6.0 CHUM SALMON

Five species of salmon occur in Alaskan waters. The remaining four species, after Chinook, are managed together in the 'other salmon' management category and reported for accounting purposes as "non-Chinook salmon". The category includes chum salmon (*Oncorhynchus keta*), sockeye salmon (*Oncorhynchus nerka*), coho salmon (*Oncorhynchus kisutch*), and pink salmon (*Oncorhynchus gorbuscha*). As chum salmon represent over 95% of 'other salmon' caught as bycatch in the groundfish fisheries, this section will focus on chum salmon.

6.1 Overview of Chum salmon biology and distribution

The overview information in this section is extracted from Buklis (1994). Other information on Chum salmon may be found at the ADF&G website, http://www.cf.adfg.state.ak.us/geninfo/finfish/salmon/salmhome.php.

Chum salmon have the widest distribution of any of the Pacific salmon. They range south to the Sacramento River in California and the island of Kyushu in the Sea of Japan. In the north they range east in the Arctic Ocean to the Mackenzie River in Canada and west to the Lena River in Siberia.

Chum salmon often spawn in small side channels and other areas of large rivers where upwelling springs provide excellent conditions for egg survival. They also spawn in many of the same places as do pink salmon, i.e., small streams and intertidal zones. Some chum in the Yukon River travel over 2,000 miles to spawn in the Yukon Territory.

Chum do not have a period of freshwater residence after emergence of the fry as do Chinook, coho, and sockeye salmon. Chum fry feed on small insects in the stream and estuary before forming into schools in salt water where their diet usually consists of zooplankton. By fall they move out into the Bering Sea and Gulf of Alaska where they spend one or more of the winters of their 3- to 6-year lives. In southeastern Alaska most chum salmon mature at 4 years of age, although there is considerable variation in age at maturity between streams. There is also a higher percentage of chums in the northern areas of the state. Chum vary in size from 4 to over 30 pounds, but usually range from 7 to 18 pounds, with females usually smaller than males.

Chum salmon are the most abundant commercially harvested salmon species in arctic, northwestern, and Interior Alaska, but are of relatively less importance in other areas of the state. There they are known locally as "dog salmon" and are a traditional source of dried fish for winter use. Sport fishermen generally capture chum salmon incidental to fishing for other Pacific salmon in either fresh or salt water. After entering fresh water, chums are most often prepared as a smoked product. In the commercial fishery, most chum are caught by purse seines and drift gillnets, but fishwheels and set gillnets harvest a portion of the catch. In many areas they have been harvested incidental to the catch of pink salmon. The development of markets for fresh and frozen chum in Japan and northern Europe has increased their demand.

Chum salmon are generally caught incidental to other species and catches may not be good indicators of abundance. In recent years chum salmon catch in many areas has been depressed by low prices (Eggers

2004). Directed chum salmon fisheries occur in Arctic-Yukon-Kuskokwim area and on hatchery runs in Prince William Sound and Southeast Alaska. Chum salmon runs to Arctic-Yukon-Kuskokwim rivers have been declining in recent years. Chum salmon in the Yukon River and in some areas of Norton Sound have been classified as stocks of concern (Eggers 2004).

6.1.1 Food habits/ecological role

Chum salmon diet composition in summer appeared to be primarily euphausids and pteropods with some smaller amounts of amphipods, squid, fish and gelatinous zooplankton (Davis et al. 2004). Chum from the shelf region contained a higher proportion of pteropods than the other regions while AI chum contained higher proportions of euphausids and amphipods and basin chum samples had higher amounts of fish and gelatinous zooplankton (Davis et al. 2004). Fish prey species consumed in the basin included northern lampfish and juvenile Atka mackerel, sculpins and flatfish while shelf samples consumed juvenile rockfish, sablefish and Pollock (Davis et al. 2004).

6.1.2 Hatchery releases

Commercial salmon fisheries exist around the Pacific Rim with most countries releasing salmon fry in varying amounts by species. The North Pacific Anadromous Fish Commission summarizes information on hatchery releases by country and by area where available. Reports submitted to the NPAFC were used to summarize hatchery information by Country and by US state below (Table 6-1, Table 6-2). For more information see the following: Russia (Anon. 2007; TINRO-centre 2006, 2005); Canada (Cook et al. 2008, Cook and Irvine 2007); USA (Josephson 2008, 2007; Eggers 2006, 2005; Bartlett 2008, 2007, 2006, 2005); Korea (YIFRI 2008, SRT 2006, 2007); Japan (Takahashi and Tojima 2008) Chum salmon hatchery releases by country are shown below in Table 6-1.

For Chum salmon, Japanese hatchery releases far exceed releases by any other Pacific Rim country. This is followed by the US and Russia. A further break-out of hatchery releases by area in the US show that the majority of chum salmon fry releases occur in the Alaska region (Table 6-2).

Combined Asian hatchery releases in 2006 (Russia, Japan, Korea) account for 76% of the total releases while Alaskan chum releases account for 24% of the total releases. Chum enhancement projects in Alaska are not active in the AYK region.

Table 6-1 Hatchery releases of juvenile chum salmon in millions of fish

Year	Russia	Japan	Korea	Canada	US	Total
1999	278.7	1867.9	21.5	172.0	520.8	2,860.9
2000	326.1	1817.4	19.0	124.1	546.5	2,833.1
2001	316.0	1831.2	5.3	75.8	493.8	2,722.1
2002	306.8	1851.6	10.5	155.3	507.2	2,831.4
2003	363.2	1840.6	14.7	136.7	496.3	2,851.5
2004	363.1	1817.0	12.9	105.2	630.2	2,928.4
2005	387.3	1844.0	10.9	131.8	596.9	2,970.9
2006	344.3	1858.0	7.3	121.2	578.8	2,895.5
2007	*	1870.0	13.8	142.0	653.3	---

*2007 data not available

Table 6-2 US west coast hatchery releases of juvenile chum salmon in millions of fish

Year	Alaska	Washington	Oregon	California	Idaho	Combined WA/OR/CA/ID	Total
1999	460.9	59.9	0	0	0		520.8
2000	507.7	38.8	0	0	0		546.5
2001	465.4	28.4	0	0	0		493.8
2002	450.8	56.4	0	0	0		507.2
2003	435.6	60.7	0	0	0		496.3
2004	578.5					51.7	630.2
2005	549.0					47.9	596.9
2006	541.2					37.6	578.8
2007	604.7					48.6	653.3

6.1.3 BASIS surveys

The Bering-Aleutian Salmon International Survey (BASIS) is an NPAFC-coordinated program of pelagic ecosystem research on salmon and forage fish in the Bering Sea. Information on BASIS can also be found in Section 5.1.3.

Stock mixtures of salmon from BASIS surveys in the Bering Sea have provided new information on oceanic migration and distribution of regional stock groups in the Bering Sea. Recent results from Japanese surveys indicate that 81% of the immature chum salmon in the Bering Sea basin were from Asian (Russia and Japan) populations during August-September in 2002. Results from U.S. surveys on the Bering Sea shelf and Aleutian chain indicate considerable spatial variation in stock mixtures; however, when pooled over location mixtures were very similar to mixtures present in the basin with 80% of the immature chum salmon from Asian populations. Immature chum salmon from western Alaska comprised 2% and 8% of immature chum salmon on the southern Bering Sea shelf and northern Bering Sea shelf, respectively. Stock mixtures of juvenile chum salmon have identified where migratory routes of western Alaska and Russian chum salmon stocks overlap and has helped identify the contribution of Russian stocks to the total biomass of juvenile chum salmon on the eastern Bering Sea shelf (JTC 2008).

During the June-July 2005 BASIS survey chum salmon was the most dominant fish species in upper epipelagic layer in the survey area (52 % from overall fish biomass estimates; NPAFC 2006). Chum salmon was a dominant Pacific salmon species in terms of its quantity (46% from overall Pacific salmon quantity). The rate of chum salmon occurrence in trawl catches was highest (92%) among all fish species (NPAFC 2006). During the survey period age 0.1 chum salmon has just started entering Bering Sea along the major pathway of Central Bering Sea Current. Age 0.2 chum salmon was distributed in the Aleutian and Commander Basins. This age group of chum salmon migrated into the Russian EEZ earlier than 0.1 along the major pathway of Central Bering Sea Current (NPAFC 2006). Near Navarin Cape and Kronotsky Capes age 0.2 chum was most proximate to the shore as compared with other areas (NPAFC 2006). Large-size (FL>53 cm) immature chum salmon was numerous in the northwestern Aleutian Basin and Navarin Shelf area (NPAFC 2006). Age 0.3 and higher was distributed almost throughout entire survey area (rate of occurrence in catches – 73%), except for inshore areas (NPAFC 2006). Maturing chum salmon individuals were noted in a high percentage of trawl catches (87 %). The overall biomass of chum salmon in the survey areas was estimated as 311.59 thousand tons (49% - immature and 51% - mature chum). Overall quantity estimates were 138.96 million individuals (57% - immature and 43% - mature chum salmon) (NPAFC 2006)

In 2007, the U.S. BASIS program sampled in the Bering Straits and the Chukchi Sea, and found water temperatures warmer than in the Bering Sea (Fig. 6-1). Substantial numbers of juvenile pink and chum salmon were caught that were larger than those caught south of the Bering Straits. Juvenile chum salmon in this area and from the Chukchi Sea may also originate from the Yukon River (JTC 2008). Auke Bay Laboratories are currently conducting genetic stock identification on these samples to determine river of origin.

Fig. 5-2 shows the relative abundance of juvenile salmon in the Northern Shelf Region of the Bering Sea as determined by the U. S. BASIS cruises from 2002 to 2007. The very low numbers of chum juveniles in 2004 may explain the relatively low chum salmon bycatch in the BSAI groundfish fishery in 2007. The numbers of juvenile chum salmon appear to be rebounding in 2006 and 2007 (Chris Kondzela, AFSC, personal communication).

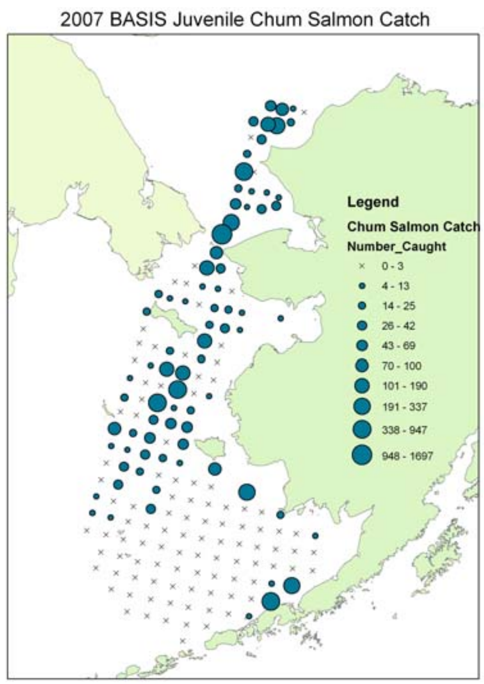

Fig. 6-1 U.S. BASIS juvenile Chum salmon catches in 2007. Source: Chris Kondzela, AFSC

6.1.4 Migration corridors

Migration corridors for western Alaska juvenile salmon are discussed in Section 5.1.4.

6.2 Salmon assessment overview by river system or region

6.2.1 Management and assessment of salmon stocks

The State of Alaska manages commercial, subsistence and sport fishing of salmon in Alaskan rivers and marine waters and assesses the health and viability of individual salmon stocks accordingly. No gillnet fishing for salmon is permitted in Federal (3-200 miles) waters, nor commercial fishing for salmon in offshore waters west of Cape Suckling.

Major chum stocks in western Alaska include Norton Sound, Yukon (Summer and Fall runs), Kuskokwim, Bristol Bay and Kotzebue. An overview of stock status and stock of concern designations for these stocks is provided in Table 6-3.

Table 6-3 Western Alaskan chum stocks and current stock of concern designations.

Chum Stock	Stock of concern?
Norton Sound	Yield concern
Yukon Fall and Summer	Yield concern discontinued 2007 for both fall and summer
Kuskokwim	Yield concern discontinued 2007
Bristol Bay	No
Kotzebue	No

6.2.2 Norton Sound Chum

Norton Sound is comprised of two districts, the Norton Sound District and Port Clarence District. Chinooks stocks are managed in the Norton Sound District. Poor market conditions exist in the Norton Sound chum fishery combined with declining runs

Stock assessment and historical stock estimates

Table 6-4 summarizes escapement assessments for the major index river systems of the Norton Sound and Port Clarence Districts in 2007. These assessments are often qualitative and relative to historical escapement sizes. Most of the chum salmon assessments are described relative to a Sustainable Escapement Goal (SEG) for an index area. An SEG is a level of escapement that is known to provide for sustained yields over a 5-to-10 year period, and is used in situations where a Biological Escapement Goal (BEG) cannot be estimated due to the absence of a stock specific catch estimate. A BEG is based on spawner-recruit relationships estimated to provide maximum sustained yield. An Optimal Escapement Goal (OEG) is a specific management objective for escapement that considers biological and allocative factors and may differ from the SEG or BEG.

ADF&G escapement projects in Norton Sound include counting towers on the Kwiniuk and Niukluk Rivers, a test net operated on the Unalakleet River, and a weir on the Nome River. Norton Sound Economic Development Corporation (NSEDC) provides essential support for these projects.

Six additional counting projects were also operated in the management area this season. The Snake, Eldorado, and Pilgrim River had weir projects which were setup and operated by Kawerak Corporation and the North River counting tower project was a cooperative project operated by Fish & Game in June and Unalakleet IRA for the remainder of the summer. NSEDC provided essential support to all organizations. The Pikmiktalik River counting tower, near Stebbins, is a cooperative project by Kawerak and U.S. Fish & Wildlife Service. Fish & Game and NSEDC operated a weir at the headwaters of Glacial Creek which flows from Glacial Lake into the Sinuk River for two weeks during peak sockeye salmon passage. Except for the Pikmiktalik River and the Glacial Lake project, most projects have been operational since the mid-1990s. All projects supplied important daily information to ADF&G that was very useful to the management of local salmon resources and will become more important the longer they operate.

Aerial survey assessment conditions were fair to good in most of Norton Sound for the 2007 season. However, the lack of aircraft hampered surveying a number of rivers. In addition, weather deteriorated after the first week of September and some rivers were not surveyed for coho salmon escapements during peak escapement periods. As usual, the Nome Subdistrict streams received the most intensive assessment efforts because salmon stocks local to the Nome area are strictly regulated, easily accessed by road system, and are exposed to intensive subsistence and sport fishing pressure.

Table 6-4 Chum salmon counts of Norton Sound rivers in 2007 and associated salmon escapement goal ranges (SEG, BEG or OEG) Source Menard and Kent 2007

	Chum			
Stream Name	Weir/ Tower Count	Escapement Goal Range	Aerial Survey Count	Escapement Goal Range
Salmon L.				
Grand Central R.				
Pilgrim R.	35,588			
Agiapuk R.				
American R.				
Glacial L.				
Sinuk R.		4,000 - 6,200 b	7,210	
Cripple R.			349	
Penny R.			14	
Snake R.	8,144	1,600 - 2,500 c	1,702	
Nome R.	7,034	2,900 - 4,300 c	1,449	
Flambeau R.		4,100 - 6,300 b	4,452	
Eldorado R.	21,312	6,000 - 9,200 c	6,315	
Bonanza R.		2,300 - 3,400 b	2,628	
Solomon R.		1,100 - 1,600 b	673	
Fish R.				
Boston Cr.				
Niukluk R.	50,994	30,000		
Ophir Cr.				
Kwiniuk R.	27,756	11,500 - 23,000 d	2,190	
Tubutulik R.		9,200 - 18,400 b, d	7,045	
Inglutalik R			9,283	
Ungalik River				
Pikmiktalik R	21,080			
Shaktoolik R.			3,531	
Unalakeet R.			1,807	Combined
Old Woman R.			95	2,400 - 4,800
North R.	8,046		295	

Chum salmon escapements were well above average in most areas in 2007. The Nome River weir passage was a record since the weir began operations in the mid-90s as 7,034 chum salmon were counted in 2007. The Eldorado River weir passage was the second best on record with 21,312 chums counted and was second only to last year when 41,985 chum salmon were counted. The Snake River weir passage of 8,144 chum salmon was the second best since counting began in 1995 and exceeded the minimum escapement goal of 1,600 chum salmon for the seventh year in a row. The 21,080 chums enumerated at the Pikmiktalik tower this season was record setting and nearly doubled last year's previous record passage of 12,711 chums. The Kwiniuk River tower counts of 27,756 chum salmon ranked fourteenth highest in the 43-year project history and the Niukluk River tower counts of 50,994 ranked fourth best since counting began in 1995. The Unalakleet River chum escapements were above average based on test net catches, but the North River chum salmon passage of 8,046 was below the 5-year average, but above the 10-year average. The Pilgrim River weir passage of 35,588 chums was over three times the 2004 and 2005 weir passage and over two times the 2003 weir passage, but behind last year's record passage of over 45,000 chum salmon.

Forecasts and precision of estimates

Salmon outlooks and harvest projections for the 2008 salmon season are based on qualitative assessments of parent year escapements, subjective determinations of freshwater overwintering and ocean survival, and in the case of the commercial fishery, the projections of local market conditions. Weak returns of Chinook salmon since 2000 have precluded the prosecution of a chum salmon fishery in Subdistricts 5 and 6 due to concerns with interceptions of Chinook in early to mid-July. Typically when Chinook runs are poor, chum commercial fishing is prohibited until the third week in July despite improved market conditions and interest in an earlier commercial fishery (S. Kent, pers. comm.).

6.2.3 Kotzebue Chum

The Kotzebue District includes all waters from Cape Prince of Wales to Point Hope. The Kotzebue District is divided into three subdistricts. Subdistrict 1 has six statistical areas open to commercial salmon fishing. Within the Kotzebue District chum salmon are the most abundant anadromous fish.

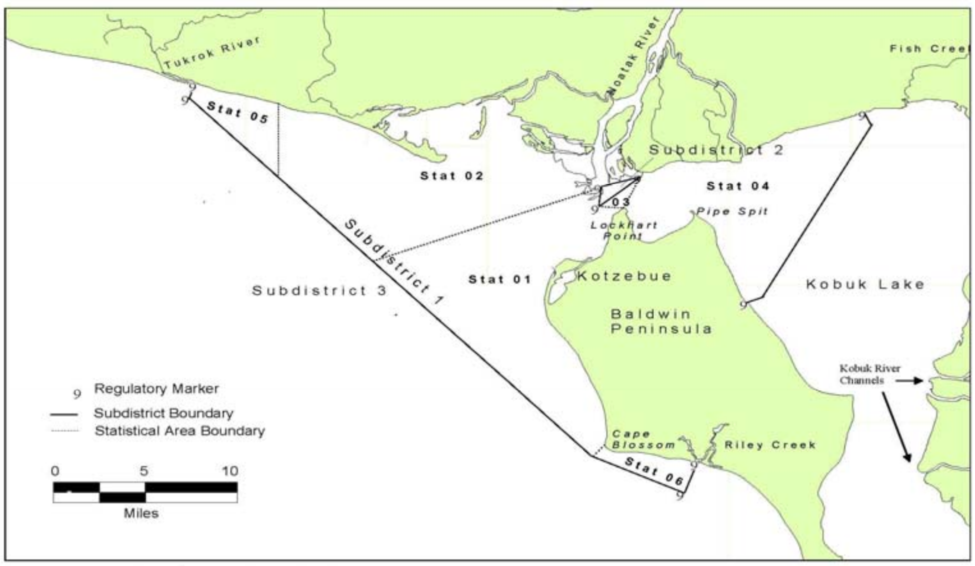

Fig. 6-2 Kotzebue Fishery Management Area

The Kotzebue fishery is primarily a chum salmon fishery, with some Chinook, sockeye, and Dolly Varden taken incidentally. The overall chum salmon run to Kotzebue Sound in 2007 was estimated to be above average based on the commercial harvest rates, subsistence fishermen reporting average to above average catches, and the Kobuk test fish index being above average. No stocks in the Kotzebue area are presently identified as being of management or yield concern and the commercial fishery is allowed to remain open continuously with harvest activity regulated by buyer interest.

Escapement is monitored by a test fish project on the Kobuk River. The lowest index recorded was in 1993. In 2002 and 2003 chum salmon runs showed a large increase in abundance as compared with runs from 1999-2001. Since the test fishery has been established, 2002 and 2003 have been the third and fourth worst years for CPUE in the test fishery (Menard 2003).

Market conditions have impacted the chum fishery in Kotzebue in recent years. A major buyer has not existed for several years and the commercial fishery is limited to a small fleet. Commercial harvests have been low due to weak chum sizes (Menard 2003).

6.2.4 Yukon River Chum

As with Chinook salmon management along the Yukon (see Section 5.2.4), chum salmon management of the Yukon fishery is difficult and complex because of the often inability to determine stock specific abundance and timing, overlapping multi-species salmon runs, increasing efficiency of the fishing fleet, the gauntlet nature of Yukon fisheries, allocation issues between lower river and upper river Alaskan fishermen, allocation and conservation issues between Alaska and Canada, and the immense size of the drainage (Clark et al 2006). Salmon fisheries within the Yukon River may harvest stocks that are up to several weeks and over a thousand miles from their spawning grounds. Since the Yukon River fisheries are largely mixed stock fisheries, some tributary populations may be under or over exploited in relation to abundance, it is not possible to manage for individual stocks in most areas where commercial and subsistence fisheries occurs (Clark et al 2006). In Alaska, subsistence fisheries have priority over other types of use. Agreements between the U.S. and Canada are in effect that commit the ADF&G to manage Alaskan fisheries in a manner that provides a Yukon River Panel agreed to passage of salmon into Canada to both support Canadian fisheries and to achieve desired spawning levels.

6.2.4.1 Stock assessment and historical run estimates

Yukon River chum salmon consists of an earlier and typically more abundant summer run and a later fall salmon run. Yukon chum salmon are harvested in commercial, subsistence and personal use fisheries.

The following information on assessment and stock status of Yukon River summer and fall chum stocks is excerpted from the Joint Technical Committee of the Yukon River US/Canada Panel Report (JTC 2008).

Yukon Summer Chum:

The strength of the summer chum salmon runs in 2008 will be dependent on production from the 2004 (age-4 fish) and 2003 (age-5-fish) escapements as these age classes generally dominate the run. The total run during 2002 and 2003 was approximately 1.2 million summer chum salmon in each year, though tributary escapements were highly variable. It appears that production has shifted from major spawning tributaries in the lower portion of the drainage, such as the Andreafsky and Anvik rivers over the last 5 years, to higher production in spawning tributaries upstream.

In 2007, the return from the 2003 brood year produced a higher than average percentage of age-4 fish. Since summer chum salmon exhibit a strong sibling relationship from age-4 fish to age-5 fish, an above average percentage of age-5 fish is expected in 2008. The 2008 run is estimated using the Anvik River brood table, sibling relationships between age-4 and age-5 fish, and the 5-year average ratio between the Anvik River and Pilot Station Sonar. It is expected that approximately 600,000 summer chum salmon will return to the Anvik River in 2008 and the total run in the Yukon River could be approximately 2.0–2.5 million summer chum salmon which constitutes an average run.

The 2008 run is anticipated to be near average and provide for escapements and support a normal subsistence and commercial harvest. Summer chum salmon runs have exhibited steady improvements since 2001 with a harvestable surplus in each of the last 5 years (2003–2007). If inseason indicators of run strength suggest sufficient abundance exists to allow for a commercial fishery, the commercial harvest surplus in Alaska could range from 500,000 to 900,000 summer chum salmon. The actual commercial harvest of summer chum salmon in 2008 will likely be dependent on market conditions and may be affected by a potentially poor Chinook salmon run, as Chinook salmon are incidentally harvested in chum salmon-directed fisheries.

Yukon Fall chum

Yukon River drainage-wide estimated escapements of fall chum salmon for the period 1974 through 2002 have ranged from approximately 180,000 (1982) to 1,500,000 (1975), based on expansion of escapement assessments for selected stocks to approximate overall abundance (Eggers 2001). Escapements in these years resulted in subsequent returns that ranged in size from approximately 311,000 (1996 production) to 3,000,000 (2001 production) fish, using the same approach to approximating overall escapement. Corresponding return per spawner rates ranged from 0.3 to 9.0, averaging 2.1 for all years combined (1974–2001).

A considerable amount of uncertainty has been associated with these run projections particularly recently because of unexpected run failures (1997 to 2002) followed by a strong improvement in productivity from 2003 through 2006. Weakness in salmon runs prior to 2003 has generally been attributed to reduced productivity in the marine environment and not as a result of low levels of parental escapement. Similarly, the recent improvements in productivity may be attributed to the marine environment. Projections have been presented as ranges since 1999 to allow for adjustments based on more recent trends in production. Historical ranges included the normal point projection as the upper end and the lower end was determined by reducing the projection by the average ratio of observed to predicted returns from 1998 to each consecutive current year through 2004. In 2005, the average ratio of the years 2001 to 2004 was used, in attempts to capture some of the observed improvement in the run.

Yukon River fall chum salmon return primarily as age-4 and age-5 fish, although age-3 and age-6 fish also contribute to the run (JTC 2008). The 2008 run will be comprised of parent years 2002 to 2005. Estimates of returns per spawner based on brood year return were used to estimate production for 2002 and 2003. An auto-regressive Ricker spawner-recruit model was used to predict returns from 2004 and 2005. The point estimate in 2006 and 2007, utilized 1974 to 1983 even/odd maturity schedules to represent years of higher production. The 2008 estimated point projection uses years 1984–2001 of the even/odd maturity schedule, because current production is reduced from the pre-1984 level, and resulted in an estimate of 1.0 million fall chum salmon with the approximate age composition provided in JTC (2008).

Table 6-5 Preseason drainage-wide fall chum salmon outlooks and observed run sizes for the Yukon River, 1998–2007

Year	Expected Run Size (Preseason)	Estimated Run Size (Postseason)	Proportion of Expected Run
1998	880,000	334,000	0.38
1999	1,197,000	420,000	0.35
2000	1,137,000	239,000	0.21
2001	962,000	383,000	0.40
2002	646,000	425,000	0.66
2003	647,000	775,000	1.20
2004	672,000	614,000	0.92
2005	776,000	2,325,000	3.00
2006	1,211,000	1,144,000	0.94
2007	1,106,000	1,098,000	0.99
	Average (1998 to 2007)		0.90

The forecast range is based on the upper and lower values of the 80% confidence bounds for the point projection. Confidence bounds were calculated using deviation of point estimates and observed returns from 1987 through 2007. Therefore, the 2008 run size projection is expressed as a range from 890,000 to

1.2 million fall chum salmon. However, this projection appears to be high based on other information, such as the lack of immature chum salmon encountered in the high seas BASIS research as well as notable declines in chum salmon bycatch levels, and the low probability of another record even-numbered-year run.

Escapements for the 2002 and 2004 parent years, that will contribute age-6 and age-4 fish in the 2008 run, were below the upper end of the drainage-wide escapement goal of 300,000 to 600,000 fall chum salmon. The 2003 and 2005 escapements, that will contribute age-5 and age-3 fish in the 2008 return, were above the upper end of the drainage-wide escapement goal range. The major contributor to the 2008 fall chum salmon run is anticipated to be age-4 fish returning from the 2004 parent year. The average age-3 component is 1.8%, however, the contribution is expected to be low (0.52) based on poor returns per spawner for the 2005 brood year.

Table 6-6 Projected return of fall chum salmon based on parent year escapement for each brood year and predicted return per spawner (R/S) rates, Yukon River, 2002–2005

Brood Year	Escapement	Estimated production (R/S)	Estimated Production	Contribution based on age	Current Return
2002	397,977	1.71	680,541	1.0%	10,083
2003	695,363	1.83	1,272,514	32.9%	346,163
2004	537,873	2.01	1,081,125	64.3%	675,059
2005	2,035,183	0.52	1,058,295	1.8%	19,345
				Total expected run (unadjusted)	1,050,649
Total expressed as a range based on the forecasted vs. observed returns from 1987 to 2007 (80% CI):					890,000 to 1.2 million

The 2001 brood year produced exceptionally well with a return of approximately 3.0 million fish including record contributions in nearly all age classes. Return of age-4 fish from even-numbered brood years during the time period 1974 to 2001 typically average 385,000 chum salmon, and ranges from a low of 175,000 for brood year 1988 to a high of 2.2 million for brood year 2001. Based on the high production years from 1974 to 1983, the return of even-numbered brood years averages 436,000 chum salmon. Return of age-5 fish from even-numbered brood years during the time period 1974 to 2001 typically averages 187,000 chum salmon, and ranges from a low of 57,000 for brood year 1998 to a high of 675,000 for brood year 2001. The estimated 2002 brood year return appears to be above average for an even-numbered year and the 2003 brood year is on track to contribute an average return for an odd-numbered year.

If the 2008 run size is near the projected range of 890,000 to 1,200,000 million, it will be well above the upper end of the BEG range of 600,000 fall chum salmon. A run of this projected size should support normal subsistence fishing activities and provide opportunity for commercial ventures where markets exist. The strength of the run will be monitored inseason to determine appropriate management actions and levels of harvest based on stipulations in the Alaska *Yukon River Drainage Fall Chum Salmon Management Plan*.

Canadian-Origin Upper Yukon River Fall Chum Salmon

The outlook for the 2008 Upper Yukon River fall chum salmon run is an above average run of 229,000 fish. The average Upper Yukon River fall chum salmon run size for the 1998–2007 period was estimated to be 181,000 fish.

The 2008 Upper Yukon River fall chum salmon outlook was developed using the potential production from the 2002–2005 brood years which will produce the 3 to 6 year old fish returning in 2008. For even-year returns, on average, 51% of Upper Yukon River adult fall chum salmon return as age-4 and 47%

return as age-5. The major portion of the 2008 fall chum salmon run will originate from the 2003 and 2004 brood years. The estimated escapements for these years were 142,683 and 154,080 fish, respectively, based on the Fisheries and Oceans Canada (DFO) mark–recapture program[44]; both years exceeded the escapement goal for rebuilt Upper Yukon River fall chum salmon of >80,000 fish. The weighted average (by age) brood escapement (2002–2005 BY's) contributing to the 2008 Upper Yukon River fall chum salmon run is approximately 152,700 fish.

Based on the Upper Yukon River spawner-recruitment model, poor production should be expected from escapements of this magnitude. However, the return from the escapements exceeding 100,000 fall chum salmon used in the stock recruitment model occurred during a period of low marine survival. Spawner-recruitment relationships have not been determined for the 2003–2007 runs when the estimated spawning escapements ranged from 143,000 to 438,000 fish. The 2008 outlook was therefore developed using a conservative R/S value of 1.5 for the 2002–2005 brood years. The expected 2008 production was then estimated by assuming that each brood year would produce the average age composition for even-year returns within the 1988 to 2006 period, i.e., 1.6% age-3, 50.6% age-4, 46.7% age-5, and 1.1% age-6. The estimated contribution from each brood year was then summed to estimate an above average run size of 229,000 Upper Yukon River fall chum salmon in 2008.

Prior to 2002, preseason outlooks for Upper Yukon River fall chum salmon were based on an assumed productivity of 2.5 returning adults per spawner (i.e., R/S). This was the same productivity used in the joint Canada/U.S. Upper Yukon River fall chum salmon rebuilding model. There was very low survival for the 1994 to 1997 brood years with R/S values equal to or below the replacement value (i.e., R/S=1.0). The average estimated production for the 1998-2002 brood years was 2.5, excluding 2001 with an unprecedented high R/S value of 20.3.

Since 2002, preseason outlooks have been based on stock/recruitment models, which incorporate escapement and subsequent associated adult return by age data. Annual runs were reconstructed using mark–recapture data and assumed contributions to U.S. catches. Although insufficient stock identification data was available to accurately estimate the annual U.S. catch of Upper Yukon River fall chum salmon, estimates have usually been made based on the following assumptions:

i. 30% [45] of the total U.S. catch of fall chum salmon is composed of Canadian-origin fish;
ii. The U.S. catch of Canadian-origin Upper Yukon River and Canadian-origin Porcupine River fall chum salmon is proportional to the ratio of their respective border escapements; and
iii. The Porcupine River border escapement consists of the Old Crow aboriginal fishery catch plus the Fishing Branch River weir count.

All of these assumptions require additional evaluation as some recent Porcupine River mark-recapture data are available and advances in genetic stock identification (i.e., mixed stock analyses) should permit more accurate estimates of the proportion of Canadian fall chum salmon run harvested in U.S. fisheries. A summary of preseason outlooks, postseason run size estimates and the proportion of the expected run size observed for the 1998 to 2007 period is presented in Table 6-7.

[44] Unlike Chinook salmon, the mark-recapture estimates for fall chum salmon generally agree with the Eagle sonar estimates.

[45] Recent tagging information has been incorporated into the Porcupine River run reconstruction and there has been some minor deviation from the assumption that 30% of the total U.S. catch of fall chum salmon is composed of Canadian-origin fish.

Table 6-7 Preseason Upper Yukon River fall chum salmon outlooks and observed run sizes for the 1998–2007 period

Year	Expected Run Size (Preseason)	Estimated Run Size (Postseason)	Proportion of Expected Run
1998	198,000	61,400	0.31
1999	336,000	98,400	0.29
2000	334,000	62,900	0.19
2001	245,000	45,100	0.18
2002	144,000	109,900	0.76
2003	145,000	179,800	1.18
2004	146,500	181,300	1.24
2005	126,000	515,200	4.09
2006	126,000	284,200	2.26
2007	147,000	278,500	1.89
Average (1998 to 2007)			1.24

Conservation concerns for the Fishing Branch River fall chum salmon run arose in the late 1990s and were heightened in year 2000 when the count through the Fishing Branch River weir was only 5,053 fish, the lowest on record. However, run sizes improved somewhat within the 2001–2007 period when observed counts ranged from a low of 13,563 in 2002 to a high of 121,413 in 2005.

The 2008 fall chum salmon run to Canadian portions of the Porcupine River drainage should originate primarily from the 2003 and 2004 escapements. The Fishing Branch River weir counts for these years were 29,519 and 20,274 fall chum salmon, respectively. These counts were 99.8% and 68.5% of the 1997–2006 average of 29,577 fish. The 2003 and 2004 counts both fell below the lower end of the Fishing Branch River escapement goal range of 50,000 to 120,000 fall chum salmon established under the Yukon River Salmon Agreement. The weighted average (by age) base year escapement for the 2008 Fishing Branch River fall chum run is approximately 24,800 fish.

Assuming a return/spawner value of 2.5[46], and using the long-term average (1986–2006) even-year age at maturity for Fishing Branch River fall chum salmon of 49.8.% age-4 and 47.1% age-5 fish, an above average return of 62,000 fall chum salmon is expected in 2008 (Table 6-8).

Table 6-8 Preseason outlook for the 2008 Fishing Branch River fall chum salmon run developed using brood year escapement data, a return per spawner value of 2.5 and an average age composition

Brood Year	**Escapement**	**Estimated Production @ 2.5 (R/S)**	**Contribution based on age**	**Expected 2007 Run**
2003	29,519	73,798	47.1%	34,738
2004	20,274	50,685	49.8%	25,250
Sub-total				59,988
Total expected run (expanded for other age classes and rounded)				62,000

The 2008 outlook is the estimated number of fish entering the mouth of the Yukon River and this number will be decreased by U.S. and Canadian fisheries prior to the fish being counted at the Fishing Branch

46 The R/S value (2.5) used for the 2008 Fishing Branch River fall chum salmon outlook is higher than the R/S value (1.5) used for the 2008 Upper Yukon River fall chum salmon outlook. The principal reason for this measure is that Upper Yukon River returns from escapements exceeding 100,000 chum salmon occurred during a period of low marine survival. A more conservative (i.e., lower) Upper Yukon River R/S value captures the uncertainty associated with returns from higher escapements.

River weir. It has been difficult to accurately estimate the U.S. harvest rate (and catch) of Porcupine stocks, although DNA analyses may improve this situation in the near future. Nevertheless, the 2008 Fishing Branch River fall chum salmon run may be sufficiently strong to exceed the 1997–2006 average weir escapement of 29,577 fall chum salmon.

As was observed with the Upper Yukon River fall chum salmon stocks, the postseason estimates of the estimated Porcupine River fall chum salmon run sizes were consistently below preseason outlooks throughout the period 1998 to 2002 (Table 6-7). Postseason estimates consistently exceeded preseason outlooks from 2003 to 2005, and the 2006 postseason estimate was 10% lower than the preseason estimate. The 2007 postseason run size estimate was 34% lower than the preseason outlook; however, unusually late run timing may have adversely affected the principal assessment program, the Fishing Branch River weir, as there was no reliable timing information from 2007 assessment programs that could be used to expand the weir count which ended before the run had completely passed upstream. The Porcupine River outlook includes the Fishing Branch River as well as other spawning areas. While it is believed that most fall chum salmon return to the Fishing Branch River, there is little information available on other spawning locations.

Table 6-9 Preseason Porcupine River fall chum salmon outlooks and observed run sizes for the 1998–2007 period

Year	Expected Run Size (Preseason)	Estimated Run Size (Postseason)	Proportion of Expected Run
1998	112,000	24,700	0.22
1999	124,000	23,600	0.19
2000	150,000	12,600	0.08
2001	101,000	32,800	0.32
2002	41,000	19,300	0.47
2003	29,000	46,100	1.59
2004	22,000	31,700	1.44
2005	48,000	189,700	3.95
2006	53,500	48,200	0.90
2007	79,500	52,700	0.66
	Average (1998 to 2007)		0.98

6.2.5 Kuskokwim River Chum

The Kuskokwim management area includes the Kuskokwim River drainage, all waters of Alaska that flow into the Bering Sea between Cape Newenham and the Naskonat Peninsula, as well as Nelson, Nunivak, and St Matthew Islands. The management area is divided into 5 districts. District 1, the lower Kuskokwim District, is located in the lower 125 miles of the Kuskokwim River from Eek Island upstream to Bogus Creek. District 2 is about 50 miles in length and is located in the middle Kuskokwim River from above District 1 to the Kolmokov River near Aniak. An upper Kuskokwim River fishing district, District 3, was defined at Statehood, but has been closed to commercial fishing since 1966. Salmon returning to spawn in the Kuskokwim River are targeted by commercial fishermen in District 1 and 2. District 4, the Quinhagak fishing district, is a marine fishing area that encompasses about 5 miles of shoreline adjacent to the village of Quinhagak. The Kanektok and Arolik Rivers are the primary salmon spawning streams that enter District 4. District 5, the Goodnews Bay fishing district, a second marine fishing area, was established in 1968. District 5 encompasses the marine water within Goodnews Bay and the Goodnews River is the major salmon spawning stream that enters District 5 (Clark et al. 2006). Mainland streams north of the Kuskokwim River and streams of Nelson, Nunivak, and St Matthew Islands are not typically surveyed for salmon. Information presented in this section focuses upon the Kuskokwim River chum salmon.

Management of Kuskokwim area salmon fisheries is complex. Annual run sizes and timing is often uncertain when decisions must be made, mixed stocks are often harvested several weeks and hundreds of miles from their spawning grounds, allocative issues divide downriver and upriver users as well as subsistence, commercial, and sport users, and the Kuskokwim area itself is immense. In 1988, the BOF formed the Kuskokwim River Salmon Management Working Group in response to users seeking a more active role in management of fisheries. Working group members represent the various interests and geographic locations throughout the Kuskokwim River who are concerned with salmon management. The Working Group has become increasingly active in the preseason, inseason, and postseason management of Kuskokwim River salmon fisheries. Over the last 10 to 20 years, the fishery management program in the Kuskokwim area has become both more precautionary and more complex with the addition of several BOF management plans, improved inseason and postseason stock status information, and more intensive inseason user group reviewing management of the salmon fisheries (Clark et al 2006). The salmon stocks of the Kuskokwim area have been sustained at a high level, and the large subsistence fishery has been sustained, while the commercial salmon fisheries of the Kuskokwim are have been greatly reduced as a result of the precautionary management approach that has been implemented over the last 15 years.

6.2.5.1 Stock status and historical run estimates

Inseason management of the various Kuskokwim area salmon fisheries is based on salmon run abundance and timing factors, including data obtained through the Bethel test fishery, subsistence harvest reports, tributary escapement monitoring projects, and when available, commercial catch per unit effort data.

Kuskokwim River chum salmon are an important subsistence species as well as the primary commercially targeted salmon species on the Kuskokwim River in June and July. Kuskowim River chum salmon were designated a stock of concern under yield concern in September 2000 and this designation was continued in September 2003. Since 2000 however chum salmon runs on the Kuskokwim have been improving and in January 2007, the BOF discontinued this designation. Escapement is evaluated through enumeration at weirs on six tributary streams, sonar on the Aniak River. Escapement information review indicates that chum salmon escapement was below average from 1999-2000. However since 2001 escapement has been average or better (Bue et al. 2008). Declining salmon markets for chum have increased the difficulty of evaluating the abundance of chum salmon in the Kuskokwim (Bue et al. 2008). While a harvestable surplus was identified in 2002 and 2003, no market existed for the fishery.

Historical run reconstruction for 1976-2000 was evaluated by Shotwell and Adkison (2004). More recent run reconstruction work was completed for the Kuskokwim (Bue et al. 2008). Comparative results between the studies are shown in Fig. 6-3. These indicate that while the stock was increasing since 2003 and in general since a low in 2000, recent years appear to be declining (Fig. 6-3).

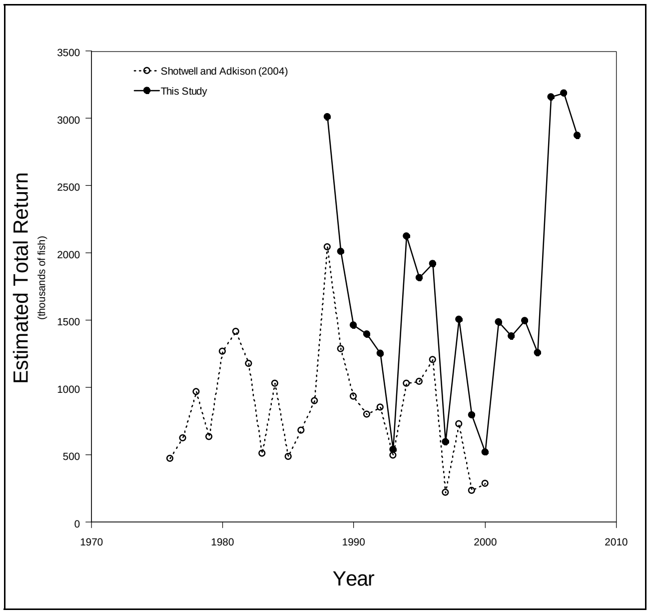

Fig. 6-3 Comparison of the time series of total run estimates for chum salmon returning to the Kuskokwim River obtained by Shotwell and Adkison (2004) and total run estimates from this study. The estimates made by this study were for the purpose of illustrating the performance of the run reconstruction model and are not actual estimates of total run. From Bue et al. 2008.

6.2.5.2 Forecasts and precision of estimates

ADF&G does not produce formal run forecasts for most salmon runs in the Kuskokwim region, due to lack of information with which to develop rigorous forecasts. Commercial harvest outlooks are typically based upon available parent year spawning escapement indicators, age composition information, recent year trends, and the likely level of commercial harvest that can be expected to be available from such indicators, given the fishery management plans in place. Fisheries are managed based upon inseason run assessment.

6.2.6 Bristol Bay Chum: Nushagak River

There are five discrete commercial fishing districts in Bristol Bay: the Ugashik, the Egegik, the Naknek-Kvichak, the Nushagak, and the Togiak (Fig. 5-21). Salmon management in Bristol Bay is primarily directed at the commercially harvested sockeye salmon which are found throughout the Bay.

6.2.6.1 Methodology and historical run estimates

In the Bristol Bay District chum salmon stocks are fished commercially on the Nushagak and Togiak Rivers Management of the commercial fishery in Bristol Bay is focused on discrete stocks with harvests directed at terminal areas around the mouths of major river systems. Each stock is managed to achieve a spawning escapement goal based on sustained yield. Escapement goals are achieved by regulating fishing time and area by emergency order (EO) and/or adjusting weekly fishing schedules.

Escapement data together with catch and total run estimates are shown for the Nushagak and Togiak Districts from 1987-2007 (Sands et al 2008) in Table 6-10. Escapement and catch in the Nushagak has been increasing in recent years with 2006 well above the 20-year average (Table 6-10).

Table 6-10 Inshore commercial catch and escapement of chum salmon in the Nushagak and Togiak Districts, in numbers of fish, 1987–2007 (Sands et al. 2008)

	Nushagak District			Togiak District			
Year	**Catch**	**Escapement** [a]	**Total Run**	**Catch**	**Escapement** [b]		**Total Run**
1987	416,476	147,433	563,909	419,425	361,000		780,425
1988	371,196	186,418	557,614	470,132	412,000		882,132
1989	523,903	377,512	901,415	203,178	143,890		347,068
1990	378,223	329,793	708,016	102,861	67,460		170,321
1991	463,780	287,280	751,060	246,589	149,210		395,799
1992	398,691	302,678	701,369	176,123	120,000		296,123
1993	505,799	217,230	723,029	144,869	98,470		243,339
1994	328,267	378,928	707,195	232,559	229,470		462,029
1995	390,158	212,612	602,770	221,126	163,040		384,166
1996	331,414	225,331	556,745	206,226	117,240		323,466
1997	185,620	61,456	247,076	47,459	106,580		154,039
1998	208,551	299,443	507,994	67,408	102,455		169,863
1999	170,795	242,312	413,107	111,677	116,183		227,860
2000	114,454	141,323	255,777	140,175	80,860	c	221,035
2001	526,602	564,373	1,090,975	211,701	252,610		464,311
2002	276,845	419,969	696,814	112,987	154,360		267,347
2003	740,311	295,413	1,035,724	68,406	39,090	d	107,496
2004	470,248	283,805	754,053	94,025	103,810		197,835
2005	874,090	448,059	1,322,149	124,694	108,346		233,040
2006	1,240,235	661,003	1,901,238	223,364	26,900	c,d	250,264
20-Year Ave.	445,783	304,119	749,901	181,249	147,649		328,898
1987-96 Ave.	410,791	266,522	677,312	242,309	186,178		428,487
1997-06 Ave.	480,775	341,716	822,491	120,190	109,119		229,309
2007			0	220,633		c,d	220,633

Note: Blank cells represent no data.

[a] Escapement based on sonar estimates from the Portage Creek site

[b] Escapement estimates based on aerial surveys
Estimates for 1987-88 rounded to the nearest thousand fish.

[c] No escapement counts were made for the Togiak River.

[d] Partial count

6.2.7 Gulf of Alaska

Primary chum salmon stocks in the GOA are located primary in Cook Inlet, Prince William Sound, Kodiak-Chignik, and Southeast-Yakutat regions. Approximately 75% of chum production is known to occur from salmon enhancement programs (Nelson et al. 2008) The 2007 chum salmon returns were considerably lower than forecasts of 15.7 million for the region as a whole with hatchery returns much lower than expected (Nelson et al. 2008). Reasons for low marine survivals were not well known (Nelson et al. 2008). Wild salmon escapements were lower than average. The weighted rank index of peak survey estimates of 82 streams in Southeast Alaska was 70 % of the 10-year average (Nelson et al. 2008).

In Prince William Sound, threshold escapement goals have been established for chum salmon in 5 districts (Clark et al. 2006). For Cook Inlet, 12 sustainable escapement goals for chum salmon exist for rivers in Lower Cook Inlet and one sustainable escapement goal exists in Upper Cook Inlet. The largest stock of chum salmon in lower Cook Inlet spawns in the McNeil River with an SEG of 13,750-25,750 (Clark et al. 2006) In the time period 1984-2004, this goals was met in 15 of the 21 years (Clark et al. 2006). Nine of the 11 other Lower Cook Inlet chum salmon stocks have exceeded escapement goals 87% of the 10-year time period (1995-2004) (Clark et al. 2006).

In Upper Cook Inlet (UCI) assessments of annual chum salmon runs are made difficult because of the lack of data other than commercial harvest figures. Indications from the OTF project, the commercial fishery, and the few escapement programs where chum salmon are encountered would in general support the characterization that the 2000–2004 runs were much improved from those realized during the 1990s (Shields 2007). Aerial census counts of chum salmon in Chinitna Bay revealed an escapement estimate of nearly 23,000 fish in 2000, which is the largest aerial census estimate ever recorded for this area (Shields 2007). The 2002 escapement counts of chum salmon at the Little Susitna River, Willow Creek, and Wasilla Creek weirs were the highest counts ever observed for these systems, while the 2001 chum salmon escapement in the Little Susitna River was the second largest ever observed (Shields 2007). Assessing the 2005–2007 runs of chum salmon in UCI, however, was difficult (Shields 2007). For example, although the commercial harvest of chum salmon during these 3 years was the lowest observed during the past 40 years, the 2005 OTF cumulative chum salmon CPUE of 300 was only about 35% less than the 1988–2004 average cumulative CPUE of 464, while the 2006 OTF cumulative chum salmon CPUE of 632 was the 6th highest in the past 19 years (Shields 2007). In addition, the 2006–2007 peak aerial census estimates of chum salmon escapement in streams draining into Chinitna Bay showed 11,000 and 12,100 fish, respectively, which led to Chinitna Bay being opened to drift gillnetting for regular Monday and Thursday fishing periods during both years to harvest excess chum salmon (Shields 2007). Chum salmon are no longer enumerated at any weir sites in UCI, but they are encountered and enumerated at the Yentna River sockeye salmon sonar project. However, it must be pointed out that this is a sockeye salmon project and therefore chum salmon enumeration estimates must be viewed only as rough trends (Shields 2007). Although information is limited, the past 3 years of chum salmon returns may have been less than average, but there are no obvious concerns for UCI chum salmon stocks at this time (Shields 2007).

In Lower Cook Inlet (LCI), after a seven-year string of relatively strong returns, chum salmon were a disappointment in the 2007 LCI commercial salmon season (Hammarstrom and Ford 2008). The chum salmon harvest of less than 1,800 fish was the lowest catch on record for the species in LCI. For the first time in many seasons, several areas of Kamishak Bay District on the west side of LCI were closed to commercial fishing in order to protect chum salmon for escapement purposes (Hammarstrom and Ford 2008).. Escapements into most Kamishak Bay chum systems were sufficient to achieve goals, with the exception of McNeil River, where the escapement fell short of its established goal range for the thirteenth time in the last 18 years (but only by 200 fish). Elsewhere in the management area, Outer District chum salmon returns were considered weak, and no directed openings were allowed (Hammarstrom and Ford 2008).

In the Southeast-Yakutat area, the stock assessment program for chum salmon is less developed than regional programs for other salmon species (Clark et al. 2006). Escapements are assessed through aerial and foot surveys but are limited in their utility due to the fact that most counts are obtained opportunistically during surveys to monitor pink salmon escapement complicating the ability to enumerate chum amidst the numbers of pink salmon, as well as the act that there is currently no means to adjust survey counts for boas among observers (Clark et al. 2006). The region's total harvest of wild chum salmon is estimated but detailed stock-specific information is not available for many stocks (Clark et al. 2006). Trends in overall escapement and harvest of wild chum stocks however appear to be increasing in the Southeast Alaska region (Clark et al. 2006).

6.3 Impact analysis methods

As with the pollock and Chinook analysis, chum bycatch levels were tabulated on a fleetwide basis given estimated closure dates for the years 2003–2007. These dates are replicated here in Table 6-13 for Alternative 2. The corresponding levels of chum that were observed during the remaining period was computed and provides a coarse means to evaluate the level of potential reduction in chum bycatch that might have occurred had hard caps been in place. Given that Chinook bycatch rates are often highest later in the B-season, we provide some analysis showing the possible impact of chum salmon bycatch if the historical (2003-2007) fishery had concentrated fishing on the earlier part of the season. This was accomplished by computing the chum salmon bycatch rate (chum per 1,000 t of pollock) for the period of concentration. For this hypothetical scenario, we presume that the effort is concentrated such that all the pollock were taken at shorter season lengths (60%, 70%, 80% and 90%). To arrive at hypothetical chum salmon bycatch levels for these cases, the mean rates were computed at these season lengths and multiplied by the pollock that was caught after these dates. This effectively concentrates the pollock into the shorter season-length (and assumes that it is feasible to do so). This is for evaluation purposes and is unlikely to be strictly applicable in any year. This method provides flexibility to gain appreciation of the impact potential Chinook salmon bycatch regulations may have on the bycatch of chum salmon.

Changes in fleet-specific B-season closure dates change by alternatives (Table 6-13, Table 6-15,

Table 6-16). The relative impact of each alternative is evaluated in terms of the overall anticipated reduced season lengths in order to evaluate possible impacts on chum salmon bycatch.

For triggered closures (Alternative 3), spatial bycatch rates of chum/ t of pollock were estimated outside of closure area to examine the extent that bycatch rates may increase under proposed Chinook salmon trigger closure areas. As with the Chinook analyses, we assume that the pollock *could* be taken outside the area. For a more detailed presentation on the pollock catch rates outside of the area, please refer to Chapter 4. The analysis of chum bycatch within and outside of the Chinook trigger closure area serves as a reasonable proxy for how the industry may redistribute effort to avoid reaching hard caps.

The chum bycatch rates were computed two different ways:

1) as a mean rate from a given date forward to the end of the year. This is the sum the year's chum numbers from that day forward to the end of the year divided by the sum of the pollock caught from that day forward.
2) as a 10-day moving average rate centered on particular dates. This is simply the 10-day sum of chum numbers divided by the analogous 10-day sum of pollock

The rate from 1) provides a way to compare how chum bycatch might change under triggered closures whereas the values from 2) provide a clearer picture of how within-season bycatch rates change. This latter value may provide insight on tendencies for the pollock fleet to fish earlier in the season in order to avoid Chinook bycatch.

6.4 Non-Chinook Salmon Bycatch in the Bering Sea Pollock Fishery under Alternative 1

6.4.1 Bycatch Management

The Chum Salmon Savings Area closures are triggered by separate non-CDQ and CDQ chum caps. This area is closed to directed fishing for pollock from August 1 through August 31. Additionally, if 42,000[47] "other" salmon are caught in the Catcher Vessel Operational Area (CVOA) during the period August 15-October 14, the Chum Salmon Savings Area remains closed to directed fishing for pollock for the remainder of the period September 1 through October 14. As catcher processors are prohibited from fishing in the CVOA during the "B" season, unless they are participating in a CDQ fishery, only catcher vessels and CDQ fisheries are affected by the chum salmon PSC limit. Under Amendment 84, pollock vessels that participate in the VRHS ICA are exempted from the area closures.

[47] This number includes the allocation of 4,494 non-Chinook salmon to the CDQ Program. The remaining 37,506 non-Chinook salmon are allocated as a prohibited species catch limit to the non-CDQ pollock fisheries.

6.4.2 Overview of non-Chinook bycatch

For catch accounting and PSC limits 4 species of salmon (Sockeye, Coho, Pink and Chum) are aggregated into an 'other salmon' or non-Chinook salmon species category. Chum salmon comprises over 99.6% of the total catch in this category (Table 6-11).

The majority of non-Chinook bycatch occurs in the pollock trawl fishery. Historically, the contribution of non-Chinook bycatch from the pollock trawl fishery has ranged from a low of 88% of all bycatch to a high of >99.5% in 1993. Since 2002 bycatch of non-Chinook salmon in the pollock fishery has comprised over 95% of the total. Historical bycatch of non-Chinook salmon in the pollock fishery from 1991-2007 is shown in Fig. 6-4 and Table 6-12.

Total catch of non-Chinook salmon in the pollock fishery reached an historic high in 2005 at 705,963 fish (Table 6-12; Fig. 6-4). Bycatch of non-Chinook salmon in this fishery occurs almost exclusively in the B season. Bycatch since 2005 has declined substantially, with the 2007 total of 94,072.

Bycatch rates for chum salmon (chum salmon/ t of pollock) from 1991-2007 are shown in Fig. 6-5. There is substantial interannual variability in the distribution of chum bycatch prompting a range of historical management actions for time and area closures (NPFMC 1995, NPFMC 2006). Currently the Chum Salmon Savings Area as shown in Fig. 6-5 is invoked in the month of August annually and when triggered, closes again in September and October, however the fleet is exempt from these closures under regulations for Amendment 84.

Table 6-11 Composition of bycatch by species in the non-Chinook salmon category from 2001-2007

Year	sockeye	coho	pink	chum	Total	% chum
2001	12	173	9	51,001	51,195	99.6%
2002	2	80	43	66,244	66,369	99.8%
2003	29	24	72	138,772	138,897	99.9%
2004	13	139	107	352,780	353,039	99.9%
2005	11	28	134	505,801	505,974	100.0%
2006	11	34	235	221,965	222,245	99.9%
2007	3	139	39	75,249	75,430	99.8%

*source NMFS catch accounting, extrapolated from sampled hauls only

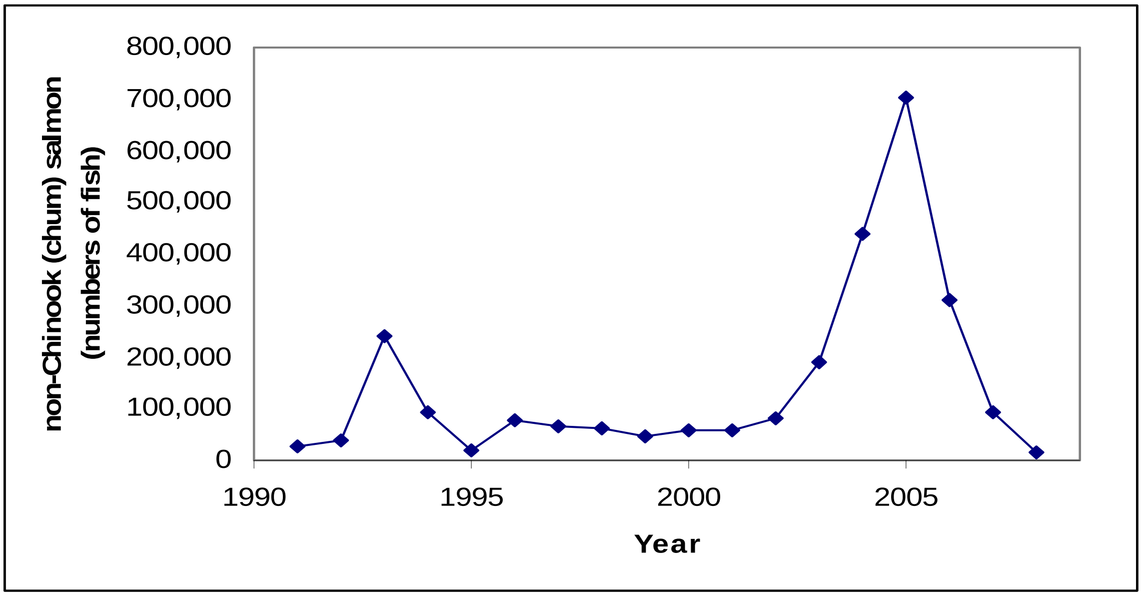

Fig. 6-4 Non-Chinook salmon bycatch in the EBS pollock trawl fishery 1991-2008. Note 1991-1993 values do not include CDQ

Table 6-12 Non-Chinook salmon catch (numbers of fish) in the BSAI pollock trawl fishery (all sectors) 1991-2008, CDQ is indicated separately and by season where available. Data retrieval from 3/19/09. ‘na’ indicates that data were not available in that year

Year	Annual with CDQ	Annual without CDQ	Annual CDQ only	A season With CDQ	B season With CDQ	A season Without CDQ	B season Without CDQ	A season CDQ only	B season CDQ only
1991	Na	28,951	na	na	na	2,850	26,101	na	na
1992	na	40,274	na	na	na	1,951	38,324	na	na
1993	na	242,191	na	na	na	1,594	240,597	na	na
1994	92,672	81,508	11,165	3,991	88,681	3,682	77,825	309	10,856
1995	19,264	18,678	585	1,708	17,556	1,578	17,100	130	456
1996	77,236	74,977	2,259	222	77,014	177	74,800	45	2,214
1997	65,988	61,759	4,229	2,083	63,904	1,991	59,767	92	4,137
1998	64,042	63,127	915	4,002	60,040	3,914	59,213	88	827
1999	45,172	44,610	562	362	44,810	349	44,261	13	549
2000	58,571	56,867	1,704	213	58,358	148	56,719	65	1,639
2001	57,007	53,904	3,103	2,386	54,621	2,213	51,691	173	2,930
2002	80,782	77,178	3,604	1,377	70,404	1,356	75,821	21	3,583
2003	189,184	180,782	8,404	3,834	185,350	3,597	177,185	237	8,165
2004	440,472	430,284	10,188	422	440,050	395	429,889	27	10,161
2005	704,590	696,880	7,710	595	703,995	563	696,317	32	7,678
2006	309,643	308,429	1,214	1,332	308,311	1,266	307,163	66	1,148
2007	93,660	87,191	6,469	8,523	85,137	7,368	79,823	1,155	5,314
2008	15,423	14,992	431	320	15,103	247	14,745	73	358

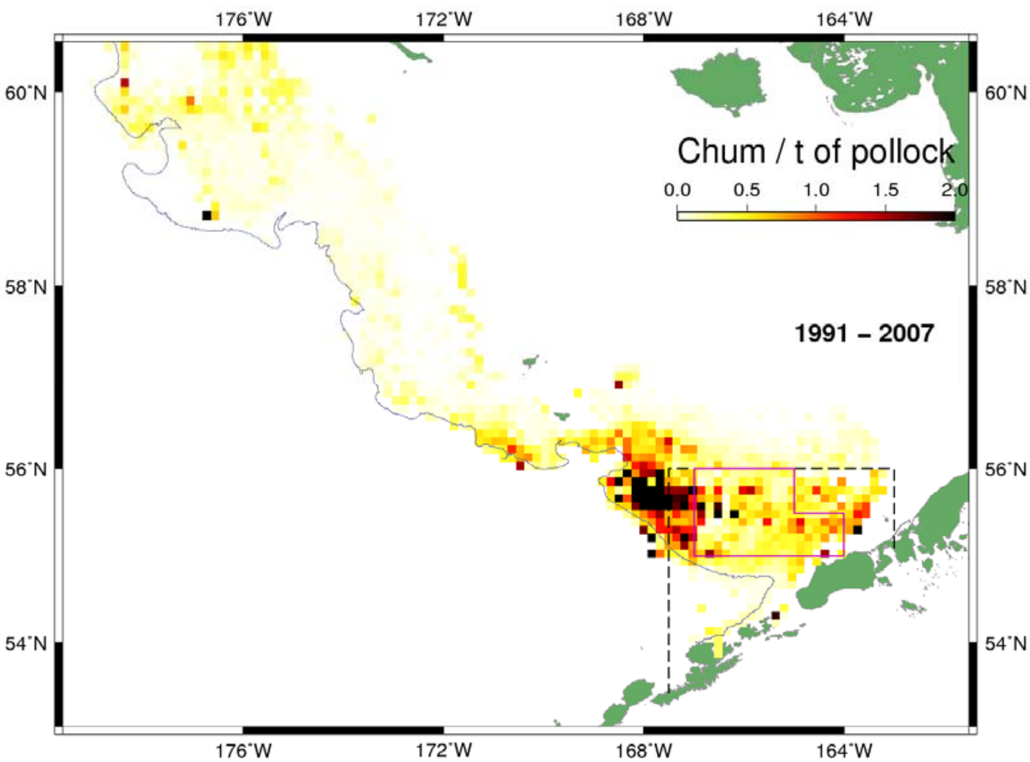

Fig. 6-5 Historical chum B-season bycatch rates 1991-2007. Note the Chum Salmon Savings Area closure (solid line) and the Catcher Vessel Operational Area (dotted line)

6.4.3 Bycatch stock of origin overview

A study conducted by NMFS evaluated bycatch samples of chum salmon from the 1994-1995 pollock trawl fishery in the Eastern Bering Sea and employed genetic stock identification methodology to evaluate the stock composition of these bycaught fish (Wilmot et al. 1998). Results from this study indicated that in 1994 between 39% and 55% of samples were of Asian origin, 20%–35% were western Alaskan stocks, and 21%–29% were from the combined Southeasten Alaska, British Columbia and Washington stocks. (Wilmot et al. 1998). The 1995 samples indicated a range of 13%–51% Asian, 33%–53% western Alaska, and 9%–46% Southeastern Alaska, British Columbia or Washington stocks (Wilmot et al. 1998). Estimates for immature versus maturing fish differed with both years indicating that a higher contribution of maturing fish originated from BC than the relative contribution from the immature fish (Wilmot et al. 1998). Differences in relative stock composition also varied temporally throughout the B season and by region (Wilmot et al. 1998). Additional work is currently underway at the NMFS Auke Bay Laboratory to evaluate more recent chum bycatch samples from the pollock fishery for stock composition estimates.

Additional studies of research trawl caught fish in the Bering Sea have looked at the origin and distribution of chum salmon (Urawa et al. 2004; Moongeun et al. 2004). Genetic stock identification with allozyme variation was used to determine the stock origin of chum salmon caught by a trawl research vessel operating in the central Bering Sea from late August to mid September 2002 (Urawa et al. 2004). Results indicated that the estimated stock composition for maturing chum salmon was 70% Japanese, 10% Russian and 20% North American stocks, while immature fish were estimated as 54% Japanese, 33% Russian, and 13% North American (Urawa et al. 2004). Stock composition of North American fish was identified for Northwest Alaska, Yukon, Alaskan Peninsula/Kodiak, Susitna River, Prince William Sound, Southeast Alaska/Northern British Columbia and Southern British

Columbia/Washington State. Of these the majority of mature chum salmon for North America stocks came from Southern BC/Washington State and Alaska Peninsula/Kodiak (Urawa et al. 2004). For immature chum salmon, the largest contribution for North American stocks came from Southeast Alaska/Northern BC, followed by Alaska Peninsula/Kodiak and Southern BC/Washington State.

6.5 Impacts of Alternatives 2, 3, 4, and 5

Results using hypothetical past closure dates reduced the chum salmon bycatch by small fractions or not at all (Table 6-14). This result suggests that, had the fleet stopped fishing on those dates, then relative savings to chum salmon would be minimal. This is due to the fact that during these years, most of the chum bycatch occurred earlier in the season (Table 6-6). Under the most constraining Chinook management measure, the savings to chum salmon total ranged from a 5% to 34% reduction in chum bycatch, depending on the year (Table 6-14). For Alternative 4 (annual scenarios 1 and 2, assuming 70:30 A-B season Chinook allocation and 80% rollover with sector transferability), and Alternative 5 (annual scenario 1) the sector date closures are generally later than those for many of the options under Alternative 2 (Table 6-15, Table 6-16). Consequently, the chum salmon bycatch reductions will be lower. For this phase of analysis then, assuming re-allocations in space and time will not occur, then the impact of Chinook management measures on chum salmon bycatch generally are anticipated to be lower. However, scenarios where these spatial and temporal assumptions are removed were also examined.

For the spatial component, the original “triggered closure area” evaluation provides a means to understand the potential impact of Chinook salmon bycatch measures. For example, the pattern of chum bycatch within and outside of the Chinook triggered closure area shows that on average, the bycatch rate is about 4-fold higher inside the closure area than outside (Table 6-7). Therefore, any regulation or industry-activity that displaces fishing inside of the closure area is likely to reduce chum salmon bycatch levels.

For temporal patterns, one can imagine that fishermen are likely to confront Chinook hard cap scenarios with a variety of strategies to minimize their interference with pollock fishing. One option at their disposal is to try to fish earlier in the B-season when Chinook bycatch rates tend to be lower. This possible action was evaluated by concentrating pollock that was caught after a specified date into the earlier period and compute the chum salmon bycatch increase given the rates for that period. There are peak periods near the beginning of the B-season where chum bycatch rates peak, particularly within the trigger closure area (Table 6-8). For the entire region, if “planned season length” dates had concentrated to the earlier period, then in some years the chum bycatch increased slightly (Table 6-17). However, based on these speculative actions—that fishermen would concentrate effort earlier in the season—the average impact due to that factor is minimal. On the whole, it appears that the Chinook management measures for the alternatives are likely to slightly reduce chum salmon bycatch in the EBS pollock fishery.

Stock specific impacts of Chinook caps and triggered closures are uncertain. Since it appears under these scenarios, the level of chum bycatch decreases, then the benefits to source river systems and hatcheries would be improved returns. In Section 6.4.3, estimates of the proportions of bycatch indicate that the largest source of chum bycatch originates in Asian and that up to 35% originated from western Alaska stocks.

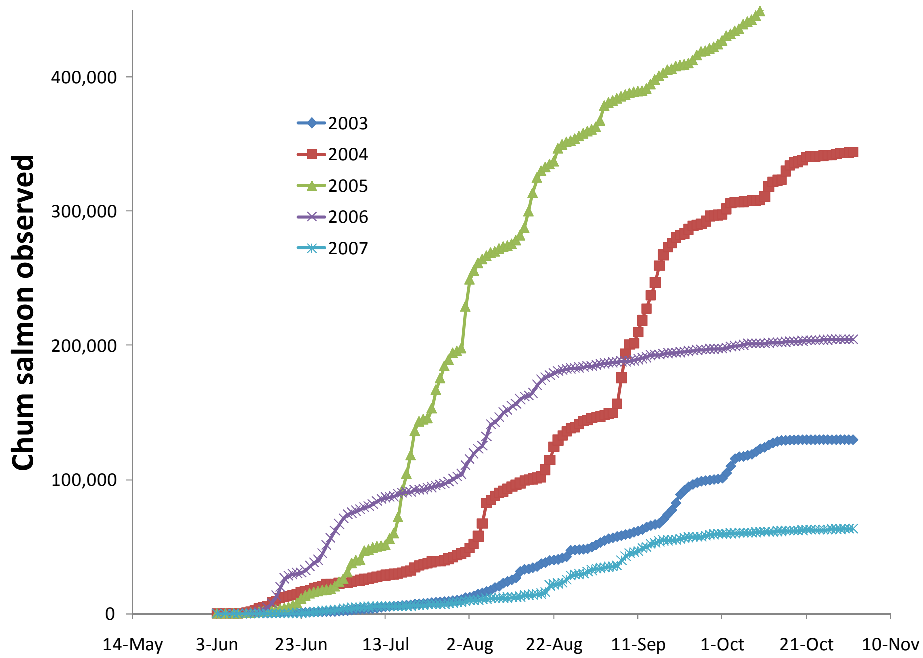

Fig. 6-6 Observed cumulative bycatch of chum salmon during the B-season, 2003-2007

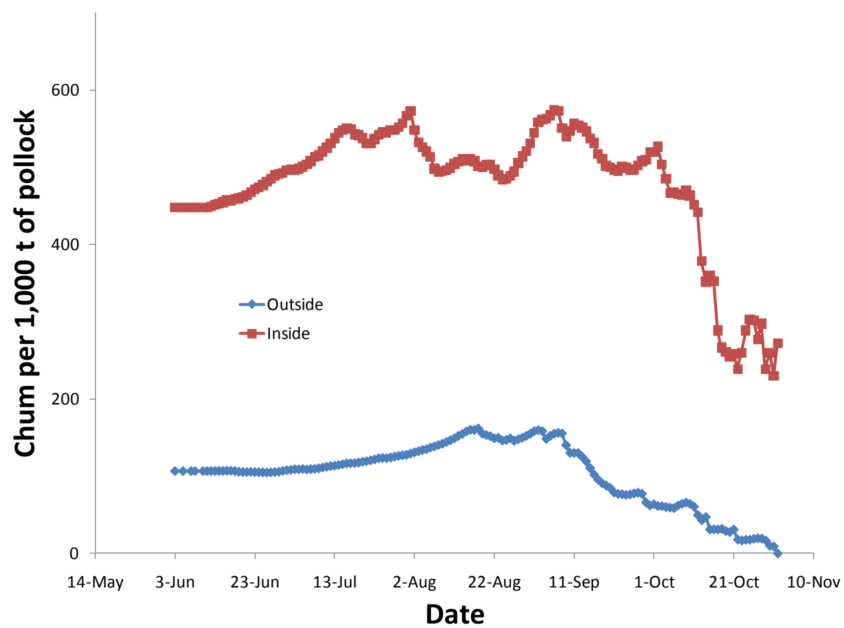

Fig. 6-7 Mean 2003-2007 chum bycatch rate (chum salmon per 1,000 t of pollock) inside and outside of Chinook salmon trigger closure area by date. Note that the numerator (chum numbers) were based solely on observer data whereas the pollock in the denominator was from the entire fleet. The chum rate on a given date represents the mean rate from that date till the end of the year.

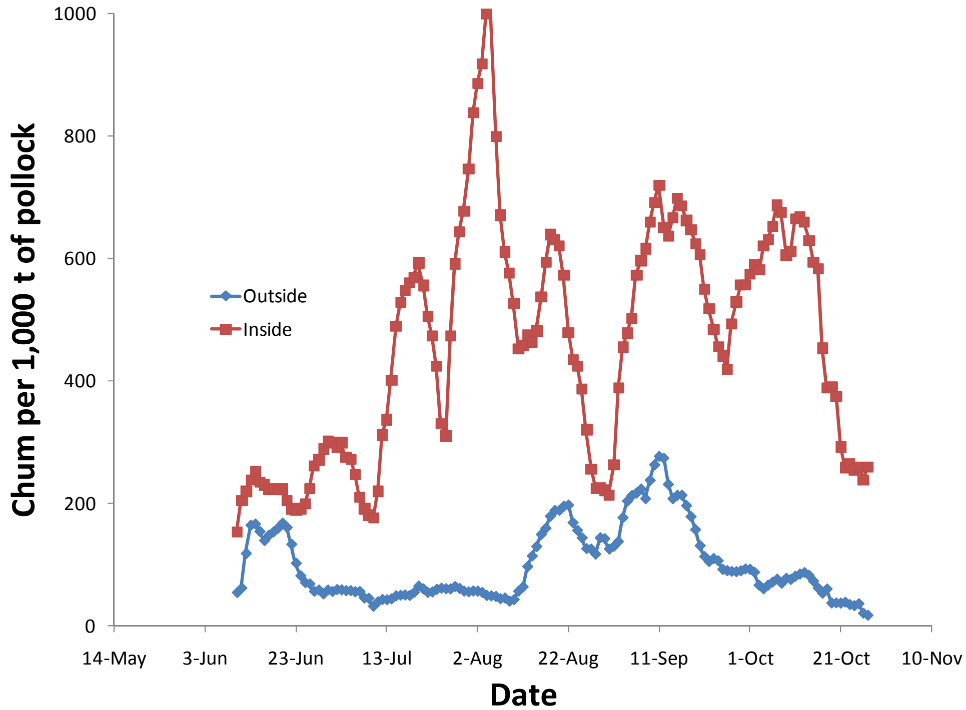

Fig. 6-8 Mean 2003-2007 chum bycatch rate (chum salmon per 1,000 t of pollock) inside and outside of Chinook salmon trigger closure area by date. Note that the numerator (chum numbers) were based solely on observer data whereas the pollock in the denominator was from the entire fleet. The chum rate on a given date represents the 10-day moving average.

Table 6-13 Hypothetical B-season closure dates under the scenarios by year, indicating when the cap level would have been exceeded in each year.

Cap scenario		CAP	2003	2004	2005	2006	2007
87,500	1-1: 70/30	26,250		25-Oct	13-Oct		13-Oct
	1-2: 58/42	36,750			30-Oct		26-Oct
	1-3: 55/45	39,375					28-Oct
	1-4: 50/50	43,750					31-Oct
68,100	1-1: 70/30	20,430		12-Oct	7-Oct	22-Oct	9-Oct
	1-2: 58/42	28,602		30-Oct	19-Oct		16-Oct
	1-3: 55/45	30,645			25-Oct		18-Oct
	1-4: 50/50	34,050			28-Oct		23-Oct
48,700	1-1: 70/30	14,610		2-Oct	1-Oct	12-Oct	30-Sep
	1-2: 58/42	20,454		12-Oct	7-Oct	22-Oct	9-Oct
	1-3: 55/45	21,915		14-Oct	9-Oct	26-Oct	10-Oct
	1-4: 50/50	24,350		20-Oct	11-Oct		11-Oct
29,300	1-1: 70/30	8,790	8-Oct	14-Sep	10-Sep	21-Sep	16-Sep
	1-2: 58/42	12,306	14-Oct	27-Sep	24-Sep	3-Oct	23-Sep
	1-3: 55/45	13,185		1-Oct	26-Sep	5-Oct	27-Sep
	1-4: 50/50	14,650		2-Oct	1-Oct	12-Oct	30-Sep

Table 6-14 Expected chum catch remaining by **all vessels** if B-season trigger-closure was invoked.

Chum bycatch remaining Cap scenario		**CAP**	**2003**	**2004**	**2005**	**2006**	**2007**
87,500	1-1: 70/30	26,250		1%	4%		3%
	1-2: 58/42	36,750			0%		1%
	1-3: 55/45	39,375					1%
	1-4: 50/50	43,750					0%
68,100	1-1: 70/30	20,430		10%	7%	0%	4%
	1-2: 58/42	28,602		0%	2%		3%
	1-3: 55/45	30,645			2%		2%
	1-4: 50/50	34,050			1%		1%
48,700	1-1: 70/30	14,610		14%	11%	1%	6%
	1-2: 58/42	20,454		10%	7%	0%	4%
	1-3: 55/45	21,915		6%	7%	0%	4%
	1-4: 50/50	24,350		2%	5%		4%
29,300	1-1: 70/30	8,790	9%	34%	18%	5%	16%
	1-2: 58/42	12,306	2%	16%	13%	3%	11%
	1-3: 55/45	13,185		14%	12%	2%	9%
	1-4: 50/50	14,650		14%	11%	1%	6%

Table 6-15 Sector-specific closure date scenarios for B-seasons by year reflecting when the cap level would have been exceeded in each year under the two annual scenarios in alternative 4 with A-B split equal to 70:30, 80% rollover from A to B season , and between sector transferability, 2003-2007.

Alt 4			B-Season			
AS	Year	Sector:	CDQ	M	P	S
1	2003		--	--	--	--
	2004		--	--	--	--
	2005		--	--	--	29-Oct
	2006		--	--	--	22-Oct
	2007		15-Oct	25-Oct	10-Oct	7-Oct
2	2003		--	16-Oct	--	--
	2004		--	--	--	11-Oct
	2005		--	--	25-Sep	5-Oct
	2006		--	--	--	10-Oct
	2007		7-Oct	17-Oct	29-Sep	26-Sep

Table 6-16 Sector-specific closure date scenarios for B-seasons by year reflecting when the cap level would have been exceeded in each year under Alternative 5 with A-B split equal to 70:30, 100% rollover from A to B season, and between sector transferability, 2003-2007.

Alt 5			B-Season			
AS	Year	Sector:	CDQ	M	P	S
1	2003		---	---	---	---
	2004		---	---	---	---
	2005		---	---	---	26-Oct
	2006		---	---	---	19-Oct
	2007		8-Oct	21-Oct	6-Oct	5-Oct

Table 6-17 Expected chum catch from **all vessels** if the B-season fishery had shortened their season and pooled effort into the period prior to the date in first column (set to roughly 60%, 70%, 80%, and 90% of the original season length).

Planned season completion date	2003	2004	2005	2006	2007
2-Sep	69,776	195,775	453,466	259,783	40,868
17-Sep	79,683	300,133	450,281	242,697	62,657
2-Oct	109,808	313,399	449,780	221,067	65,894
17-Oct	130,144	337,304	469,481	210,763	65,016
Actual Completion date Nov 1	129,788	343,981	474,636	204,705	63,308

6.6 Consideration of future actions

CEQ regulations require that the analysis of environmental consequences include a discussion of the action's impacts in the context of all other activities (human and natural) that are occurring in the affected environment and impacting the resources being affected by the proposed action and alternatives. This cumulative impact discussion should include incremental impacts of the action when added to past, present, and reasonably foreseeable future actions. Past and present actions affecting the chum salmon resource have been incorporated into the impacts discussion above. Section 3.4 provides a detailed discussion of reasonably foreseeable future actions that may affect the Bering Sea pollock fishery, the salmon caught as bycatch in that fishery, and the impacts of salmon bycatch on other resource components analyzed in the EIS.

6.6.1 Ecosystem-sensitive management

Measures to minimize chum salmon bycatch

The Council is considering action on management measure to minimize chum salmon bycatch in the Bering Sea pollock fishery. A suite of alternative management measures was proposed in April 2008, and a discussion paper was presented to the Council in October 2008. In December 2008, the Council developed a range of alternatives for analysis. Because any revised chum salmon bycatch measures will also regulate the pollock fishery, there will be a synergistic interaction between the alternatives proposed in this EIS and those considered under the chum salmon action. Analysis has not yet begun on the chum salmon action, but will be underway before this EIS is finalized, and a further discussion of the impact interactions will be included at that time. As with new chum salmon measures, analysis of any new management measures for the pollock fleet would consider the impacts of adding those new measures to the existing suite of management measure for the pollock fleet and analyzing those impacts on non-target species, such as chum salmon.

Changes to fishery management based on ongoing research and understanding of ecosystem interactions and the effects of climate change

Many efforts are underway to assess the relationship between oceanographic conditions, ocean mortality of salmon and their maturation timing to their respective rivers of origin for spawning (see Section 5.1). It is unclear whether the observed changes in salmon bycatch in recent years is due to fluctuations in salmon abundance, or whether there is a greater degree of co-occurrence between salmon and pollock stocks as a result of changing oceanographic conditions. Pollock distribution has been shown to be affected by bottom temperatures, with densities occurring in areas where the bottom temperatures are greater than zero (Ianelli et al. 2008). Specific ocean temperature preferences for salmon species are poorly understood. Regime shifts and consequent changes in climate patterns in the North Pacific ocean has been shown to correspond with changes in salmon production (Mantua et al 1997). Archival tags affixed to Asian chum salmon indicate that behavior and migration in juvenile, immature, and maturing fish are linked to temperature gradients (Friedland et al. 2001) and that immature chum exhibit a tendency to remain above the thermocline along the continental shelf (Azumaya et al. 2006). Anecdotal information suggests that Chinook and chum salmon prefer different (warmer) ocean water temperatures than adult pollock. A study linking temperature and salmon bycatch rates is underway and preliminary evidence indicates a relationship, even when factoring for month and area (Ianelli et al. 2009).

Compelling evidence from studies of changes in Bering Sea and Arctic climate, ocean conditions, sea ice cover, and permafrost and vegetation indicate that the area is experiencing warming trends in ocean temperatures and major declines in seasonal sea ice (IPCC, 2007; ACIA, 2005). Some evidence exists for a contraction of ocean habitats for salmon species under global warming scenarios (Welch et al. 1998). Studies in the Pacific northwest have found that juvenile survival is reduced when in-stream temperatures increase (Marine and Cech 2004, Crozier and Zabel 2006). A correlation between sea surface temperature and juvenile salmon survival rates in their early marine life has also been proposed (Mueter et al. 2002). The variability of salmon responses to climate changes is highly variable at small spatial scales, and among individual populations (Schindler et al 2008). This diversity among salmon populations means that the uncertainty in predicting biological responses of salmon to climate change remains large, and the specific impacts of changing climate on salmon cannot be assessed.

6.6.2 Traditional management tools

Development of the salmon excluder device

The development and deployment of the salmon excluder device may reduce chum salmon bycatch. The salmon excluder is still being tested in pollock fisheries, and is not yet in wide-scale use, however many of the early design flaws have been corrected at this stage.

6.6.3 Actions by Other Federal, State, and International Agencies

State salmon fishery management

ADF&G is responsible for managing commercial, subsistence, sport, and personal use salmon fisheries. The first priority for management is to meet spawning escapement goals to sustain salmon resources for future generations. Highest priority use is for subsistence under both State and Federal law. Surplus fish beyond escapement needs and subsistence use are made available for other uses. The BOF adopts regulations through a public process to conserve fisheries resources and to allocate fisheries resources to the various users. Subsistence fisheries management includes coordination with U.S. Federal government agencies where federal rules apply under ANILCA. Subsistence salmon fisheries are an important culturally and greatly contribute to local economies. Commercial fisheries are also an important contributor to many local communities as well as supporting the subsistence lifestyle. While specific aspects of salmon fishery management continue to be modified, it is reasonably foreseeable that the current State management of the salmon fisheries will continue into the future.

Future exploration and development of offshore mineral resources

The Minerals Management Service (MMS) expects that reasonably foreseeable future activities include development of oil and gas deposits over the next 15-20 years in federal waters off Alaska. Potential environmental risks from the development of offshore drilling include the impacts of increased vessel offshore oil spills, drilling discharges, offshore construction activities, and seismic surveys. The MMS has published a notice of intent to prepare an Environmental Impact Statement for oil and gas lease Sale 214 which is tentatively scheduled for 2011 in the “program area” of North Aleutian Basin, offshore the State of Alaska. Many of the western Alaska salmon migration corridors pass through the program area identified by MMS, and adverse environmental impacts resulting from exploration and development in the future could impact salmon stocks. The extent to which these impacts may occur is unknown.

Hatchery releases of salmon

The continued release of salmon fry into the ocean by domestic and foreign hatcheries is also expected to continue at similar levels. Hatchery production increases the numbers of salmon in the ocean beyond what is produced by the natural system, however some studies have suggested that efforts to increase salmon populations with hatcheries may have an impact on the body size of Pacific salmon (Holt et al 2008).

6.6.4 Private actions

Commercial pollock and salmon fishing (domestic and foreign), subsistence and sport fisheries for Chinook salmon

The reasonable foreseeable future actions that will most impact chum salmon stocks are the continuation of the management of the directed commercial, subsistence, and sport fisheries for chum salmon and changes to the management of the Bering Sea pollock fishery. The analysis of direct effects assumes that these activities will continue at similar levels into the future.

Future exploration and development of onshore mineral resources

Salmon stocks may also be affected by onshore mining activities, to the extent that pollutants or contaminants from those operations may affect salmon spawning streams. Some instances of mining operations in southwestern Alaska are discussed in Section 3.4.

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