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, 2003-2008

Alaska Fisheries Data Series Number 2009–6

Anchorage Fish and Wildlife Field Office
Anchorage, Alaska
May 2009

The Alaska Region Fisheries Program of the U.S. Fish and Wildlife Service conducts fisheries monitoring and population assessment studies throughout many areas of Alaska. Dedicated professional staff located in Anchorage, Juneau, Fairbanks, and Kenai Fish and Wildlife Offices and the Anchorage Conservation Genetics Laboratory serve as the core of the Program's fisheries management study efforts. Administrative and technical support is provided by staff in the Anchorage Regional Office. Our program works closely with the Alaska Department of Fish and Game and other partners to conserve and restore Alaska's fish populations and aquatic habitats. Additional information about the Fisheries Program and work conducted by our field offices can be obtained at:

http://alaska.fws.gov/fisheries/index.htm

The Alaska Region Fisheries Program reports its study findings through two regional publication series. The **Alaska Fisheries Data Series** was established to provide timely dissemination of data to local managers and for inclusion in agency databases. The **Alaska Fisheries Technical Reports** publishes scientific findings from single and multi-year studies that have undergone more extensive peer review and statistical testing. Additionally, some study results are published in a variety of professional fisheries journals.

Disclaimer: The use of trade names of commercial products in this report does not constitute endorsement or recommendation for use by the federal government.

Alaska Fisheries Data Series Number 2009-6, May 2009
U. S. Fish and 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, 2003-2008

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, managers 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 needs to be monitored. Monitoring of sockeye salmon *O. nerka* 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 2008, 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 and run timing of coho salmon in 2008 were similar to previous years. Sockeye salmon counts in the Clark River were lower in 2008 than in previous years. Local water conditions prevented us from obtaining complete counts in some streams. Coho salmon returns to streams near Perryville and late run sockeye salmon returns to the Clark River have been sufficient to meet subsistence needs while maintaining population levels in recent years. Given current levels of harvest and escapement, we do not recommend continuing this project. However, changes in commercial or subsistence harvest patterns can threaten the viability of local stocks.

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) (ADF&G 2002). Returns of coho salmon in the Kametolook, Three Star, and Long Beach rivers in the 1990's declined, with escapement estimated at about 200 fish in 1996 (ADF&G 1997). Several reasons for the decline of coho salmon stocks in the Kametolook River watershed were 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 prompted 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 (ADF&G) 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 (ADF&G 1997).

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

Author: The author is a fishery biologist with the U. S. Fish and Wildlife Service and can be contacted at Anchorage Fish and Wildlife Field Office, 605 W. 4th Ave., Anchorage, AK 99501; or jeffry_anderson@fws.gov.

vicinity of Perryville. In many ways, these streams are similar to streams near Perryville in that they are short streams with limited coho salmon abundance. With fishing effort spread out to other streams, managers 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. The annual coho salmon subsistence harvest in the Perryville subarea has shown a decreasing trend in recent years, from a high of 1,931 coho salmon in 2003 to a low of 1,184 coho salmon in 2007 (mean: 1,489 coho salmon; ADF&G 2008).

Sockeye salmon *O. nerka* in the Chignik River watershed is an important species for commercial and subsistence harvest. However, subsistence fishers in the Chignik area have reported difficulty harvesting enough late run fish and are concerned that the runs have declined (BBNA 2004). State subsistence regulations were changed to provide more opportunities for subsistence fishers to harvest sockeye salmon by allowing commercial fishers to participate in subsistence fisheries and subsistence fishers to harvest sockeye salmon in the Chignik River prior to 1 July (Stichert 2008). The ADF&G also increased escapement objectives that allow an additional 25,000 sockeye salmon past the weir in August and 25,000 in September to provide additional late season subsistence opportunities (Stichert 2008). These regulatory changes appear to be effective, and it appears that subsistence needs are once again being met. Subsistence harvests from Chignik Lake were 3,143 sockeye salmon in 2003, dropped to 1,789 in 2004, and then continually increased each year to 2,528 by 2007 (2003-2007 mean: 2,336 sockeye salmon; ADF&G 2008). Managers must continue to monitor sockeye salmon escapements and harvests in the Chignik River watershed to ensure that this trend continues.

The ADF&G 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 because of frequent inclement weather (Finkle and Vining 2009). Escapement information is needed for effective in-season and post-season management of these stocks. The objectives of this project have been to estimate minimum numbers of coho salmon returning to streams near the village of Perryville and estimate minimum numbers of late run sockeye salmon returning to the Clark River, a tributary to Chignik Lake. The run timing of coho and late run sockeye salmon in the Chignik River watershed 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 River watershed (Clark River) since 2003. Anderson (2004a; 2005a; 2005b; 2006; 2007) presents results from the first five years of monitoring. This report summarizes the sixth year of survey data and presents a synthesis of results over all years.

Study Area

The Perryville and Chignik 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 (ADF&G stream numbers in parentheses; Johnson and Weiss 2007): 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

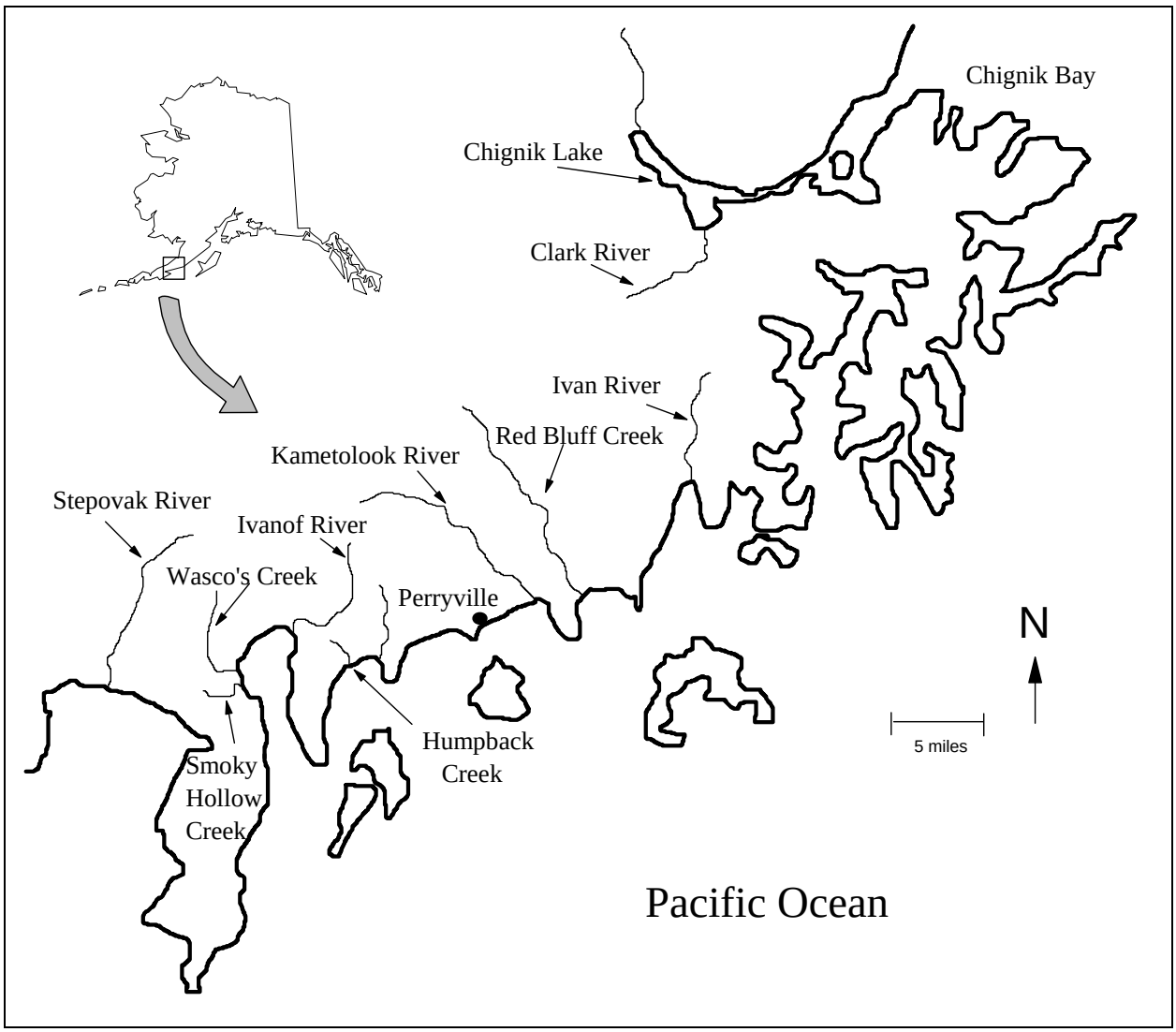

Figure 1. Location of streams in the Perryville area, Alaska Peninsula National Wildlife Refuge.

river in Humpback Bay (275-50-10200; Figure 1). Clark River (271-10-10310-2021; Figure 1) was also included in the survey since it was the site of a nearby monitoring project where walking surveys proved to be unsuccessful (Anderson 2004b). Since 2004, Artemie's Creek (275-60-10000-2005), Three Star River (275-60-10050), Spring Creek (no ADF&G stream number), Cross Creek Slough (no ADF&G stream 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 in all years. The same observer has conducted all surveys since 2003 and the same pilot has flown all but one survey since 2003. During counts, the pilot maintained the slowest necessary airspeed at an altitude ranging from 15 to 50 m above the streambed depending on terrain and vegetation. The aircraft hovered over large schools of fish and schools with mixed species to assist with counting when necessary. Some reaches were flown more than once to verify numbers or species. Complete circuits of the study areas were surveyed 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 15:00 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 aggregations of migrating or staging salmon were noted, as were locations and numbers of active fishermen.

Two stream surveys were planned, one in late September and one in early October as recommended by Anderson (2007). Surveys were scheduled based on weather forecasts, local stream conditions, and pilot availability. Flights were coordinated to avoid periods of turbid stream flow and inclement weather. The first survey was completed during 24 and 25 September and the second survey was completed during 7 and 8 October 2008. Due to logistic constraints (fuel range and available funding), entire watersheds were not surveyed. In general, 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. The stream reach delineations developed during the 2003 surveys were used in all years including 2008.

The mainstem Ivanof River and its major tributary were surveyed until the canopy limited our ability to see the stream during both surveys in 2008 (Figure 3). Smoky Hollow Creek was surveyed until the canopy limited visibility, and the unnamed river in Humpback Bay was surveyed until the main stream split into two small tributaries (Figure 3). We were not able to survey the mainstem Three Star or Kametolook rivers on either flight because turbid glacial run-off produced poor visibility that prohibited us from counting fish. Artemie's Creek (Figure 2) was surveyed until overhead vegetation limited our ability to see the stream during the

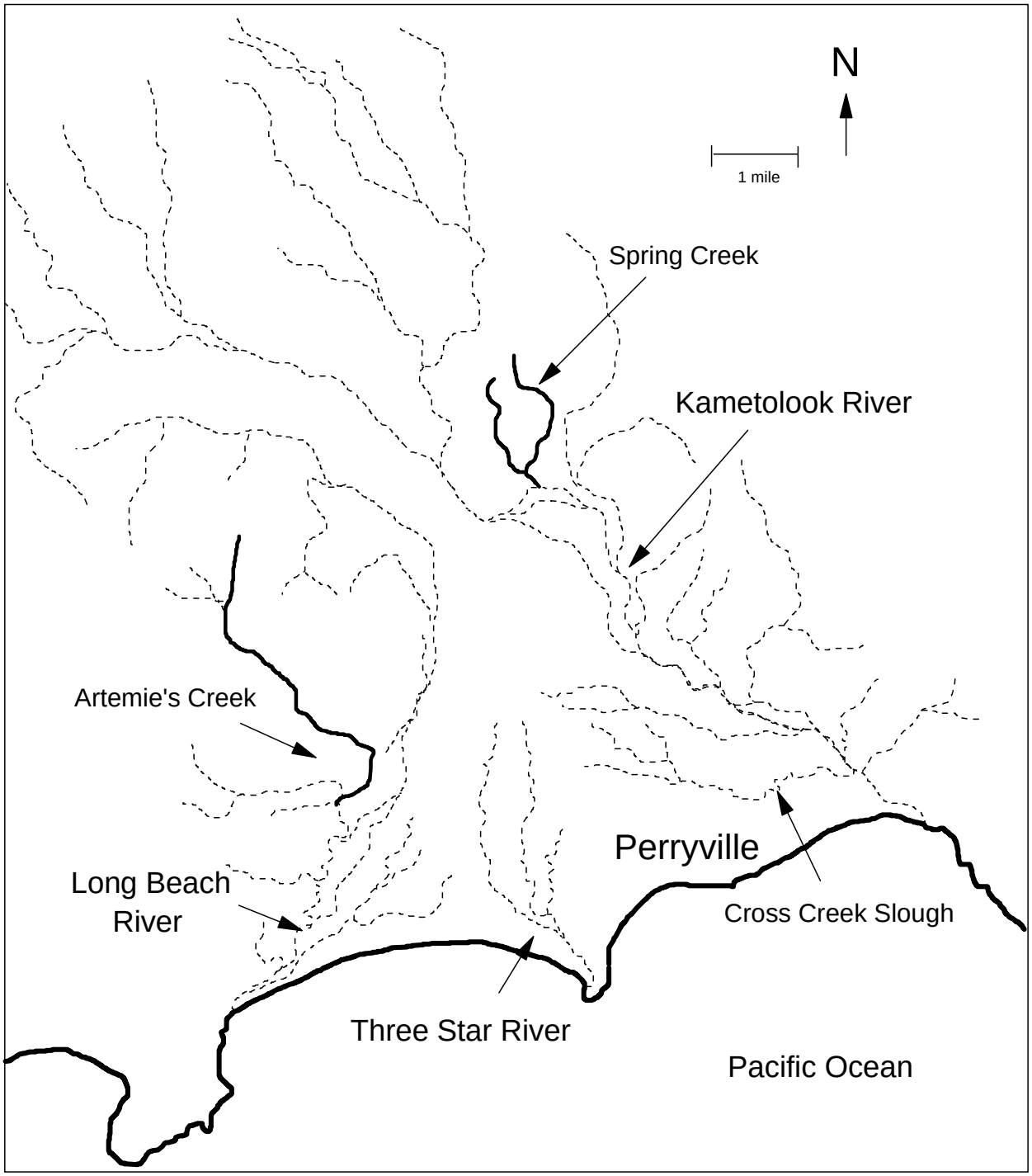

Figure 2. Perryville survey area, Alaska Peninsula National Wildlife Refuge. Streams shown with dashed lines were not surveyed.

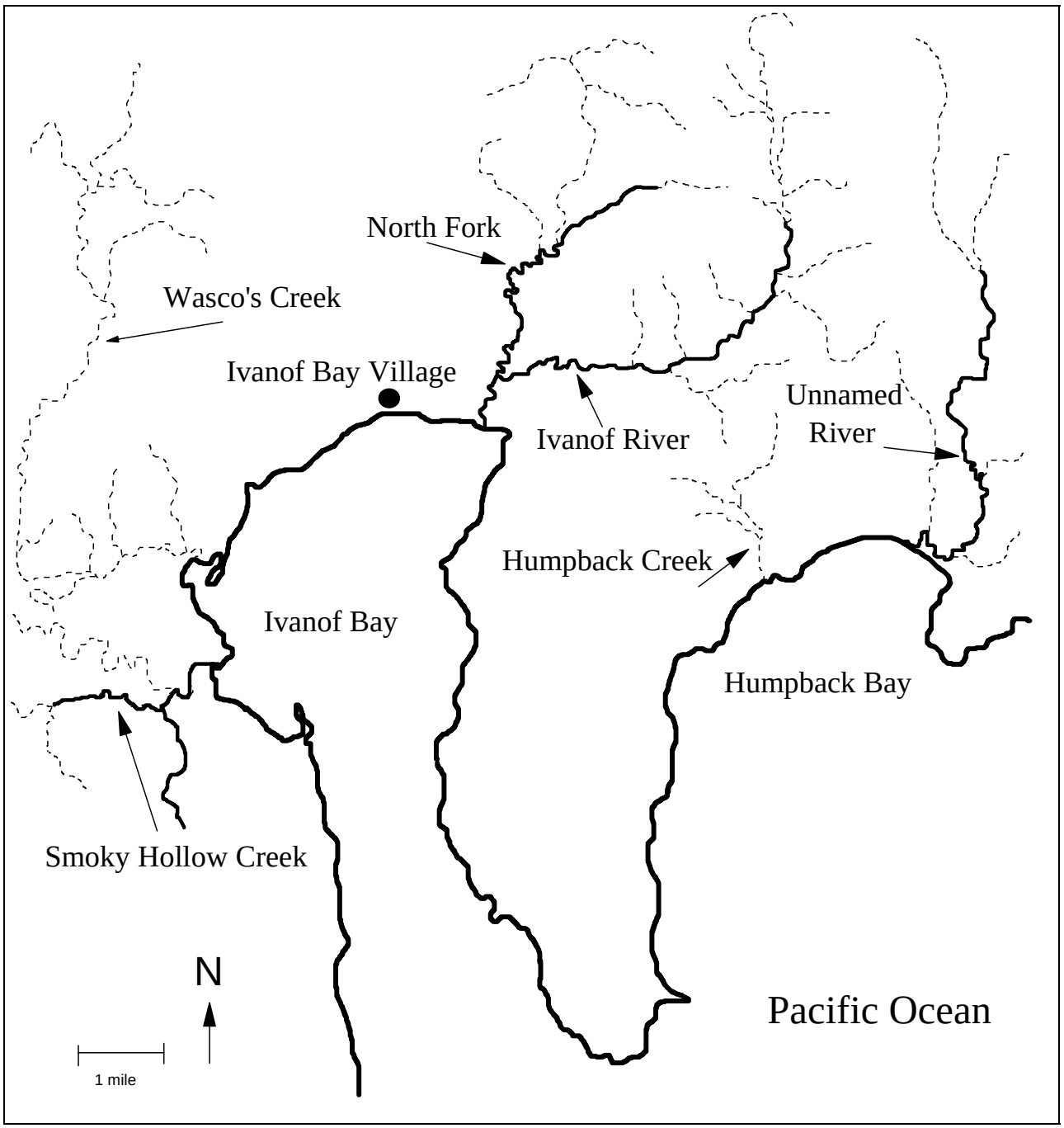

Figure 3. Ivanof and Humpback Bay survey areas, Alaska Peninsula National Wildlife Refuge. Streams shown with dashed lines were not surveyed.

September flight. The entire Spring Creek system was surveyed on both occasions (Figure 2). Cross Creek Slough and all forks of the Three Star River were not surveyed on either flight and Artemie's Creek was not surveyed on the second flight due to fuel limitations. Red Bluff Creek and its major tributary (Figure 4) were surveyed until the canopy limited visibility on both flights. The mainstem Ivan River (Figure 5) was surveyed until it became a series of braided, intermittent channels during both surveys. The mainstem Clark River (Figure 6) was surveyed until it branched into two smaller tributary streams during both surveys.

We assumed that our aerial counts spanned the time period each year when most coho and sockeye salmon had entered their spawning streams and provided a minimum index of coho and sockeye salmon abundance. We also assumed that the peak aerial count for each stream during a given year represented the date when most salmon had entered that stream. Using these assumptions, we examined differences in coho salmon abundance among and within streams and years by plotting aerial counts and characterized relative abundance by calculating means, standard deviations, and coefficients of variation (CV) for each stream's annual peak counts. We examined sockeye salmon abundance in Clark River among and within years using these same techniques. We also examined the relationship between peak aerial survey counts of sockeye salmon in Clark River and estimated escapement of late run sockeye salmon past the Chignik River weir using simple linear regression. The regression was considered to be significant, if the slope of the line differed from zero at $P < 0.05$.

Results

During 2008, coho salmon peak counts for the seven streams that were surveyed twice ranged from 30 in Spring Creek to 3,100 in Red Bluff Creek, and the total of these seven peak counts was 6,314 (Table 1). Most coho salmon were observed in large pods in mainstem rivers during both surveys and few fish were observed spawning. Coho salmon peak counts were made during the September survey for two streams and during the October survey for five streams. Almost all sockeye salmon were observed in Clark River, which had a peak count of 3,700 during the October survey. Most sockeye salmon were actively spawning in the upper half of Clark River during the September survey, but most fish were holding in large groups in the lower river in October. Pink salmon were only observed during the September survey. We did not observe fishing activity during either survey.

For the period 2003 to 2008, observed peak abundance of coho salmon in the seven survey streams has ranged from 22 in the Kametolook River watershed (2004) to 7,600 in Red Bluff Creek (2004), while observed peak abundance of sockeye salmon in Clark River has ranged from 3,700 (2008) to 11,230 (2006; Table 2). Peak counts in the unnamed river in Humpback Bay have been the least variable ranging from 760 to 1,120 (CV = 15%) while peak counts in Red Bluff Creek have been the most variable ranging from 880 to 7,600 (CV = 74%; Table 2). Coho salmon peak counts for each year were usually made during early to mid October surveys (Figure 7). Peak counts of sockeye salmon in Clark River were not associated with any particular survey month (Figure 8). No significant linear relationship was found between peak aerial survey counts of sockeye salmon in Clark River and total escapement of late run sockeye salmon past the Chignik River weir for the period 2003 to 2008 ($P > 0.2$; Figure 9). Counts in Clark River were lower for 2008 than for any previous year.

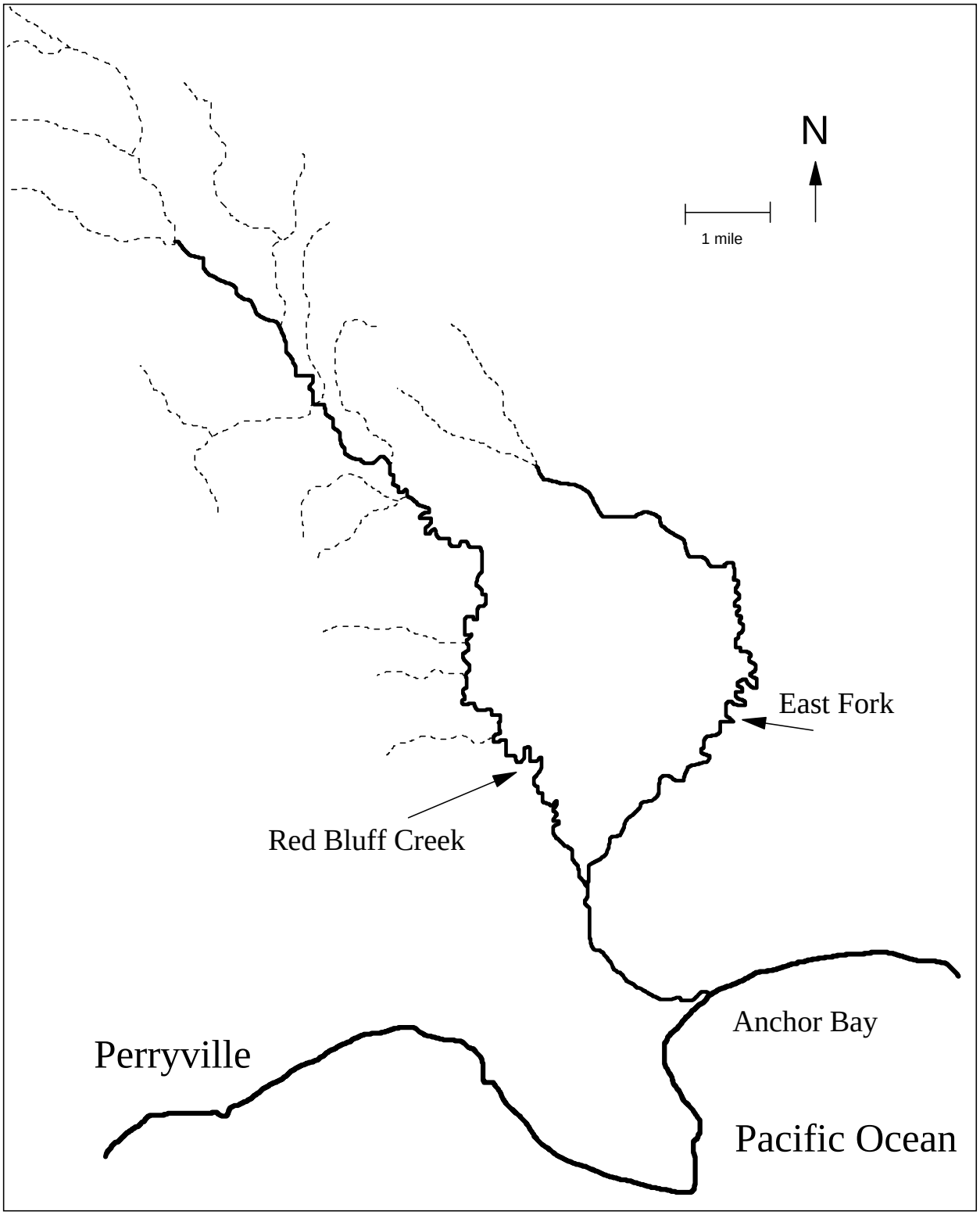

Figure 4. Red Bluff Creek survey area, Alaska Peninsula National Wildlife Refuge. Streams shown with dashed lines were not surveyed.

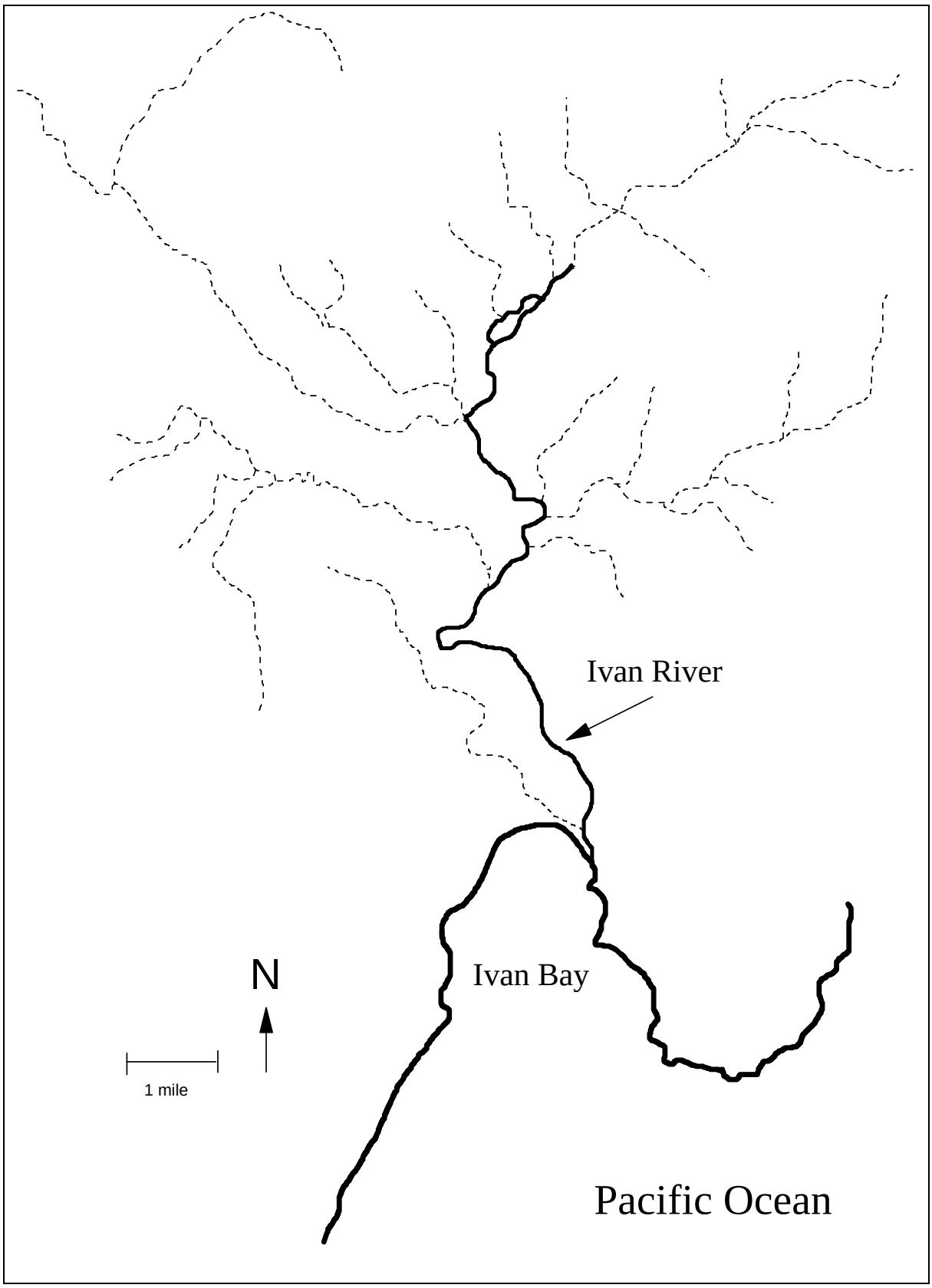

Figure 5. Ivan River survey area, Alaska Peninsula National Wildlife Refuge. Streams shown with dashed lines were not surveyed.

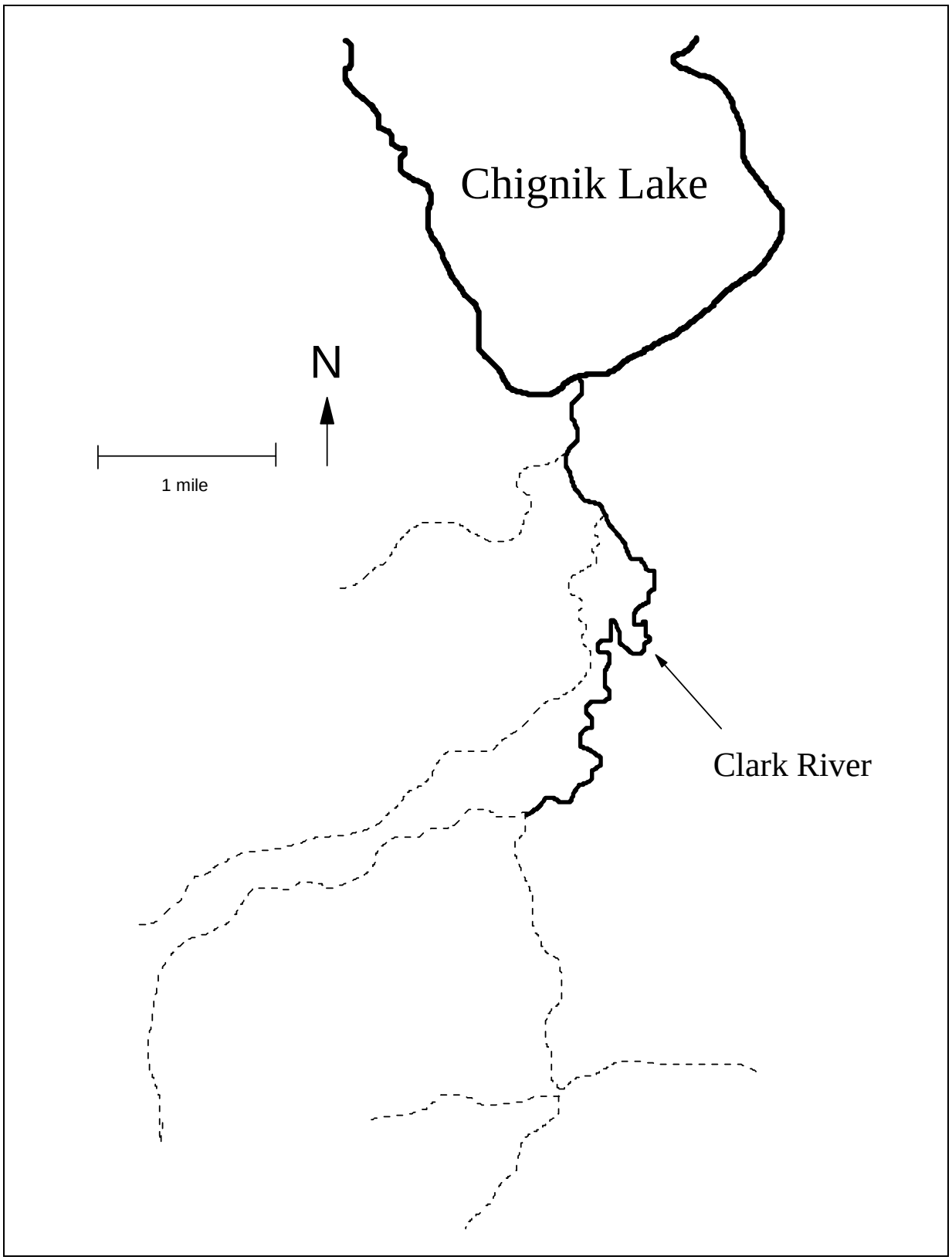

Figure 6. Clark River survey area, Alaska Peninsula National Wildlife Refuge. Streams shown with dashed lines were not surveyed.

Table 1. Numbers of coho (CO), sockeye (SE), and pink (PK) salmon observed during aerial surveys of streams near Perryville, 2008. Dashes (--) indicate stream was not surveyed.

	24-25 September Survey			7-8 October Survey		
Stream	CO	SE	PK	CO	SE	PK
Smokey Hollow Creek	322	0	0	0	0	0
Ivanof River	1,202	0	150	460	0	0
Unnamed River, Humpback Bay	840	0	27	890	0	0
Artemie's Creek (Long Beach)	0	0	0	--	--	--
Three Star River	--	--	--	--	--	--
Spring Creek System (Kametolook)	0	2	240	30	0	0
Kametolook River	--	--	--	--	--	--
Red Bluff Creek	1,360	0	199	2,100	0	0
Ivan River	1,430	4	2,600	1,770	5	0
Clark River	0	3,420	0	200	3,700	0

Table 2. Peak salmon counts, mean, and coefficient of variation (CV) for seven Perryville area streams surveyed from 2003 to 2008. Dashes (--) indicate stream was not surveyed. A plus sign (+) after a count indicates survey was not complete due to poor water clarity and count was excluded from summary statistics.

Stream	2003	2004	2005	2006	2007	2008	Mean	CV
			coho salmon					
Smoky Hollow Creek	--	300+	147	470	130	322	267	60
Ivanof River	2,600	1,300	1,170	3,305	3,703[a]	1,202	2,213	52
Unnamed river, Humpback Bay	1,120	1,040	207[b]	760	1,080	890	978	15
Kametolook River watershed[c]	--	22+	516	72+	62+	30+		
Red Bluff Creek	5,000	7,600	2,482	270+	880	2,100	3,612	74
Ivan River	2,150	1,840	507	80+	1,400	1,770	1,533	41
			sockeye salmon					
Clark River	9,700	5,890	4,100	11,230	10,100	3,700	7,453	44

[a] Partial count due to presence of hunters.
[b] Survey timing did not capture a peak count and was excluded from summary statistics.
[c] Counts include Kametolook River, Spring Creek, and Cross Creek Slough.

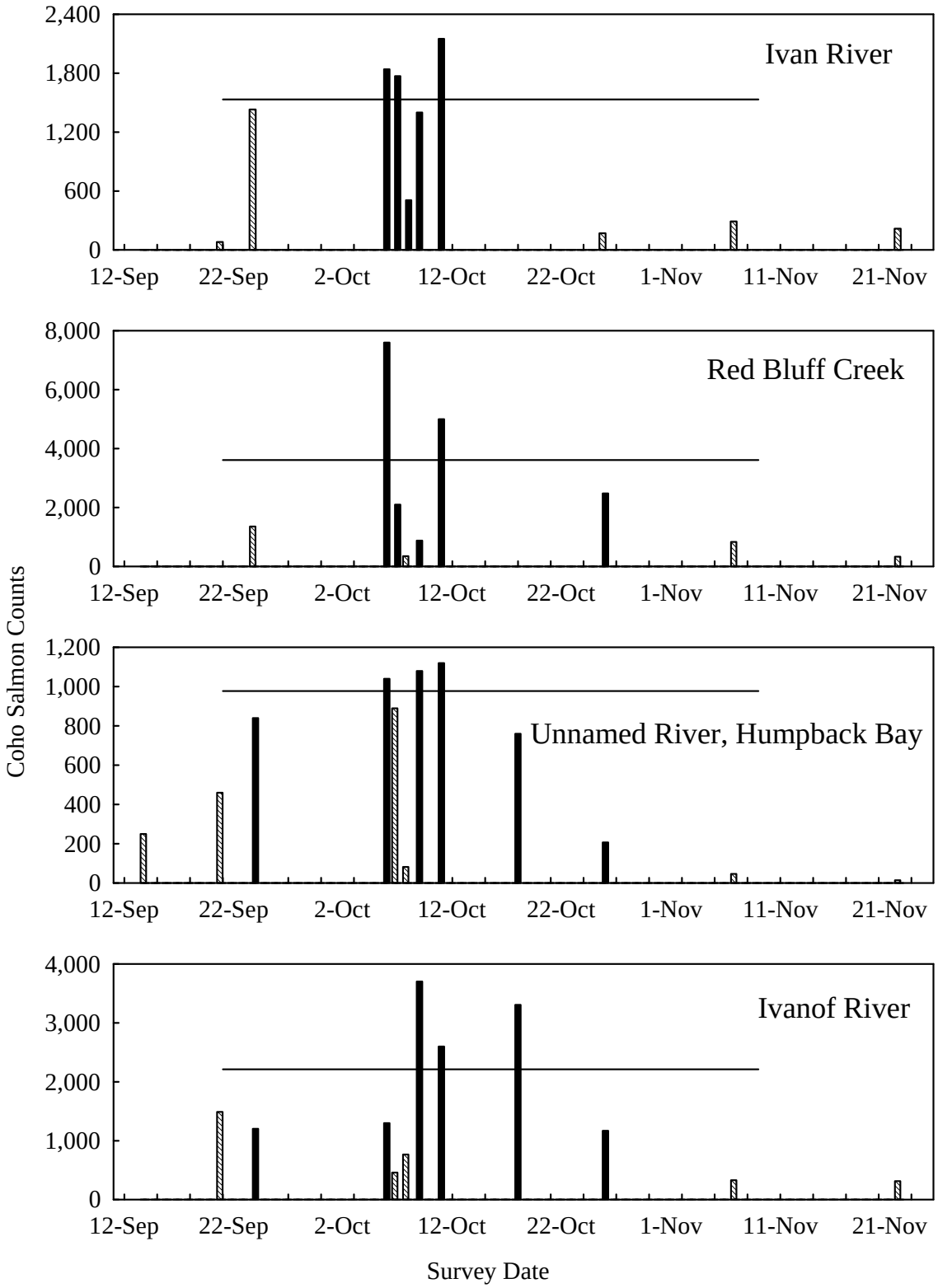

Figure 7. Coho salmon counts made during aerial surveys of the four streams with the greatest counts during 2003-2008. Horizontal lines are means of peak annual counts, which are shown as solid black bars.

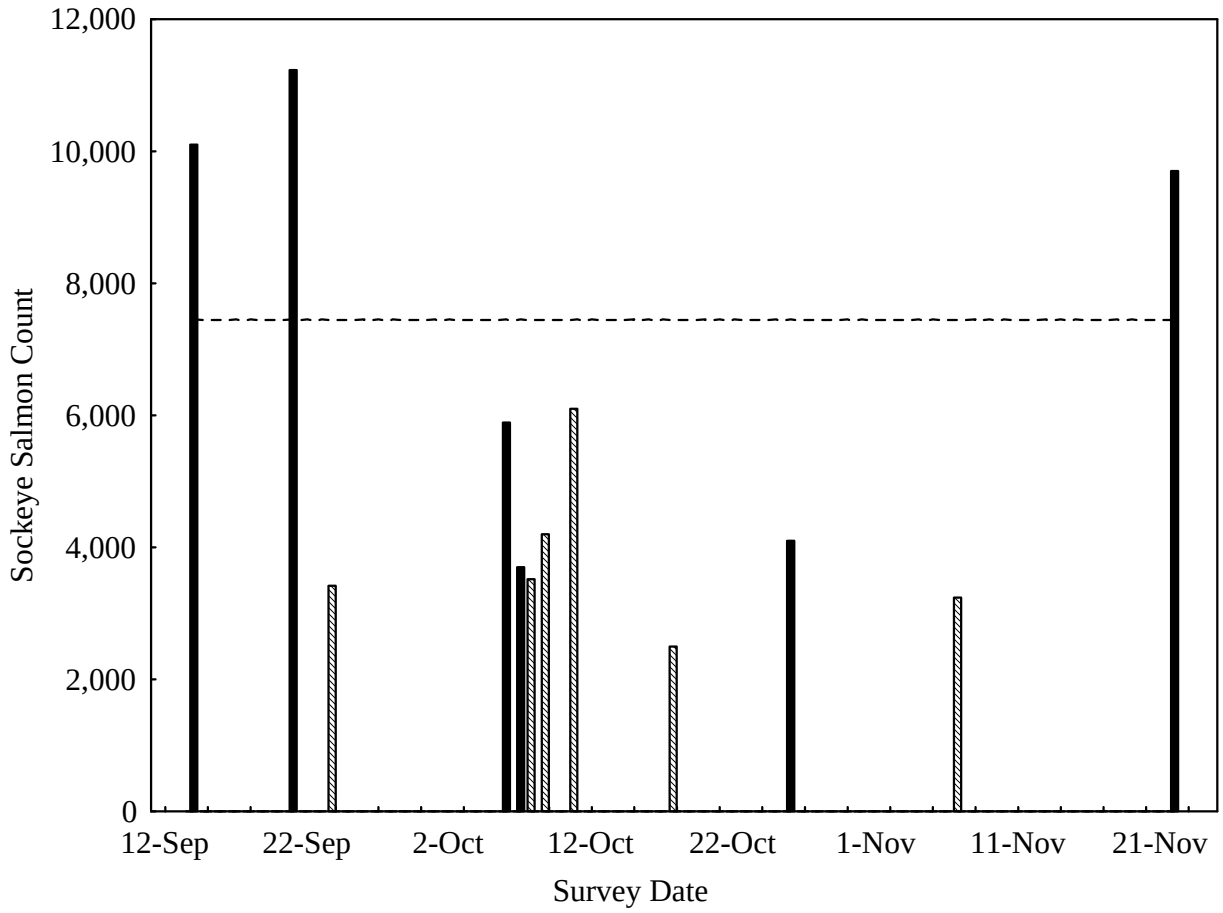

Figure 8. Sockeye salmon counts made during aerial surveys of Clark River during 2003 to 2008. Horizontal line is the mean of annual peak counts, which are shown as solid black bars.

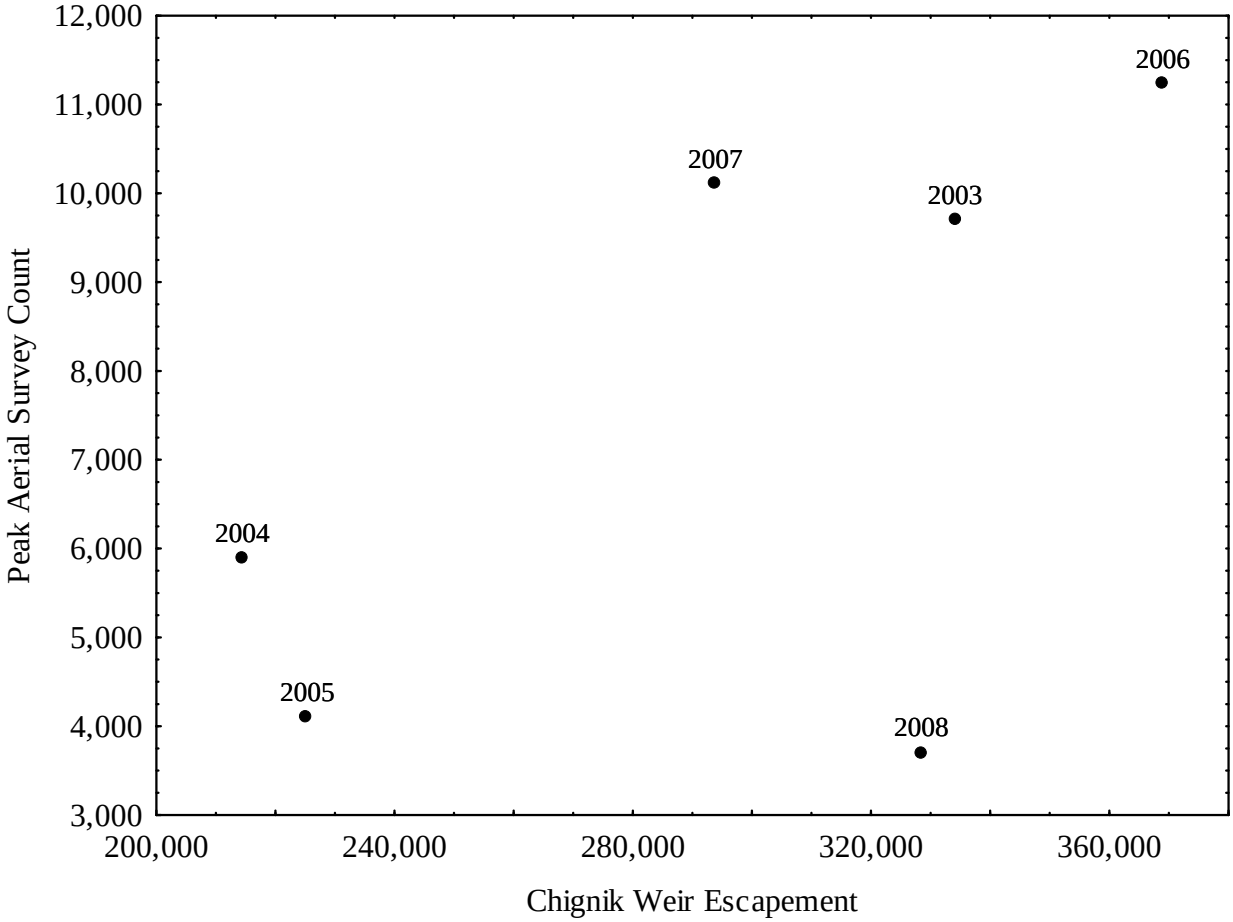

Figure 9. Comparison of peak aerial survey counts of sockeye salmon in Clark River and escapement of late run sockeye salmon past the Chignik River weir. ADF&G data for 2003 to 2008 are from Anderson (2008).

Discussion

Although our surveys have targeted coho salmon staging in mainstem rivers and major tributaries, coho salmon often spawn in small tributary streams (Sandercock 1991). Therefore, coho salmon may have been present in smaller tributary streams that were not surveyed in 2008 and previous years. We think our surveys in 2008 and other years probably accounted for most coho salmon present in each stream because we observed most of them in large aggregations in mainstem rivers and rarely observed any spawning activity. However, since we were not able to survey entire drainages and only flew two surveys each year, we considered counts to be gross indices of coho salmon abundance for a given stream reach and survey period, and not estimates of total abundance.

We chose to use the peak count each year as the best index of abundance for each stream rather than trying to combine counts from both surveys. The interval between our surveys in 2008 was about two weeks and the interval between surveys in previous years ranged from three to six weeks. 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 at least three week intervals

between surveys in most years to gain insight into run timing. Since average reported stream or survey life estimates for coho salmon range from 11.4 days (Perrin and Irvine 1990) to 13.7 days (Hetrick and Nemeth 2003), it is possible that some coho salmon entered our study steams and died between our two surveys. It is also possible that coho salmon entered the systems after our last survey in 2008 (7-8 October) and other years.

Water visibility affected our ability to observe and count salmon during aerial surveys in 2008 and previous years. Glacial runoff from Mount Veniaminof near Perryville has consistently obscured the mainstem Three Star River, the lower portions of Artemie's Creek, and the Kametolook River during most surveys since 2003. Surveys were possible on the mainstem Kametolook River only in 2004 and 2005 when the second survey was conducted in late October and early November, respectively, and cold weather had lessened glacial runoff. After 2005, all surveys have been completed by mid October and glacial runoff has affected visibility in some other streams, including Red Bluff Creek and Ivan River (Anderson 2007). However, shifting our survey timing later in the season to avoid glacial runoff would probably have prevented us from obtaining peak counts in most streams.

The relatively high counts of coho salmon this year in Ivanof River, Ivan River, Red Bluff Creek, and the unnamed river in Humpback Bay suggest that 2008 was probably a good return year for coho salmon in most area streams. The presence of relatively large number of coho salmon may also be reflected by the commercial harvest of 161,536 coho salmon in 2008 (Anderson 2008). This was more than triple the most recent five-year average harvest of 44,677 coho salmon, and also higher than the 20-year average of 144,213 coho salmon. No information on 2008 subsistence harvests is available yet, but reports from local residents indicated that coho salmon abundance in area streams has been sufficient to meet subsistence needs in recent years.

Although the peak count of sockeye salmon in Clark River was lower in 2008 than in previous years, we do not think this represents a conservation concern. The sustainable escapement goal of 200,000 to 400,000 late run sockeye salmon past the Chignik weir has been consistently achieved in recent years, and the 2008 estimated escapement of 328,479 late run sockeye salmon is great than the prior 5-, 10-, and 20-year averages (Anderson 2008). Our low counts in 2008 are probably the result of survey timing not coinciding with peak timing of staging or spawning fish in Clark River. This may account for the lack of a significant ($P > 0.05$; Figure 9) linear relationship between peak aerial survey counts for Clark River and Chignik weir counts of late run sockeye salmon for the period 2003-2008, while a significant ($P = 0.028$) relationship was found for the period 2003-2007 (Anderson 2007). Since the relationship is based on so few data points, the addition of a single data point—which may be an outlier—greatly affected results.

Efforts to determine coho salmon escapement in streams adjacent to Perryville (Anderson and Hetrick 2004) and sockeye escapement in Clark River (Anderson 2004b) began in 2002 in response to problems reported by subsistence users. Frequent inclement weather, high water events, and the inaccessibility of most of these streams make it logistically difficult and expensive to obtain accurate and precise estimates of coho and sockeye salmon escapement using weirs, counting towers, sonar, and mark-recapture experiments. Aerial surveys were chosen as the most practical and cost effective method to obtain qualitative escapement information for these systems. These surveys have provided 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, since 2003. After 6 years of monitoring, we have concluded that coho and sockeye escapements in monitored streams have

been adequate to maintain the runs while allowing for subsistence harvest. Based on watershed size and available habitat (Anderson 2006) and taking into account the variability of stream conditions and run timing from year to year, coho salmon returns are at or near ranges that we would expect in these systems. Therefore, given current levels of harvest and escapement, we do not recommend continuing this project. However, changes in commercial or subsistence harvest patterns have the potential to threaten the viability of local stocks. Since there are no established escapement goals and no directed escapement monitoring efforts for coho salmon on the Alaska Peninsula, managers should be aware of changes in the harvest patterns in all fisheries. Active management of late run sockeye salmon to achieve sustainable escapement goals in the Chignik River watershed should ensure the continued health these stocks barring drastic changes in subsistence harvests or freshwater rearing conditions.

Acknowledgements

S. Fried (USFWS), J. Jackson (ADF&G), and M. B. Loewen (ADF&G) provided critical reviews of an earlier version of this report. The Office of Subsistence Management provided funding support through the Fisheries Resource Monitoring Program, as Project Numbers FIS 03-043, 05-405, and 07-404, and this report serves as the Final Project Report for 07-404. Egli Air Haul in King Salmon provided flight service for the project. 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

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

ADF&G (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.

ADF&G (Alaska Department of Fish and Game). 2008. Alaska Subsistence Fisheries Database Version 3.5. Alaska Department of Fish and Game, Division of Subsistence, Anchorage, 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. 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. 2007. Estimation of coho salmon escapement in streams adjacent to Perryville and sockeye salmon escapement in Chignik Lake tributaries, Alaska Peninsula National Wildlife Refuge, 2007. U. S. Fish and Wildlife Service, Anchorage Fish and Wildlife Field Office, Alaska Fisheries Data Series Report Number 2007-12, Anchorage, 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.

Anderson, T. 2008. Chignik management area 2008 commercial salmon fishery summary. Alaska Department of Fish and Game, Division of Commercial Fisheries, Kodiak, Alaska.

BBNA (Bristol Bay Native Association). 2004. Proceedings of Chignik Fishery Subsistence Summit, October 2, 2004, Chignik Lake, AK. BBNA Natural Resources Department, Dillingham, AK.

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.

Finkle, H., and I. W. Vining. 2009. Determination of aerial survey index streams used to assess salmon stocks in the Westward Region. Alaska Department of Fish and Game, Fishery Data Series No. 09-09, Anchorage, Alaska.

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.

Johnson, J., and E. Weiss. 2007. Catalog of waters important for spawning, rearing, or migration of anadromous fishes – Southwestern Region, Effective June 1, 2007. Alaska Department of Fish and Game, Special Publication No. 07-07, Anchorage, 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.

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. A. 2008. Chignik Management Area commercial salmon fisheries and stock status report to the Alaska Board of Fisheries, January 2008. Alaska Department of Fish and Game, Fishery Management Report Number 07-63, Anchorage, Alaska.