

# Interactions between brown bears and chum salmon at McNeil River, Alaska

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**Abstract:** Predation on returning runs of adult salmon (*Oncorhynchus* spp.) can have a large influence on their spawning success. At McNeil River State Game Sanctuary (MRS GS), Alaska, brown bears (*Ursus arctos*) congregate in high numbers annually along the lower McNeil River to prey upon returning adult chum salmon (*O. keta*). Low chum salmon escapements into McNeil River since the late 1990s have been proposed as a potential factor contributing to concurrent declines in bear numbers. The objective of this study was to determine the extent of bear predation on chum salmon in McNeil River, especially on pre-spawning fish, and use those data to adjust the escapement goal for the river. In 2005 and 2006, 105 chum salmon were radiotagged at the river mouth and tracked to determine cause and location of death. Below the falls, predators consumed 99% of tagged fish, killing 59% of them before they spawned. Subsequently, the escapement goal was nearly doubled to account for this pre-spawning mortality and to ensure enough salmon to sustain both predators and prey. This approach to integrated fish and wildlife management at MRS GS can serve as a model for other systems where current salmon escapement goals may not account for pre-spawning mortality.

**Key words:** Alaska, brown bear, chum salmon, escapement, McNeil River, *Oncorhynchus keta*, predation, *Ursus arctos*, wildlife–salmon interactions

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Food webs involving Pacific salmon (*Oncorhynchus* spp.) and their predators are complex (Willson et al. 1998, Cederholm et al. 2000), and the importance of the predator–prey relationship between bears (*Ursus* spp.) and salmon in ecosystem processes has received increased attention (Reimchen 2000, Gende 2002). The ecological consequences of bear–salmon interactions and the nutritional importance of salmon to bears are both well documented (Hilderbrand et al. 1999a,b; Ben-David et al. 2004; Gende and Quinn 2004; Hilderbrand et al. 2004). Brown bears (*U. arctos*) with access to salmon achieve heavier body weights, produce larger litters, and are found at higher population densities than bears without access to salmon (Hilderbrand et al.

1999b). Conversely, the age at first reproduction and the interval between litters are increased for bears without access to high quality food resources, such as salmon (Bunnell and Tait 1981, Rogers 1987, Stringham 1990a,b).

McNeil River State Game Sanctuary (MRS GS) is recognized internationally as a world-class brown bear viewing destination because of its uniquely high concentration of bears in a natural setting (Sellers and Aumiller 1993). MRS GS was created by the Alaska State Legislature in 1967 and is managed by the Alaska Department of Fish and Game (ADFG) to “provide permanent protection for brown bears and other fish and wildlife populations and their habitats, so that these resources may be preserved for scientific, aesthetic, and educational purposes” (Schempf and Meehan 2008:3). When compatible with this goal, other human uses, such as bear

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viewing and fishing, are permitted (Schempf and Meehan 2008). For example, when human visitation in the early 1970s was found to be having an adverse effect on the number of bears, a permit system was established to limit visitation (Faro and Eide 1974).

Chum salmon (*O. keta*) are an important seasonal food source for the extraordinarily high concentration of brown bears that aggregate annually at McNeil River Falls. Few places in the world provide such a dramatic example of how direct can be the relationship between bears and salmon. As many as 101 individual bears (144 including cubs) have been identified at MRS GS within a 10 km<sup>2</sup> area during a single year (Schempf and Meehan 2008), and >40 bears at one time are commonly viewable from the falls (J. Peirce, unpublished data, 2006).

Assuring a predictable food resource is an important factor in maintaining consistent bear use of an area (Aumiller and Matt 1994). Despite annual closures to the McNeil River commercial fishery since 1994, the escapement goal (the total number of adult chum salmon that fishery managers want to reach their natal spawning grounds to sustain future returns) has been met only sporadically. A post-1988 decline in chum salmon returns to the McNeil River coincided with the beginning of a decade-long decrease in chum salmon returns throughout Lower Cook Inlet. Beginning around 1999, chum salmon returns rebounded everywhere in Lower Cook Inlet except the McNeil River, suggesting a freshwater cause for the lack of recovery.

Brown bears are a major source of mortality to chum salmon at MRS GS, but the rate of mortality has not been quantified. Our objective was to estimate the amount of bear predation on chum salmon and specifically predation on pre-spawning fish in the McNeil River. Fish stocks are unique and cannot be managed successfully without taking into consideration the context of the watersheds they inhabit (Williams 2000). Consideration of ecosystem needs is becoming increasingly recognized as an important factor in fisheries management (Cederholm et al. 2000, Knudsen et al. 2003, Michael 2003, Hilderbrand et al. 2004). The State of Alaska has codified this consideration in its Policy for the Management of Sustainable Salmon Fisheries (5 AAC 39.222), where section (c)2(G) states: "The role of salmon in ecosystem functioning should be evaluated and considered in harvest management decisions and setting of salmon escapement goals." Marine fishery scientists have also recently begun

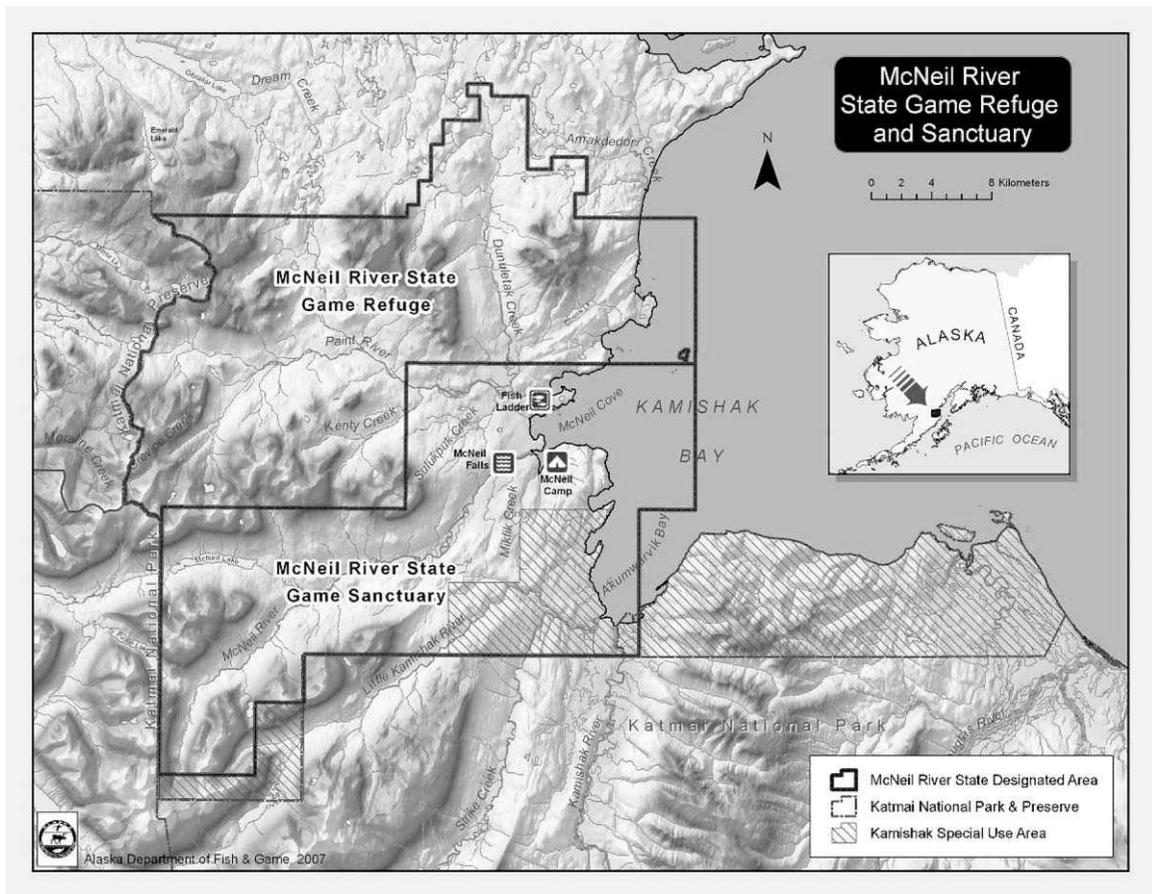
advocating that predator effects be explicitly accounted for prior to estimating the harvestable surplus for some species (e.g., Overholtz et al. 2008). We propose a similar approach herein, with the purpose of this work being to explicitly incorporate pre-spawning mortality into a revised escapement goal for McNeil River chum salmon that aims to help ensure long-term viability of both predator (brown bears) and their prey (chum salmon).

## Study area

The MRS GS is approximately 340 km southwest of Anchorage and 160 km west of Homer, Alaska (Fig. 1). MRS GS encompasses both the McNeil River and Mikfik Creek drainages and is approximately 51,800 ha. McNeil Lagoon is formed by a long spit that nearly separates it from McNeil Cove (Fig. 2) and the larger Kamishak Bay (Fig. 1). McNeil River and Mikfik Creek both drain into the lagoon, which is flooded at high tide and channeled mud flats at low tide. High quality chum salmon spawning habitat is located in several sections of stream within the lower 20 km of McNeil River, the vast majority of which occurs above McNeil Falls; however, most spawning and associated bear activity occurs below McNeil Falls.

Bears begin to arrive at MRS GS each year in late May and concentrate their feeding activities on the protein rich sedge (*Carex lyngbyei*) flats until the Mikfik Creek run of sockeye salmon (*O. nerka*) begins in early June. In late June to early July, bear activity gradually shifts to the McNeil River for the chum salmon run, which lasts into mid-August. During the peak of the chum salmon run in mid-to late-July, bears are concentrated in the vicinity of McNeil Falls, 1.6 km upstream of the lagoon. Here salmon are made vulnerable to bears by a cascading series of rapids formed from eroded conglomerate rock as they rest in pools or attempt to ascend the falls (Fig. 3).

The majority of adult chum salmon do not successfully ascend the falls (only 10–15% during this study; Peirce et al. 2011), and by late July to early August chum salmon below the falls drop back to the lower McNeil River, including the tidally influenced area, to spawn. The activity of bears follows the fish, and they shift their fishing effort from the falls to the shallow spawning grounds downstream. Both sockeye and chum salmon are heavily preyed upon in the lagoon and cove by



**Fig. 1.** Map of McNeil River State Game Sanctuary (MRSGS), Alaska, USA, for a 2005–06 study of interactions between brown bears and chum salmon.

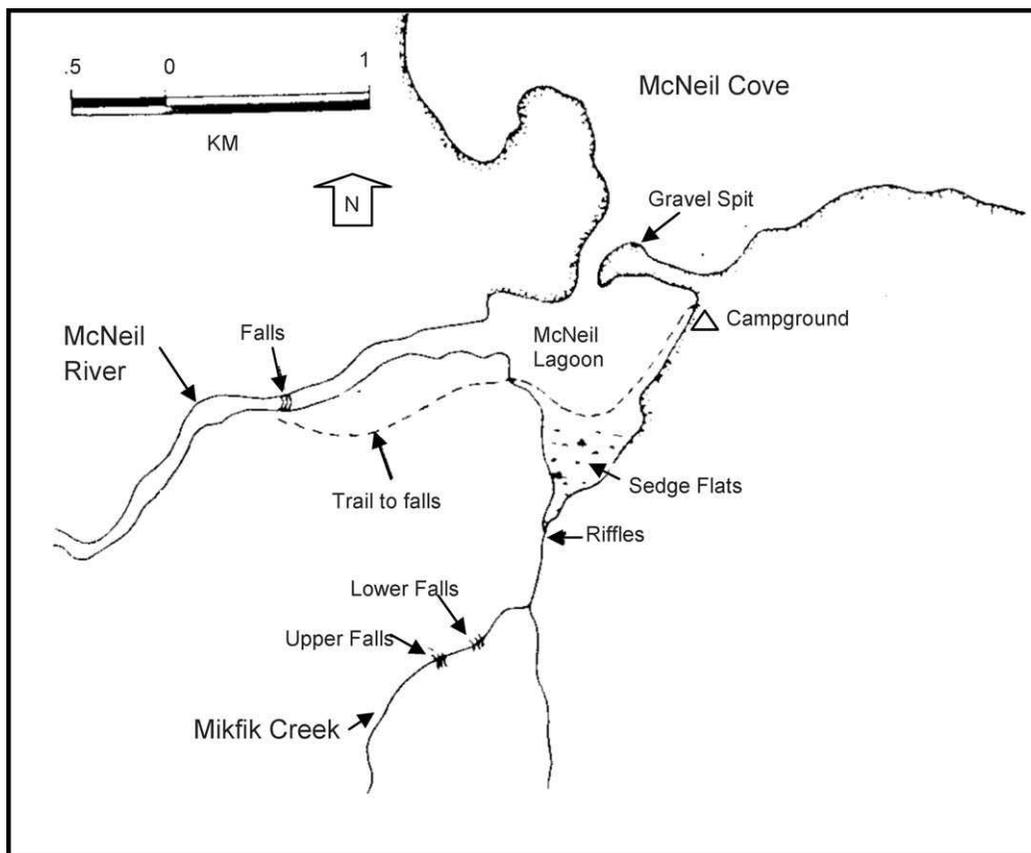
harbor seals (*Phoca vitulina*) at high tide and bears at low tide. By mid to late August most chum salmon have spawned and died, and bear activity at MRSGS diminishes substantially.

## Methods

We conducted fieldwork during June through August in 2005 and 2006. Bear-use days at McNeil Falls were recorded by visually identifying individual bears using distinguishing characteristics and behavior (Sellers and Aumiller 1993, Peirce and Van Daele 2006). This included the total number of adult males, adult females, adult females with offspring, and subadults. Each individual bear observed on any given day represented 1 bear-use day. For example, an individual bear present at the falls 2 days in a row was counted as 2 bear-use days. Mean and 95% CI of bear-use days were calculated for the month of July.

From approximately 5 July to 5 August during both 2005 and 2006, daily observations were made to determine hourly catch rates of chums by bears at McNeil Falls. Chum salmon captured by bears were recorded during continuous half-hour scans during approximately 1200–1900 daily (the time staff took visitors to the falls). The number of chum salmon captured by bears at the falls was also recorded during 1985–87, 1989–98, and 2003 using similar methods (P. Hessing, ADFG retired, Anchorage, Alaska, USA, unpublished data, 2007). Aerial indices of escapement were determined for these same years using the area under the curve as described in Peirce et al. (2011). Linear regression was used to investigate the relationship between catch rates and escapement, as well as between catch rates and the average bear use at the falls in July.

In 2005 and 2006, chum salmon were captured using rod and reel, as soon as they left the ocean and



**Fig. 2.** Detail of lower McNeil River and Lagoon, McNeil River State Game Sanctuary, Alaska, USA. Fish were tagged at the tip of the gravel spit as they entered freshwater. Remote data loggers were located on the spit and immediately upstream of McNeil Falls to monitor the status (live/dead) of radiotagged chum salmon in the lower river and to document tagged fish ascending or descending the falls.

entered McNeil Lagoon, and fitted with gastrically implanted radiotransmitters with mortality sensors (Peirce et al. 2011). All adult chum salmon were monitored from the time they were tagged until mortality (a period we defined as “stream life”). Below the falls, we monitored fish continuously using fixed telemetry stations as well as daily ground tracking to determine their live/dead status. Fish above the falls were tracked 1–2 times/week by aircraft. We recovered transmitters from dead fish as soon as possible. However, the need to avoid disturbing bears and concerns for human safety sometimes precluded immediate recovery of transmitters.

Studies have indicated if a salmon is going to regurgitate a transmitter it is likely to do so shortly after capture (Ramstad and Woody 2003; J. Eiler, National Marine Fisheries Service, Juneau, Alaska, USA, personal communication, 2006). Additionally, we were concerned with post-handling stress, which may have

made some fish more susceptible to predation. To avoid such biases many researchers do not include tagged fish in their analysis unless they pass a data logger some distance upstream from the capture location (Eiler et al. 2006). However, this was not an option at McNeil River, where most spawning occurs within 1.6 km of the ocean. Therefore, we excluded from our analyses tagged chum salmon that died within 24 hours later to avoid biasing our estimates of stream life.

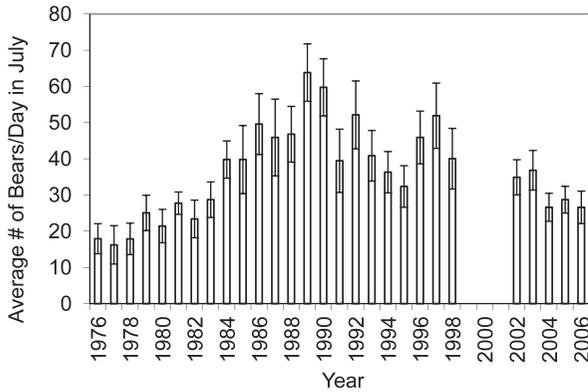
We assigned a cause of death for each radiotagged fish based on the location of the transmitter when it was recovered, how long the fish was alive in fresh water, and time of death relative to the onset of spawning. Cause of death was categorized as bear, unknown (bears or seals), or post-spawning senescence. Other sources of predation were negligible.

In cases where only a transmitter was found, we used the following assumptions to determine whether or not the fish had spawned:



**Fig. 3.** Ground-level view of McNeil Falls, Alaska, USA, located 1.6 km upstream from the ocean, illustrating the high concentration of brown bears and the physical impediments to chum salmon migration beyond this point. Photos by Joshua Peirce.

1. The average stream life of fish above the falls where predation was low was 21.9 days (Peirce et al. 2011). Therefore, all fish that lived longer than 20 days were assumed to have spawned.
2. The stream-wide average stream life was 13.8 days (Peirce et al. 2011). Therefore, all fish above the falls that lived at least 7 days (half the average stream life) and died on or after 15 July (the approximate date of the



**Fig. 4.** Mean (with 95% CI bars) number of brown bears per day in July at McNeil Falls, Alaska, USA. No daily bear-use data were collected in 1999–2001.

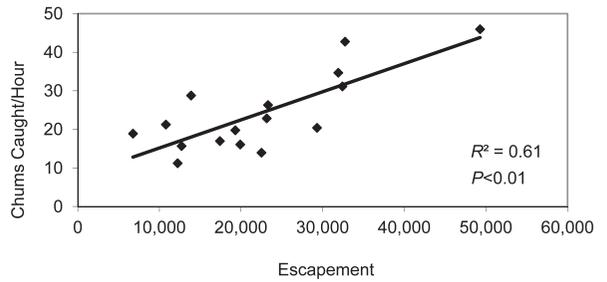
onset of spawning above the falls) were assumed to have spawned. These data were also reanalyzed using alternative assumptions of 3 days and 5 days.

3. All other fish above the falls with mortality-signaling transmitters were considered to have been killed by a bear prior to spawning.
4. Chum salmon do not spawn at the falls and harbor seals do not ascend that far upriver, so all fish that died at the falls were assumed to be pre-spawning fish that were killed by bears.
5. All fish below the falls that lived at least 7 days (half the average stream life) and died on or after 25 July (the approximate date of the onset of spawning below the falls) were considered to have spawned. These data were also reanalyzed using alternative assumptions of 3 days and 5 days.
6. All other fish with mortality-signaling transmitters below the falls were considered to have been killed prior to spawning by either a bear or a seal.

The data collected using radiotelemetry were summarized to determine sources of mortality and spawning success for individual adult chum salmon.

**Results**

We documented 804 bear-use days at McNeil Falls during July 2005. During the 28 days of observations, average use was 29 bears/day (95% CI = 25.3–32.7). In 2006, we documented 665 bear-use

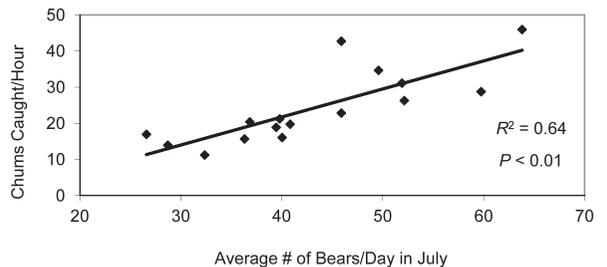


**Fig. 5.** Relationship between the average number of chum salmon caught per hour in July by brown bears (*Ursus arctos*) at McNeil River Falls and the annual chum salmon escapement index at MRSGS, Alaska, USA, 1985–87, 1989–98, 2003, and 2005–06.

days over 25 days ( $\bar{x} = 27$  bears/day, 95% CI = 22.5–31.5). The most recent year that average bear-use days had been that low was in 1983 (Fig. 4).

In 2005, we observed 2,332 adult chum salmon being captured by bears at the falls during 167 hours of observation. In 2006, we observed 2,504 chum salmon being captured during 147.5 hours of observation. Catch rates were a positive function of annual total escapement ( $\beta = 0.0007$ ,  $n = 16$ ,  $r^2 = 0.61$ ,  $P < 0.01$ ; Fig. 5). Similarly, catch rate was a positive function of bear-use days at the falls in July ( $\beta = 0.78$ ,  $n = 16$ ,  $r^2 = 0.64$ ,  $P < 0.01$ ) (Fig. 6).

Of the 155 chum salmon tagged in 2005 and 2006, 105 lived >24 hours and were used to determine fate. In 2005, 98% of the tagged chum salmon that remained below the falls were consumed by bears or seals, either before or after spawning, and in 2006, 100% were consumed. In the 2 seasons of this study, only 1 tagged spawned out chum salmon carcass (a senescent male) was found, and the overall



**Fig. 6.** Relationship between the average number of chum salmon caught per hour in July by brown bears and the average number of brown bears observed per day in July at McNeil River Falls, MRSGS, Alaska, USA, 1985–87, 1989–98, 2003, and 2005–06.

**Table 1. Chum salmon mortality at McNeil River, Alaska, USA, 2005–06.**

	Stream wide	Above falls	Below falls
<b>2005</b>			
Tagged fish that lived >24 hr	43	3	40
Pre-spawning tagged fish killed (%)	27 (63%)	0 (0%)	27 (68%)
Tagged fish assumed to spawn	16 (37%)	3 (100%)	13 (33%)
<b>2006</b>			
Tagged fish that lived >24 hr	62	17	45
Pre-spawning tagged fish killed	25 (40%)	2 (12%)	23 (51%)
Tagged fish assumed to spawn	37 (60%)	15 (88%)	22 (49%)
<b>2005–06</b>			
Tagged fish that lived >24 hr	105	20	85
Pre-spawning tagged fish killed	52 (50%)	2 (10%)	50 (59%)
Tagged fish assumed to spawn	53 (50%)	18 (90%)	35 (41%)

consumption rate of tagged fish below the falls was 99%. Only 1 transmitter was recovered above the falls in 2005. In 2006, 2 tagged fish that died prior to spawning were assumed to have been consumed by bears. Because we were unable to reach most upstream areas on foot, we were not able to determine how many senescent tagged chum salmon were consumed by bears above the falls. We never observed nor found any evidence that bears consumed the radio transmitter while eating tagged fish.

We estimated that 37% of the tagged chum salmon spawned stream-wide in 2005; 100% of those that ascended the falls spawned, and 33% of tagged fish below the falls spawned. In 2006 we estimated 60% spawning success stream-wide for all tagged salmon, with 88% and 49% spawning success above and below the falls, respectively. The 2-year average percent of tagged chum salmon that spawned successfully was 50% stream-wide: 90% above the falls and 41% below the falls (Table 1). To ensure we did not misrepresent spawning success, these data were reanalyzed using a more conservative 3 and 5 day time frame (instead of 7 days), and the results did not change.

## Discussion

### *Bear predation of salmon*

Bears represent the largest and most widely distributed terrestrial predator of salmon (Reimchen 2000). Many individual bears return year after year to fish at McNeil River (Luque and Stokes 1976; J. Peirce, unpublished data, 2006). Consumption rates of pre-spawning salmon by bears vary greatly depending on the size of the stream and the numbers of bears and salmon (Quinn and Kinnison 1999, Reimchen 2000, Ruggerone et al. 2000, Quinn et al.

2001, Dickerson et al. 2002). In our study, we found that 59% of all tagged chum salmon below the falls were killed before they spawned. Above the falls, where salmon are much less susceptible to predation, pre-spawning mortality was only 10% (Table 1).

Over the 2 years of our study, 99% of all tagged fish below the falls were entirely consumed by the time we located them (generally within 24 hr of detecting a mortality signal). Because there was usually no carcass to recover, we were unable to determine spawning status by physical examination. It was only through the use of radio telemetry that we were able to estimate each tagged salmon's final fate. Untagged salmon carcasses were rarely found along McNeil River in 2005–06, and the complete consumption of our tagged chum salmon was typical of the overall population. With the intensive fishing of the lower river by bears and the limited salmon availability in recent years, pre- and post-spawning salmon alike were captured and consumed entirely.

We are confident that our estimates of stream life were sufficiently precise to justify using it as a determinant of whether a fish had spawned. All tagged fish were detected and their positions along the river determined for each survey. We monitored all tagged fish below the falls continuously and monitored tagged fish above the falls 1 to 2 times/week. Peirce et al. (2011) documented the potential error in stream life for fish above the falls as  $\pm 2.5$  days in 2005 and  $\pm 3.3$  days in 2006. We reviewed these data, taking this error into account, and estimated that only 2 fish above the falls in 2006 could have been incorrectly classified as having not spawned. If so, and these fish actually did spawn, then 100% of the fish above the falls would have spawned in 2006, a

result that does not change our interpretations based on our estimate of 88% spawning success.

Carlson et al. (2007) documented that senescence in salmon can be driven by bear predation. Studies have also documented variation in stream life associated with sex and date of stream entry (Ames 1984, Perrin and Irvine 1990). However, Peirce et al. (2011) found no significant difference in stream life between sexes or related to timing of entry in McNeil River. We hypothesize that this unique finding is related to McNeil bears exerting predation pressure consistently enough throughout the run that it masks the normal stream life differences one would typically see associated with sex and date of stream entry.

Esophageal tags are generally preferred for studies of adult salmonids (Eiler 1990, Burger et al. 1995, Ramstad and Woody 2003) because they result in tag retention rates of up to 98% (Eiler et al. 1992, Ramstad and Woody 2003) and associated tagging mortality as low as 1.5% (Ramstad and Woody 2003, Eiler et al. 2006). Esophageal tags were particularly well suited to our study given the potential for external transmitters to provide a visual cue or inhibit swimming performance (Mellas and Haynes 1985), both of which would make tagged fish more vulnerable to predators.

Of the 155 chum salmon we tagged, 105 survived at least 24 hours. The loss of 50 tagged salmon is much higher than can reasonably be expected by regurgitation or tagging-related mortality (Ramstad and Woody 2003). We hypothesize that the high mortality we observed in the first 24 hours was due to tagged fish experiencing short-term post-handling stress that made them more vulnerable to predation. We tagged fish primarily on incoming tides and suspect that most of the fish lost in the initial 24 hours were killed by seals shortly after we handled them. We often observed salmon being caught by seals with the incoming tide, and observed one of our freshly released salmon being killed by a seal. Transmitters from 68% of tagged fish that died during the initial 24 hours were on mortality mode once the tide during which they had been captured receded. To minimize bias, we therefore excluded these fish from our analyses.

Other techniques that have been used to investigate the pre-spawning mortality of salmon caused by bears include weirs (Shuman 1950), visual observations (Frame 1974), stream carcass surveys (Gard 1971), and tagging–recovery surveys (Hanson 1992; Quinn

et al. 2001, 2003). These techniques were effective only because bears were high-grading salmon (consuming only certain parts) and leaving fish pieces behind.

Complete consumption of carcasses by bears can be indicative of scarce salmon resources (Quinn and Buck 2000) or of difficulty in capturing them (Gende et al. 2004). Where there is easy access to salmon, the majority of carcasses are not fully consumed, and bears are highly selective (Quinn and Buck 2000, Gende et al. 2004), allowing them to put on additional fat reserves (Gende 2002). In years of high salmon abundance, bears at McNeil River were commonly observed high-grading, and there were more salmon carcasses and parts scattered along the river than we observed during 2005–06 (L. Aumiller, ADFG retired, Missoula, Montana, USA, personal communication, 2005).

Not surprisingly, capture rates tend to track escapement (Fig. 5). However, multiple factors such as social dominance (Stonorov and Stokes 1972; Gende and Quinn 2004; J. Peirce, unpublished data, 2006) and physical and cognitive skills (Gill and Helfield 2012) can play important roles in determining foraging rates. Even while considering these factors, the lack of high-grading in recent years suggests that it remains to be seen what level of escapement would result in the number of chum salmon killed at McNeil by bears becoming asymptotic. It is clear, however, that this point has not been reached in recent years.

### **Factors potentially affecting chum salmon production**

A preliminary investigation of spawning habitat in the lower 20 km of McNeil River indicated that considerable spawning habitat exists in 2 large braided river sections 10–15 km above McNeil Falls (E. Otis, unpublished data, 2003). However, 85 of 105 tagged chum salmon in our study remained below McNeil Falls (Table 1), an area comprising <10% of the available spawning habitat. These observations suggest that the physical and biological impediments imposed at McNeil Falls constitute a potential bottleneck in the freshwater production of chum salmon in the McNeil River (Fig. 3).

Although the respective contributions to stream-wide population productivity derived from spawners above versus below the falls is difficult to determine with currently available data, it is clear that chum salmon spawning below the falls experience significant challenges. Returning adult chum salmon are

disturbed nearly continuously by bears fishing in the shallow areas at and below the falls, and at high tide there is predation from seals in the lagoon and the lower river. In addition, McNeil River chum salmon regularly spawn in intertidal areas where survival of eggs is likely lower (Salo 1991). Chum and pink (*O. gorbuscha*) salmon both spawn at high densities in the same areas below McNeil Falls, and there may be considerable intra and interspecific competition as well as higher egg retention by females (Salo 1991).

When considering the high bear-induced mortality, high densities of spawners, and limited spawning areas below the falls, it appears likely that escapements above the falls may contribute disproportionately more to the stream-wide production of chum salmon at McNeil River than fish below the falls, even though they represent only 10–15% of the total run (Peirce et al. 2011). In the 2 years of this study 90% of the tagged chum salmon ( $n = 20$ ) that made it above McNeil Falls lived long enough to spawn. In contrast we estimated that only 41% of all tagged chum salmon ( $n = 85$ ) below the falls lived long enough to spawn (Table 1).

### **Integrated management of fish and wildlife**

Of the 105 chum salmon tagged, we recovered only 1 spawned-out carcass in 2 years; all others were fully consumed. We found very few spawned-out salmon during extensive daily foot surveys in the lower river and lagoon. Spawned-out fish we found were always gone by the next time we passed the site. Our observation that 99% of tagged fish below the falls were consumed pre- or post-spawning is particularly noteworthy in Alaska, where high-grading by bears is commonly observed (Shuman 1950, Frame 1974, Quinn and Buck 2000, Gende 2002). The near complete utilization of chum salmon by bears at McNeil River in recent years also contrasts sharply with observations during the 1980s, when high-grading was common and carcasses were more abundant (L. Aumiller, ADFG retired, Missoula, Montana, USA, personal communication, 2005). Aerial survey indices also suggest there were, on average, twice as many chum salmon in McNeil River during the 1980s than during the 1990s and 2000s (E. Otis, unpublished data, 2007).

These observations, along with aerial indices, suggest that chum salmon escapement and productivity have decreased at McNeil River in recent years. This reduced productivity likely derives from the limited spawning area available to chum salmon that

are effectively confined to the lower 1.6 km of McNeil River by the high concentration of bears fishing at McNeil Falls (Peirce et al. 2011). We hypothesize that when conditions are good (e.g., high fish density or moderate discharge), chum salmon can saturate predators and more fish ascend the falls to seed upriver spawning areas, boosting stream-wide production. In low escapement years or in low water, bears may limit stream-wide production by effectively blocking upriver migration and constraining spawning escapement to the limited area available below McNeil Falls. This hypothesized scenario represents a variation of the classic ‘predator pit’ used to describe some predator–prey population cycles in terrestrial (Messier and Crete 1985) and aquatic ecosystems (Bakun 2006).

In rivers with high predation, such as the McNeil River, total in-river escapement does not equal spawning escapement (Table 1). High predation rates in McNeil River were responsible for the relatively low average stream life estimate documented by our telemetry study (Peirce et al. 2011). Stream life is a key variable in the area-under-the-curve method used to calculate a total escapement index from periodic aerial survey counts (Bue et al. 1998, Peirce et al. 2011). A lower stream life value results in a higher escapement index because fewer repeat observations of the same fish are made on consecutive surveys. ADFG used the predation data and revised stream life estimate from this study to reconstruct the history of McNeil River chum salmon escapements (Otis and Szarzi 2007). As a result the escapement goal at McNeil River was revised upward from 13,750–25,750 to 24,000–48,000 fish. While this revision mitigated for pre-spawning mortality, it was also intended to facilitate more consistent seeding of upriver spawning areas in an attempt to boost stream-wide production of chum salmon.

Meeting these new escapement goals is not entirely within a fishery manager’s control. Factors such as ocean conditions (Mantua et al. 1997, Beamish et al. 1999), river discharge (Wickett 1958, Beamish et al. 1994), and bear abundance (Quinn et al. 2003) can play a significant role in affecting annual salmon production. There has not been a commercial fishery at McNeil River since 1994, and the entire run has been allowed to escape to the river annually since that time. Hence, increasing the escapement goal will not have the desired effect of higher salmon production at McNeil River until the chum salmon run naturally recovers to historic levels. Once seeding of upriver spawning areas is restored and higher stream-wide

production is realized, we anticipate the McNeil River will once again provide commercial fishing opportunities during years of high abundance while continuing to sustain high annual rates of in-river predation by bears. Timely in-season escapement monitoring will allow fishery managers to respond quickly to changes in run strength by limiting or liberalizing fishery openings, as appropriate.

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