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, 2006

*Alaska Fisheries Data Series Number 2006–15*


**King Salmon Fish and Wildlife Field Office**
**King Salmon, Alaska**
**December 2006**


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# Estimation of Coho Salmon Escapement in Streams Adjacent to Perryville and Sockeye Salmon Escapement in Chignik Lake Tributaries, Alaska Peninsula National Wildlife Refuge, 2006

**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 2006, 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 2006 and run timing were similar to previous years, and most coho salmon were counted during the survey in mid October. More sockeye salmon were counted in Clark River in 2006 than in previous years. Local water conditions prevented us from obtaining 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 recent Board of Fisheries and Perryville Subsistence Working Group meetings, 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 effort is 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 become effective. With fishing effort spread out to other streams, we need to ensure these runs are

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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 harvest. 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) presents results from the first three years of monitoring, and this report summarizes the fourth 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 15:00 hours to increase the likelihood of direct overhead sunlight, and polarized sunglasses were

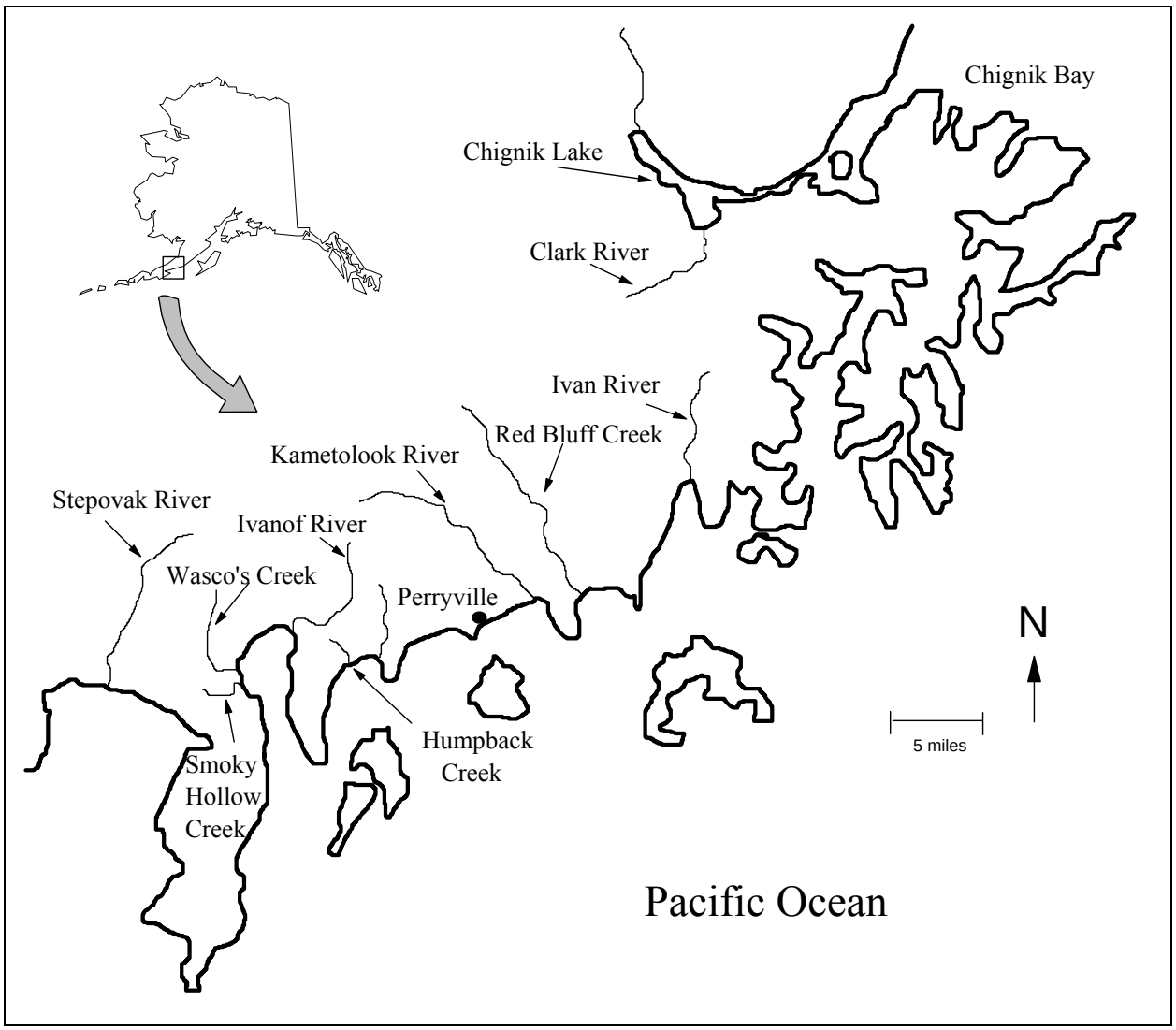


Figure 1. Location of streams in the Perryville area, Alaska Peninsula National Wildlife Refuge.

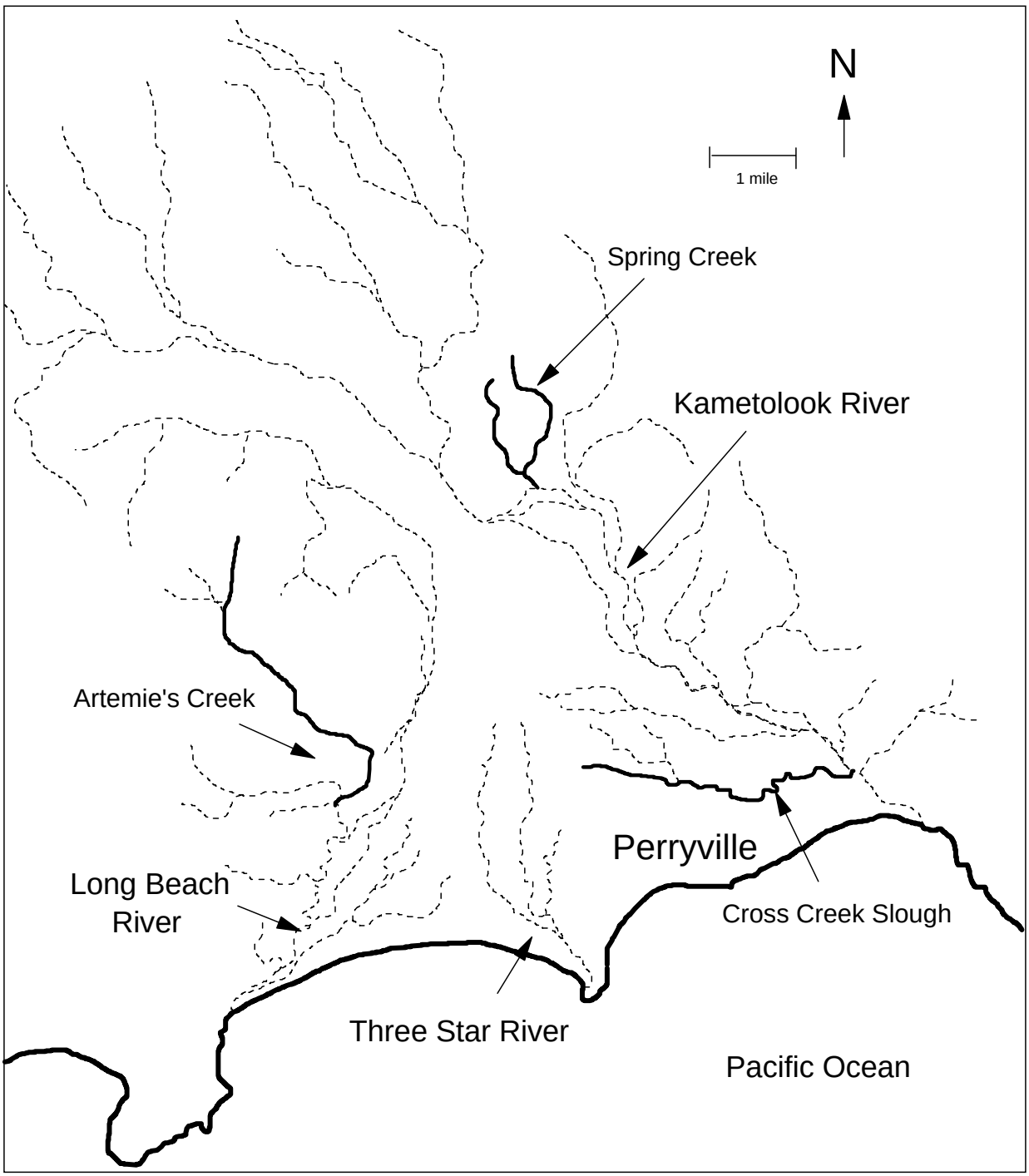


Figure 2. Perryville survey area, Alaska Peninsula National Wildlife Refuge. Stream sections shown as solid lines were surveyed.

worn to reduce glare. Starting and stopping points for each stream survey reach were marked on topographic maps. During each aerial survey, total numbers of coho 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 salmon spawning activity, and large congregations of migrating or staging coho salmon were noted, as were locations and numbers of active fishermen.

Two stream surveys were planned, one in late September and one in mid 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 20 and 21 September, and the second survey was completed during 17 and 18 October 2006. 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 2006. Survey reaches are considered to be index areas, and counts are minimum estimates of coho salmon abundance. Our assumption is that periodic aerial counts will provide a minimum index of coho salmon escapement.

The mainstem Ivanof River and its major tributary were surveyed until the canopy limited our ability to see the stream (Figure 3). 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 the first survey, and until impassable waterfalls were encountered during the second survey. The entire Spring Creek system was surveyed on both occasions (Figure 2). We were not able to survey the Three Star and Kametolook rivers on either flight because both streams were still affected by turbid glacial run-off, and visibility prohibited counting fish. 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 on both occasions. The mainstem Ivan River (Figure 5) was surveyed until it became a series of braided, intermittent channels during the first survey, but turbid conditions following an overnight rain event prevented us from counting fish on the second survey. The mainstem Clark River (Figure 6) was surveyed until it branched into two smaller tributary streams during the first survey, but only the upper reaches were surveyed during the second survey; turbid conditions following an overnight rain event prevented us from surveying most of the Clark River during the second survey.

In 2006, we applied a model based on stream length to estimate coho salmon smolt abundance and potential adult production in our study streams. Bradford et al. (1997) related 474 estimates of smolt abundance to habitat features derived from maps and discharge records for 86 streams in western North America to predict average abundance of coho salmon smolt ($p < 0.001$ and $r^2 = 0.70$). Anderson and Hetrick (2004) found that the model of Bradford et al. (1997) closely approximated smolt production estimated from an intensive habitat inventory model (Nickelson 1998) for streams on the Alaska Peninsula, except where large amounts of off-channel rearing habitat (i.e., large ponds) were present. Mean coho salmon smolt abundance ($Y$) was estimated based on stream length ($X$, km) for our study streams as

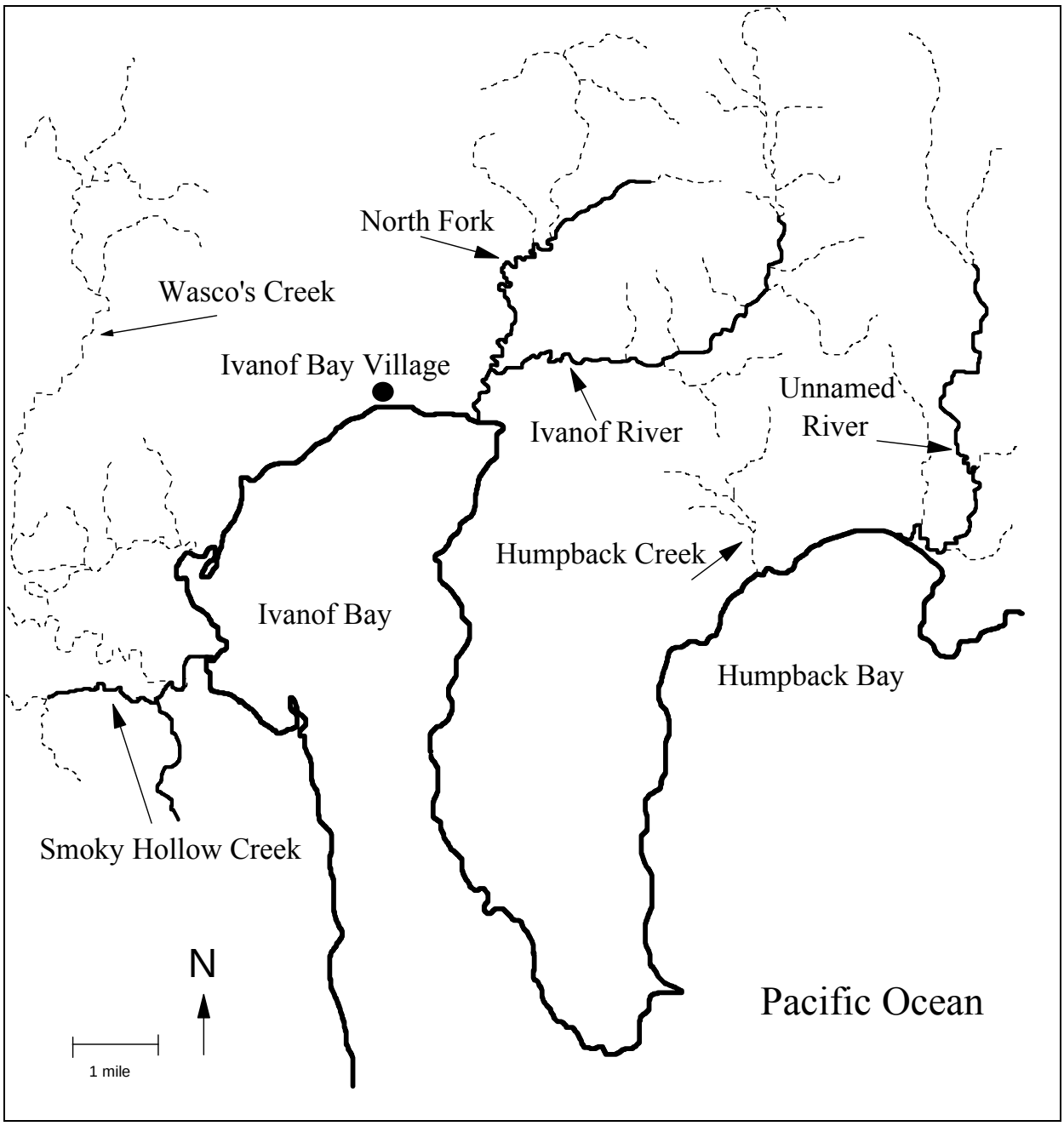


Figure 3. Ivanof and Humpback Bay survey areas, Alaska Peninsula National Wildlife Refuge. Stream sections shown as solid lines were surveyed.

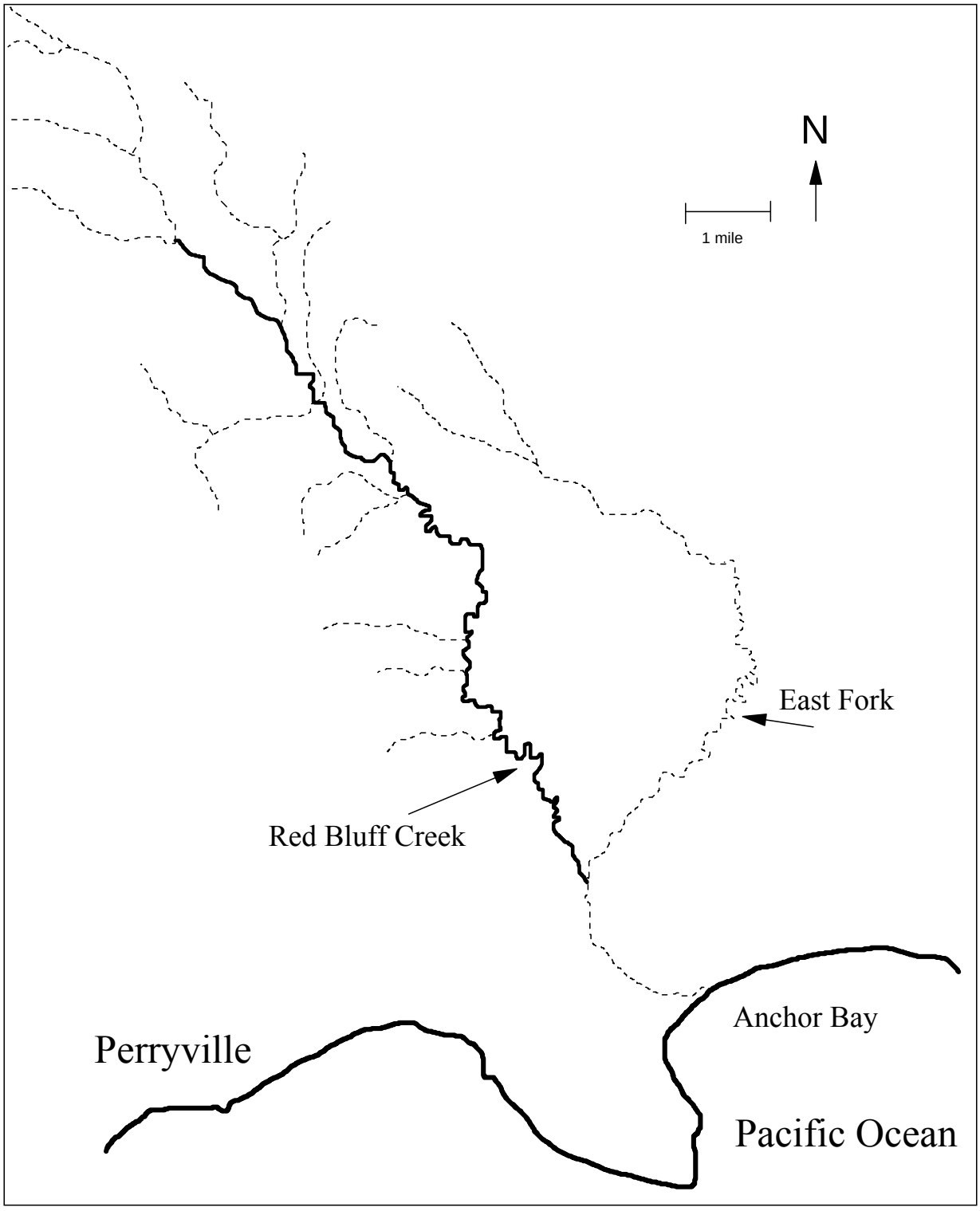


Figure 4. Red Bluff Creek survey area, Alaska Peninsula National Wildlife Refuge. Stream sections shown as solid lines were surveyed.

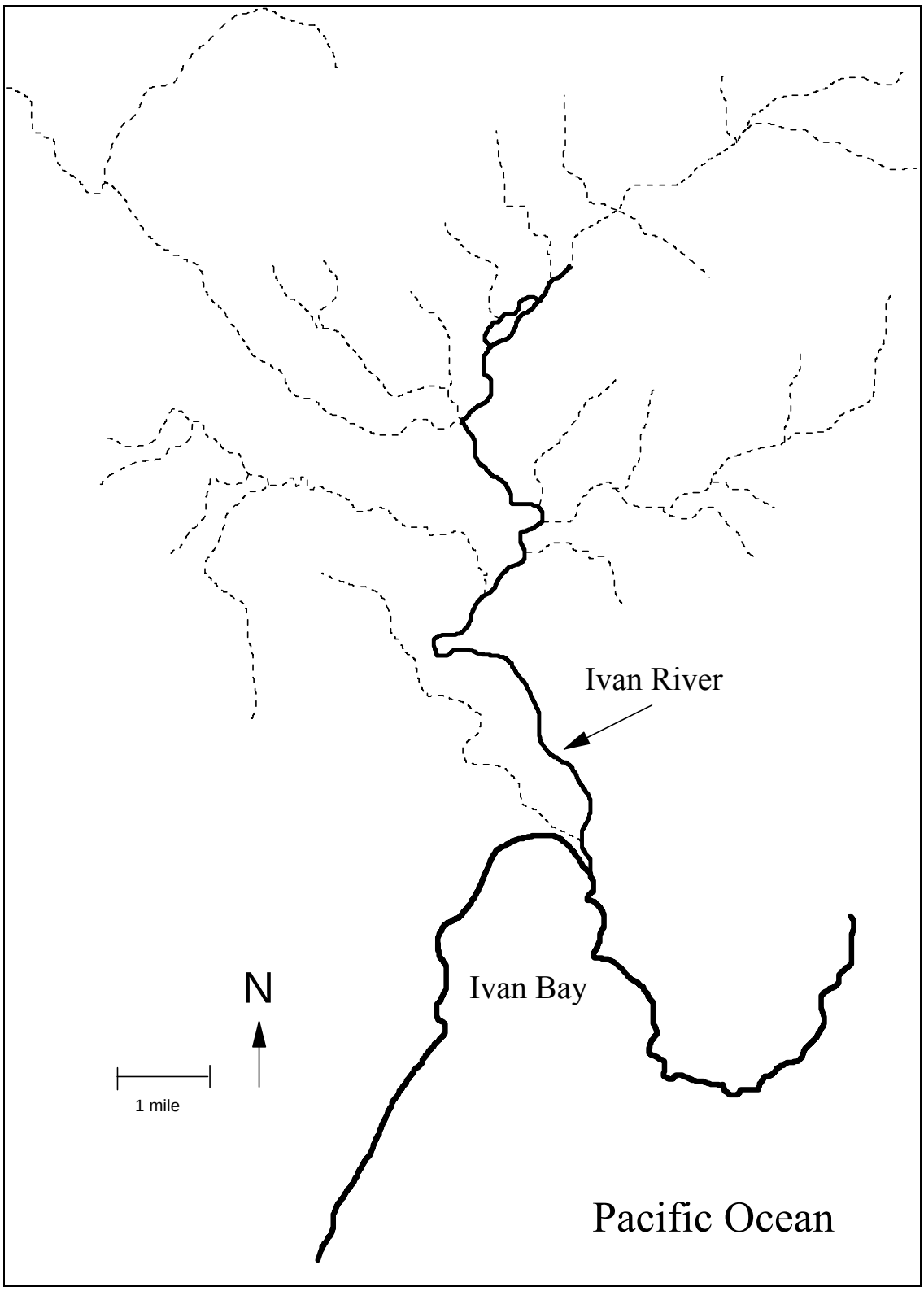


Figure 5. Ivan River survey area, Alaska Peninsula National Wildlife Refuge. Stream sections shown as solid lines were surveyed.

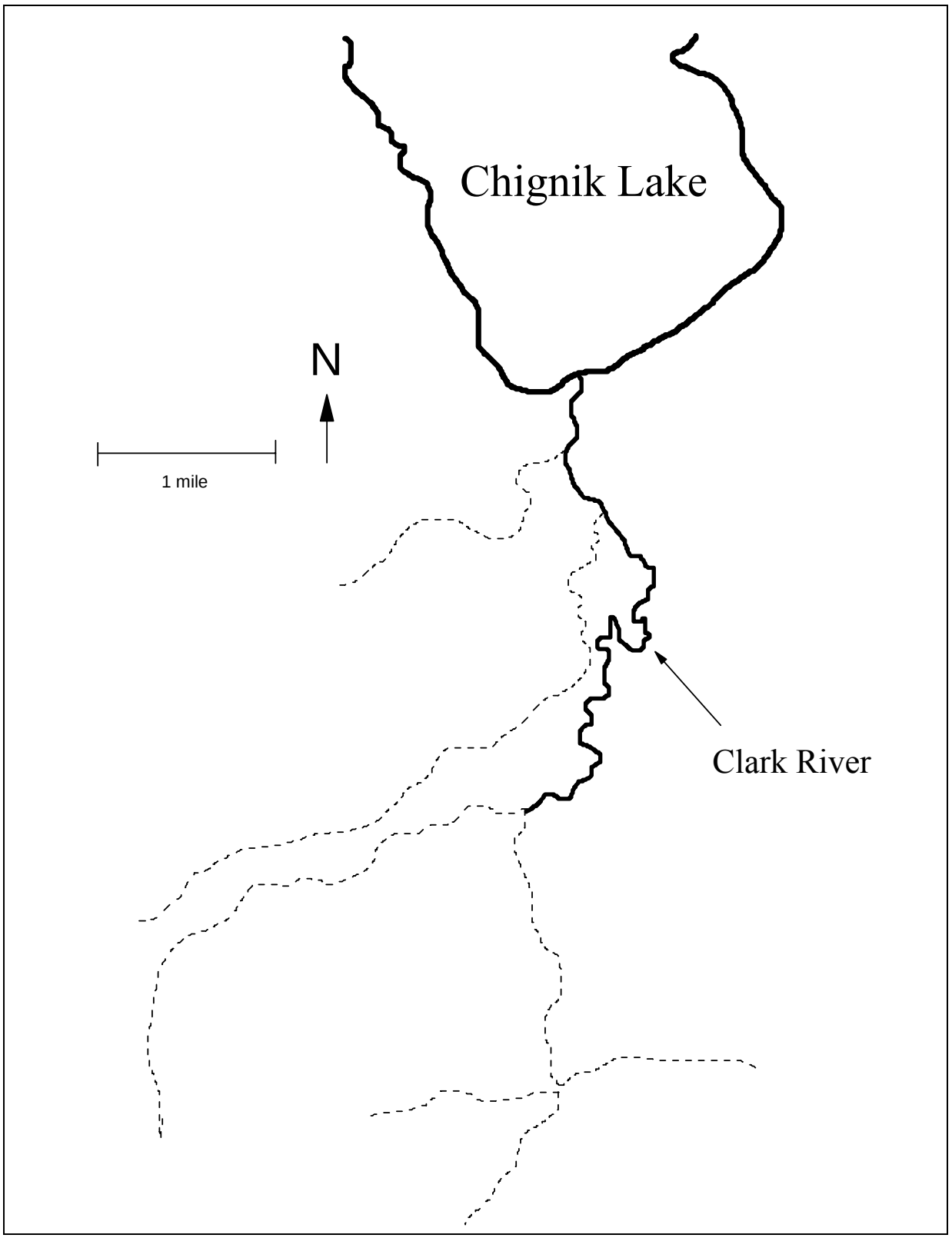


Figure 6. Clark River survey area, Alaska Peninsula National Wildlife Refuge. Stream sections shown as solid lines were surveyed.

$$Log_e(Y) = 6.90 + 0.97 Log_e(X).$$

We chose a conservative marine survival rate of 5% applied to the smolt estimates ($Y$) to provide a general estimate of adult production; Bradford (1995) reports a mean smolt-to-adult survival rate of 9.8% for Pacific Northwest coho salmon. Stream length for most streams was measured from U.S. Geological Survey 1:63,360 scale digital line graphs. Lengths used for streams in the Perryville valley (Artemie's Creek, Cross Creek Slough, Three Star River, Spring Creek system) were from field measurements during habitat surveys in 2002 and 2003 (Anderson and Hetrick 2004).

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 2006. Chignik River weir counts for 2003 to 2006 are from Stichert (2006). Results were considered significant at $P \leq 0.05$.

## Results

For most streams surveyed in 2006, more coho salmon were observed during the aerial survey in October than were observed during the survey in September (Table 1). 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. Pink and chum salmon were observed spawning in most systems during the September survey, but few were observed during the second survey. Most coho salmon were observed in large pods in mainstem rivers during both surveys, and little spawning activity was observed. Although we looked for fishing activity in and around the study streams, no fishermen were observed during the flights.

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, the entire Three Star River, the mainstem Kametolook River, and parts of Red Bluff Creek during both surveys in 2006. A heavy rain event overnight on 17 October caused turbid conditions in Ivan and Clark rivers, and prevented us from getting complete counts on those streams during the second survey. In contrast to previous years, both surveys were completed within one day of the scheduled date and were not postponed because of weather conditions; both surveys were postponed one day due to pilot availability.

Estimated potential adult coho salmon production for study streams ranged from 296 for Cross Creek Slough to over 6,200 for Ivan River (Table 2). The model predicts that Ivan River, Red Bluff Creek, and Ivanof River should be the most productive streams in the survey area.

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 2006 ($r^2 = 0.88$, $P = 0.04$; Figure 7).

Table 1. Numbers of coho (CO) and sockeye (SE) salmon observed during aerial surveys of streams near Perryville, 2006. Dashes (--) indicate survey not done due to poor water clarity.

| | 20-21 September Survey | | 17-18 October Survey | |
|---|---|---|---|---|
| Stream | CO | SE | CO | SE |
| Smokey Hollow Creek | 100 | 0 | 470 | 0 |
| Ivanof River | 1,490 | 4 | 3,305 | 0 |
| Unnamed River, Humpback Bay | 460 | 0 | 760 | 0 |
| Artemie's Creek (Long Beach)[a] | 80 | 0 | 46 | 0 |
| Three Star River | -- | -- | -- | -- |
| Spring Creek System (Kametolook) | 40 | 11 | 46 | 0 |
| Kametolook River | -- | -- | -- | -- |
| Cross Creek Slough | 0 | 0 | 26 | 0 |
| Red Bluff Creek[b] | 40 | 2 | 270 | 0 |
| Ivan River | 80 | 2 | -- | -- |
| Clark River[c] | 0 | 11,230 | 0 | 2,500 |

[a] Lower reaches captured by turbid Long Beach water.
[b] East Fork and lower mainstem never surveyed due to poor water clarity.
[c] Lower half of river not surveyed in October due to poor water clarity.

Table 2. Stream length, potential adult production (assuming 5% marine survival using the Bradford et al. (1997) model), and maximum observed numbers of coho salmon in streams near Perryville.

| Stream | Length (km) | Potential Adult Production | Maximum Count (Year) |
|---|---|---|---|
| Smoky Hollow Creek | 27.2 | 1,222 | 470 (2006) |
| Ivanof River | 67.4 | 2,947 | 3,305 (2006) |
| Unnamed, Humpback Bay | 34.9 | 1,557 | 1,120 (2003) |
| Artemie's Creek | 8.6 | 400 | 80 (2006) |
| Three Star River | 27.3 | 1,227 | 107[a] (2005) |
| Cross Creek Slough | 6.3 | 296 | 27 (2004) |
| Spring Creek System | 7.5 | 350 | 46 (2006) |
| Red Bluff Creek | 127.1 | 5,451 | 7,600 (2004) |
| Ivan River | 146.6 | 6,261 | 2,150 (2003) |

[a] Partial count. We have not been able to obtain a complete count for Three Star River.

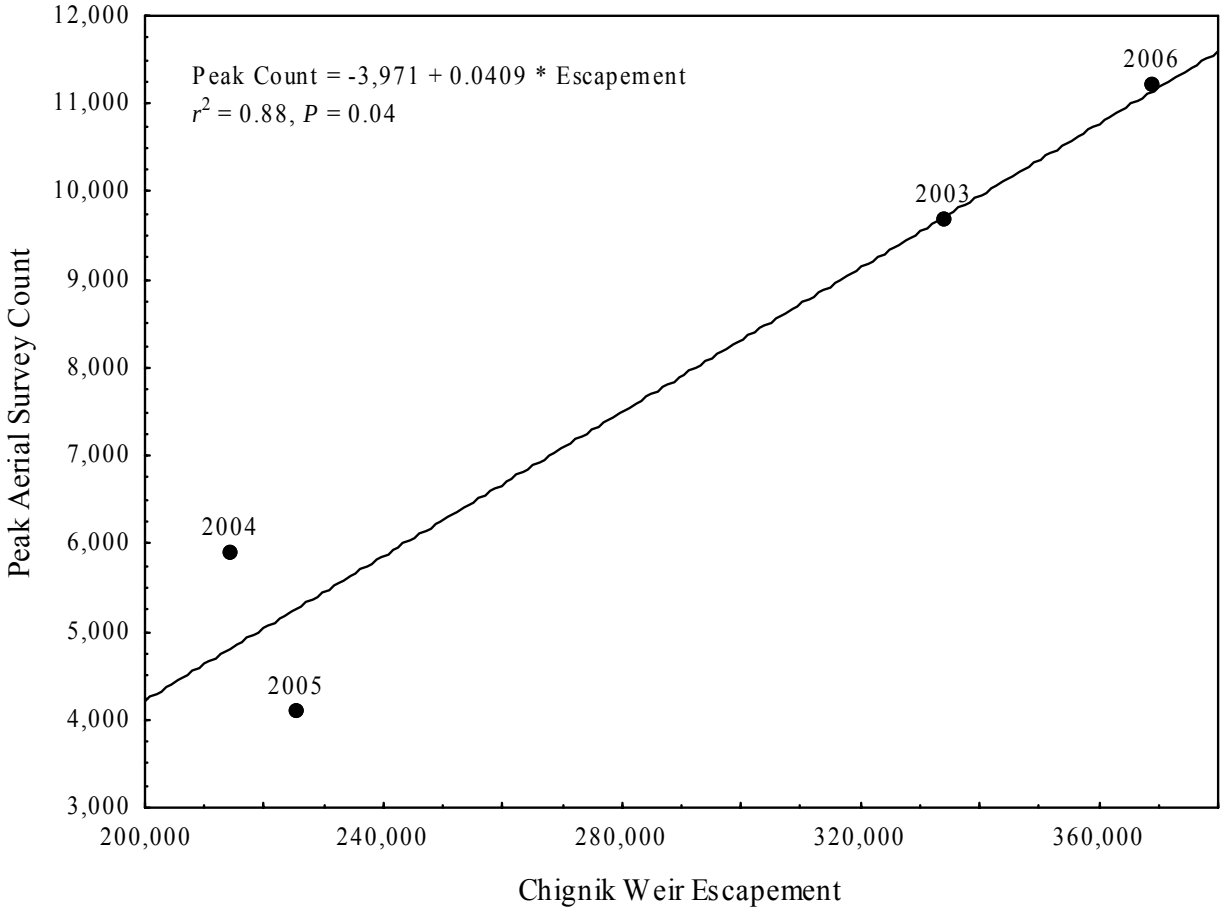


Figure 7. Relationship between peak aerial survey counts of sockeye salmon in Clark River and escapement of late run sockeye salmon past the Chignik River weir.

## Discussion

Coho salmon may have been present in smaller tributary streams that were not surveyed. These smaller streams were not surveyed because of logistical constraints, primarily fuel range of the helicopter and available funding. It is unlikely that coho salmon were present in the smaller tributary streams during the first survey because most fish were observed in large pods lower in the mainstem rivers. Few coho salmon were observed spawning in mainstem rivers during the second survey, although it is possible that some spawning fish were not counted as coho salmon often spawn in smaller tributary streams (Sandercock 1991). Because entire drainages were not surveyed and count intervals were not adequate for expansion to area-under-the-curve estimates, surveys should be considered index counts of coho salmon abundance for a given stream reach and survey period, and not estimates of total abundance.

Water conditions affected the aerial surveys in 2006. Glacial run-off from Mount Veniaminof near Perryville had captured the Three Star River, the lower portions of Artemie's Creek, and the Kametolook River during both surveys. This was the first year since 2004 that we were unable to count fish in the mainstem Kametolook River during our second survey, although our second survey in 2006 was completed earlier than in previous years. Glacial water from an unnamed braided river to the east of Anchor Bay had captured the major tributary to Red Bluff Creek,

which also affected visibility in the lower mainstem of Red Bluff Creek. This also occurred in 2004, but conditions did not prevent us from counting the lower mainstem in that year (Anderson 2005a). An overnight rain event during our second survey in 2006 also caused turbid conditions in Ivan and Clark rivers, preventing us from obtaining complete counts in both rivers. As opposed to all previous years, weather conditions did not affect the survey interval in 2006, although both surveys occurred one day later than originally scheduled due to pilot availability.

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 to 8 October survey. Based on numbers of coho salmon observed in streams we were able to survey in 2006, we expected a peak count in Ivan River and Red Bluff Creek on our 17 to 18 October survey if visibility had permitted counting. Future surveys scheduled from late September 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, as happened in 2006 and in previous years.

Observed abundance of coho salmon in study streams has been variable in most systems (Table 3). Peak annual counts in Ivanof River have been the least variable, ranging from 1,170 to 3,305. 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. Survey timing in 2005 probably missed the peak runs in both systems (Anderson 2005b), and water conditions prevented us from getting good counts in 2006. Survey timing in 2005 probably did not capture peak numbers in other survey streams (Anderson 2005b).

Our survey data generally supports predictions of the Bradford et al. (1997) model: our highest observed counts were in the streams predicted to support the largest runs (Table 2). In general, our peak counts trended in the right direction with model estimates of production. For some streams, the model may predict higher potential production than is possible because of discrepancies between the digital line graphs and actual stream networks, as we have observed elsewhere for streams on the Alaska Peninsula (Anderson *In review*). For example, many tributary streams present on the digital line graphs for Ivan River occur above barriers to coho salmon migration, and are not productive habitat for anadromous salmonids (J. Anderson, personal observation). Also, habitat factors other than stream length, such as amount of suitable overwintering habitat, have been shown to limit coho salmon production in many streams (Mason 1976; Nickelson et al. 1992). The predictions of the Bradford et al. (1997) model provide general targets to compare our index counts, although more detailed study could provide better estimates of potential coho salmon production for some study streams.

Although we were unable to get peak counts for Red Bluff Creek and Ivan River in 2006 and for most streams in 2005, there are no indications that these populations are declining. Coho salmon harvests by the commercial fishery in the area have been very low in recent years (Stichert 2006), 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

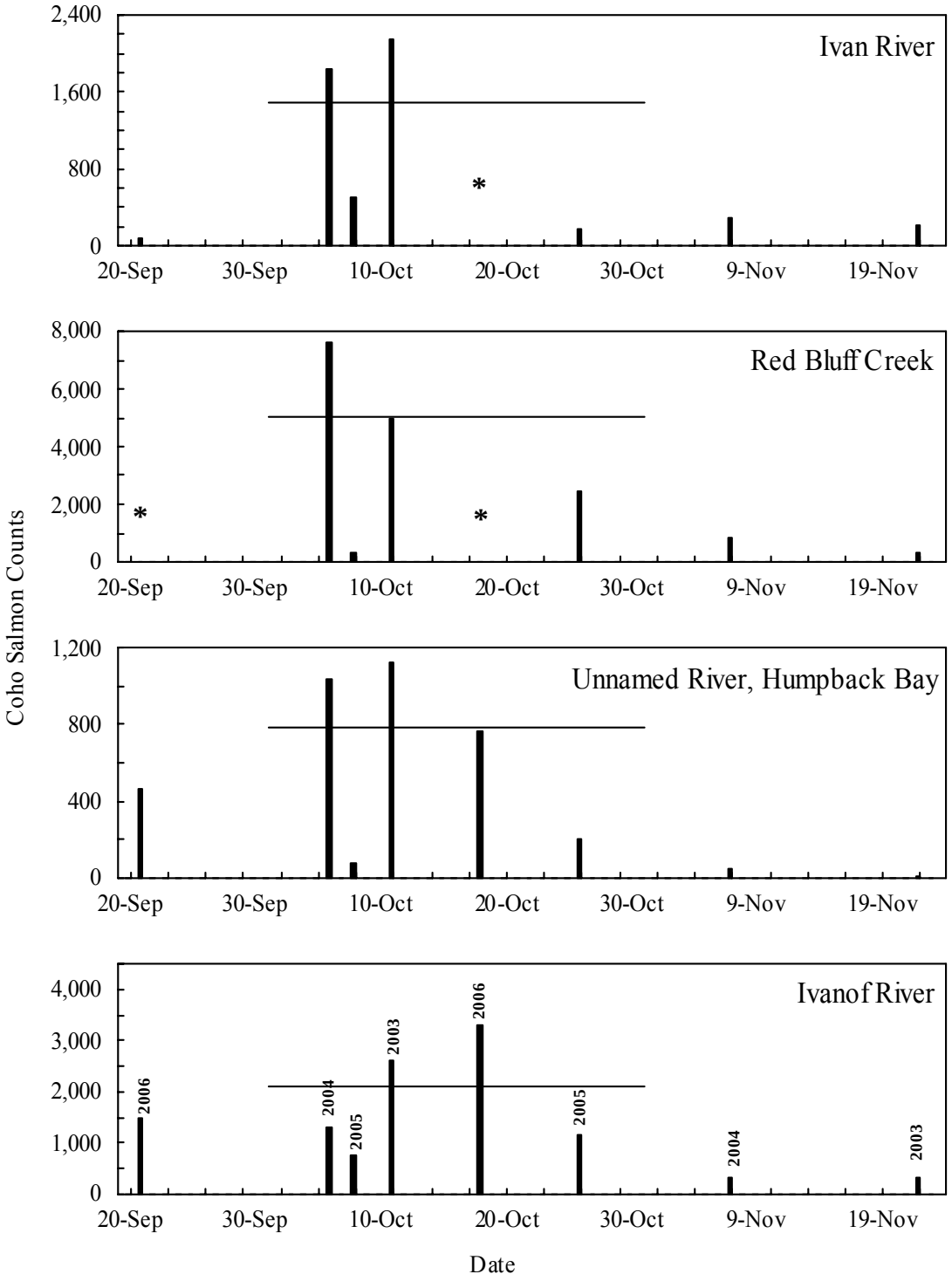


Figure 8. Numbers of coho salmon observed during aerial surveys of the four Perryville area streams having the greatest counts, 2003-2006. Survey years for all streams are noted above bars for the Ivanof River graph. Horizontal lines are means of peak annual counts. An asterisk (*) indicates incomplete count data.

Table 3. Salmon counts for Perryville area streams surveyed from 2003 to 2006. Count data for years prior to 2006 are from Anderson (2004; 2005a; 2005b). A plus sign (+) after a count indicates survey was not completed due to poor water clarity.

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

[a] Mainstem Kametolook River only surveyed on 7 Nov. 2004 and 26 Oct. 2005 due to poor water clarity on other dates.

needs in recent years. Strong returns this year in Ivanof River and the unnamed river in Humpback Bay suggest that 2006 was probably a good return year for coho salmon in most other area streams.

Although our surveys occurred earlier in 2006 compared to previous years, the interval between surveys was about four weeks. It is likely that some coho salmon entered the systems, spawned, and died between and after our surveys in 2006. Perrin and Irvine (1990) report an average survey life for coho salmon of 11.4 days, which was compiled from 22 separate estimates throughout 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 four week interval this year to gain more insight into overall run timing.

No trends in run timing or abundance are evident from sockeye salmon count data in Clark River from 2003 to 2006 (Table 3; Figure 9). Two peak counts in 2003 and 2006 were well above numbers observed in other years. 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 2006). The relationship between our peak aerial survey counts in Clark River and escapement of late run fish past the Chignik River weir (Figure 7) indicates that fish that spawn in Clark River in October and November migrate through the Chignik River in August and

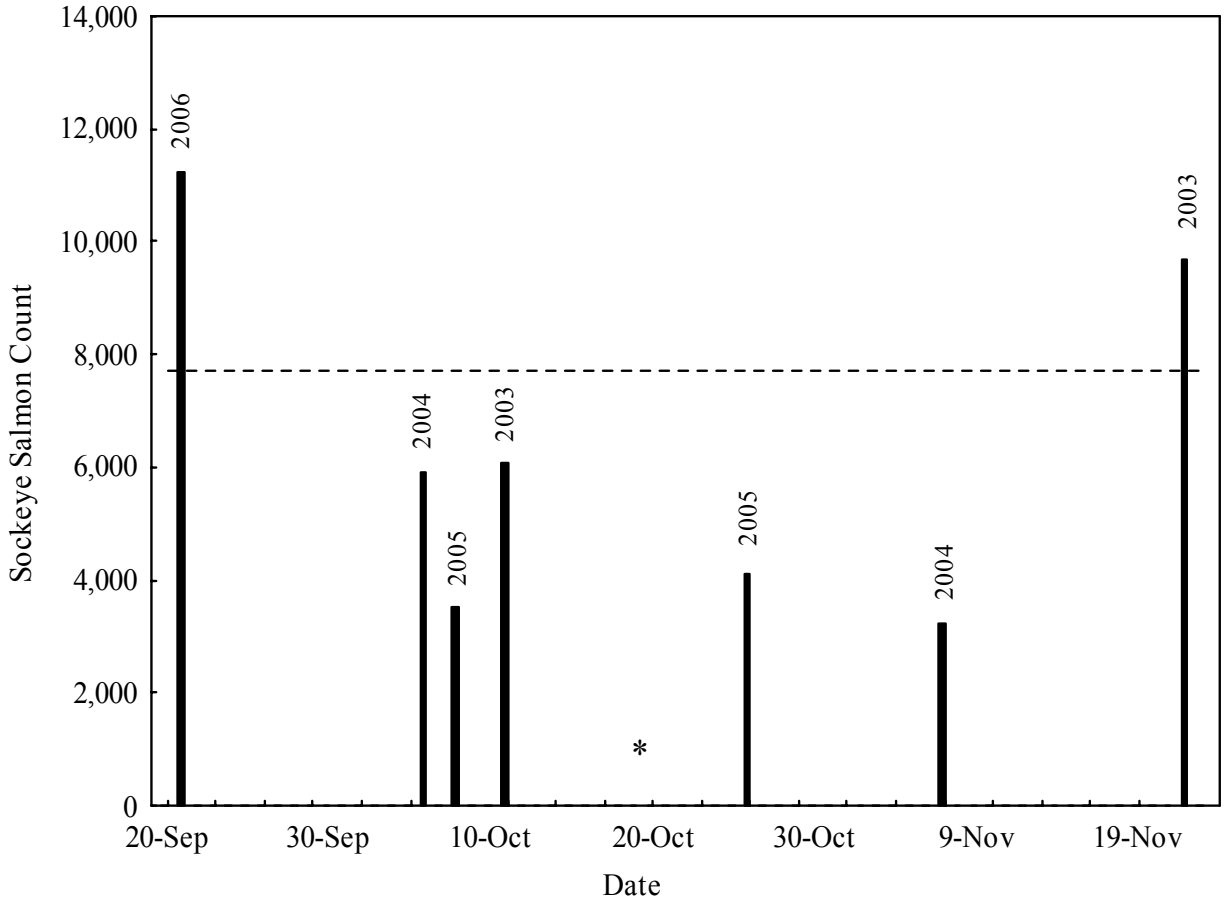


Figure 9. Numbers of sockeye salmon observed during aerial surveys of Clark River. Survey years are noted above bars. Horizontal line is the mean of peak annual counts. An asterisk (*) indicates incomplete count data.

early September while the weir is operational. Previous work using radio telemetry also found that 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 through December and January in some years and these fish likely pass through the Chignik River after the weir is removed in early September (Anderson 2003).

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 additional years. 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. However, stream and weather conditions will continue to strongly influence the effectiveness of these surveys.

## 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 Report for this project. Egli Air Haul provided flight service; the City of Chignik and NorQuest 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. *In review*. Coho salmon population assessment in streams on the Pacific Ocean side of the Alaska Peninsula, Alaska Peninsula National Wildlife Refuge, 2006. U. S. Fish and Wildlife Service, King Salmon Fish and Wildlife Field Office, Alaska Fisheries Technical Report Number XX, King Salmon, 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., 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.

Bradford, M. J. 1995. Comparative review of Pacific salmon survival rates. Canadian Journal of Fisheries and Aquatic Sciences 52:1327-1338.

Bradford, M. J., G. C Taylor, and J. A. Allan. 1997. Empirical review of coho salmon smolt abundance and the prediction of smolt production at the regional level. Transactions of the American Fisheries Society 126:49-64.

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.

Mason, J. C. 1976. Response of underyearling coho salmon to supplemental feeding in a natural stream. Journal of Wildlife Management 40:775-788.

Nickelson, T. E. 1998. A habitat-based assessment of coho salmon production potential and spawner escapement needs for Oregon coastal streams. Oregon Department of Fish and Wildlife Information Reports Number 98-4, Portland, Oregon.

Nickelson, T. E., Rodgers, J. D., S. L. Johnson, and M. F. Solazzi. 1992. Seasonal changes in habitat use by juvenile coho salmon (*Oncorhynchus kisutch*) in Oregon coastal streams. Canadian Journal of Fisheries and Aquatic Sciences 49:783-789.

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. 2006. Chignik management area 2006 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.