho salmon *Oncorhynchus kisutch*) accounts for more than half of the subsistence food they consume (Hutchinson-Scarborough and Fall 1993). The average harvest of coho salmon in the Perryville area from 1993 to 2000 was estimated to be over 1,900 fish, with a range from 993 (1995) to 3,501 (1994) (ADFG 2002). Recent runs of coho salmon in the Kametolook, Three Star, and Long Beach rivers have declined, with escapement estimated at about 200 fish in 1996 (ADFG 1997a). Several reasons for the decline of coho salmon stocks in the Kametolook River drainage have been suggested, including a decrease in carrying capacity resulting from changes in habitat, over fishing in the river, and over fishing in the ocean. Concerns over poor returns and the inability of local residents to meet their subsistence needs in those three systems motivated the Native Village of Perryville to pass an ordinance that prohibits subsistence harvest in the Kametolook River. In addition, the Alaska Department of Fish and Game (ADFG) engaged in a project in 1996 to rebuild coho salmon stocks in the Kametolook River drainage using incubation boxes, with the intent of improving adult returns by increasing survival from the green egg to swim-up fry stage (ADFG 1997a).

During meetings of the Board of Fisheries and Perryville Subsistence Working Group, local residents stated that they were now taking coho salmon from other streams outside the immediate vicinity of Perryville. In many ways, these streams are similar to streams near Perryville in that they are short, high gradient streams with limited coho salmon abundance. As long as harvest and effort are spread among several small streams and not concentrated on one system, the subsistence needs of the village should be met until rebuilding efforts on the Kametolook River

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become effective. With fishing effort spread out to other streams, we need to ensure these runs are maintained to meet the subsistence needs of the Native Village of Perryville. In order to prevent over harvest of these small stocks, escapement in those other streams needs to be monitored.

Sockeye salmon *O. nerka* in the Chignik watershed are an important species for commercial and subsistence fisheries. In recent years, subsistence fishers in the Chignik area have had difficulty harvesting enough late run fish and are concerned that the runs have declined. We need to monitor sockeye and coho salmon escapement in the Chignik watershed to ensure escapement is maintained to meet subsistence needs for residents of the Chignik villages.

The ADFG monitors Pacific salmon escapement in the Chignik and Perryville areas until early September as part of their normal operation, but discontinue aerial surveys prior to the peak of coho salmon runs (Pappas et al. 2003). Escapement information is needed for effective in-season and post-season management of these stocks, and this project was initiated to address these needs. The run timing of coho and late run sockeye salmon is similar and makes concurrent monitoring practical. Aerial surveys have been used to monitor coho salmon escapement in streams near Perryville and sockeye salmon in the Chignik watershed (Clark River) since 2003. Anderson (2004a; 2005a; 2005b; 2006) presents results from the first four years of monitoring, and this report summarizes the fifth year of surveys.

Study Area

The Perryville aerial survey area is located on the Pacific Ocean side of the Alaska Peninsula, and is entirely within the boundaries of the Alaska Peninsula National Wildlife Refuge Federal Conservation Unit (Figure 1). Coho, Chinook *O. tshawytscha*, pink *O. gorbuscha*, chum *O. keta*, and sockeye salmon, as well as Dolly Varden *Salvelinus malma*, and steelhead *O. mykiss*, are present in area streams. Streams were selected for monitoring based on consultations with local residents, documented presence of coho salmon from previous surveys (Pappas et al. 2001), and documented use by Perryville residents for subsistence harvest (Hutchinson-Scarbrough and Fall 1999). Streams chosen for coho salmon surveys included (ADFG stream numbers in parentheses; ADFG 1997b): Smoky Hollow Creek (275-40-10200), Ivanof River (275-40-10600), Red Bluff Creek (273-70-10200), Ivan River (273-72-10200), and an unnamed river in Humpback Bay (275-50-10200; Figure 1). Clark River (271-10-10310-2021) was also included in the survey since it was the site of a nearby monitoring project for which walking surveys had proven to be unfeasible (Anderson 2004b). Since 2004, Artemie's Creek (275-60-10000-2005), Three Star River (275-60-10050), Spring Creek (no ADFG number), Cross Creek Slough (no ADFG number), and portions of the Kametolook River (275-60-10100) have been included in the surveys (Figure 2). Prior monitoring in these streams had been accomplished using walking surveys in 2002 and 2003 (Anderson and Hetrick 2004).

Methods

Aerial surveys were conducted using low-level helicopter flights. During counts, the pilot maintained the slowest airspeed possible at an altitude ranging from 15 to 50 m above the streambed, depending on the terrain and vegetation. When necessary, the aircraft hovered over large schools of fish and schools with mixed species to assist with counting. Complete circuits of the study areas were completed either moving upstream from the mouth or moving downstream from the headwaters. Direction of the surveys (upstream or downstream) was dictated by local wind and visibility conditions. Surveys were conducted between 10:00 and

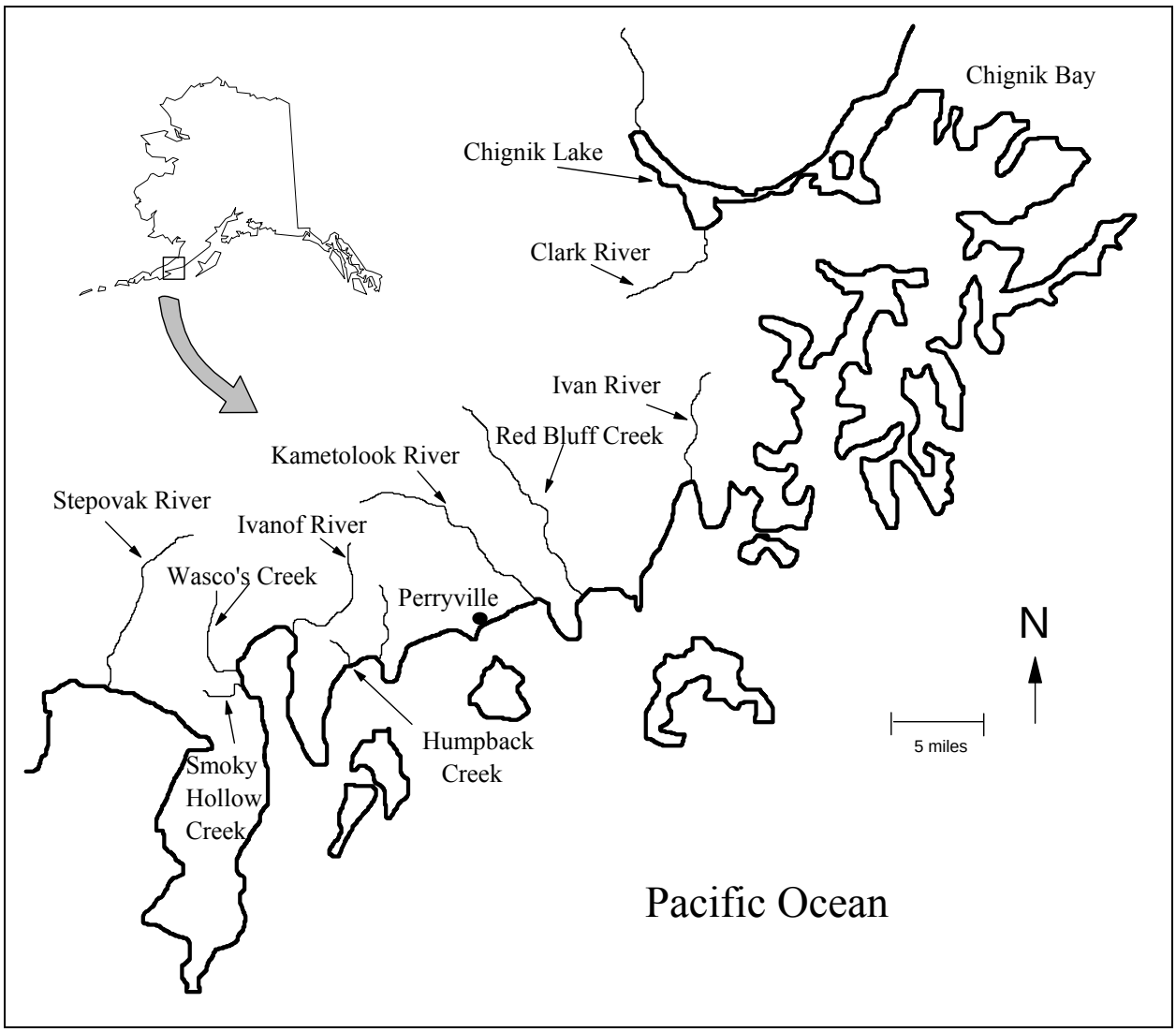

Figure 1. Location of streams in the Perryville area, Alaska Peninsula National Wildlife Refuge.

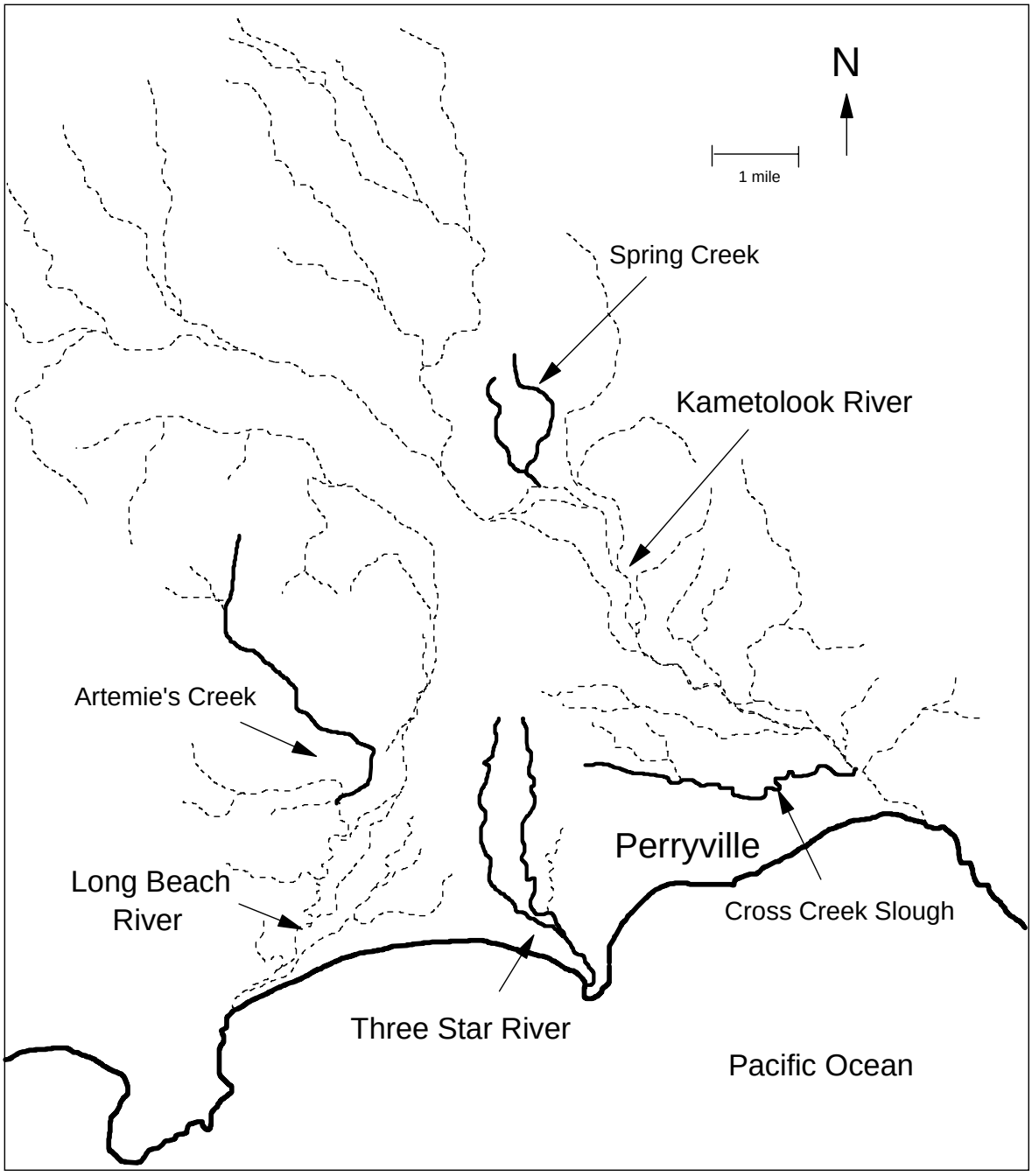

Figure 2. Perryville survey area, Alaska Peninsula National Wildlife Refuge. Streams shown with dashed lines were not surveyed.

15:00 hours to increase the likelihood of direct overhead sunlight, and polarized sunglasses were worn to reduce glare. Starting and stopping points for each stream survey reach were marked on topographic maps and latitude and longitude coordinates of the upstream extent of surveys were recorded with a global positioning system. During each aerial survey, total numbers of coho and sockeye salmon and other species observed were recorded for each reach. Lighting conditions (sun, partial overcast, overcast), water clarity (excellent, good, poor), and wind-generated surface turbulence (calm, moderate, rough) were qualitatively estimated for each reach. Locations of large areas of coho and sockeye salmon spawning activity, and large congregations of migrating or staging coho and sockeye salmon were noted, as were locations and numbers of active fishermen.

Two stream surveys were planned, one in mid September and one in early October, and were scheduled based on weather forecasts, local stream conditions, and pilot availability. Flights were coordinated to avoid periods of turbid flow and inclement weather. The first survey was completed during 14 and 15 September and the second survey was completed during 9 and 10 October 2007. Due to logistic constraints (fuel range and available funding), entire watersheds were not surveyed. Generally, mainstem rivers and major tributary streams were surveyed until they began branching into numerous small tributaries, or until the vegetation canopy limited the ability of observers to count fish. Where practical, the stream reach delineations developed during the 2003 surveys were used in 2007. Survey reaches are assumed to provide an index of the total escapement; however, this assumption is largely untested and the scaling factor unknown for coho salmon. Our assumption is that periodic aerial counts will provide a minimum index of coho and sockeye salmon escapement that reflect gross levels of abundance.

The mainstem Ivanof River and its major tributary were surveyed until the canopy limited our ability to see the stream (Figure 3). The October survey on the major tributary to Ivanof River was only completed on the lower 500 m to avoid conflicts with sport hunters targeting brown bear *Ursus arctos* in the drainage. Smoky Hollow Creek (Figure 3) was surveyed until the canopy limited visibility, and the unnamed river in Humpback Bay (Figure 3) was surveyed until the main stream split into two small tributaries. Artemie's Creek and Cross Creek Slough (Figure 2) were surveyed until overhead vegetation limited our ability to see the streams during both surveys. The entire Spring Creek system was surveyed on both occasions (Figure 2). We were not able to survey the mainstem Three Star River on the first flight or the Kametolook River on either flight because of turbid glacial run-off; visibility prohibited counting fish. The eastern fork of the Three Star River was surveyed until it the canopy limited visibility, and the mainstem Three Star River was surveyed until it branched into small tributary streams on the second flight (Figure 2). Only the upper mainstem of Red Bluff Creek was surveyed until the canopy enclosed the stream on both occasions (Figure 4). The major tributary to Red Bluff Creek had captured turbid glacial water, which also caused the lower mainstem to be too turbid to survey during the September flight. Red Bluff Creek and its major tributary were surveyed until the canopy limited our ability to count fish during the October flight. The mainstem Ivan River (Figure 5) was surveyed until it became a series of braided, intermittent channels during both surveys, although the lower mainstem river was turbid in deep pools during the first flight because of glacial run-off. The mainstem Clark River (Figure 6) was surveyed until it branched into two smaller tributary streams during both surveys.

We used simple linear regression to examine the relationship between peak aerial survey counts of sockeye salmon in Clark River and escapement of late run sockeye salmon past the Chignik River weir from 2003 to 2007. Chignik River late run sockeye salmon escapement estimates

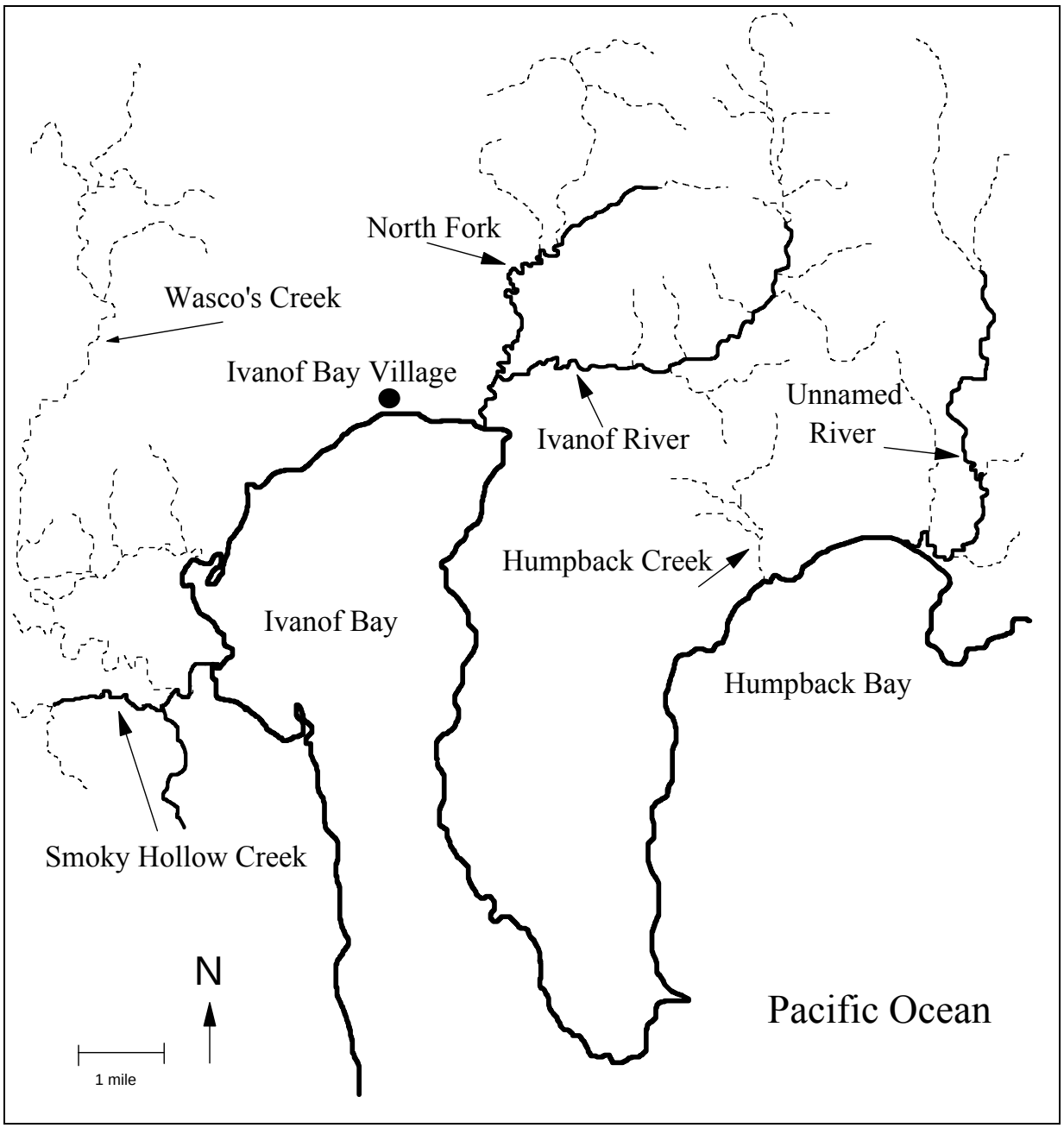

Figure 3. Ivanof and Humpback Bay survey areas, Alaska Peninsula National Wildlife Refuge. Streams shown with dashed lines were not surveyed.

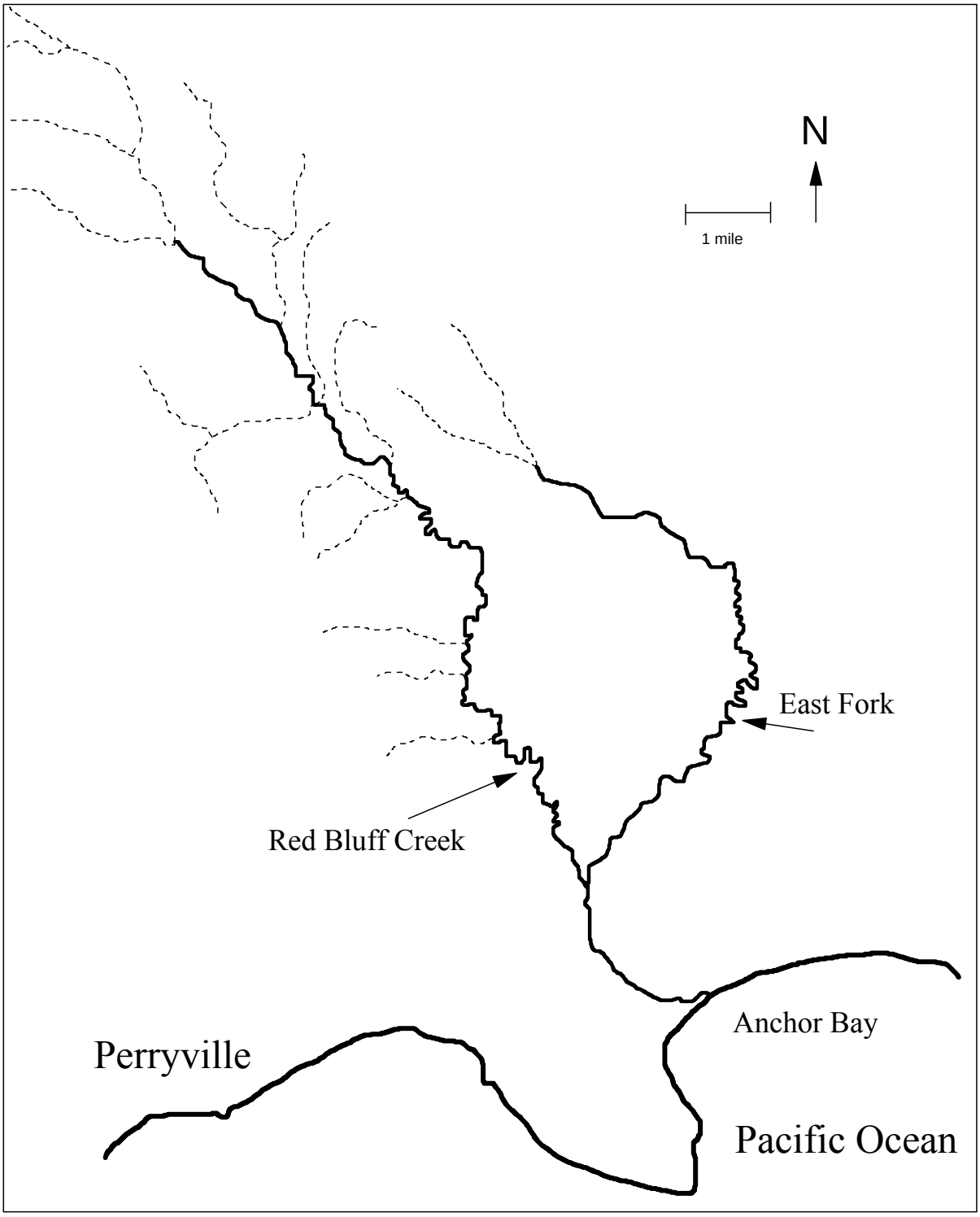

Figure 4. Red Bluff Creek survey area, Alaska Peninsula National Wildlife Refuge. Streams shown with dashed lines were not surveyed.

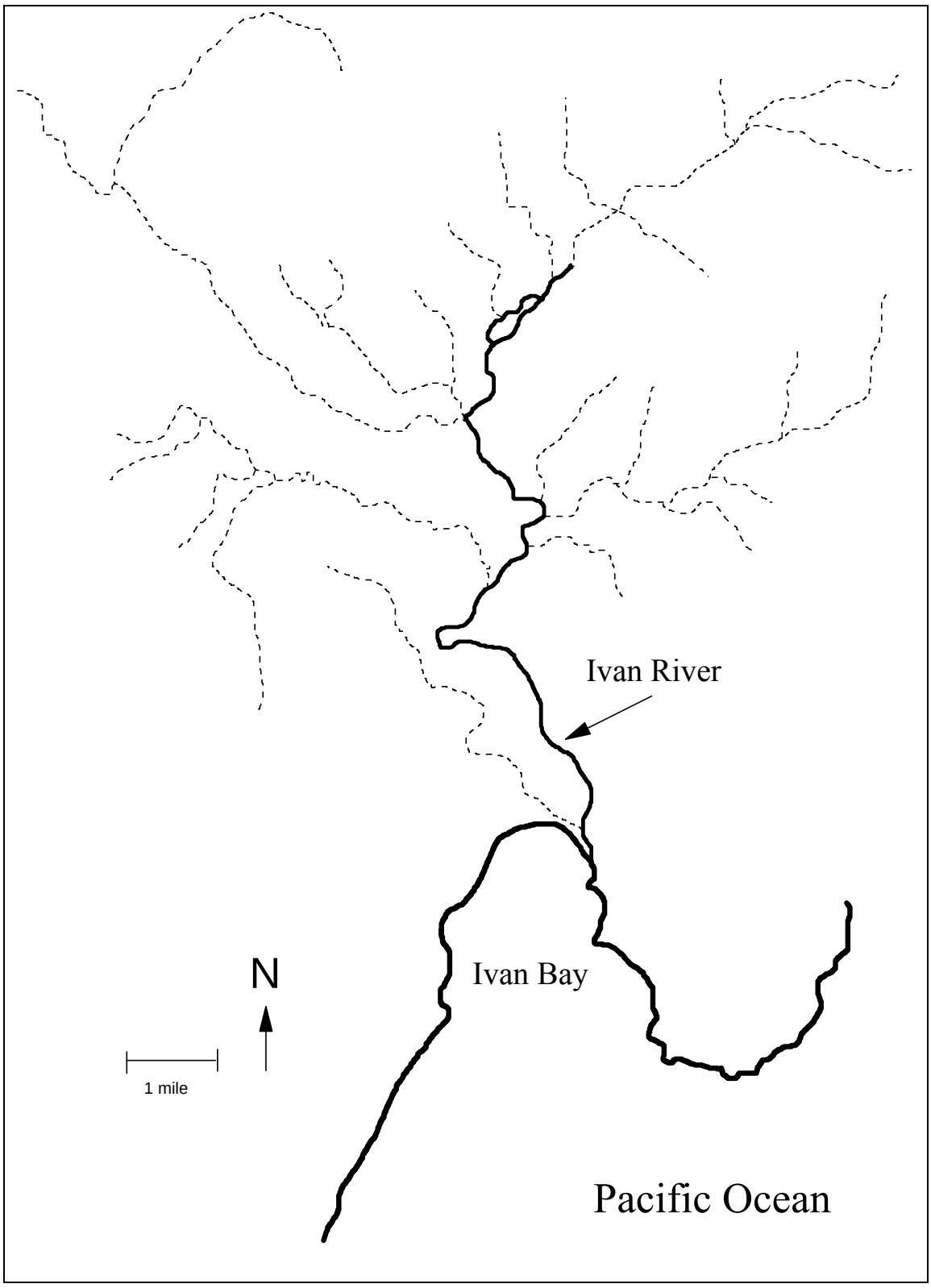

Figure 5. Ivan River survey area, Alaska Peninsula National Wildlife Refuge. Streams shown with dashed lines were not surveyed.

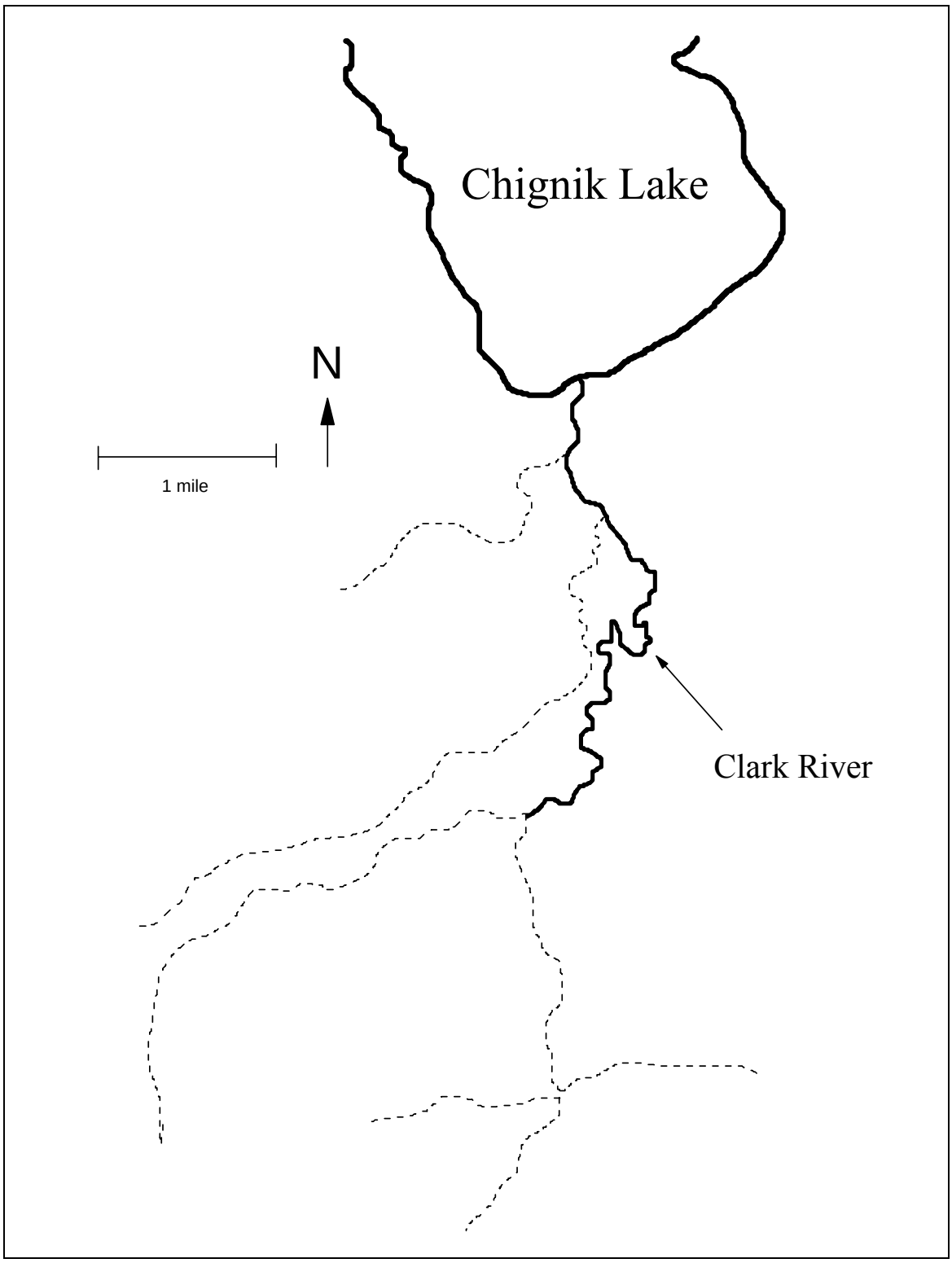

Figure 6. Clark River survey area, Alaska Peninsula National Wildlife Refuge. Streams shown with dashed lines were not surveyed.

past the Chignik River weir for 2003 to 2007 are from Stichert (2007). Results were considered significant at $P \leq 0.05$.

Results

Coho salmon were not present in most streams during the aerial survey in September but were the most abundant species counted during the October survey (Table 1). Most coho salmon were observed in large pods in mainstem rivers during the October survey, and little spawning activity was observed. Pink salmon were the most abundant species observed during the aerial survey in September and were absent from most streams by early October (Table 1). Pink and chum salmon were actively spawning in most systems during the September survey; less than 200 chum salmon were observed among all streams. More coho salmon were observed in Ivanof River than in other systems, and more sockeye salmon were observed in Clark River than in other systems. Most sockeye salmon were actively spawning in the upper half of the Clark River during the September survey, but most fish were holding in large groups in the lower river in October. Although we looked for fishing activity in and around the study streams, no fishermen were observed during either flight.

With few exceptions, surveys were conducted when lighting, water clarity, and surface turbulence allowed for good visibility of fish in the streams. Turbid glacial runoff from Mount Veniaminof prevented us from counting fish in the lower portions of Artemie's Creek and the mainstem Kametolook River during both surveys in 2007. The mainstem Three Star River, the eastern tributary to Red Bluff Creek, and the lower mainstem Ivan River were also affected by glacial runoff during the survey in September although a count was still completed on Ivan River. In contrast to all previous years, both surveys were completed as scheduled and were not postponed because of weather conditions, stream conditions, or pilot availability.

Observed abundance of coho salmon in study streams has been variable (Table 2). Peak counts in the unnamed river in Humpback Bay have been the least variable, ranging from 760 to 1,120, while peak counts in Red Bluff Creek have been the most variable ranging from 880 to 7,600 (Table 2).

A significant relationship was found between peak aerial survey counts of sockeye salmon in Clark River and escapement of late run sockeye salmon past the Chignik River weir from 2003 to 2007 ($r^2 = 0.79$; $F_{(1,3)} = 16.17$; $P = 0.028$; Figure 7).

Discussion

Coho salmon may have been present in smaller tributary streams that were not surveyed but this is unlikely based on run timing observed in 2007. It is not likely that coho salmon were present in smaller tributary streams during the first survey because few were counted in any of the mainstem streams. Most coho salmon observed during the second survey were in pods in mainstem rivers and were not actively spawning. Although coho salmon often spawn in smaller tributary streams (Sandercock 1991), our counts in mainstem rivers and major tributary streams in 2007 probably accounted for most fish present. However, because entire drainages were not surveyed and count intervals were not adequate for expansion to area-under-the-curve estimates, surveys should be considered gross indices of coho salmon abundance for a given stream reach and survey period, and not estimates of total abundance.

Table 1. Numbers of coho (CO), sockeye (SE), and pink (PK) salmon observed during aerial surveys of streams near Perryville, 2007. A plus sign (+) after a count indicates survey was not complete and data represent partial counts.

Stream	15-16 September Survey			9-10 October Survey		
	CO	SE	PK	CO	SE	PK
Smokey Hollow Creek	0	0	3,240	130	0	0
Ivanof River	0	0	25,070	3,703+	0+	0+
Unnamed River, Humpback Bay	250	0	1,040	1,080	0	0
Artemie's Creek (Long Beach)	0	0	140	22	2	0
Three Star River	0+	0+	790+	6	0	0
Spring Creek System (Kametolook)	0	28	1,270	56	5	0
Kametolook River	0+	0+	0+	0+	0+	0+
Cross Creek Slough	0	2	90	6	0	0
Red Bluff Creek	0+	20+	5,200+	880	0	0
Ivan River	0	8	9,350	1,400	5	4
Clark River	0	10,100	0	0	4,200	0

Table 2. Salmon counts for Perryville area streams surveyed from 2003 to 2007. Count data for years prior to 2007 are from Anderson (2004; 2005a; 2005b; 2006). Dashes (--) indicate stream was not surveyed. A plus sign (+) after a count indicates survey was not complete due to poor water clarity.

	2003		2004		2005		2006		2007	
Stream	11 Oct	22 Nov	6 Oct	7 Nov	8 Oct	26 Oct	21 Sep	18 Oct	16 Sep	10 Oct
					coho salmon					
Smoky Hollow Creek	--	--	300+	140	54	147	100	470	0	130
Ivanof River	2,600	314	1,300	330	766	1,170	1,490	3,305	0	3,703[a]
Unnamed river, Humpback Bay	1,120	14	1,040	46	82	207	460	760	250	1,080
Kametolook System[b]	--	--	22+	96	12+	516	40+	72+	0+	62+
Red Bluff Creek	5,000	330+	7,600	836	352	2,482	40+	270+	0+	880
Ivan River	2,150	217	1,840	290	507	170	80	0+	0	1,400
					sockeye salmon					
Clark River	6,100	9,700	5,890	3,240	3,520	4,100	11,230	2,500+	10,100	4,200

[a] Partial count due to presence of hunters.
[b] Mainstem Kametolook River only surveyed on 7 Nov. 2004 and 26 Oct. 2005 due to poor water clarity on other dates. Counts include Spring Creek and Cross Creek Slough.

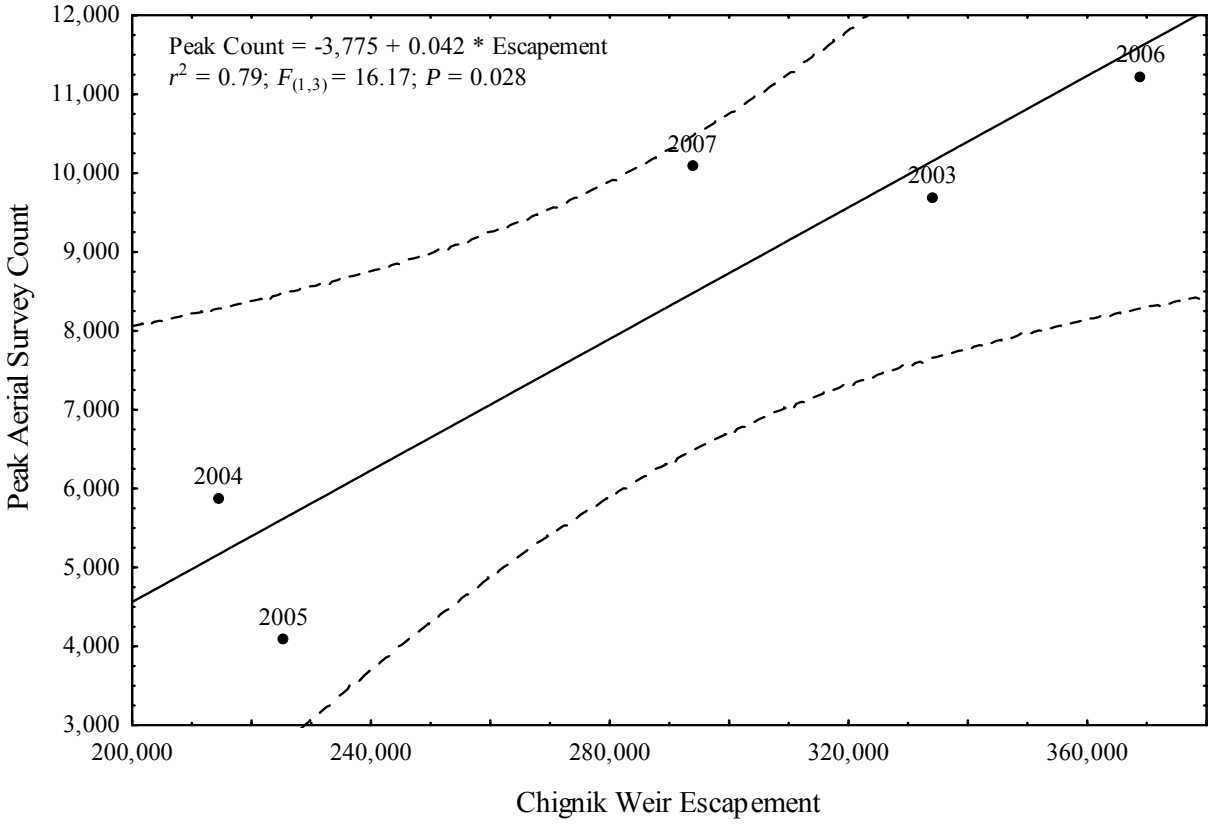

Figure 7. Relationship between peak aerial survey counts of sockeye salmon in Clark River and escapement of late run sockeye salmon past the Chignik River weir. Dashed line represents 95% prediction interval. ADFG data for 2003 to 2007 are from Stickert (2007).

The interval between our surveys in 2007 was about three weeks. It is possible that some coho salmon entered the systems, spawned, and died between our two surveys, but what is more likely is that coho salmon entered the systems after our last survey on 9-10 October. Perrin and Irvine (1990) report an average survey life for coho salmon of 11.4 days for the Pacific Northwest and Alaska. Hetrick and Nemeth (2003) determined an average stream life for coho salmon of 13.7 days for coho salmon in a small stream on the Alaska Peninsula during October and November. Both estimates suggest that coho salmon may have entered, spawned, and died within surveyed streams without having been observed. Survey life for Pacific salmon can vary among and within streams and years (Perrin and Irvine 1990; Bue et al. 1998), and we intentionally scheduled the three week interval this year to gain more insight into early run timing; our surveys occurred earlier in 2007 compared to other years and our first survey was completed before coho salmon entered most survey streams.

Water conditions affected the aerial surveys in 2007, although not as much as some previous years. Glacial run-off from Mount Veniaminof near Perryville had captured the mainstem Three Star River, the lower portions of Artemie's Creek, and the Kametolook River during the September survey, but had cleared in the mainstem Three Star River during our second survey. This was the second year in a row that we were unable to count fish in the mainstem Kametolook River during our second survey, but surveys in 2006 and 2007 were completed by mid October before cold weather had moderated the glacial runoff. Turbid glacial water from an unnamed

braided river to the east of Anchor Bay had captured the major tributary to Red Bluff Creek and also affected visibility in the lower mainstem of Red Bluff Creek, but had cleared by our second survey on 9 October.

Coho salmon run timing for our survey streams appears to be consistent between years and among streams, with counts in early to mid October representing peak numbers in most streams (Figure 8). The exception to this generalization was 2005, when few coho salmon were observed in any stream on the 7 – 8 October survey. Future surveys scheduled from early to mid October should capture a peak count in most streams in a given year. However, surveys during this period may prevent us from counting fish in the mainstem Kametolook River, Three Star River, and parts of Red Bluff Creek because glacial runoff may still influence water clarity at this time of year.

Observed abundance of coho salmon in study streams has been variable between 2003 and 2007. The first two years of surveys produced consistent peak counts in Red Bluff Creek and Ivan River, but counts in 2005 and 2006 were considerably less (Table 2). Survey timing in 2005 probably missed the peak runs in both systems (Anderson 2005b), and water conditions prevented us from getting good counts in either stream in 2006 (Anderson 2006). Survey timing in 2005 did not capture peak numbers in other survey streams (Anderson 2005b). Peak annual counts in the unnamed river in Humpback Bay have been the least variable, ranging from 760 to 1,120 Table 2).

Although our observed count for Red Bluff Creek in 2007 was low and we have been unable to get peak counts in all streams in all years, there are no indications that coho salmon populations in study streams are declining. Coho salmon harvests by the commercial fishery in the area have been very low in recent years (Stichert 2007), and probably have little effect on these populations. Reports from local residents also indicate that coho salmon abundance in area streams has been sufficient to meet subsistence needs in recent years. Strong returns again this year in Ivanof River, Ivan River, and the unnamed river in Humpback Bay suggest that 2007 was probably a good return year for coho salmon in most other area streams.

No trends in run timing or abundance are evident from sockeye salmon count data in Clark River from 2003 to 2007 (Table 2; Figure 9). Peak counts in 2003, 2006, and 2007 were well above numbers observed in other years. Peak sockeye salmon counts have been observed both early and late in the fall and have been less variable than our counts of coho salmon in other area streams (Table 2). Escapement of late run sockeye salmon past the Chignik River weir over the same period ranged from about 215,000 in 2004 to nearly 370,000 in 2006 (Stichert 2007). As in 2006, the relationship between our peak aerial survey counts in Clark River and escapement of late run fish past the Chignik River weir was significant (Figure 7). Regardless of significance, fish observed spawning during our mid September survey in 2007 passed through the Chignik River in August and early September while the weir was operational. Previous work using radio telemetry also found sockeye salmon that spawn in Clark River migrated past the Chignik River weir in late August and early September (Anderson 2003; 2005c). However, many sockeye salmon spawn in Clark River from November through January in most years and these fish likely pass through the Chignik River after the weir is removed in early September (Anderson 2003). Reports from local residents indicate that late run sockeye salmon abundance has been sufficient to meet subsistence needs in recent years.

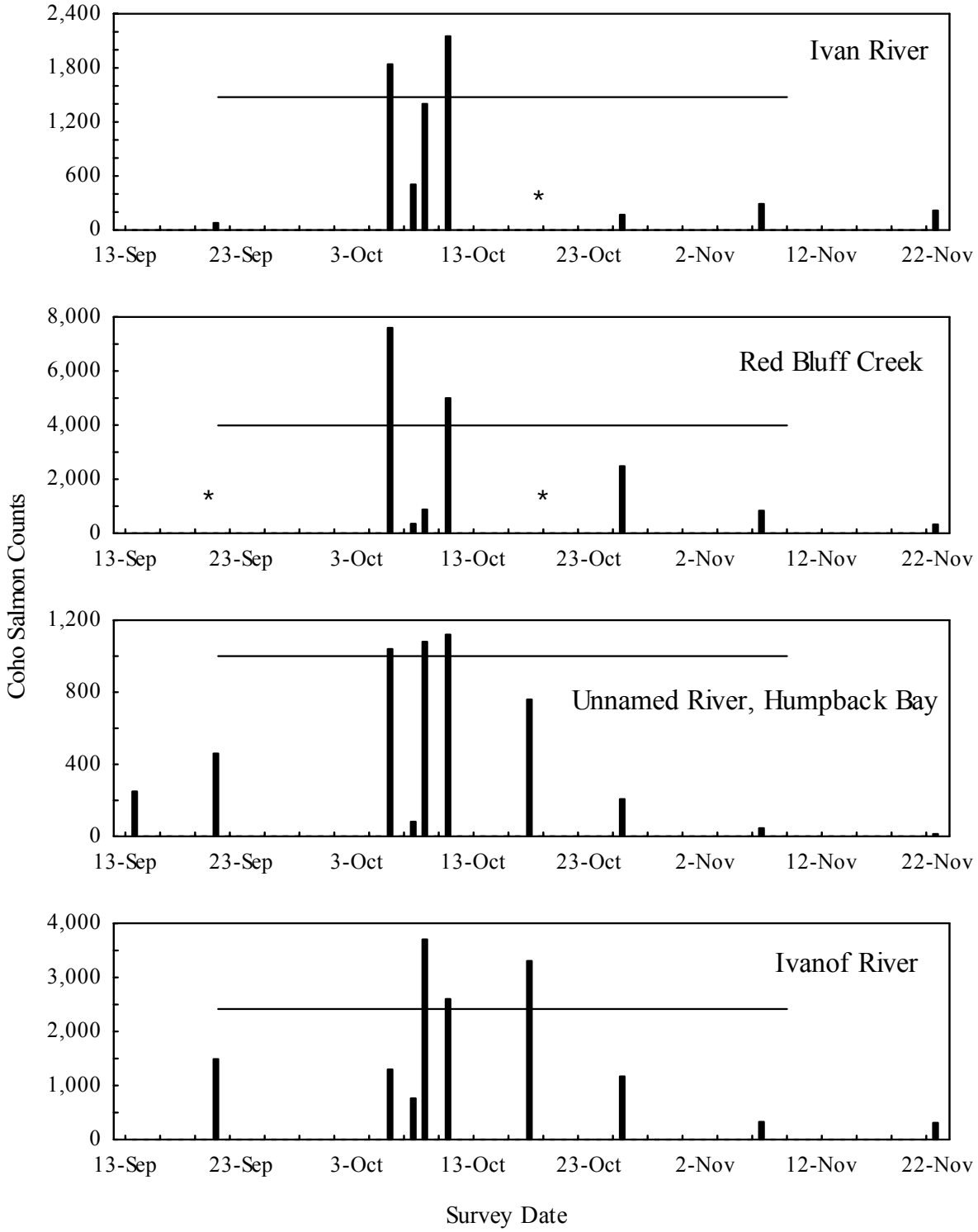

Figure 8. Peak coho salmon counts from 2003 to 2007 in survey streams with the highest counts. Horizontal lines are means of peak annual counts. An asterisk (*) indicates incomplete count data.

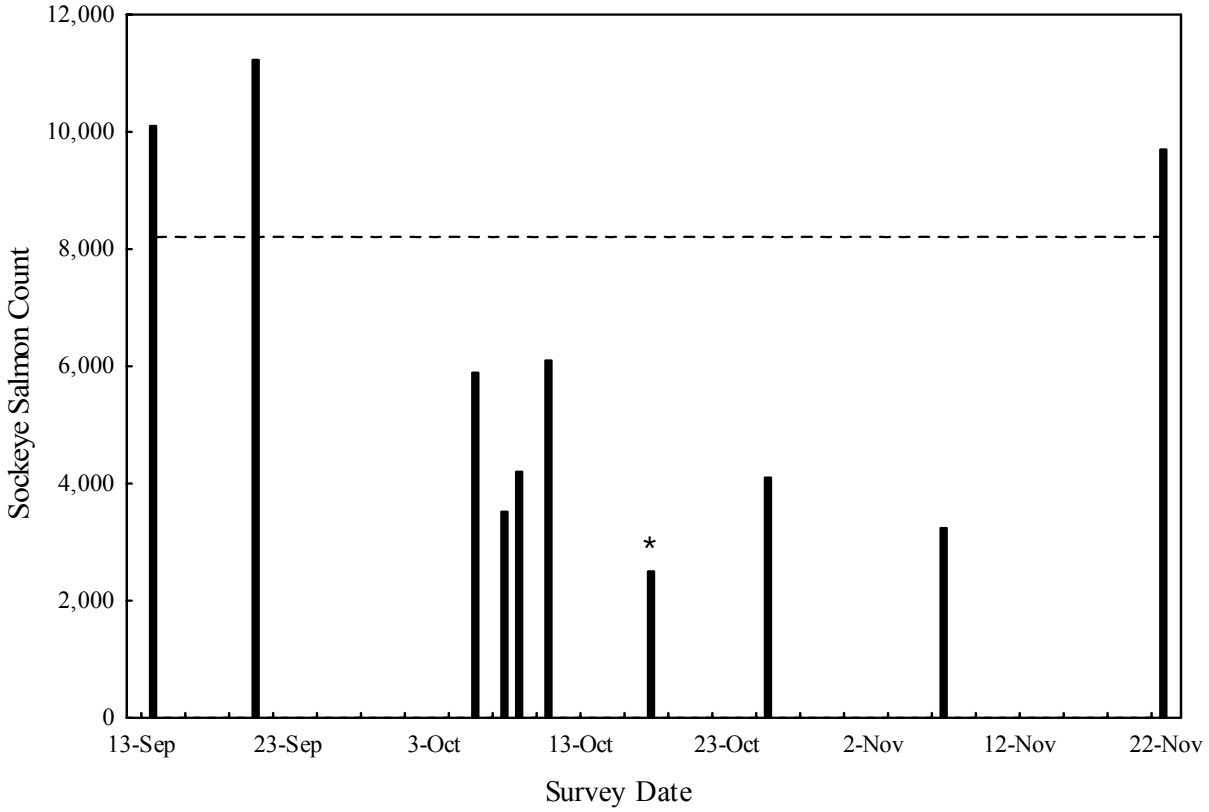

Figure 9. Peak counts from 2003 to 2007 for sockeye salmon in Clark River. Horizontal line is the mean of peak annual counts. An asterisk (*) indicates incomplete count data.

Although not a total spawning escapement estimate, aerial survey counts can provide valuable information for area managers. The fundamental assumption is that these are index counts that represent a constant proportion of the actual counts across time. In general, the usefulness of any population survey depends upon obtaining unbiased, or nearly unbiased, and precise parameter estimates in a cost-efficient, logistically feasible manner (Thompson et al. 1998). Due to frequent inclement weather, high water events, and the inaccessibility of most of these streams, getting accurate and precise estimates of coho salmon escapement would be logistically difficult and expensive to obtain with other commonly used methods and equipment such as weirs, counting towers, sonar, and mark-recapture experiments. Walking surveys, which are subject to the same problems and limitations as aerial surveys, have not been effective in this area (Anderson 2003; Anderson 2004b; Anderson and Hetrick 2004).

We recommend continuing the aerial surveys for most streams. This project provides managers with the only information available for coho salmon spawning populations in streams near Perryville and sockeye salmon in Clark River, including minimum numbers and migration timing. As we continue to gather data, trends in run timing and abundance are becoming apparent for some streams. Monitoring in future years should be scheduled from late September to mid October to coincide with peak staging and migration timing of coho salmon observed to date, although stream and weather conditions will continue to strongly influence the effectiveness of these surveys.

However, aerial surveys are not practical nor are they providing useful information about coho salmon runs in the Kametolook River. We have only been able to get an adequate count of the mainstem Kametolook River in one year (2005) out of four attempts. In two years (2006 and 2007), the river was still too turbid from glacial runoff to count fish. Our 2004 surveys had just missed the peak abundance based on reports of local residents (Anderson 2005a). Modifying the survey timing to early November should minimize glacial influence in most years, but would be too late for getting a peak count in other area streams and might be too late to count fish in the Kametolook River in some years. We recommend a project using local residents to conduct visual counts with ground surveys of the Kametolook River throughout the coho salmon run as the best alternative, although this technique was not practical in 2002 and 2003 because of weather and stream conditions (Anderson and Hetrick 2004).

Acknowledgements

The Office of Subsistence Management provided funding support through the Fisheries Resource Monitoring Program, as Project Number FIS 05-405, and this report serves as the Annual Project Report. Egli Air Haul provided flight service; the City of Chignik and Trident Seafood assisted with logistical support. Residents of the Native Village of Perryville provided information on local weather and stream conditions.

References

ADFG (Alaska Department of Fish and Game). 1997a. Kametolook River coho salmon restoration project, Environmental Assessment. Alaska Department of Fish and Game, Habitat and Restoration Division, Anchorage, Alaska.

ADFG (Alaska Department of Fish and Game). 1997b. Catalog of waters important for spawning, rearing or migration of anadromous fishes. Alaska Department of Fish and Game, Habitat and Restoration Division, Anchorage, Alaska.

ADFG (Alaska Department of Fish and Game). 2002. Customary and traditional use worksheet salmon: Chignik Management Area. Report to the Alaska Board of Fisheries. Alaska Department of Fish and Game, Division of Subsistence, Anchorage, Alaska.

Anderson, J. L. 2003. Estimation of late run sockeye and coho salmon escapement in the Clark River, a tributary to Chignik Lake, Alaska Peninsula National Wildlife Refuge, 2002. U. S. Fish and Wildlife Service, King Salmon Fish and Wildlife Field Office, Alaska Fisheries Technical Report Number 64, King Salmon, Alaska.

Anderson, J. L. 2004a. Estimation of coho salmon escapement in streams adjacent to Perryville, Alaska Peninsula National Wildlife Refuge, 2003. U. S. Fish and Wildlife Service, King Salmon Fish and Wildlife Field Office, Alaska Fisheries Data Series Report Number 2004-2, King Salmon, Alaska.

Anderson, J. L. 2004b. Estimation of late run sockeye and coho salmon escapement in the Clark River, a tributary to Chignik Lake, Alaska Peninsula National Wildlife Refuge, 2003. U. S. Fish and Wildlife Service, King Salmon Fish and Wildlife Field Office, Alaska Fisheries Data Series Report Number 2004-3, King Salmon, Alaska.

Anderson, J. L. 2005a. Estimation of coho salmon escapement in streams adjacent to Perryville, Alaska Peninsula National Wildlife Refuge, 2004. U. S. Fish and Wildlife Service, King Salmon Fish and Wildlife Field Office, Alaska Fisheries Data Series Report Number 2005-3, King Salmon, Alaska.

Anderson, J. L. 2005b. Estimation of coho salmon escapement in streams adjacent to Perryville, Alaska Peninsula National Wildlife Refuge, 2005. U. S. Fish and Wildlife Service, King Salmon Fish and Wildlife Field Office, Alaska Fisheries Data Series Report Number 2005-17, King Salmon, Alaska.

Anderson, J. L. 2005c. Estimation of late run sockeye salmon spawning distribution in the Chignik River watershed, 2004. U. S. Fish and Wildlife Service, King Salmon Fish and Wildlife Field Office, Alaska Fisheries Technical Report Number 79, King Salmon, Alaska.

Anderson, J. L. 2006. Estimation of coho salmon escapement in streams adjacent to Perryville and sockeye salmon escapement in Chignik Lake tributaries, Alaska Peninsula National Wildlife Refuge, 2006. U. S. Fish and Wildlife Service, King Salmon Fish and Wildlife Field Office, Alaska Fisheries Data Series Report Number 2006-15, King Salmon, Alaska.

Anderson, J. L., and N. J. Hetrick. 2004. Carrying capacity of habitats used seasonally by coho salmon in the Kametolook River, Alaska Peninsula National Wildlife Refuge, 2002-2003. U. S. Fish and Wildlife Service, King Salmon Fish and Wildlife Field Office, Alaska Fisheries Technical Report Number 73, King Salmon, Alaska.

Bue, B. G., S. M. Fried, S. Sharr, D. G. Sharps, J. A. Wilcock, and H. J. Geiger. 1998. Estimating salmon escapement using area-under-the-curve, aerial observer efficiency, and stream-life estimates: the Prince William Sound pink salmon example. North Pacific Anadromous Fish Commission Bulletin 1:240-250.

Hetrick, N. J., and M. J. Nemeth. 2003. Survey of coho salmon runs on the Pacific Coast of the Alaska Peninsula and Becharof National Wildlife Refuges, 1994 with estimates of escapement for two small streams in 1995 and 1996. U. S. Fish and Wildlife Service, King Salmon Fish and Wildlife Field Office, Alaska Fisheries Technical Report 63, King Salmon, Alaska.

Hutchinson-Scarbrough, L., and J. A. Fall. 1993. An overview of subsistence salmon and other finfish fisheries of the Chignik Management Area, Alaska Peninsula, Southwest Alaska. Alaska Department of Fish and Game, Subsistence Division, Report prepared for the Alaska Board of Fisheries, Kodiak, Alaska.

Hutchinson-Scarbrough, L., and J. A. Fall. 1999. Interim progress report: Supplemental information on subsistence uses of salmon in the Chignik Management Area by the residents of Perryville, Southwest Alaska. Alaska Department of Fish and Game, Division of Subsistence, Report to the Alaska Board of Fisheries, Fairbanks, Alaska.

Pappas, G. E., R. T. Baer, and M. A. LaCroix. 2001. Chignik Management Area annual finfish management report, 1999. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 4K01-49, Kodiak, Alaska.

Pappas, G. E., M. J. Daigneault, and M. LaCroix. 2003. Chignik Management Area annual finfish management report, 2000. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 4K03-62, Kodiak, Alaska.

Perrin, C. J., and J. R. Irvine. 1990. A review of survey life estimates as they apply to the area-under-the-curve method for estimating the spawning escapement of Pacific salmon. Canadian Technical Report of Fisheries and Aquatic Sciences No. 1733.

Sandercock, F. K. 1991. Life history of coho salmon (*Oncorhynchus kisutch*). Pages 395-446 *in* C. Groot and L. Margolis, editors. Pacific salmon life histories. University of British Columbia Press, Vancouver, British Columbia.

Stichert, M. 2007. Chignik management area 2007 commercial salmon fishery summary. Alaska Department of Fish and Game, Division of Commercial Fisheries, Kodiak, Alaska.

Thompson, W. L., G. C. White, and C. Gowan. 1998. Monitoring vertebrate populations. Academic Press, San Diego, California.