

**Cumulative
Salmon
Mortality:**

**The Fates and Impact on
Spawning Salmon as a
Result of
Catch/Hook and Release Practices**

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Table of Contents

Abstract.....3

Introduction.....3

A. Fates and Impacts of Chinook Salmon, Kenai River.....4

 1. Chinook Salmon – the First 5 Days – Mortality,
 Morbidity and Lost Spawners.....4

 2. Chinook Salmon, Final Fates, Cumulative Mortality,
 Morbidity and Lost Spawners.....6

 3. Other Practices Considered: Catch and Release or
 Slot Limits.....6

 4. Early Run Chinook and Catch and Release.....6

 5. Movements Through the Lower Kenai River Sport Fishery.....6

 6. Early-Run Component Spawning Activity.....7

 7. Late-Run Component Spawning Activity.....7

 8. Early Run Spawning Destinations.....7

 9. Lower Kenai River Sport Fishery.....7

 10. Exodus of Chinook, Both Early and Late Components, from the
 Lower Reaches of the Kenai River.....8

 11. Multiple Hooking Events.....8

 12. Targeting of Large Female Chinooks.....9

B. Sustina River Chinook.....9

 1. Susitna River Spawning Destinations and Milling Areas.....9

C. Successful Spawning of Catch & Release Salmon.....9

 1. Conclusion.....9

 2.(4.3) Conclusions and Management Considerations.....10

D. Fate(s) of Coho Caught and Released.....11

E. Application of Catch and Release Mortality.....12

All Five Salmon Species C&R Mortality, Morbidity and Spawning Failures.....13

Summary.....13

Implications for fisheries.....14

Arctic-Yukon-Kuskokwim Chinook Action Research Plan.....15

| | | |
|-------|--|----|
| 5.6 | Hypothesis 6 – Escapement Quality..... | 15 |
| 5.6.1 | Description of the Hypothesis..... | 15 |
| 5.6.2 | Plausibility of the Biological Mechanism(s)..... | 16 |
| 5.6.3 | Summary of Evidence for Hypothesis..... | 16 |
| 5.6.4 | Priority Research Themes and Example Question..... | 17 |

Tables

| | | |
|----------|---|----|
| Table 1. | Five-day and final fates for 466 chinook salmon that were tagged and released in the Kenai River during 1989 through 1991. (Bendock, 1992)..... | 4 |
| Table 2. | Total number of salmon released in Upper Cook Inlet..... | 12 |
| Table 3. | Average, 1996-2009, Mortality, Morbidity and Spawning Failures..... | 12 |
| Table 4. | Total of 1996-2009 Mortality, Morbidity and Spawning Failures..... | 13 |

Cumulative Salmon Mortality: The Fates and Impact on Spawning Salmon as a Result of Catch/Hook and Release Practices

Abstract:

Nearly half (50%) of the salmon caught/ hooked and released (C&R) fail to successfully spawn. These C&R practices prevent salmon from reaching a spawning location or result in poor spawning success. Salmon mortality and mortality rates have a wide range of definitions in scientific reports. The Alaska Department of Fish & Game (ADF&G), Federal agencies, stakeholders and the general public all limit or expand the definition of mortality. Mortality as discussed here refers to all the forms of removing salmon from a spawning population. This total cumulative mortality includes dead, diseased, back-outs, physically damaged, including biased sex ratios, egg/sperm (gamete) retentions and spawning of infertile eggs. This total cumulative mortality is seven to ten times (7 to 10x) greater than most of the mortality rates reported by ADF&G, especially for Chinook and Coho. All salmon management models and techniques involve accurate estimates of the spawning population. Biological, enumeration, management, allocation and regulatory errors are made whenever these total cumulative mortalities are not accurately assessed.

Introduction:

The survival and spawning success of Chinook and Coho salmon are significantly lower (50 to 90%) after a catch/hook and release (C&R) event, thus, creating morbid salmon that maybe still live, but never arrive at a spawning location or fail to successfully spawn. Over thirty-six percent (36.8%) of the Chinook that were C&R in the Kenai River failed to reach the spawning grounds. Over seventy percent (70%) of the Coho in the Little Susitna River that had a C&R event failed to survive or even attempt to spawn. In the Unalakleet River, of the coho that had a C&R event, fifteen percent (15%) also failed to reach the spawning areas. None of these studies examined the spawning success of the surviving salmon. Not recognizing effects of C&R practices resulting in salmon morbidity, lost spawners and poor spawning success rates go to the very core of why we establish escapement goals, regulate fishing activities (harvests) and apply prudent management practices. The real question is "How do C&R practices impact the spawning numbers, sex ratios, salmon morbidity, spawning success and quality of the spawn, collectively labeled non-survivors or total cumulative salmon mortality?"

A. Fates and Impacts on Chinook Salmon, Kenai River

1. Chinook Salmon - the First 5 Days - Mortality, Morbidity and Spawning Failures

Table 1, (Table 5, Bendock 1992) has been reconstructed below. It describes a 15.9% non-survivor, mortality rate within the first five (5) days following a C&R event. Table 5 doesn't include spawning failures (egg retention, infertile eggs and mate selection failures) once these Chinook are on the spawning beds

| Table 5. Five-day and final fates for 466 chinook salmon that were tagged and released in the Kenai River during 1989 through 1991. (Bendock, 1992) | | | | | | | | |
|--|------------------------|-------------------------|------------------------|-------------------------|-----|----------------|--------------|--------------|
| Fates | 1989 | 1990 | | 1991 | | All (n=446) | Percent % | Percent % |
| | Late Run (n=100) | Early Run (n=125) | Late Run (n=120) | Early Run (n=101) | | | | |
| Five Day Fates (Mortality) | | | | | | | | |
| Survivor | 63 | 112 | 106 | 94 | 375 | | | 84.1% |
| <i>Non-Survivor Mortality</i> | | | | | 71 | | | 15.9% |
| 1) Mortality | 9 | 11 | 7 | 4 | 31 | | 7.0% | |
| 2) Sport Harvest | 13 | 1 | 3 | 0 | 17 | | 3.8% | |
| 3) Set Net | 6 | 0 | 1 | 0 | 7 | | 1.6% | |
| 4) Tag Net | 7 | 1 | 1 | 3 | 12 | | 2.7% | |
| 5) Sub Net | 1 | 0 | 0 | 0 | 1 | | 0.2% | |
| 6) Drop Out | 0 | 0 | 2 | 0 | 2 | | 0.4% | |
| 7) Unknown | 1 | 0 | 0 | 0 | 1 | | 0.2% | |
| Final Fates (Mortality) | | | | | | | | |
| Survivor | 40 | 94 | 71 | 77 | 282 | | | 63.2% |
| <i>Non-Survivor Mortality</i> | | | | | 164 | | | 36.8% |
| 1) Mortality | 9 | 15 | 7 | 6 | 37 | | 8.3% | |
| 2) Sport Harvest | 22 | 9 | 12 | 5 | 48 | | 10.8% | |
| 3) Set Net | 9 | 0 | 5 | 0 | 14 | | 3.1% | |
| 4) Tag Net | 7 | 2 | 6 | 4 | 19 | | 4.3% | |
| 5) Sub Net | 1 | 0 | 0 | 0 | 1 | | 0.2% | |
| 6) Drop Out | 7 | 3 | 11 | 3 | 24 | | 5.4% | |
| 7) Up Lost | 3 | 2 | 8 | 4 | 17 | | 3.8% | |
| 8) Unknown | 2 | 0 | 0 | 2 | 4 | | 0.9% | |

Definitions used in Table 5 on the previous page:

Survivor: a fish that has sustained upstream movement, transmitted radio signals in either normal or active modes, or were harvested after 5 days at large;

Mortality: a fish that failed to move upstream from the intertidal area (rkm 19.3, rm 12), transmitted radio signals in mortality mode, or was recovered as a carcass within 5 days of release (see discussion below),

Note: Mortality definition does not included total cumulative mortality;

Sport Harvest: fish tagged with transmitters that were recovered in the recreational fishery;

Set Net Harvest: fish tagged with transmitters that were recovered in the eastside Cook Inlet commercial set net fishery or fish processing plants;

Tag Net Harvest: fish tagged with transmitters that were recovered in the ADF&G gill net studies conducted in the Kenai River;

Education Net Harvest: fish tagged with transmitters that were recovered in the inriver Kenaitze Tribal education fishery;

Drop-Out: fish that returned to Cook Inlet and were not subsequently relocated.

Please note in Table 5 on the previous page, the non-survivor mortality rates for Five Day Fates, 71 (15.9%), is much lower than the Final Non-Survivor Fates, 164 (36.8%). These results indicate that 71 (15.9%) Chinook were not surviving after 5 days. At the Final Fates measurement, 164 (36.8%) had suffered some form of mortality, morbidity, or removal from the spawning population (non-survivors).

It is noted in Table 5 that the Five Day Fate mortality rate (fate 1) was 31, or 7.0% of the Chinook. This Five Day mortality, 7%, is one of the seven (7) fates that, when combined, comprise the non-survivor 15.9% mortality rate. This 7% Five Day Fate (fate 1) mortality rate is often reported as the only and total C&R mortality. This 7% Five Day Fate mortality is somewhat accurate, but highly misleading, as this 7% Five Day Fate mortality rate totally ignores the 15.9% or 71 mortality, morbidity, or removals. During the first Five Days, 15.9% of the Chinook were non-surviving, morbid, or removed from the population.

2. Chinook Salmon – Final Fates – Mortality, Morbidity and Spawning Failures

The bottom half of Table 5 summarizes the Final Fates of the 446 Chinook that were caught and released. There were 164 (36.8%, Fates 1-8) of the original C&R (n=446) Chinook that never reached survivor status. In total, 164 (36.8%) Chinook were categorized as non-survivors. Just because Bendock listed Chinook (n=282) as survivors, doesn't mean successful spawning occurred. Survivors are not the same as spawners. No verification was made concerning egg/sperm retention, quality of spawn, mate selection, selection or defense of redd sites or the viability of eggs or fry. This 164 (36.8%) mortality or morbidity rate is attributable to C&R practices. These 164 fish do not contribute to the spawning population or future generations. These 164 (36.8%) morbid removals are 5 to 6 times larger than the reported 5 day mortality rate of 7%. To accurately determine and describe the Total Cumulative Mortality, Morbidity or Spawner removals, the final non-survivor (36.8 %) must be added to the Spawning failure (10-15 %). For Chinook about 50% of the caught/hooked and released fish will not successfully spawn, deposit viable eggs.

3. Other Practices Considered: Catch and Release or Slot Limits

The voluntary practice of C&R fishing for Chinook salmon in the Kenai River has been increasing. Even now, some individuals only practice C&R Chinook fishing. Some eight years ago, a reverse slot limit regulation relied on a 6-7% Five Day mortality rate, while totally ignoring that 36.8% are non-survivors. Total cumulative mortality of these C&R Chinook are dead, morbid, or never survive to spawn. The absence of large, over 55 inch, Chinook and the slot limit size Chinook have been all but eliminated from the Kenai River returns in both early and late runs.

4. Early Run Chinook and Catch and Release

In the early run component of the Kenai Chinook population, some years 90% of these fish were caught and released, or harvested and released. In recent years, the percentage of the early run component that is being caught has decreased.

5. Movements Through the Lower Kenai River Sport Fishery

Holding or milling behavior was observed for most radio-tagged fish. Few fish migrated directly to a spawning destination following release and many spent a week or longer milling in the intertidal zone before initiating upstream movement. Often, these Chinook spent 30-31 days in the river before spawning.

6. Early-Run Component Spawning Activity

Completion of early-run spawning activity, as evidenced by consecutive mortality signals or downstream movement from maximum upper locations, occurred from 24 June through 23 August with peak spawning in mid-July. Median spawning dates were 15 July for Funny River, 17 July for Killey River, 22 July for Benjamin Creek and 19 July for mainstem spawners.

7. Late-Run Component Spawning Activity

Completion of late-run spawning activity, evidenced by consecutive mortality signals or downstream movement from maximum upper locations, occurred from 24 July to 11 September with a median spawning date of 17 August. Median spawning date for radio-tracked fish was earliest for the lower reach (10 August), latest for the upper reach (25 August), and intermediate for the middle and interlake reaches (16 and 22 August, respectively)

8. Early Run Spawning Destinations

Holding or milling behavior of radio-tracked salmon was observed both enroute to, and near spawning destinations. An average of approximately 1 month transpired between tagging and spawning destinations during this period. Lower Kenai River spawners frequently milled for one to several weeks in the upper intertidal reach before migrating the remaining few kilometers to a spawning site. Several fish that did not move for up to 10 days in the lower river were subsequently sport harvested and reported to be in excellent condition. Early-run fish often entered tributaries such as Beaver Creek or the Funny River for one or more days before continuing up the mainstem to a final destination.

9. Lower Kenai River Sport Fishery

If salmon backed down to Cook Inlet in response to hooking events, it is possible that mandatory catch and release fishing during a late-run conservation shortfall may result in higher gill net mortalities, due to sustained high catch rates in the lower river recreational fishery. However, the disproportionately high sport fishing harvest occurs in the lower 32 river kilometers (Hammarstrom 1989) likely targets on lower-river spawners.

Salmon that back downstream and possibly return upstream a second time, or mill in the lower Kenai River, may result in multiple sonar counts which can affect the accuracy

of the inriver return estimate. Other studies have shown that salmon may return to salt water after being handled in fresh water, and there is abundant anecdotal evidence of these movements based on the presence of sportfishing tackle (hooks and lures) on salmon caught in Cook Inlet gill net fisheries.

10. Exodus of Chinook, Both Early and Late Components, from the Lower Reaches of the Kenai River

The slow exodus of early-run fish from the reach of the river open to fishing makes them vulnerable to harvest throughout much of both the early and late runs. Since early-run fish cannot be physically distinguished from late run fish, additional closures in the fishery may be necessary to protect them from harvest in years of a conservation shortfall.

11. Multiple Hooking Events

All of the Chinook salmon used in this study, Bendock 1992, were hooked and released at least once, and 48 of these fish (the sport harvested component) were hooked at least twice. Anglers reported additional hook-and-release events for 18 fish during the 3 years of study; thus, at least 15% of the fish in this study were hooked multiple times. Of fish that were released more than once, the proportion that spawned was half of the overall rate, while the proportion of drop outs was three times (3x) higher. Additional hooking events and subsequent injuries may explain the abrupt downstream movements we observed in some fish that had penetrated several kilometers upstream. Furthermore, as catch rates increase in the sport fishery, morbidity and mortality may also increase due to cumulative injury from multiple hooking events.

The 15.9% Five Day Fate and the 36.8% Final Fate mortalities include those Chinook that were caught and released once, only to be caught a second time. These Chinook were harvested or released. Fifteen percent (15%) of the (n=446) or 67 Chinook were hooked multiple times. The Five Day and Final Fate mortality rates include the harvested portion of these 67, twice-caught Chinook. The Five Day and Final Fate cumulative mortalities do not include Chinook that were hooked and escaped (not landed) or hooked with fishing line break-offs. These Chinook also have an associated hooking and escape mortality. It is generally accepted that a second hooking of a Chinook, regardless of escape or release, will result in a 100% mortality, morbidity, or removal from the spawning population. Extended hook and struggle (playing) times also are not included in the 15.9% Five Day Fate or 36.8% Final cumulative mortality, morbidity or spawner removals.

12. Targeting of Large Female Chinooks

Large female Chinook are regularly targeted and are involved in C&R events. As a result, these large female Chinook have higher hooking rates, even multiple C&R events. Their Five Day and Final Fates both reveal higher spawning failures, morbidity, than other components of the return. These C&R events resulted in male-biased sex ratios, 80% male and 20% female, in many locations in the Kenai River and its tributaries.

B. Susitna River Chinook

1. Susitna River Spawning Destinations and Milling Areas

Similar behaviors were observed for Chinook salmon spawning in tributaries to the Susitna River (ADF&G 1983). The variability we observed in movement rates for salmon between the point of release and the upper automated data collection computer (DCC) may be explained, in part, by the tendency of Chinook salmon to hold for prolonged periods or temporarily back downstream, and because fish spawning in the vicinity of the DCC spent their entire stream life enroute to that location.

C. Successful Spawning of Catch & Release Salmon

McConnachie, et al, 2012, *Hormones and Behavior* 62 (2012) 67-76
62, P 67-76. Consequences of Acute Stress and Cortisol Manipulation on the Physiology, behavior, and reproductive outcome of female Pacific salmon on spawning grounds

1. Conclusion

Because the migratory and spawning processes of Pacific salmon are regarded as remarkable challenges, we strive to understand the links among physiology, behavior and fitness in these animals. Salmon migrations historically have shown a large degree of consistency, but any environmental changes or anthropogenic perturbations are considered a potential threat to reproduction, and thus survival, of a given population. Our results suggest that acute stressors do not influence behavior or reproductive outcome when experienced upon arrival at spawning grounds. However, there is a limit to the ability of these fish to tolerate elevated cortisol levels because experimental cortisol elevation for several days negatively affected reproductive success and longevity. Collectively, our results address a void in current research, explaining how