Freshwater life cycle of Kuskokwim Area chum salmon

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LIFE CYCLE OF CHUM SALMON

Introduction

Chum salmon (*Oncorhynchus keta*) are a widely-distributed species with a high dependence on marine waters. Chum spawn in natal streams along the Arctic coasts of North America and Asia, southward to Korea on the Asian continent and to at least Tillamook Bay, Oregon, on the North American continent. Chum are semelparous, breeding only once, and spawn primarily in freshwater or, less commonly, intertidal areas. Chum salmon rear for only days or weeks in freshwater but may spend up to 5 years at sea, with the marine environment thus comprising a high proportion - relative to other salmon species - of their overall life cycle (Salo 1991). This marine dependence is reflected in several important aspects of their life history. Chum salmon are strictly anadromous, for example, with no landlocked or naturalized freshwater populations having been documented (Randall et al. 1987). Most chum populations spawn relatively close to the ocean (Salo 1991), although they are also capable of extensive freshwater spawning migrations (e.g., 2500 km for Yukon River populations). Juvenile chum usually migrate to sea immediately after hatching, and almost always reach marine waters by their first winter. Juvenile chum travel in schools during downstream and ocean migration, presumably to reduce their vulnerability to predators. This ocean-type life history is in contrast to the stream-type life histories of sockeye, coho, and chinook salmon, which typically rear for months to years in freshwater, enter the ocean at a larger size, and do not exhibit as much schooling behavior (Johnson et al. 1997). Finally, many adult chum salmon return to freshwater late in the year; these populations are often referred to as "fall" chum, and may be the most abundant run timing group in some rivers. Because of these characteristics, the marine environment exerts a stronger influence on chum than it does on other salmon; consequently, chum survival and abundance are thought to be closely linked to marine conditions (Johnson et al. 1997).

The greater marine residence time also means that many life stages of chum are difficult to study, and less is known about these stages than for more freshwater-dependent species such as coho, chinook, and sockeye salmon. Juvenile chum salmon in western Alaska (Figure 1) appear to migrate seaward at ice-breakup, perhaps as soon as streambed ice lifts (J. Finn, Alaska Biological Science Center, personal communication). From there, juvenile chum spend an indeterminate amount of time in estuaries, where they encounter their first substantial food resources and begin to grow to sizes needed for subsequent marine migration. Larger juvenile chum eventually move seaward towards pelagic feeding grounds, but the time at which western Alaskan populations move from estuaries to nearshore marine areas to pelagic zones is unknown.

Many river drainages contain sympatric populations of chum salmon that achieve reproductive isolation by returning to spawn at different times. Where present, these populations typically consist of earlier-spawning “summer chum” and later-spawning "fall chum" (Salo 1991). The major biological differences between the two life history types are that summer chum often are smaller, have lower fecundity (both absolute and relative), arrive earlier in the year in more advanced spawning coloration, and are less apt to use spawning grounds marked by springs or groundwater upwelling (Merritt and Raymond 1983).

Egg Stage

Fecundity

Salmon fecundity can be an inherited trait and may be associated with both biological and environmental variables. Fish body length, egg size, inriver migration distance, and run time have all been correlated with chum salmon fecundity (Salo 1991; Beacham and Murray 1993). These associations are not always present, however, and especially little is known about how different variables influence the fecundity of salmon at the northern edge of their North American distributions. Chum salmon fecundity generally ranges from 2,000 to 4,000 eggs per fish (Buklis and Barton 1984), but has been reported as high as 8,000 eggs per fish for Asian populations (Salo 1991). General trends reported by Salo (1991) for North American chum include (1) increased fecundity with body size, (2) decreased fecundity with increased latitude among fall chum, (3) chum returning to smaller, shorter streams have lower fecundity than chum returning to longer streams, and (4) summer chum have lower fecundity than fall chum. There are notable exceptions to these trends; in the Yukon River, for example, summer chum have had higher relative fecundity (eggs/ cm body length) than fall chum (Anderson 1983 and Trasky 1974, reported in Salo 1991). An overall lack of fecundity data for different run time groups, body sizes, and ages limits current knowledge of fecundity trends within and among chum salmon populations (Johnson et al. 1997).

Knowledge of the association between fecundity and biological or environmental variables can help provide inferences about a population's fecundity when direct calculations are not possible. Fecundity of chum from the Unalakleet River (a major tributary to Norton Sound) increased with fish length (Nemeth et al. 2004); when chum lengths from nearby populations are known, some inference of fecundity can be drawn from the length / fecundity association on the Unalakleet. Fecundity of Unalakleet River chum ranged from 47.0 to 48.5 eggs per cm of body length (approximately 2800 total eggs per fish) over two years, and was affected by fish length but not by fish age (Nemeth et al. 2004). Fecundity was similar to the 41 eggs/cm (total fork length) reported by Trasky (1974) for Yukon River fall chum and 46 eggs/ cm (total fork length?) for Yukon River summer chum (Johnson et al. 1997). There do not appear to be any published reports of fecundity of Kuskokwim Area chum. Based on data from elsewhere in North America, it appears likely the Kuskokwim chum fecundity would range between 40 and 50 eggs/cm of fork length. The unknown variation in fecundity among populations or years is an important information gap. In the Unalakleet River, chum salmon fecundity varied by 8% from 2002 to 2003 for age 0.3 chum (Nemeth et al. 2004); there do not appear to be any other assessments of variability over time or place for western Alaska populations.

Egg deposition and production

Egg deposition estimates can be useful to salmon management in a number of ways. The total number of fertilized eggs deposited each year places an upper limit on the number of adults produced in the next generation, and can thus be useful for estimating future production (NSSTC 2002). Egg deposition estimates can also be combined with counts of subsequent juvenile abundance to estimate juvenile survival (e.g., Buklis and Barton 1984). Potential egg deposition (PED) is also useful for habitat restoration projects because these projects may target certain PED levels as a measure of success (Mangel 1996). PED can be approximated by multiplying escapement by average fecundity to estimate total egg deposition. Although PED has not been estimated for Kuskokwim salmon species, it could be modeled on the tributaries that have escapement monitoring projects. Particular attention needs to be paid to interannual variation in fecundity because such variation could either amplify or buffer the production consequences of interannual variation in escapement.

Egg development and physiology

Egg size is an important component of salmon early life history because egg size can determine the amount of yolk available to the pre-feeding juvenile (Groot et al. 1995) and can influence embryo survival and alevin or fry size (Beacham and Murray 1993). Egg size and its role in determining the survival of juvenile chum has not been studied in Kuskokwim Area chum salmon.

Water temperature is thought to have the greatest influence on chum salmon embryonic development (Johnson et al. 1997). Time to yolk absorption, for example, was up to two months longer for eggs incubated at 2.1 and 2.9 °C than for eggs incubated at 4.0 °C in a controlled laboratory environments (Wangaard and Burger 1983). Chum salmon eggs typically require the accumulation of between 400 to 600 thermal units to hatch, with a thermal unit defined as one degree above 0° C for one day (Salo 1991). Complete yolk absorption typically requires 700 to 1,000 thermal units (Salo 1991); Susitna River chum salmon were estimated to require 600 to 850 thermal units (Wangaard and Burger 1983). Upon hatching the alevins are photonegative for up to 25 days (Fast and Stober 1984), during which time they rely on the yolk sac as a food source. After the yolk is absorbed the fry become photopositive and emerge from the gravel to begin their downstream migration to the ocean.

Development and emergence times of chum eggs and alevins represent some of the earliest detectable differences among chum populations (Johnson et al. 1997). In Washington state, fry emergence took an average of 35 days longer for summer than for fall chum, and this extended time was consistent among years (Koski 1975, reported in Johnson et al 1997). Beacham and Murray (1986) reported no differences in laboratory hatching times for eggs reared under three different temperature regimes from adults with early, middle, and late spawning times; by extension, eggs from early-spawning fish took the longest to develop. It is possible that chum egg (and embryo) development times may differ with latitude, and that time to specific development stages may be less flexible where the climatic conditions offer a relatively narrow "window" of optimal emergence times.

The egg development and emergence of juvenile chum salmon have not been studied for Kuskokwim Area chum salmon. Particularly useful information would include whether development rates and/or emergence times differ between 1) fall and summer run chum, and 2) chum spawning in coastal streams, the lower Kuskokwim drainage, and the upper Kuskokwim drainage. Improved knowledge of development rates and emergence times would help to determine when to measure the physical (temperature etc.) and biological (food availability, predation, etc.) conditions that may be important to chum fry.

Egg survival

The total number of eggs deposited by the spawners is always much greater than the number of fry that survive to the swim-up stage. Mortality factors for chum eggs are known to include crowding, which may increase the fraction of eggs that are not deposited in a nest (Schroder 1981). Freezing, low oxygen, fungus, silt, and predation can also reduce the fraction of eggs surviving to emergence, and can also affect the condition of fry at emergence (Salo 1991). Eggs that take longer to incubate obviously have a greater exposure time to these variables.

In field studies of egg survival in the Tanana River drainage, Finn and Baker (2004) reported egg survival rates of 40% to 100% from fertilization to the eyed-egg stage, and 26% to 91% to the pre-emergent stage. Survival from egg to fry was estimated at 2.5% for chum salmon in the Delta River (Yukon River watershed), based on potential egg deposition. Elsewhere, egg to fry survival rates have been estimated to range from 1.5% to 27.6%, also based on potential egg depositions (Buklis and Barton 1984). Egg survival, and the factors that influence it, have not been assessed for Kuskokwim Area chum.

Fry Stage – hatching and freshwater emigration

Freshwater emergence, migration and feeding

Chum salmon fry typically emerge during nighttime hours and begin their downstream migration (Salo 1991). Chum salmon fry downstream migration probably includes different combinations of displacement and active swimming depending upon their actual age and the relative strength of currents, temperature, and visual reference points (Hoar 1958). Chum are thought to move primarily at night, but Salo (1991) notes that northern populations also move during daylight. The length of stream probably affects several aspects of juvenile chum salmon ecology, including total time spent migrating (Salo 1991). Chum salmon in a Yukon River tributary began migrating as soon as anchor ice lifted off the stream bottom (J. Finn, ABSC, personal communication). Juvenile chum salmon were still present in two short (<100 km) Norton Sound tributaries as long as a month after ice breakup in 2004, but it is not known what proportion of the overall run these chum represented (M. Nemeth et al., unpublished data, 2004).

An important element of chum early life history is the onset of first feeding. Some juvenile chum salmon may not feed in fresh water, instead migrating into estuaries before they begin to feed. In general, the degree to which juvenile chum feed and migrate varies among populations, and is probably influenced to some degree by the length of river and the time of hatching. Juvenile chum salmon school during downstream migration, but not as tightly as pink and sockeye fry (Johnson et al. 1997). Most research on the feeding and migration behavior of fry has been in Japan and Russia, with little empirical data collected in Alaska (Salo 1991). Yukon River chum salmon are thought to feed while migrating downstream, based on the size range (variance) of juvenile chum captured at the river's mouth (Martin et al. 1986). Loftus and Lenon (1977) found that juvenile chum salmon in the Salcha River, Alaska, fed extensively on drift organisms. The Kuskokwim Area contains populations that must travel long (e.g., the George River) and short (e.g., the Middle Fork Goodnews River) distances to reach marine waters (Figure 2). It is not known what differences chum from these populations exhibit in terms of feeding, migration, or other migration behavior.

A study begun in 2004 by the Alaska Biological Science Center should provide the first descriptions of juvenile chum salmon ecology in the Kuskokwim River. The project is designed to 1) describe and compare the diet and physiology of juvenile chum salmon hatching low (<200 km from the estuary) and high (hatching > 900 km from the estuary), and 2) test methods that could be used to describe timing of juvenile chum downstream migrations (AYK SSI 2004). No prior studies have targeted the freshwater ecology of juvenile chum salmon in the Kuskokwim Area.

Freshwater survival

A variety of fish and birds preys on juvenile chum migrating in freshwater (Groot and Margolis 1991). In the Kuskokwim Area, likely predators are juvenile coho salmon, Dolly varden (*Salvelinus malma*), and terns. Risk from predation is also probably influenced by time spent in freshwater and by the size of juvenile chum. Salmon fry survival typically increases with size (Groot and Margolis 1991), and juvenile coho salmon preying on chum fry have been found to select smaller chum salmon (Beall 1972). The sources of mortality and rates of survival have not been studied for juvenile chum in freshwater of the Kuskokwim Area.

Juvenile stage – estuarine and nearshore marine

Entry into marine and estuarine waters

Coastal estuaries are an important part of the early life history of juvenile chum salmon and can influence ocean growth, survival, and the subsequent return of spawning chum. Estuaries provide environmental gradients that allow fry to transition from lower to higher salinity waters (Salo 1991), increased opportunities for early feeding and growth (Thom 1987), and refuge from predators (Pearcy 1992). Entry of chum salmon into seawater is commonly correlated with the warming of nearshore waters and the accompanying plankton blooms (Salo 1991). Variations in time of entry into estuaries due to fluctuations in weather and stream runoff patterns ultimately affect survival. Ideally, entry timing corresponds to spring plankton blooms.

In northern latitudes, juvenile chum salmon enter estuaries in early and mid-summer, which is generally sooner than for more southern populations. Peak arrival into estuaries was thought to be in June and July for chum from the Noatak River of Kotzebue Sound (Merritt and Raymond 1983) and from the Yukon River (Martin et al. 1986). In Norton Sound, juvenile chum entered the Eldorado River estuary from June through early July, but the size of the run before June was not known (Nemeth et al. 2003).

Juvenile chum salmon may move quickly through estuaries, or remain for extended periods of time. Johnson et al. (1997) reviewed residence times of various chum salmon populations and reported that juvenile chum commonly spent about 24 days in estuaries, with residence times ranging from 4 to 32 days. Juvenile chum in the Eldorado River estuary in Norton Sound increased in size over a 45-day period in 2003, suggesting an extended estuarine residence time (Nemeth et al. 2003; unpublished data 2004). Martin et al. (1986) found few chum in the Yukon River delta, and suggested that juvenile chum had a relatively short estuarine residence time.

A newly-begun study conducted cooperatively by the University of Alaska and the Alaska Biological Science Center should provide the first descriptions of the estuarine ecology of juvenile chum salmon in the Kuskokwim Area. The project began in 2003 and is designed to describe 1) spatiotemporal patterns in estuarine chum distribution and environmental variables, 2) the relationship between environmental variables and chum distribution, 3) diet and feeding patterns, 4) size and growth, and 5) the bioenergetics of juvenile chum in the Kuskokwim Bay (Hillgruber and Zimmerman 2004). No prior studies have targeted the estuarine ecology of juvenile chum salmon in the Kuskokwim Area.

Movement of juvenile chum salmon from estuaries into nearshore or offshore habitats may be a result of changes in diet brought about by increased chum size. Larger fish are better able to feed on larger, neritic (i.e. e., extending out to about 200m in depth) prey, and the availability of such prey often coincides with declining prey resources in inshore or estuarine areas (Johnson et al. 1997).

Diet, growth, and survival

Juvenile chum salmon feeding in estuaries are thought to rely heavily on benthic organisms (Johnson et al. 1997). As they grow in size, juvenile chum have also been found to switch from an epibenthic (i.e. e., on the surface of the estuary floor) prey base of harpacticoid copepods, isopods, and amphipods to a base of drift insects, calanoid copepods, and larvae (Simenstad 1982). In Kotzebue Sound, dipterans were the predominant prey for juvenile chum (Merritt and Raymond 1983). In the Eldorado River estuary of Norton Sound, the primary chum prey items changed from copepods and insects in June to amphipods and mysids in July. Mysids were the predominant prey of chum in July 2002 in again in July of 2003 (Nemeth et al. 2003; unpublished data 2004).

Growth of juvenile chum in estuaries has been reported at 2.7% to 10.1% of their body mass per day, depending on location and time (Johnson et al. 1997). In Cook Inlet, estimated chum growth rates ranged from 0.23 to 1.15 mm/day (fork length; Moulton 1997). These rates were similar to those estimated in the Eldorado River estuary in Norton Sound (Nemeth et al. 2003). Both the Cook Inlet and Eldorado River studies may have underestimated true chum growth rates because of any inability to detect smaller fish moving into the study area as larger fish moved out.

Although individual fish growth is thought to be crucial for juvenile salmon to optimize prey, move into favorable habitats, and avoid predation, it has not been studied for Kuskokwim Area chum salmon. The current UA-USGS collaborative study should provide the first descriptions of chum feeding and growth in the region (Hillgruber and Zimmerman 2004).

Survival of juvenile chum in estuaries has rarely been quantified. Johnson et al. (1997) reviewed the topic and reported average daily mortalities of 29% to 46%. Smaller chum were less likely to survive than larger chum, either because of selective predation by predators or because larger chum could inhabit safer areas. Juvenile chum survival in western Alaska estuaries has not been estimated.

Migration and potential offshore movement

Movement offshore by chum salmon may correspond to decline of inshore prey resources and is normally at the time when the fish are larger, can seek larger prey and avoid nearshore predators (Salo 1991).

Martin et al. (1986) found that juvenile chum salmon of the Yukon River did not utilize the nearshore habitat of the delta. Outmigrants were thought to be dispersed by the large river plume, and the smaller fry (36.8-43.8 mm) were particularly vulnerable. In Norton Sound, juvenile chum were not present in trawls conducted within 1 km of shore in late June and early July (Tetra Tech 1981). In Prince William Sound the offshore migration is at 60 mm fork length (Cooney et al. 1978). Offshore movement by juvenile Kuskokwim Area chum salmon has not been described.

Returning adult (spawning) stage

Run timing groups

In western Alaska, adult chum salmon typically migrate from seawater to natal rivers anytime between June and November. Returns to many rivers have a bimodal distribution, and these two modes have historically been used to distinguish among populations separated in time, or "runs" (Johnson et al. 1997). In Alaska, the early run is often referred to as summer chum and the late as fall chum. Summer and falls runs are recognized in three of the four main salmon-producing regions of western Alaska; Kotzebue Sound, the Yukon River, and the Kuskokwim River. In the fourth region, Norton Sound, there appears to be only a summer run of chum.

At the northern end of the chum range, in Kotzebue Sound, early- and late-returning chum are sympatric in the Kobuk River (Bigler and Burwen 1984). Early-run fish typically peak before 1, whereas late-run fish peak after August 1. Further south, Norton Sound area chum salmon are primarily summer-run fish (Clark 2001a; Clark 2001b), entering in June and July and spawning in July and August (Brennan et al. 2002). Still further south, summer chum return to the Yukon River in early May through mid-July. Entry of summer and fall chum may overlap in June and July (Buklis and Barton 1984), but summer chum typically spawn earlier (Johnson et al. 1997) and lower in the drainage (Holder and Senecal-Albrecht 1998). The two runs are thus separated more by eventual spawning time than by original freshwater entry timing.

Kuskokwim chum are also thought to have early and late components of the chum salmon run, similar to Kotzebue Sound and the Yukon River. The fall chum run has only recently been recognized, however (AYK SSI 2004), and most chum salmon information is thus from summer chum, or from an unknown mixture of summer and fall chum. Chum salmon biological information is collected from aerial surveys, ground-based escapement assessments, inseason run strength assessments, and research projects (Ward et al. 2003). A proposed project to summarize fall chum salmon characteristics[*] should substantially improved knowledge of fall chum biology and distribution, thereby helping to understand differences between summer and fall runs of Kuskokwim River chum.

Distribution, inriver migration time, and spawning time

Upon returning to freshwater, adult chum salmon may either "mill" in the river mouth or estuary for as long as three weeks (Eames 1981, in Johnson et al. 1997), or may immediately begin migrating upstream. Chum tagged in Kotzebue Sound milled for an average of 5 days (Bigler and Burwen 1984). Gaudet and Shaeffer (1982) found that chum salmon marked and recaptured within the Nome Subdistrict of Norton Sound milled for up to seven days. Once migrating upstream, chum are known to travel between 15 and 80 km/d (Salo 1991). Chum are not considered powerful swimmers, and spawning adults are typically limited to the lower reaches of rivers. Where chum travel beyond the lower reaches, the rivers are typically large, low-gradient, and have minimal migration obstructions (Johnson et al. 1997). Examples of such rivers include the Yukon, Amur, and Kuskokwim rivers.

Once in rivers and streams, chum migration rates generally decrease to an observed maximum of 40-50 km/d. Males tend to arrive at the spawning grounds earlier than females do, resulting in an increase in the female-to-male ratio over the course of the spawning season. Many runs also display trends in age classes over the course of the

[*] AYK SSI Project 04-409

season. These trends differ among regions; younger fish arrive earlier than older fish in some populations, but arrive later than older fish in other populations. Size trends reported over the course of the spawning run may be due to changes in age and sex ratios rather than to differences in size alone (Salo 1991).

Kuskokwim Area chum are known to return to most of the major Kuskokwim River tributaries upstream at least as far as the town of McGrath (river km 815; Table 1), as well as major tributaries feeding directly into Kuskokwim Bay. Known distribution is likely incomplete, however, due to the difficulty of surveying the entire river, and to ongoing changes in chum spawning distribution. Chum salmon in the Takotna River, for example, were apparently abundant in the early 1900s, scarce in the 1960s and 1970s, began increasing in the 1980s, and began to be evaluated by managers in the 1990s (Gilk and Molyneaux 2004). In general, chum salmon appear to return to most major tributaries up to McGrath, and may also be well distributed in the river forks above it (ADF&G, various reports).

Entry timing to the Kuskokwim River by specific populations or summer vs. fall-run chum is not well known. Entry timing data is collected from commercial fisheries and inriver test fisheries. Between 1984 and 1999, the majority of chum passage past the Bethel test fishery (river km 130) was between June 25 and July 15 (Molyneaux 2003; Table 2). Further upstream, median chum passage was from early to mid-July at both the George River weir (river km 502; Linderman et al. 2004) and the Takotna River weir (river km 900; Gilk and Molyneaux 2004) from 1996 to 2003. Since 2000, mean run timing has been able to be compared in 7 tributaries (Figure 2). Despite great differences in the travel distances to these 7 locations, mean passage dates typically only differ by a week or so (Table 3). Given the similarity in passage times at points so far apart, it is likely that tributary-specific populations of chum salmon enter the mainstem Kuskokwim at different times, with farther-traveling fish entering earlier.

Initial evidence from a current mark-recapture project (Kerkvliet et al. 2003) supports the idea that chum migrating to tributaries of the upper Kuskokwim drainage may enter the lower river earlier than stocks that spawn lower in the drainage. Chum marked in the Kuskokwim River at river km 310 are recovered in tributaries such as the Aniak, George, Tatlawiksuk, Kogrukluk, and Takotna rivers (Figure 2). In 2003, run timing at river km 310 was progressively earlier for chum stocks that had the greatest distance to travel upstream before spawning (Linderman et al. 2004). This study should greatly improve knowledge of stock-specific run times.

Chum salmon tagged in the Holitna drainage (entering the Kuskokwim at river km 540) had upstream migration rates ranging from 19 to 43 km/day, depending on tributary and time or distance since tagging (Chythlook and Evenson 2003). The ongoing mark-recapture study by Kerkvliet et al. (2003) has also provided initial estimates of daily chum migration rates. In 2003, chum migration rates ranged from 27 (Linderman et al. 2004) to 40 km/day (Gilk and Molyneaux 2004). These rates include travel within both the mainstem river and the spawning tributaries, and study fish may not be representative of the entire chum run. Rates in 2003 were consistent with preliminary data collected in 2002.

Adult age composition

Chum salmon mature at varying ages, typically after two to five winters at sea. Northern populations of chum tend to have a higher proportion of older fish than do more southern populations (Johnson et al. 1997), and the majority of western Alaska chum salmon mature after 3 or 4 winters at sea (Buklis and Barton 1984; Brennan et al 2002; Folletti 2003). The age structure may vary substantially among years; within a drainage, age is generally more variable among years than among subdrainage populations in the same year (Johnson et al. 1997). As part of this, summer and fall chum typically have similar age structures within a river in a given year (Johnson et al. 1997).

Ages of Kuskokwim Area chum salon are reported using the European aging system, which reports the winters in freshwater and winter in saltwater, separated by a period. Age 0.3 chum, for example, have spent 0 winters in freshwater and 3 in saltwater. Kuskokwim Area chum are composed almost entirely of age 0.3 and age 0.4 fish, but the proportions of each may vary substantially from year to year (Table 4). The mixed-stock catch in the commercial fishery (District 1) has averaged 63% age 0.3 and 34% age 0.4 over time. The proportion of 0.3 chum can vary substantially (87% of the total run in 1998, 58% in 1999, and 74% in 2000) but has always accounted for the majority of the annual catch (Folletti 2003). Further south, in Districts 4 and 5, age 0.4 chum have comprised a larger proportion of the catch over time, and may outnumber age 0.3 chum in some years (Folletti 2003). In the Kuskokwim Area, large returns of age 0.3 chum are often associated with large returns of age 0.4 chum in the next year (Gilk and Molyneaux 2004). Older chum are a more prominent part of tributary escapements early in the run, with the proportion of 0.2 and 0.3 chum increasing as the run progresses (Gilk and Molyneaux 2004).

Straying

Little is known about the straying of chum salmon, especially in Alaska. Salo (1991) reports no conclusive evidence that chum salmon stray rates differ from those of other species. Johnson et al. (1997) reported a number of reasons why chum salmon stray rates might theoretically exceed those of other salmon (e.g., less freshwater imprinting time as juveniles), but also reported a lack of good evidence. There have been no attempts to quantify straying rates of Kuskokwim Area chum salmon.

Spawning habitat characteristics

As with most salmon, adult chum spawning habitat is thought to be heavily influenced by water velocity, depth, and substrate particle size (Salo 1991). Depending on the area, the suitability of the habitat may also be strongly influenced by other variables such as sediment deposition and groundwater upwelling. Although chum salmon tend to spawn in shallower, lower-velocity water (including side sloughs) than other salmon (Salo 1991), this may only be to avoid habitat overlap with spawning pink salmon (Johnson et al. 1997), and chum salmon should probably be considered able to spawn in a variety of habitat conditions. In Alaska, median particle sizes of spawning gravels ranged from 10 mm to 38 mm in the Porcupine Creek drainage and from 21 mm to 62 mm in the Susitna River drainage. Notably, chum also spawned in silt (median particle size = 0.1 mm) on the Susitna River (data summarized in Kondolf and Wolman 1993).

Salo (1991) reported a wide range of chum salmon egg burial depths. This range may be explained by a study in Washington state, in which Montgomery et al. (1996) found close correlation between burial depths and the depth of normal streambed scour. This association suggests that chum salmon may have adapted to bury their eggs according to the bed scour characteristics of individual streams. The authors also noted that increased spawning activity reduced bed scour, suggesting a positive feedback between mass spawning and protection of eggs from overwinter erosion.

There are numerous reports that chum salmon prefer to spawn in areas with groundwater upwelling (Salo 1991). Groundwater helps prevent eggs from freezing, and may thus be more important in some regions than in others. Brook trout (*Salvelinus fontinalis*) at northern latitudes are more dependent on upwelling groundwater than brook trout at lower latitudes (Curry and Noakes 1995). If upwelling is important to chum salmon for the same reasons, it may be more important for chum spawning at higher latitudes, higher elevations or colder sites.

Characteristics of chum salmon spawning sites in the Kuskokwim River drainage are largely unknown. The most transferable data may come from studies conducted by Finn et al. (2004) in the Tanana River drainage (tributary to the Yukon River). Chum salmon eggs successfully incubated where intragravel temperatures ranged from 7 to 9.5 °C in the summer and from 0.5 to 2.0 °C in the winter. Dissolved oxygen was also more stable from summer to winter at redd sites than in surrounding non-redd sites. Both spawning sites appeared to be associated with groundwater upwelling (Finn et al. ABSC 2004).

Most chum salmon spawning habitat in the Kuskokwim River is thought to be relatively undisturbed, but the lack of habitat descriptions precludes quantification of total spawning habitat or evaluation habitat disturbance. Bergstrom and Whitmore (2004) suggested that most habitat was undisturbed by humans, but noted that mining has probably affected spawning habitat in many of the major tributaries. In addition, they noted the potential for bed scour disturbance from the rafting of logs felled by proposed timber projects.

Sources of mortality

Once in freshwater, adult Kuskokwim chum are subject to harvest by humans in sport, subsistence and commercial fisheries, and in the Bethel test fishery. Chum are also subject to predation by bears, and may incur mortality from disease. Over the 1993 – 2002 time period, the commercial fishery accounted for approximately 68% of the overall human harvest, the subsistence fishery approximately 30%, and the test and sport fisheries less than 3% combined. These numbers are skewed by high commercial catches in the mid-1990s and in 1998, however; from 1999 through 2002, low salmon abundance and poor chum salmon markets caused major decreases in the commercial salmon harvests. During this time, the subsistence fishery accounted for between 65% and 94% of the annual chum harvest (Lafferty 2004).

Chum salmon are captured in subsistence fisheries in tributaries to Kuskokwim Bay, in the mainstem Kuskokwim River, and in Kuskokwim River tributaries (Ward et al. 2003). In 2002, an estimated 76,818 chum salmon were caught in subsistence fisheries throughout the entire Kuskokwim Area (Table 5). Of these, Ward et al. (2003) estimated that approximately 74% were caught in the lower Kuskokwim River and tributaries, 12% were caught in the middle Kuskokwim River and tributaries, and 5% were caught in the upper Kuskokwim River and tributaries. The remaining fish were split relatively evenly between communities in the North Kuskokwim Bay, South Kuskokwim Bay, and the Bering Sea coast. Overall, the 2002 subsistence harvest of chum was about 3% lower than the 1989 – 2001 average from the entire Kuskokwim Area (Ward et al. 2003).

Chum salmon commercial fisheries take place primarily in Districts 1, 4, 5. Commercial fisheries may also operate in District 2, but the District has rarely opened in recent years. In 2002, an estimated 34,951 chum salmon were caught in the commercial fisheries throughout the Kuskokwim Area. The catch was substantially below the 1992-2001 average of 237,891 fish due to a convergence of low prices, low processor interest, limited fishing time, and low salmon abundance (Ward et al. 2003). For the 10-year period 1992-2001, 71% of the average annual catch came from District 1, 21% came from District 4, 6% came from District 5, and the remaining 2% came from District 2 (Ward et al. 2003).

The majority of sport-caught chum have historically come from Kuskokwim Bay rivers (Lafferty 2004). The sport fish harvest of Kuskokwim Area chum salmon was 598 in 2002, slightly below the 10-year average catch of 629 chum from 1992 to 2001.

The Bethel test fishery harvested 2,666 chum salmon in 2002. This was approximately double the annual harvest of 1,430 chum for the five year period from 1998 to 2002 (Lafferty 2004).

There have been no estimates of adult chum mortality due to predation or disease in the Kuskokwim Area.

Chum salmon health

Disease

One of the primary salmon health concerns in western Alaska is the recent infestations of salmon with *Icthyophonous hoferi,* a parasitic fungus that causes lesions in fish tissue and organs. Salmon are thought to ingest the parasite in marine waters, probably by feeding on herring (*Clupea pallasi*), and thus already carry it when they enter freshwater. Once in freshwater, the fungus begins causing lesions in fish organs and flesh when water temperatures reach a threshold level. The fungus appears most prevalent in the Yukon River, where an estimated 25-30% of chinook salmon were infected with *Icthyophonous* from 1999 to 2002; circumstantial evidence indicated that infestations caused pre-spawning mortality (Kocan et al. 2003). The incidence of infestations has increased with historical water temperatures, leading to speculation that infestations will continue as long as global climate change raises Alaskan water temperatures. Because the infestation has also been found in other species (Yukon River chum salmon) and other Alaskan Rivers (Taku River, Kuskokwim River), it appears to have the potential to affect other species and river systems.

As part of the Yukon River study, Kocan et al. (2003) also found present in heart muscle tissue sampled in 3 out of 20 chum salmon sampled from the Kuskokwim River in 2001. *Icthyophonous* has not been identified as a major problem in the Kuskokwim River yet, but its presence in the chum salmon samples is troubling given the extent of the disease in Yukon River chinook, its association with rising water temperatures, and the potential for water temperature increases in the Kuskokwim Area.

Contaminants

Two recent studies have evaluated levels of heavy metals and persistent organic pollutants (POPs) in Kuskokwim Area chum salmon. The first study was conducted by the USFWS and evaluated chum collected from the Kuskokwim River near Bethel in 2001 (Matz and Mueller 2004). The second study was conducted by the Alaska Department of Environmental Conservation (ADEC) and evaluated chum from the Bering Sea (ADEC 2004). The ADEC Bering Sea samples included samples from Kuskokwim Bay.

The USFWS evaluated contaminant levels to assess the risk to human health and to the health of the fish themselves. To assess risk to humans, heavy metals and persistent organic pollutants (DDT and PCBs) were measured from a variety of chum salmon tissues, including fillets. Preliminary findings are that contaminant levels are relatively low and thus do not pose a consumption risk to humans (Matz and Mueller 2004). To assess the effects on fish health, indicators such as reproductive hormones, enzyme levels, vitamins, tissue lesions, and sex chromosomes were studied. None of these indicated health abnormalities (Matz and Mueller 2004). A full report will be released in late 2004.

The ADEC study measured heavy metals and POPs in salmon collected from various regions of Alaska in 2002. The Bering Sea samples included salmon combined from Kuskokwim Bay (18 chum for heavy metal analysis, an unknown number for POP analysis), the Yukon River, and Bristol Bay. Results are not available for only Kuskokwim chum, but the entire Bering Sea group had metal and POPs contaminants within acceptable levels for human health. More samples were collected in 2003 and 2004, but have not yet been analyzed (B. Gerlach, ADEC, personal communication).

Chum salmon genetics

Genetic differences among chum salmon from different regions has been evaluated using allozymes, nuclear DNA, and mitochondrial DNA. Analyses using allozymes suggest that chum salmon populations from Asia and northwestern Alaska are more similar to each other than they are to populations from the Alaska Peninsula, central Alaska, and southeastern Alaska (Wilmot et al. 1994; Seeb et al. 1999). Analyses using nuclear (Taylor et al. 1994) and mitochondrial DNA (Park et al. 1993) suggest that Yukon River and Russian chum may share a grouping, but that these populations are substantially different from populations from Japan. Regardless of the technique, there is general agreement that western Alaska chum are genetically separate from chum from other Alaskan regions, and may be more closely related to Russian than to other Alaskan populations.

The population genetics of chum salmon are influenced by general life history traits such as age structure and spawning habits. Chum salmon tend to spawn relatively low in a river drainage, reducing spatial reproductive isolation and thereby helping to reduce genetic differentiation. Chum salmon also tend to have multiple age classes within a spawning run, which helps to decrease random genetic-drift variability, both among and within populations (Johnson et al. 1997). The widespread range of chum salmon, however, results in some exceptions to these life history tendencies. One such exception is in large western Alaskan rivers, where chum salmon exhibit a relatively large diversity of spawning behavior.

Chum salmon returning to the Yukon and Kuskokwim rivers spawn over large area and length of time (i.e., summer and fall runs), increasing the chance for spatial and temporal isolation. This spatiotemporal separation appears to have influenced genetic relationships of chum salmon in Yukon River chum, with fall run fish in the upper river genetically distinct from summer-run chum in the lower river (Wilmot et al. 1994, Seeb et al. 1999). Kuskokwim chum salmon share many of the relevant attributes of Yukon chum (e.g., upper-river fall runs vs. lower-river summer runs), and preliminary data show that these attributes have yielded the genetic separation seen in the Yukon (Seeb et al. 1997). More genetic sampling is needed, however, to establish chum salmon groupings from within the Kuskokwim watershed. In particular, more samples are needed from fall-run fish returning to the upper river. A study of fall-run chum begun in 2004 (S. Gilk, ADF&G) will collect many of the data needed to examine genetic groupings of Kuskokwim River chum.

Genetic data can help address several topics that are important to the management of Kuskokwim River salmon. First, genetic data from populations and subpopulations is needed to estimate minimum effective population size, the minimum number of individuals in an ideal population that has the same genetic properties as the real population (Avise 1994). Such knowledge is important for evaluating escapement levels and the genetic health of populations. Minimum effective populations size can also be combined with genetic differentiation data to help assess the potential for recovery of salmon populations without human intervention. Second, genetic techniques offer managers the ability to differentiate among populations are being harvested in mixed-stock fisheries. Such differentiation can help prevent low-abundance populations from over-exploitation when harvested among higher-abundance populations, or, conversely, help prevent fisheries of higher-abundance populations from being erroneously closed to protect low-abundance populations (Pella and Milner 1987). Genetic identification of populations can also be used to describe and compare run timing of populations. Genetic techniques can now differentiate among mixed Kuskokwim stocks for chum and chinook salmon (Templin et al. 2004), and will be able to differentiate among mixed coho stocks in the near future (P. Crane, pers. comm.). Third, the genetic classification of populations or groups can help assess the potential for local adaptations by indicating differences in genetic loci that are under selection. Salmon evolving in different environments can develop genetic-based life history differences that allow them to optimize survival and reproduction, especially where selective pressure by the environment is strong (Taylor 1991). Where environmental pressures have been strong enough to cause local adaptations, the environments may also be difficult for fish without these adaptations (such as those transplanted from other places) to survive. Consequently, local adaptations have important ramifications for conservation and restoration (Montalvo 1997), and are thought to have been responsible for both the success and failure of past salmonid conservation initiatives (Raleigh 1967; Krueger et al. 1981). Of particular relevance to a large watershed with diverse populations, such as the Kuskokwim, is the scenario in which donor populations may be slow or unable to replace a population that was extirpated, whether by natural causes, over harvest by humans, or habitat degradation.

A final reason to obtain genetic diversity data for Kuskokwim salmon is to be able to include Koskokwim salmon in any future identification of evolutionary significant units (ESUs) in Alaska. While defined in various ways, ESUs generally are used to indicate populations with independent evolutionary histories. Genetic diversity data help evaluate the potential for reproductive isolation; when combined with other ecological and biological data, these form the basis for identifying ESUs (Johnson et al. 1997). Where salmon have suffered sharp declines in abundance, management policies have identified ESUs to help identify populations, manage them at the appropriate level of organization, and to assist with conservation and restoration efforts. Having the ability to identify these on the Kuskokwim before an abundance crisis, instead of in the throes of one, will help Kuskokwim Area managers respond quickly to conservation issues related to low abundance.

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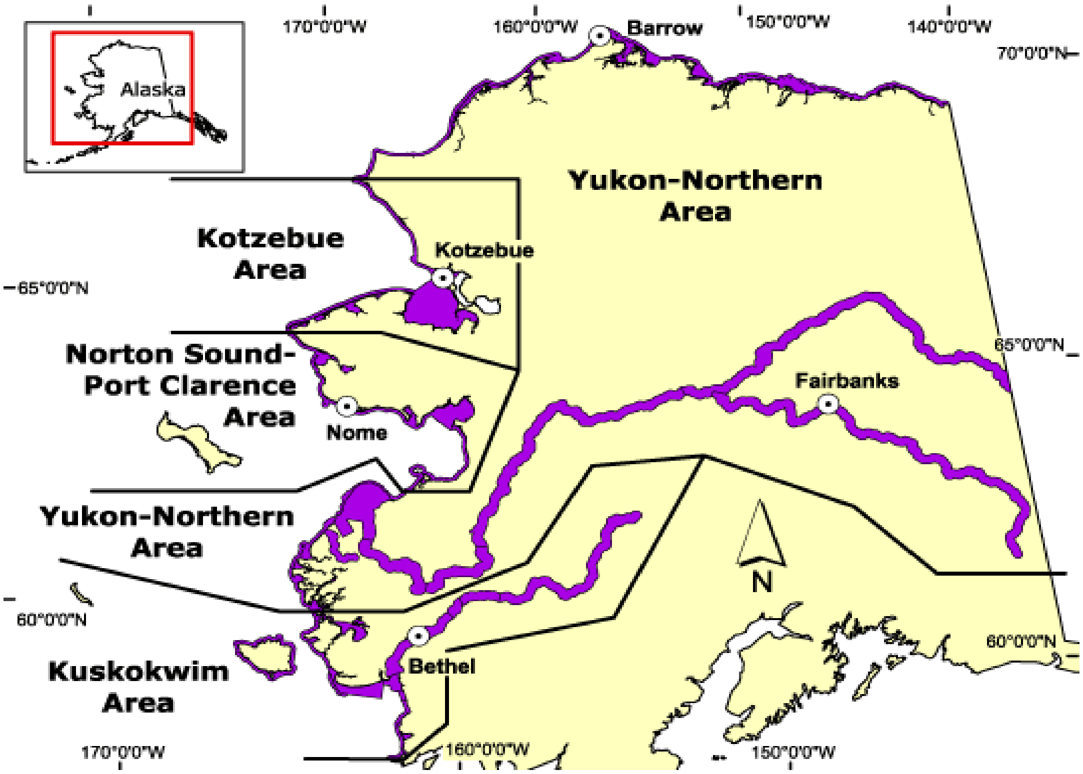

Figure 1. Map of western Alaska showing four major geographic regions that produce salmon. Figure taken from website of Alaska Department of Fish and Game (URL: http://www.cf.adfg.state.ak.us/region3/finfish/salmon/maps/ayk_all.php).

Figure 2. Kuskokwim Area map showing salmon management districts and escapement monitoring projects. Map taken from Ward et al. 2003.

Table 1. Distances from mouth of Kuskokwim River to selected landmarks upstream. Distances taken from Ward et al. 2003.

Location	Distance from Kuskokwim River mouth	
	Kilometers	Miles
Kuskokwim River mouth (N 60.80, W 162.42)	0	0
Bethel City	125	78
Kwethluk Village & River	159	99
Tuluksak Village & River	218	136
District 1 upstream boundary (Bogus Creek)	234	146
District 2 downstream boundary	295	183
Kalskag Village	309	192
Aniak Village & River	362	225
District 2 upstream boundary (Chuathbaluk Village)	375	233
Georgetown Village & George River	497	309
Holitna River	540	336
Stony River	587	365
Tatlawiksuk River	616	383
McGrath Village & Takotna River	815	507
South Fork Kuskokwim	931	579
East Fork Kuskokwim	943	586
North Fork Kuskokwim	943	586
Nikolai Village	999	621
Top of Kuskokwim Drainage	1498	931

Table 2. Historical run timing of Kuskokwim chum salmon species at the Bethel test fishery, 1984-2002. Box represents the 25th to 75th percentiles of the run and gray shading represents the run timing mean. Data summarized from Molyneaux 2003.

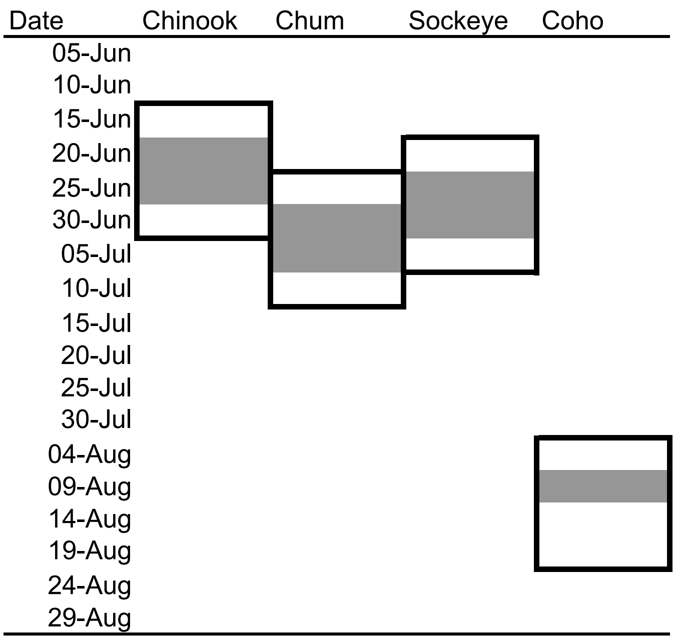

Table 3. Historical percent passage for chum salmon at Bethel and 7 tributaries in the Kuskokwim River. Unpublished data, compiled by D. Molyneaux. BTF = Bethel Test Fishery; KWE = Kwethluk River weir; TUL = Tuluksak River weir; ANI = Aniak River sonar project; GEO = George River weir; KOG = Kogrukluk River weir; TAT = Tatlawiksuk River weir; TAK = Takotna River weir.

Date	2000 BTF	KWE	TUL	ANI	GEO	KOG	TAT	TAK
6/08	0							
6/09	1							
6/10	1							
6/11	1							
6/12	1							
6/13	1							
6/14	1							
6/15	1				0		0	0
6/16	1			0	0		0	0
6/17	1			0	0		0	0
6/18	1			0	0		0	0
6/19	2			0	0		0	0
6/20	3			0	0		0	0
6/21	5			0	0		0	0
6/22	6	0		0	0		0	0
6/23	9	0		0	1		0	0
6/24	10	1		0	2		0	0
6/25	13	1		0	2		1	2
6/26	14	2		1	2		2	4
6/27	17	2		2	5		2	5
6/28	22	3		3	5		2	5
6/29	26	4		3	5		3	6
6/30	28	4		4	5		4	6
7/01	35	5		5	9		6	7
7/02	47	7		6	16	0	13	9
7/03	57	10		9	20	1	17	10
7/04	69	12		13	22	2	19	13
7/05	72	15		16	24	3	24	14
7/06	73	17		20	31	6	26	18
7/07	75	18		23	35	10	29	21
7/08	77	21		26	37	14	30	29
7/09	80	25		30	38	18	37	33
7/10	80	26		36	39	24	40	35
7/11	83	31		40	52	30	46	40
7/12	85	38		45	56	36	54	42
7/13	87	44		51	59	[illegible]	57	46
7/14	90	45		54	60	[illegible]	57	50
7/15	91	49		56	61	47	61	53
7/16	92	52		58	65	54	66	56
7/17	96	55		61	68	59	70	60
7/18	96	60		64	69	63	73	62
7/19	96	62		67	73	68	75	67
7/20	97	63		71	74	71	76	71
7/21	97	66		74	75	74	78	74
7/22	98	69		77	78	77	82	79
7/23	98	73		81	82	80	84	81
7/24	98	75		85	86	82	86	83
7/25	98	77		88	88	83	88	85
7/26	98	80		90	90	85	89	87
7/27	99	83		93	91	87	91	88
7/28	99	85		96	92	89	92	89
7/29	99	87		97	93	90	93	90
7/30	99	89		98	93	91	95	91
7/31	99	91		100	95	93	96	92
8/01	99	93			96	94	97	92
8/02	99	94			97	95	97	93
8/03	100	95			97	96	98	93
8/04	100	96			98	96	98	95
8/05	100	97			98	97	98	95
8/06	100	97			98	98	98	96
8/07	100	98			98	98	98	97
8/08	100	98			98	98	98	98
8/09	100	98			98	99	98	98
8/10	100	98			98	99	99	99
8/11	100	99			98	99	99	99
8/12	100	99			98	99	99	100
8/13	100	99			99	99	99	100
8/14	100	99			99	100	99	100
8/15	100	99			99	100	99	100
8/16	100	99			99	100	99	100
8/17	100	99			99	100	99	100
8/18	100	100			99	100	99	100
8/19	100	100			99	100	99	100
8/20		100			100	100	100	100
8/21		100			100	100	100	100
8/22		100			100	100	100	100
8/23		100			100	100	100	100
8/24		100			100	100	100	100

Date	2001 BTF	KWE	TUL	ANI	GEO	KOG	TAT	TAK
6/08	0							
6/09	0							
6/10	0							
6/11	0							
6/12	0							
6/13	0							
6/14	0							
6/15	0				0		0	0
6/16	0			0	0		0	0
6/17	0			0	0		0	0
6/18	2			0	0		0	0
6/19	2			0	0		0	0
6/20	2			0	0		0	0
6/21	2			0	0		0	0
6/22	2			0	0		0	0
6/23	3			0	1		0	0
6/24	5			0	2		0	0
6/25	10			0	2		1	0
6/26	16			0	2		1	0
6/27	18			0	3		1	1
6/28	19			0	3	0	2	1
6/29	19		0	0	4	0	3	1
6/30	19		1	0	4	0	4	1
7/01	20		2	0	5	0	6	2
7/02	22		2	0	5	1	7	3
7/03	27		3	0	6	1	7	4
7/04	34		4	0	6	2	8	4
7/05	36		5	0	6	4	10	5
7/06	37		6	0	8	5	13	6
7/07	39		8	0	12	7	16	8
7/08	41		9	0	14	9	20	11
7/09	42		10	0	16	12	24	13
7/10	46		10	0	19	16	30	16
7/11	55		12	4	24	19	33	20
7/12	63		15	8	29	23	38	27
7/13	74		19	14	33	29	43	32
7/14	79		24	20	38	35	48	38
7/15	79		28	26	43	40	54	43
7/16	86		33	31	46	46	58	47
7/17	91		34	38	49	49	63	51
7/18	92		36	43	54	53	70	56
7/19	94		40	48	[illegible]	58	74	63
7/20	95		45	55	62	62	77	68
7/21	95		48	62	65	66	80	72
7/22	96		51	67	68	70	83	76
7/23	96		57	72	70	73	85	79
7/24	97		58	76	72	76	87	82
7/25	97		63	80	74	78	89	85
7/26	98		68	84	77	81	90	87
7/27	98		72	88	80	82	91	89
7/28	98		75	92	83	83	92	91
7/29	98		76	95	85	86	92	92
7/30	98		77	98	87	89	93	94
7/31	99		81	100	88	90	94	95
8/01	99		83		89	92	95	96
8/02	99		85		91	94	96	96
8/03	99		86		92	95	96	97
8/04	99		88		93	96	97	97
8/05	99		89		93	97	97	98
8/06	99		91		94	97	98	98
8/07	99		92		95	98	98	99
8/08	99		95		96	99	99	99
8/09	99		96		97	99	99	99
8/10	100		96		97	99	99	99
8/11	100		96		97	99	99	99
8/12	100		97		98	99	99	100
8/13	100		98		98	100	99	100
8/14	100		98		98	100	99	100
8/15	100		99		98	100	100	100
8/16	100		99		98	100	100	100
8/17	100		99		99	100	100	100
8/18	100		99		99	100	100	100
8/19	100		99		99	100	100	100
8/20	100		99		99	100	100	100
8/21	100		99		99	100	100	100
8/22			99		99	100	100	100
8/23			99		100	100	100	100
8/24			100		100	100	100	100

Date	2002 BTF	KWE	TUL	ANI	GEO	KOG	TAT	TAK
6/08	0							
6/09	1							
6/10	1							
6/11	2							
6/12	2		0					
6/13	3		0					
6/14	3		0					
6/15	4	0	0		0		0	0
6/16	4	0	0	0	0		0	0
6/17	5	0	0	0	0		0	0
6/18	8	0	0	0	0		0	0
6/19	10	0	0	0	0		0	0
6/20	12	0	0	0	0		0	0
6/21	12	0	0	0	0		0	0
6/22	13	0	0	0	2		1	0
6/23	15	0	0	0	3		2	0
6/24	17	1	0	0	3		2	1
6/25	20	1	0	0	5		3	2
6/26	22	2	1	0	9	0	4	3
6/27	24	3	1	2	11	2	6	6
6/28	28	4	3	3	14	3	8	8
6/29	30	6	5	5	16	5	12	12
6/30	31	6	5	7	20	7	14	16
7/01	34	7	7	10	22	9	16	20
7/02	39	8	8	13	23	10	20	21
7/03	41	11	9	17	25	13	22	25
7/04	46	13	10	19	26	16	26	27
7/05	51	15	12	22	29	20	31	33
7/06	56	19	14	27	36	24	38	37
7/07	60	21	17	31	42	29	41	43
7/08	64	23	17	33	45	33	44	46
7/09	69	25	18	36	48	38	47	48
7/10	71	28	19	39	52	44	51	53
7/11	73	32	24	45	[illegible]	50	56	59
7/12	75	36	27	49	[illegible]	56	59	65
7/13	76	38	31	53	65	61	62	67
7/14	81	41	34	56	68	65	65	69
7/15	85	44	36	59	72	69	70	71
7/16	87	48	43	63	75	73	72	73
7/17	90	52	50	68	78	75	76	76
7/18	91	57	57	72	81	77	80	78
7/19	91	61	63	77	83	79	83	81
7/20	92	66	64	79	84	81	85	84
7/21	92	69	66	81	85	83	87	85
7/22	93	72	68	84	86	86	89	88
7/23	93	74	72	86	88	88	90	89
7/24	94	76	73	88	89	93	91	91
7/25	95	78	75	90	90	96	92	92
7/26	96	80	78	93	91	97	93	94
7/27	96	82	80	94	92	98	94	94
7/28	97	84	83	96	92	98	95	95
7/29	97	85	85	98	93	99	96	96
7/30	98	87	87	100	94	99	96	97
7/31	99	89	88	102	95	99	97	97
8/01	99	91	90	102	95	99	97	97
8/02	99	92	91	102	95	99	98	98
8/03	99	93	92	102	96	99	98	98
8/04	99	94	93		96	100	98	99
8/05	99	95	94		97	100	98	99
8/06	99	95	94		97	100	99	99
8/07	99	96	95		97	100	99	99
8/08	100	97	95		97	100	99	99
8/09	100	97	96		98	100	99	99
8/10	100	98	96		98	100	99	99
8/11	100	98	97		98	100	100	100
8/12	100	98	97		98	100	100	100
8/13	100	99	97		99	100	100	100
8/14	100	99	98		99	100	100	100
8/15	100	99	98		99	100	100	100
8/16	100	99	98		99	100	100	100
8/17	100	99	99		99	100	100	100
8/18	100	99	99		99	100	100	100
8/19	100	100	99		99	100	100	100
8/20	100	100	99		99	100	100	100
8/21	100	100	99		99	100	100	100
8/22	100	100	100		100	100	100	100
8/23	100	100	100		100	100	100	100
8/24	100	100	100		100	100	100	100

Table 4. Age proportion of chum salmon caught in the commercial fishery from District 1 of the Kuskokwim Area. Data from Folletti 2003.

	Chum Salmon (data from 1970 - 2002)		
Age	M	F	Total
0.2	1.0%	1.1%	2.1%
0.3	28.5%	34.5%	63.0%
0.4	17.2%	16.7%	33.9%
0.5	0.6%	0.4%	1.0%
Total	47.3%	52.7%	100.0%