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Beluga, *Delphinapterus leucas*, Harvest in Cook Inlet, Alaska, 1987 to 2022

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National Marine Fisheries Service
Alaska Fisheries Science Center

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K. E. W. Shelden¹, B. A. Mahoney², G. O'Corry-Crowe³,
R. T. Stanek⁴, and K. J. Frost⁵

¹Marine Mammal Laboratory
Alaska Fisheries Science Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
7600 Sand Point Way NE
Seattle, WA 98115

⁴Alaska Department of Fish and Game (retired),
3623 Lynn Drive
Anchorage, AK 99508

²Protected Resources Division,
Alaska Regional Office, NMFS, NOAA,
222 W 7th Avenue
Anchorage, AK 99513

⁵Alaska Department of Fish and Game (retired)
73-4388 Pa'iaha Street
Kailua Kona, HI 96740

³Harbor Branch Oceanographic Institute,
Florida Atlantic University
5600 N U.S. Highway 1
Fort Pierce, FL 34946

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ABSTRACT

The Cook Inlet beluga (CIBs, *Delphinapterus leucas*) population was designated as a depleted stock under the Marine Mammal Protection Act (MMPA) in 2000, and subsequently listed under the Endangered Species Act (ESA) in 2008. To assess the role that the Alaska Native harvest played in the CIB population decline, we need to examine the harvest level in relation to the decline in the decades prior to these regulatory actions. The Cook Inlet Beluga Whale Recovery Plan (NMFS 2016) suggested the decline from 1,300 to 650 belugas between 1979 and 1994 could be explained by assuming similar harvest efforts as documented in the late 1990s, but it had very limited harvest information for that period. The rate of decline, ~6% per year for 1979-1991, compared with a decline of ~16% per year from 1991 to 1994 (from 1,000 to 650 whales), suggests increased harvest effort after 1990. Newspaper articles featuring subsistence hunters and research teams in 1994 likely increased hunting interest as well. Following a harvest moratorium in 1999, a limited harvest quota (1-2 whales/year) occurred from 2000 to 2006. Adoption of harvest criteria to calculate strike limits when the previous 5-year average abundance is below 350 whales resulted in no harvest allocation from 2008 to 2022.

Determining the magnitude of the beluga harvest during the population decline has been difficult because it was not possible to interview all hunters to obtain an accurate account of the whales landed or struck and lost. Although MMPA harvest reporting regulations enacted in 1994 improved monitoring and data collection, hunter participation is crucial to obtaining accurate take numbers. Here we review all existing data sources, including some that were not included in the Recovery Plan, to reevaluate harvest of beluga whales in Cook Inlet. Our reanalysis of reported landed and struck and lost CIBs during the 1980s and 1990s indicates that annual harvests were substantially larger than totals presented in the Recovery Plan and occurred both before and during the well-documented decline in the late 1990s. A review of genetics databases and Alaska Native Organization (ANO) reports add new data on the sex composition of harvests, and correct errors in the previously reported number of female and male belugas landed by hunters.

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INTRODUCTION

Hunting belugas, *Delphinapterus leucas*, in Cook Inlet, Alaska, has occurred since prehistoric times with harvests by Native villages, trappers, homesteaders, sportsmen, and commercial operations (Stanek 1994, Mahoney and Shelden 2000). In 1972, the Marine Mammal Protection Act (MMPA) prohibited hunting of marine mammals within the United States while exempting Alaska Natives to take marine mammals for subsistence purposes (section 101(b)). Little if any subsistence hunting occurred in Cook Inlet during the 1970s (Fall et al. 1984, Mahoney and Shelden 2000).

In 1979, the Cook Inlet beluga (CIB) population was estimated to number ~1,300 whales (Calkins 1989, Shelden et al. 2015). During the early 1980s, ~5 belugas per year were reported as harvested or entangled incidental to commercial salmon fishing (Fall et al. 1984, Burns and Seaman 1986, Mahoney and Shelden 2000). Harvest reporting through a series of interviews with hunters from 1987 to 1993 documented an increase in the number of CIB hunters (Stanek 1994). By 1991, the population was estimated at ~1,000 CIBs (Shelden and Mahoney 2016, Shelden et al. 2015). By 1994, it was estimated to number ~650 whales (Hobbs et al. 2015), a decline of about 16% per year. Since 1994, the National Marine Fisheries Service (NMFS) conducted systematic surveys of CIB, and from 1994 to 1998, CIB abundance declined by about 14% per year (~650 to ~350 whales: Hobbs et al. 2015). The only source of documented mortality during that time, other than beach-cast strandings (Moore et al. 2000), was harvest by Alaska Natives (Mahoney and Shelden 2000).

In 1999, hunters voluntarily suspended the harvest and agreed to a hunting moratorium. NMFS designated the CIB stock as depleted under the MMPA and proposed harvest regulations in 2000 (Mahoney and Shelden 2000). Although harvests were limited to 1-2 whales per year, CIBs continued to decline to ~240 whales by 2004 and were listed as a Species of Concern under the Endangered Species Act (ESA) (NMFS 2004a), and subsequently listed as Endangered under the ESA in 2008 (NOAA 2008a).

Determining the magnitude of the CIB harvest was difficult because it was not possible to interview all hunters to obtain an accurate account of whales landed or struck and lost (e.g., Stanek 1994; Huntington 2000; CIMMC 1995a, b; 1996; 1997), which we discuss in detail below. The recovery plan for CIBs (NMFS 2016; hereafter referred to as the Plan), summarized harvest data for 1987-2006. The Plan noted that under-reporting likely occurred, in particular during the 1980s and early 1990s, as some hunters recalled harvest levels were similar during those early years to harvests in the mid- to late 1990s. Amendments to the MMPA in 1994 that allowed for cooperative agreements (MMPA section 119) and requiring harvest reporting (P.L. 103-238) improved harvest monitoring and data collection (Mahoney and Shelden 2000). Using a wide range of data sources, some not previously reported, this review improves estimates of harvest numbers, notes specific instances where under-reporting likely occurred from 1987 to 1998, and updates data on age/sex composition of landed whales. We also discuss harvest regulations adopted after the moratorium in 1999 and coincidental with the ESA listing decision in 2008. As of 2022, these harvest regulations are still in effect.

METHODS

Our starting point was Figure 14 of the Plan (NMFS 2016), which summarized the number of whales landed (male, female, unknown sex) and whales struck and lost from 1987 to 2006. To corroborate or add to these data, we reviewed the following data sources:

- Tables 1 and 2 in Mahoney and Shelden (2000).
- Table 2 in Stanek (1994).
- Cook Inlet Marine Mammal Council (CIMMC 1995a, b; 1996; 1997) reports.
- Alaska and Inuvialuit Beluga Whale Committee (ABWC after 1994) meeting minutes and reports (AIBWC 1992, 1993, 1994; ABWC 1995, 1996, 1997, 1998, 1999).
- A notebook from a CIB hunter documenting the 1997 harvest.
- Interviews with CIB whaling captains/crews following the 1998 harvest.

- Alaska Fisheries Science Center (AFSC) Marine Mammal Stock Assessment Reports (SARs): Small and DeMaster (1995); Hill et al. (1997); Hill and DeMaster (1998, 1999); Ferrero et al. (2000a); Angliss et al. (2001); Angliss and Lodge (2002); Allen and Angliss (2015).
- Beluga sex/age composition from 1992 to 2015 (Vos et al. 2020).
- The genetics archives maintained by the Southwest Fisheries Science Center (SWFSC, NMFS), and Florida Atlantic University (FAU).

Some data sources contained conflicting information. We identify where numbers of whales landed, struck and lost, and males/females differed among sources. Based on our review, we provide updated summaries for both categories of data.

RESULTS

Revised Harvest for 1987 to 1998

Stanek (1994) interviewed CIB hunters from the Municipality of Anchorage, and Matanuska-Susitna and Kenai Peninsula boroughs (Fig. 1) during the period 1987-1993. Although 33 different hunting households were identified during the course of that study, the number of households that responded to surveys often fell well below that number (4-16 households), and below the number of households known to have hunted during a particular year (8-19 households).

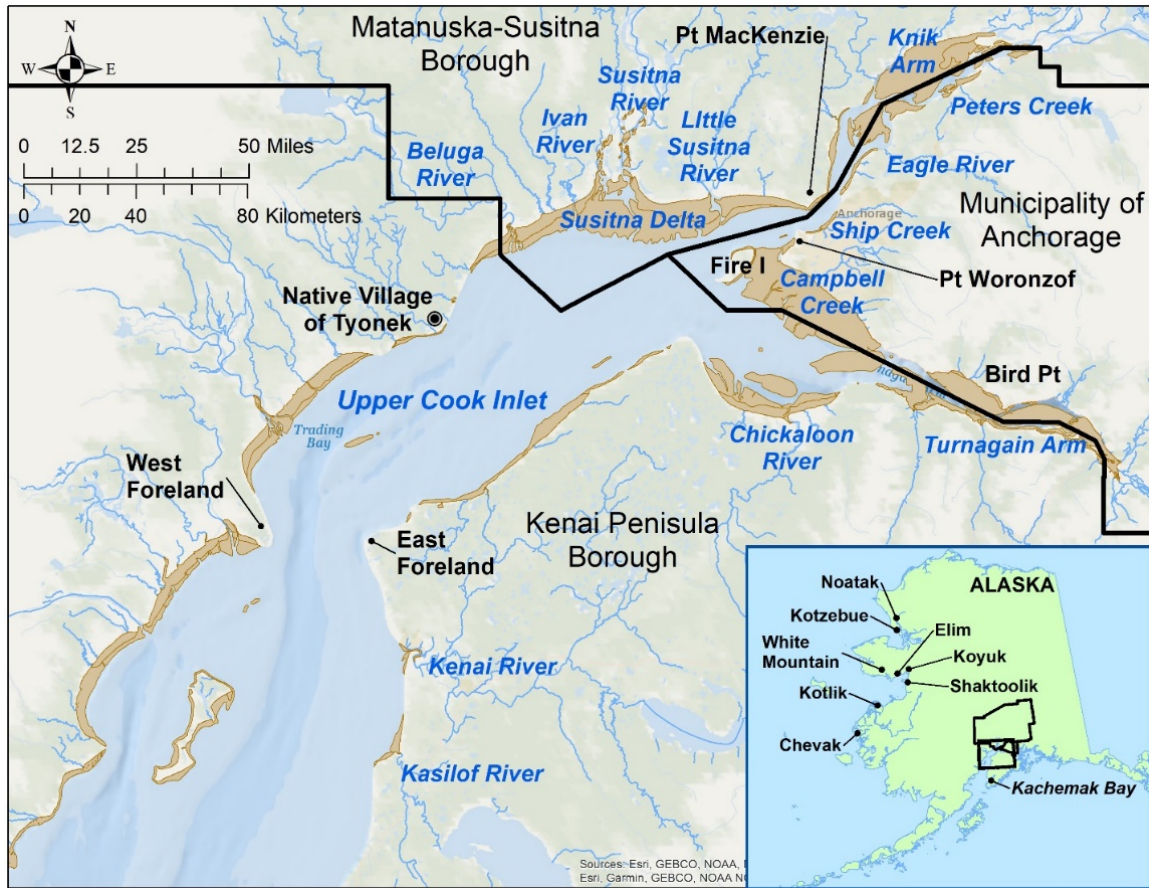


Figure 1. --Map of upper Cook Inlet with place names mentioned in the text.

Stanek (1994) noted that unlike villages where all hunters are known within the community, Cook Inlet beluga hunters included residents within villages and cities along the shores of Cook Inlet and non-locals from communities that usually hunted other beluga stocks. A hunting household could include more than one hunter and hunters from multiple households would share resources by forming hunting groups. According to some beluga hunters, visitors from Kotzebue and other non-local communities came to Cook Inlet and participated in hunts organized by local hunters. Some participated annually, others occasionally, while other visitors only hunted one or two times. Stanek (1994) concluded that possibly a third of the total harvest was not reported because of unknown hunters (both local and non-local). Overall, households within and outside Cook Inlet actively participating in beluga hunts ranged from 35 to 50 households prior to 1994 (Appendix).

We therefore estimate a higher harvest than was reported for all years prior to 1999 for the following reasons:

- Few households (an average of 8 out of a possible 33 households) responded to interview requests during 1987-1993 (Stanek 1994).
- Another 2-17 households did not receive an interview request during 1987-1993.
- There were some reports of harvests by non-local hunters during the 1980s and 1990s.
- Harvest information was collected from 12 to 25 local hunters interviewed by NMFS and CIMMC during 1995-1998.

For the period 1987-1998, we provide a detailed summary of harvest numbers for each year (Appendix). Overall, our review of the data sets increased the number of CIBs taken in the subsistence hunt for all years prior to 1999 (Table 1, Fig. 2). In part, this is because some sources (e.g., Mahoney and Shelden 2000, the Plan) reported only the actual number of whales landed or lost for 1987-1993 from Stanek (1994) in a table and figure, respectively. Mahoney and Shelden (2000) noted these were “minimal estimates” but did not include the Stanek (1994) extrapolation to households known to have hunted CIBs who had not responded to interviews (Appendix). These totals also did not include the one-third multiplier for whales taken by hunters visiting Cook Inlet from other regions of Alaska and unknown local hunters (Appendix). However, Mahoney and Shelden (2000) did cite the extrapolated estimate from 1993 that was reported in the SARs. Stanek (1994) also calculated an average harvest for 1987-1993. For 1991, we used the calculated average rather than reporting no data were collected (Table 1, Fig. 2), and then applied the one-third multiplier. In a few cases, review of the genetics databases and CIMMC reports revealed errors in the reported number of female and male belugas landed by hunters (Tables 1, 2; Fig. 2).

Table 1. -- Number of belugas from Cook Inlet, Alaska, landed and struck and lost (S/L) during subsistence hunts from 1987 to 1998. O = number originally reported in the Plan (NMFS 2016), R = revised numbers (see Appendix for details, all decimals rounded up to a whole number), ND = no data reported.

Year	O/R	Number of belugas			S/L	Total
		Landed				
		Unk. sex	Female	Male		
1987	O	8	ND	ND	1	9
	R	33	ND	ND	5	38
1988	O	12	ND	ND	3	15
	R	30	ND	ND	8	38
1989	O	11	ND	ND	2	13
	R	20	ND	1	4	25
1990	O	7	ND	ND	2	9
	R	24	ND	ND	7	31
1991	O	ND	ND	ND	ND	ND
	R	26	ND	ND	6	32
1992	O	11	ND	ND	1	12
	R	21	ND	ND	3	24
1993	O	13	ND	ND	4	17
	R	19	1	4	8	32
1994	O	16	2	1	2	21
	R	30	5	4	5	44
1995	O	28	7	9	26	70
	R	38	11	14	39	102
1996	O	42	4	3	74	123
	R	65	6	3	74	148
1997	O	32	2	1	35	70
	R	49	1	3	53	106
1998	O	17	5	3	25	50
	R	43	5	10	38	96
Total	O	197	20	17	175	409
	R	397	30	39	250	716

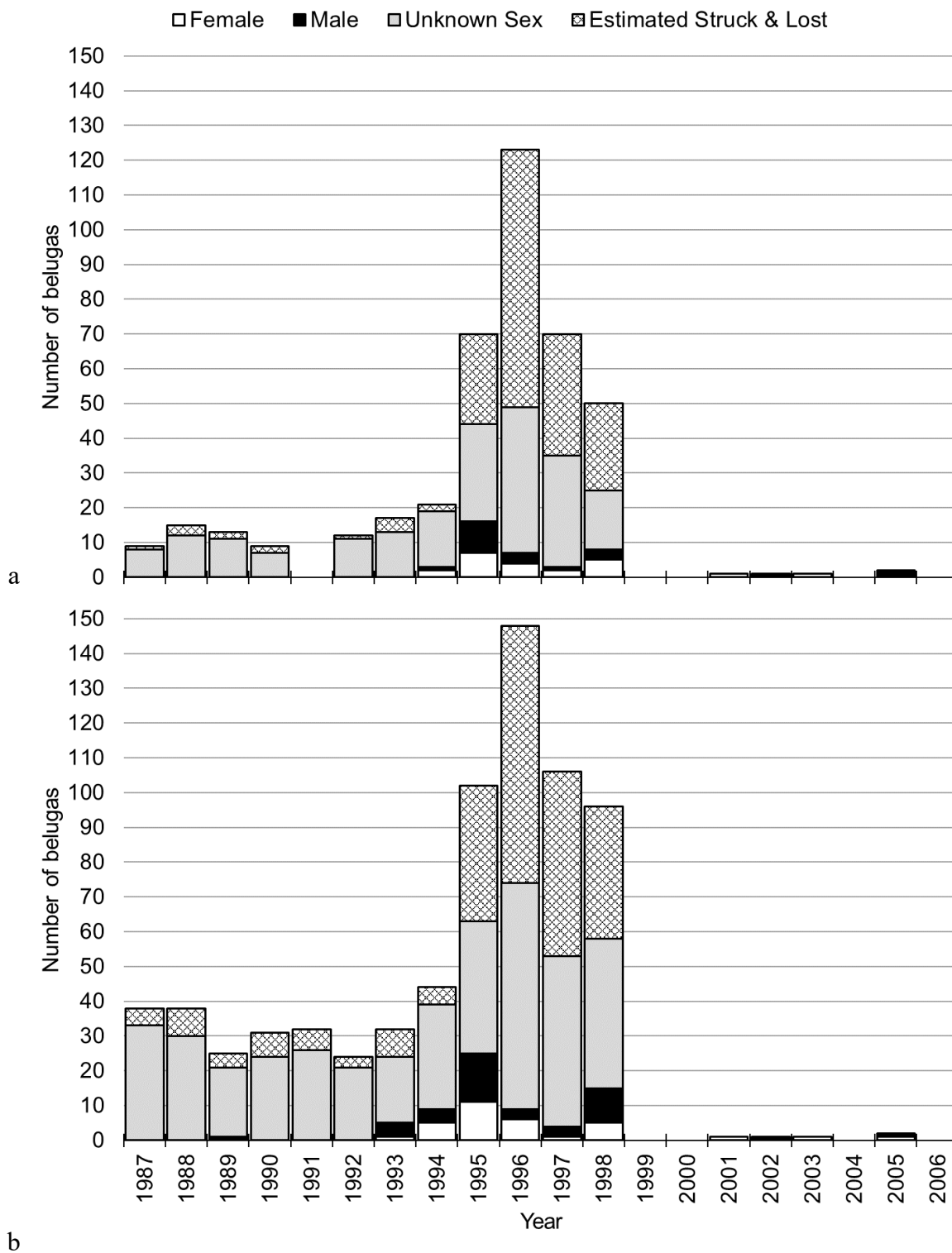


Figure 2. -- Cook Inlet beluga harvest totals for the years 1987-2006 based on (a) numbers originally reported in the Plan (NMFS 2016) and (b) revised numbers as presented in Table 1 (1987-1998) and in the text (2005).

Table 2. -- Cook Inlet belugas landed by hunters, 1989-2006, from which date, location, vital statistics and/or samples were collected. ND = no data reported; and n/a = not available, no samples obtained. Sex = male (M), female (F), or unidentified (U). Skin color = white (W), gray-white (GW), and gray (G). * = based on age at length and sex data from Vos et al. (2020). Age = one growth layer group (GLG) per year as counted in sectioned beluga teeth (Vos et al. 2020).

Year	Mo.	Day	Sex	Skin color	Length (cm)	Age (GLG)	Sampling location	Source
1989	5	3	M	ND	~435	>17*	ND	1
1992	6	2	n/a	ND	ND	n/a	Little Susitna River	2
1992	6	4	n/a	ND	ND	n/a	Susitna River, SE Big Island	2,3
1992	8	28	U	W	ND	23	Susitna River, Big Island	1,2,3,4
1993	5	25	F	ND	ND	n/a	Susitna River	1,2
1993	5	ND	M	ND	ND	n/a	Susitna River	1
1993	6	11	M	W	ND	22	Beluga River	1,2,4,5
1993	6	30	M	W	358	33	Little Susitna River	2,3,4
1993	7	1	M	ND	~381	>12*	Beluga River	2,3
1994	5	30	M	ND	~366	>8*	Susitna River	1
1994	6	5	F	ND	348	>16*	~2 mi. N. Campbell Creek	1
1994	7	19	F	ND	274	>6*	Susitna River	1
1994	7	19	F	ND	305	>10*	Susitna River	1
1994	7	22	F	ND	~305	>10*	Susitna River, Big Island	1,2,3
1994	7	23	M	ND	472	>20*	Susitna River, Big Island	1,2,3
1994	7	23	F	ND	~305	>10*	Susitna River, Big Island	1,2,3
1994	8	8	M	W	~335	>8*	Susitna River, Big Island	2
1994	8	19	U	ND	ND	16	Ivan River	1,2,4
1994	9	21	M	ND	~396	>12*	Little Susitna River	1
1994	10	12	M	ND	478	>20*	Kasilof River, Kalifornsky	1
1995	4	20	F	G	240	2	Kachemak Bay	1,2,3,4
1995	5	3	M	ND	409	23	Susitna River mouth	1,2,3,4
1995	5	9	F	GW	360	19	Susitna River, Big Island	1,2,3,4
1995	6	1	F	W	353	23	Susitna River, Big Island	1,2,3,4
1995	6	5	F	W	368	28	Susitna River, E. fork	1,2,3,4
1995	6	5	M	G	143	0 - fetus	Susitna River, E. fork	2,3,4
1995	6	19	M	W	422	25	Susitna River mouth	1,2,3,4
1995	6	27	M	W	377	18	Beluga River mouth	1,2,3,4
1995	6	28	M	ND	391	17	Beluga River mouth	1,2,3,4
1995	6	29	M	ND	~427	>14*	Susitna River	1
1995	8	11	M	W	413	>14*	Susitna River, Big Island	1,2,3
1995	9	13	F	W	~244	>4*	Eagle River	1,2,3
1995	9	22	M	ND	455	18	Pt. Woronzof	1,2,3,4
1995	10	13	F	GW	<~305	<10*	Chickaloon River	1,2,3
1995	10	13	M	W	>305	>7*	Chickaloon River	1,2,3
1995	4-10	~11	females/14 males landed by CIMMC hunters (likely includes all listed above)					6
1996	6	18	F	W	367	23	Susitna River, Big Island	1,2,3,4
1996	7	13	U	ND	ND	9	2 mi. W Susitna River	1,2,4
1996	7	15	F	W	356	22	Susitna River mouth	1,2,3,4
1996	7	29	F	W	359	29	Susitna River, Big Island	1,2,3,4
1996	8	1	F	ND	~366	18	1 km S. Susitna River	1,2,3,4
1996	8	29	F	W	377	22	Pt. MacKenzie	1,2,3,4
1996	10	7	M	W	429	28	Chickaloon River	1,2,3,4
1996	10	7	M	W	367	14	Chickaloon River	1,2,3,4
1996	10	10	M	W	415	>14*	Chickaloon River	1,2,3
1996	10	24	F	ND	~364	16	S. of Ship Creek	1,2,4
1997	4	23	F	W	ND	n/a	Susitna River	6
1997	4	26	n/a	W	ND	n/a	Susitna River	6
1997	4	27	n/a	W	ND	n/a	Susitna River	6
1997	5	3	n/a	W	ND	n/a	Susitna River	6

Year	Mo.	Day	Sex	Skin color	Length (cm)	Age (GLG)	Sampling location	Source
1997	5	4	n/a	G	ND	n/a	Susitna River	6
1997	5	5	n/a	ND	ND	n/a	Susitna River	6
1997	5	5	n/a	ND	ND	n/a	Susitna River	6
1997	5	5	n/a	ND	ND	n/a	Susitna River	6
1997	5	5	n/a	ND	ND	n/a	Susitna River	6
1997	5	9	n/a	W	ND	n/a	Susitna River	6
1997	5	22	n/a	ND	ND	n/a	Little Susitna River	6
1997	5	22	n/a	ND	ND	n/a	Susitna River	6
1997	5	24	n/a	ND	ND	n/a	Susitna River	6
1997	5	27	n/a	W	ND	n/a	Susitna River	6
1997	5	27	M	ND	450	19	Susitna River, Delta Island	1,2,3,4
1997	6	3	n/a	W	ND	n/a	Susitna River	6
1997	6	4	n/a	W	ND	n/a	Susitna River	6
1997	6	15	n/a	W	ND	n/a	Eagle River	6
1997	6	18	n/a	ND	ND	n/a	Susitna River	6
1997	6	18	n/a	ND	ND	n/a	Susitna River	6
1997	6	26	M	ND	~420	19	Ship Creek	1,2,3,4
1997	6	28	n/a	ND	ND	n/a	Susitna River	6
1997	7	19	n/a	ND	ND	n/a	Susitna River	6
1997	7	24	n/a	W	ND	n/a	Ivan River	6
1997	8	1	n/a	ND	ND	n/a	Susitna River	6
1997	8	2	n/a	G	ND	n/a	Susitna River	6
1997	8	25	n/a	G	ND	n/a	Knik Arm	6
1997	8	25	M	ND	315	8	Eagle River	1,2,3,4
1997	8	26	n/a	W	ND	n/a	Knik Arm	6
1997	9	6	n/a	W	ND	n/a	Knik Arm	6
1997	9	23	n/a	W	ND	n/a	Knik Arm	6
1997	9	28	n/a	W	ND	n/a	Peter's Creek	6
1997	10	11	n/a	ND	ND	n/a	Knik Arm	6
1998	4	22	F	W	320	22	Susitna River, Big Island	1,2,3,4
1998	4	22	F	G	126	0 - fetus	Susitna River, Big Island	1,2,3,4
1998	5	13	F	W	~320	26	Susitna River, Big Island	1,2,3,4
1998	5	13	M	W	450	25	Susitna River, Big Island	1,2,3,4
1998	5	16	M	ND	421	20	Susitna River, Delta Island	1,2,3,4
1998	6	15	F	W	350	20	Susitna River, Big Island	1,2,3,4
1998	6	16	n/a	ND	ND	n/a	Susitna River, Big Island	
1998	8	11	M	ND	~360	10	Fire Island	1,2,3,4
1998	8	11	M	ND	~360	11	Fire Island	1,2,3,4
1998	10	1	F	ND	ND	17	Chickaloon River	1,2,3,4
1998	5-10	~3 females/10 males landed by CIMMC hunters, ~2 females/all males are shown above						6
1999	No hunt. Salvaged muktuk from two dead stranded male belugas at Bird Flats/Point							1,2,4
2000	Quota for one whale, unsuccessful hunt by NVT							3
2001	7	21	F	GW	345	16	Susitna River	1,2,4
2002	7	22	M	ND	457	>18*	Susitna River	1,2
2003	8	4	F	W	365	20	Ivan River	1,2,4
2003	8	4	U	G	23	0 - fetus	Ivan River	1,2,4
2004	No subsistence hunt due to high number of strandings in 2003							
2005	7	24	M	W	439	30	Susitna River, Big Island	1,2,4
2005	8	7	F	W	366	29	Susitna River	1,2,4,7
2006	No hunt. Salvaged muktuk from a dead stranded female beluga in Turnagain Arm							1,2,4

¹ Genetics databases maintained by the Southwest Fisheries Science Center, NOAA (SWFSC) and/or Harbor Branch Oceanographic Institute, Florida Atlantic University (FAU).

² Sample collection forms kept by the Anchorage Regional Office, NMFS, NOAA.

³ Mahoney and Shelden (2000).

⁴ Burek-Huntington et al. (2015), Vos et al. (2020), and/or Shelden et al. (2020a, b).

⁵ Two teeth were assigned to this whale, one with 22 GLGs the other with 11 GLGs and a prenatal line (Vos et al. 2020). Assumed 22 years old but without a length could not determine true age until an epigenetic clock (Bors et al. 2021) was developed that confirmed age was likely 22 (within +/- 2 years).

⁶ See Appendix (logbook kept by a Cook Inlet whaling captain and CIMMC representative).

⁷ Sex reported as male in NMFS (2016:Fig. 14) but genetics databases listed sex as female.

Our review of the Southwest Fisheries Science Center (SWFSC) and Florida Atlantic University (FAU) genetics databases, and CIMMC reports, including logbooks and interviews, increased the number of known sex whales landed in the hunt during 1987-2006 from 22 females and 20 males to 32 females and 41 males (Fig. 2b), not including fetuses of known sex. We assumed these whales were previously included as unknown sex and, therefore, reduced the total count of unknown whales for those years rather than adding to the landed totals. For some whales, the hunters provided biological samples (teeth, skin) and/or information on the dates and locations of their hunts (Table 2).

It is evident that reporting the number of landed and lost whales and collecting vital statistics improved substantially with the founding of an Alaska Native Organization (ANO), the CIMMC, in 1994 (Tables 1, 2; Fig. 2). The MMPA, as amended in 1994, required that NMFS document human take of marine mammals (P.L. 103-238); and under section 119, to allow ANOs to enter into cooperative agreements with NMFS to co-manage subsistence resources. Section 119 allowed NMFS to fund ANOs to support these co-management efforts. CIMMC provided detailed, written reports to NMFS in 1995 and 1996 (Appendix). During the 1995 hunting season alone, the total reported number of landed whales was about three times that reported in the early 1990s (Fig. 2).

Of note, the harvest that year likely would have been much more had some hunters not participated in NMFS research efforts instead. From 18 July to 6 August 1995, NMFS scientists conducted a radio-tagging study in collaboration with local beluga hunters (Lerczak et al. 2000). According to the CIMMC (1996) report:

"This is usually one of the most productive periods for subsistence beluga hunters in the upper inlet. NMML [National Marine Mammal Laboratory] researchers camped at the Native whale hunting camp, at the mouth of the Big Susitna River, where the beluga congregate during this time of the year. The boats, time, and energies of some of the most prolific Native whale hunters were occupied for a month by participation in this research. Other hunters did not hunt or hunted in less productive areas during this time to avoid disturbing the research. This almost certainly reduced the number of beluga which were taken during this report period."

No boat-based scientific research occurred in 1996. The increase in CIBs landed and lost during the 1996 hunting season may be due to hunters having access to areas restricted by research activities the previous year. In 1997, CIB hunters (two captains and one crew member) spent the month of June collaborating with scientists on a CIB capture and satellite-tagging project (Ferrero et al. 2000b), thereby, missing part of their preferred hunting season. Although participation in the project may explain why landed and lost numbers were similar to 1995 (Table 1, Fig. 2), no hunter interviews were conducted by CIMMC that year (Appendix).

In 1997, the CIMMC formally withdrew from the ABWC but representatives attended the meetings to provide updates on CIB harvests. The CIMMC no longer submitted written reports to NMFS or the ABWC. For 1997 and 1998, NMFS collected CIB harvest totals from meeting minutes, interviews, unconfirmed reports, and a CIMMC captain's logbook (Appendix).

Although updated, harvest numbers for 1987-1994 are still roughly half that reported in 1995-1998 (Fig. 2). The 1987-1994 struck and lost rate is also much lower and likely underestimated, given some hunters stated harvest effort was similar to 1995-1998 (NMFS 2016). Struck and lost rate would also vary depending on skill of the hunter, familiarity with hunting in Cook Inlet, and would not always result in the death of the whale. It is also possible that hunting pressure increased following publication of four front-page articles in the *Anchorage Daily News* (Hulen 1994a, b, c, d) in June and August of 1994, one of which featured local hunters during a successful hunt (Fig. 3). Overall, our review suggests harvest increased substantially after the 1980s (Fig. 4), that total harvest from 1987 to 1993 was, and may still be, underestimated, and that the 1994 amendments to the MMPA improved monitoring and data collection.

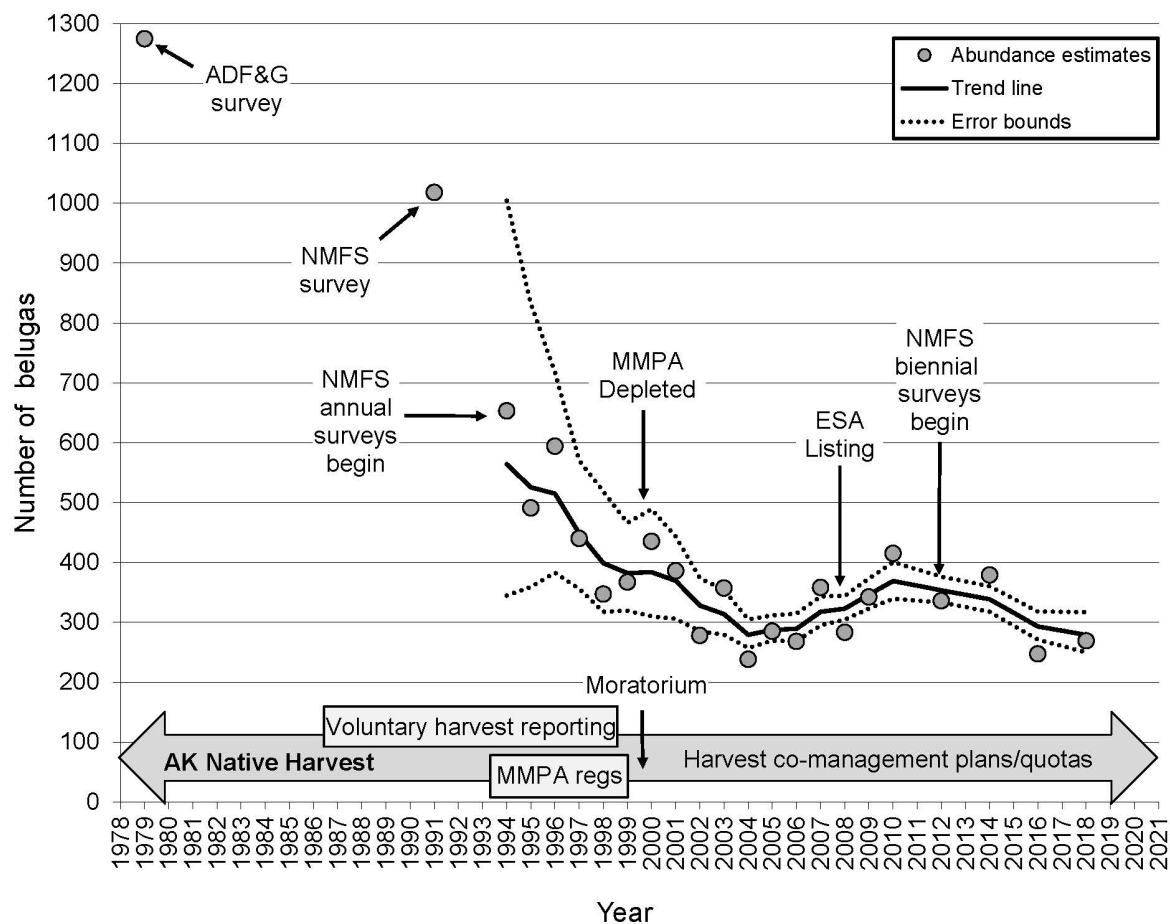


Figure 4. -- Cook Inlet beluga abundance estimates and trend with harvest, aerial survey, and population status timeline.

Hunting Moratorium and Quotas from 1999 to 2008

In 1999, beluga hunters voluntarily agreed to cease hunting in Cook Inlet after NMFS reported a steep decline in population abundance (Hobbs et al. 2000) and received a petition to list CIBs as endangered under the ESA. Two hunters assisted NMFS with a CIB capture and satellite-tagging project that took place in late May – early June 1999 during which two whales were captured and one was instrumented with a tag (Ferrero et al. 2000b). It was during 1999 that harvest reporting regulations and amendments to the MMPA were put in place (NMFS 1999a, b; P.L. 106-31 § 3022). At the ABWC meeting in November 1999, NMFS representatives reported that although subsistence hunting of CIBs did not occur, a live stranding of about 60 belugas resulted in the deaths of five whales

(ABWC 1999). NMFS was able to perform necropsies on four whales, and hunters salvaged the muktuk from two of these (Table 2).

As noted in Mahoney and Shelden (2000), the MMPA allows the sale of edible parts from marine mammals within Native villages and towns in Alaska (16 U.S.C. 1371 § 101 (b)(2)). In 1995, concerns had been expressed at the ABWC annual meeting about the sale of CIB muktuk at markets, regional offices, and corporations located in Anchorage (ABWC 1995). Similar concerns were again expressed at the ABWC meeting in December 1996, noting that letters were written to the Alaska Federation of Natives, Alaska Native hospital, and NANA corporate offices to discourage the sale of muktuk (ABWC 1996). When NMFS designated CIBs as depleted under the MMPA in 2000 (NMFS 2000a, Fig. 4), the sale of CIB muktuk was prohibited.

In 1998, the ABWC Executive Committee sent copies of newspaper articles about declining Cook Inlet belugas to the ABWC delegates and the IRA Councils in beluga hunting villages. There was also a letter from the ABWC Chairman explaining the seriousness of this matter and asking these communities to stop or restrict their hunting of CIBs. The ABWC distributed a draft resolution asking beluga-hunting villages to support efforts of the ABWC and the CIMMC to promote a co-management process for Cook Inlet belugas, to encourage the hunters to stop or reduce their harvest of Cook Inlet belugas, and to support CIMMC enforcement activities under the co-management process. The following villages located in western Alaska (Fig. 1 inset) submitted their resolutions at or shortly following the 1998 ABWC meeting: Chevak, Elim, Kotlik, Koyuk, Noatak, Shaktoolik, and White Mountain. Muktuk purchased in the market in Anchorage in 1998 was matched to DNA from two CIBs, one harvested in June 1995 and the other in May 1998 (Table 2). NMFS representatives did not know the source of muktuk for sale in Anchorage in 1999 (ABWC 1999).

In July 2000, NMFS prepared an Environmental Assessment (NMFS 2000c) and entered into a co-management agreement with the CIMMC that allowed the Native Village of Tyonek one strike during a hunting season limited to the month of July. A strike was defined in the co-management agreement as any incident during which any type of a device intended to take a whale (bullet, harpoon, spear, etc.) makes bodily contact. If additional strikes were necessary to land the struck whale these did not count toward the total allotment. Delaying the hunt until July would reduce the likelihood of killing pregnant

female belugas as most calving was thought to occur from mid-May to mid-July (Huntington 2000). The killing of calves or adults accompanied by calves was prohibited. Hunting could only occur within the Susitna River delta where the majority of whales aggregated, to reduce impacts on “smaller family groups” in other areas of the upper inlet. Hunters did not take a whale during the 2000 hunting season (Table 2, Fig. 2). As part of the co-management agreement, NMFS responsibilities included consulting with the CIMMC and including personnel in the collection of research data. In September 2000, beluga hunters assisted with a satellite-tagging project during which three whales were captured and two belugas were instrumented with tags (Shelden et al. 2018).

In October 2000, NMFS proposed rules governing the taking of CIBs for subsistence purposes (NMFS 2000b). A public hearing before an Administrative Law Judge (ALJ) took place in December 2000 when it was agreed that six strikes would be allocated during the interim, 2001-2004 (NMFS 2003a). Four strikes, not to exceed one per year, went to the Native Village of Tyonek, with the remaining two strikes for hunters from the Anchorage community of Alaska Native Cook Inlet marine mammal hunters (2003 and 2005). By 15 March 2004, NMFS was to provide a long-term harvest plan for 2005 and beyond. However, before regulations could be finalized to implement such a plan, NMFS needed to prepare and finalize an Environmental Impact Statement (EIS) subject to the requirements of the National Environmental Policy Act (NEPA).

In 2001, a single strike was allocated to the Native Village of Tyonek. Per the co-management agreement (NMFS 2003b), all hunting was to occur within 10 miles of the mouth of the Susitna River and in water shallow enough to see a visible wake from the whale as it was being pursued. To reduce losses and/or multiple strikes/takes, the whale had to be harpooned with a line and float prior to shooting to ensure that, if it sank, it could be retrieved. Hunting could not occur until after 1 July. On 21 July, hunters landed a lactating female beluga (Table 2, Fig. 2), from which NMFS collected samples. Skin samples sent to the SWFSC verified this was a female. From 10 to 20 August, two hunters from the Native Village of Tyonek assisted NMFS scientists with the capture of 11 CIBs of which seven were instrumented with satellite tags (two adults with calves were released untagged) (Shelden et al. 2018).

In 2002, one strike was allocated to the Native Village of Tyonek and one strike to the Anchorage community of Alaska Native Cook Inlet marine mammal hunters. The co-management agreement (NMFS 2003c) allowed subsistence hunting to commence on 13 July. Unlike in 2001, the hunting season was not limited to a one-month period. The Native Village of Tyonek allowed the Anchorage hunters to conduct the first hunt, with NMFS and NOAA Enforcement providing oversight (NOAA 2002). Hunters landed a male beluga south of Big Island in the Susitna River delta on 22 July and NMFS collected samples (Table 2, Fig. 2). After assisting NMFS with satellite-tagging belugas from 29 July to 5 August (Shelden et al. 2018), the Native Village of Tyonek attempted several hunts but was unsuccessful due to bad weather and encountering groups of belugas with calves.

In July 2003, NMFS completed a final EIS presenting seven alternative scenarios for future subsistence hunts in Cook Inlet (NMFS 2003d). The preferred alternative, originally recommended by the ALJ in 2000, allowed six strikes during the interim, 2001-2004, with no more than two strikes per year, and no more than three total strikes in two consecutive calendar years. Given the requirement that no more than three strikes occur within a two-year period, only the Native Village of Tyonek could hunt in 2003. On 4 August, hunters landed a pregnant female beluga (Shelden et al. 2020a, b) near the Ivan River in the Susitna River delta (Table 2, Fig. 2).

Due to an unusually high number of stranding mortalities ($n = 20$ whales) in 2003 (Vos and Shelden 2005), the subsistence hunt was suspended for 2004 (NMFS 2004b). This decision was based upon an emergency provision agreed to by NMFS and the parties to the court hearing in December 2000. When there were 18 or more stranded dead whales within a year (not including harvest), hunting halted until the next summer/season. In April 2004, interim regulations on subsistence hunting were finalized by NMFS and a hearing by the ALJ was set for August (NMFS 2008).

The co-management agreement between NMFS and the CIMMC for 2005 (NMFS 2005) allowed for two strikes, one of which was allocated to the Native Village of Tyonek. Hunting was permitted to begin on 1 July. On 24 July, hunters from the Native Village of Tyonek landed a male beluga near Big Island in the Susitna River (Table 2, Fig. 2). NMFS personnel were present and able to necropsy the whale. It was not until Anchorage Community hunters returned to Anchorage that NMFS received a report of their 7 August

hunt. Hunters had collected a skin sample and described the whale as a white adult, 366 cm in length (Table 2). The Plan shows two male belugas taken in the hunt (Fig. 2a); however, the SWFSC/FAU genetics database listed the Anchorage Community whale as female (Fig. 2b).

Hunting in 2006 and subsequent years was to be subject to P.L. 106-553 and Federal regulations under the MMPA (§101(b)), following completion of an EIS by NMFS. On 29 March 2006, NMFS formally initiated a Status Review to assist in determining if CIBs should be listed under the ESA because the estimates continued to show a population decline (Hobbs et al. 2006), despite severe limits on hunting. Within a month, NMFS received a petition from Trustees for Alaska to list the CIB Distinct Population Segment (DPS) as endangered. High winds in July and August made it unsafe to hunt that summer. Hunters were able to salvage muktuk following the necropsy of a dead female whale that stranded in Turnagain Arm in October.

NMFS issued a proposed rule to list the CIB DPS as an endangered species on 20 April 2007 (72 FR 19854). On 22 April 2008, NMFS extended the deadline for the final listing determination to 20 October 2008 (73 FR 21578) to include the abundance estimate from the aerial survey planned for June 2008. In June 2008, NMFS published a supplemental EIS (NMFS 2008) that provided management guidance for the subsistence hunt until the CIB population recovered to an optimal sustainable population (OSP) size of 780 whales. NMFS' preferred alternative included use of a Harvest Table to calculate strike limits and language stating, "unless the recent 5-year average abundance (2003 to 2007) is greater than 350 whales, there would be no harvest from 2008 to 2012." A supplemental Status Review was completed in October 2008 (Hobbs and Shelden 2008), updating abundance, trend, and extinction risk analyses presented in the April 2008 Status Review (Hobbs et al. 2008). The final rule listing the CIB DPS as endangered under the ESA was published in October 2008 and this rule went into effect on 22 December 2008 (NOAA 2008a). Coincidental to the listing decision, regulations setting long-term limits on the number of belugas that could be taken for subsistence and handicrafts (Table 3) were published in October 2008 and became effective that November (NOAA 2008b).

Table 3. -- Cook Inlet Harvest Table. Number of strikes is based on the average population abundance from the previous 5-years and the trend over the past 10 years. Additional criteria are included for 1) the years after 2015, 2020-2034, and after 2034; 2) various probabilities (20, 25, 75 %) that the growth rate is less than 1 or 2 %, or more than 3 %; and 3) estimated excess mortalities should strandings exceed the expected mortality limit (<https://federalregister.gov/a/E8-24511>).

5-year population averages	Number of strikes in 5 years			Expected mortality limit
	"High" growth rate	"Intermediate" growth rate	"Low" growth rate	
Below 350	0	0	0	-
350-399	8	5	5	21
400-449	9	8	5	24
450-499	10	8	5	27
500-524	14	9	5	30
525-549	16	10	5	32
550-574	20	15	5	33
575-599	22	16	5	35
600-624	24	17s	6	36
625-649	26	18rs	6	38
650-699	28	19rs	7	39
700-779	32	20	7	42
780 +	Consult with co-managers to expand harvest levels while allowing for the population to grow			

Current Status of CIB Subsistence Hunting

With adoption of the Harvest Table (NMFS 2008), subsistence hunting was not allowed during the period 2008-2012, as the average estimate of abundance for 2003-2007 was less than 350 whales (Allen and Angliss 2015). The average abundance estimate for 2008-2012 also fell below the 350-whale threshold; therefore, hunting was not authorized for the period 2013-2017 (Allen and Angliss 2015). On 20 June 2012, the CIMMC was disbanded by unanimous vote of the CIMMC member Tribes' representatives.

A reanalysis of the 1994-2016 abundance estimates conducted in 2018 found that while the population did continue to decline following implementation of harvest

regulations, there were signs of population growth from 2004 to 2010 (Fig. 4), after which a precipitous decline occurred once again (Boyd et al. 2019, Wade et al. 2019). This suggests that removal of hunting pressure resulted in a period of growth for the population, but some other factor(s) is now affecting recovery. The corrected abundance estimates did not, however, affect the previous Harvest Table determination as average abundance based on the revised 2004-2018 estimates remained below the 350-whale threshold for each time period (2003-2007 = 301 whales; 2008-2012 = 344 whales). For the period 2013-2017, average abundance was 313 whales; therefore, subsistence hunting was not authorized for the 5-year period 2018-2022.

DISCUSSION

Our reanalysis of published harvests and of unpublished accounts of CIBs during the late 1980s and throughout the 1990s indicates that annual harvests were substantially larger than initially reported, cumulatively taking more than half of the estimated 1,300 whales in the population. This was primarily due to applying correction factors for 1) households known to have hunted that did not participate in interviews about CIB harvests, and 2) local/ non-local hunters not within the survey network who were not interviewed. From 1979 to 1991, the CIB population declined by ~6% per year compared with the ~16% per year decline from 1991 to 1994 (Fig. 4). The highest documented harvests were during the mid-late 1990s, years when the population was already declining. Even as their overall abundance decreased, CIBs continued to congregate in relatively large numbers in certain areas, like the Susitna River delta (Rugh et al. 2010, Sheldon et al. 2015, McGuire et al. 2020a), which meant classic catch per unit effort (CPUE) models that predict a decline in catch rates with declining abundance did not apply. This behavior in combination with accessibility from Cook Inlet villages, the city of Anchorage, and visitors to the area, led to large-scale removal.

Beluga hunters typically focus on the largest and therefore, oldest, whales in the population which for some beluga populations, with significant sexual dimorphism, skews

the harvest to male belugas (e.g., Harwood et al. 2002, Suydam 2009). Some CIB hunters reported behavioral differences between the sexes:

“Female belugas in the Susitna River have gotten used to one hunter who does not hunt females, and so they do not flee at his approach, though they will flee from other boats” (Huntington 2000:139), and *“Solitary large male belugas are sometimes seen along the edge of the flats between the Little Susitna River and Knik Arm and to the southwest of Point Woronzof, moving back and forth with the tide”* (Huntington 2000:136).

Vos et al. (2020) found sexual dimorphism for age at length in CIBs: males ~438 cm (95% CI: 425–451 cm) and females ~384 cm (95% CI: 372–395 cm). However, the turbid waters of Cook Inlet meant hunters could not necessarily judge the size of the whales hunted. Often when pursued by boats, CIBs only expose the top of their head to breathe, rarely exposing their entire back (Lerczak et al. 2000). Once landed, hunters removed the skin, blubber, tail, and sometimes flippers, but not internal organs (Stanek 1994, Mahoney and Shelden 2000). The sex of a whale was often determined via genetics or during necropsy by NMFS personnel (Table 2). From these data, we determined landed CIBs ranged in age from 2 to 33 years old (Table 2), were relatively evenly split among males ($n = 41$) and females ($n = 32$) (Fig. 2b), with the average age of both sexes in the 20s (e.g., Vos et al. 2020, McGuire et al. 2021). For a species that may live as long as 70–90 years (Burns and Seaman 1986, Ferguson et al. 2020), the removal of young, reproductively mature adults of both sexes likely had a much greater impact than the decline in numbers alone (e.g., Tarsi and Tuft 2012, Wade 2018). The loss of these whales not only removed future reproductive potential from the Cook Inlet population but also potentially eliminated important sources of cultural transmission (e.g., O’Corry-Crowe et al. 2018) and key individuals that may have maintained social cohesion in the population (e.g., O’Corry-Crowe et al. 2020).

Timing of the hunt may also have inadvertently targeted pregnant females. Although hunters avoided whales accompanied by calves, calving may occur throughout the ice-free period (April–October), and recent studies on seasonality of breeding and calving in Cook Inlet indicated most births occurred between late July and October (Shelden et al. 2020a, b; McGuire et al. 2020a, b). This raises the possibility that the harvested females taken late in

spring or early summer would be newly pregnant or carrying near term fetuses (Table 2, Sheldon et al. 2020a, b). This, in part, may explain the continued decline observed in the population after the 1999 hunting moratorium. Incorporating these findings into population models may also help determine why the population is failing to recover.

With a limited hunt of 1-2 whales per year, the CIB population began to show signs of growth after 2004, however, after 2010 the population once again began to decline (Fig. 4; Wade et al. 2019). The cause of the current decline is unknown. As a NMFS “Species in the Spotlight” (<https://www.fisheries.noaa.gov/species/beluga-whale#spotlight>), priority actions needed to understand why this population is failing to recover include enhancing stranding response, reducing anthropogenic noise, protecting foraging and reproductive areas, understanding population characteristics, and ensuring prey species are healthy, plentiful, and remain available to the whales.

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APPENDIX

Chronicle of Revisions to Cook Inlet Beluga Harvest 1987 to 1998

1987

Stanek (1994) interviewed beluga hunters from the Municipality of Anchorage, and Matanuska-Susitna and Kenai Peninsula boroughs in 1987-1993. Although 33 different hunting households were identified when interviewing hunters, the number of households that responded to surveys often fell well below that number. In 1987, 4 of 11 households known to have hunted belugas that year reported eight belugas landed and one beluga lost (text Table 1). Stanek (1994:15) estimated that if all 11 households had similar numbers of landed and lost belugas the totals would be 22.0 belugas landed and 2.8 belugas lost (hereafter, all totals are rounded up to whole numbers as in this case to 3 belugas). The physical locations of these households were not provided in Stanek (1994).

On 4 March 1988, the Alaska and Inuvialuit Beluga Whale Committee (AIBWC) was established (Adams et al. 1993). Dedicated to conserving beluga whales and their habitat while preserving traditional hunting, participants included hunters from Alaskan and Canadian villages and scientists from management agencies. As part of the conservation effort, participants gathered information from each village on belugas successfully landed, and belugas that were struck and lost. In two documents that summarized the number of whales landed by each Alaskan village (Frost 1990, Frost and Suydam 1995) both reported whales landed by hunters from the “Anchorage area” and by the Native Village of Tyonek (NVT). Frost and Suydam (1995) listed the reported landings for the Anchorage area as 8-22 whales and none from the NVT, presumably based on numbers reported by Stanek (1994); however, a source was not cited in their paper.

These harvest estimates did not include whales taken by hunters who did not reside in the Cook Inlet region. Stanek (1994) reported one account of hunters from Kotzebue, Alaska, joining Anchorage hunters in 1986 when they were unable to hunt belugas locally due to ice. Stanek (1994) suggested that possibly a third of the total hunt was not reported because of unknown hunters. We updated the totals in the Plan (text Fig. 2a) and from Mahoney and Shelden (2000) to include this multiplier, now accounting for 11 whales

landed and 1.4 whales lost by unknown local and non-local hunters (text Fig. 2b, text Table 1). The total revised take is now 33 whales landed and 5 stuck and lost (text Table 1). Hunters did not report the number of male and female belugas landed, and the genetics archive did not contain any samples from Cook Inlet for 1987 (text Table 2).

1988

Stanek (1994) reported that five of the eight households known to have hunted in 1988 landed 12 belugas and struck and lost three whales (text Table 1). Accounting for three households that did not participate in the survey, increased the estimated totals to 19.2 and 4.8 whales, respectively (Stanek 1994:15). After including possible unknown hunters (the one-third multiplier for landed and struck and lost), the number landed increased to 29 whales, and lost to 8 whales.

Frost and Suydam (1995) reported landings in 1988 for the Anchorage area as 12-19 whales, and one whale by the Native Village of Tyonek for an overall total of 13-20 whales landed from Cook Inlet in 1988. We added the one whale landed by the Native Village of Tyonek to the total number of landed whales resulting in a total take of 38 whales (text Table 1, text Fig. 2b). Hunters did not report the number of male and female belugas landed in 1988, and the genetics archive did not contain any samples from Cook Inlet (text Table 2).

1989

For 1989, Frost and Suydam (1995) reported that the Native Village of Tyonek did not land a beluga, while hunters from the Anchorage area landed 11-13 belugas. Stanek (1994) reported the belugas landed and struck and lost as 11 and 2 whales, respectively. That year, 9 of 11 hunting households responded to the survey. Including the 2 households that did not respond to the survey, Stanek (1994:15) estimated the harvest at 13.4 belugas landed and 2.4 belugas struck and lost. Accounting for unknown and non-local hunters (the one-third multiplier: 20 landed, 4 lost) resulted in a total take of 24 whales (text Table 1).

Review of the SWFSC genetics archive produced one male beluga from Cook Inlet identified as hunted on 3 May 1989 (text Table 2). Other than listed as Cook Inlet, no other information on location was provided. This male beluga is not listed in Mahoney and

Shelden (2000) and it is not in the Plan (NMFS 2016) (see text Fig. 2a). Assuming this beluga was not reported to Stanek (1994) increases the total take to 25 whales in 1989 (text Table 1, text Fig. 2b).

1990 and 1991

In 1990, Stanek (1994) reported the number landed and struck and lost as 7 and 2 belugas, respectively. Because of a lack of research funding to conduct surveys, hunting households were not interviewed in 1991. Hunters did not report the number of male and female belugas landed, and the genetics archive did not contain any samples from Cook Inlet for 1990 or 1991 (text Table 2). In 1990, 5 of 11 households known to have participated in beluga hunts responded to the survey. Adding the six households that had not responded, Stanek (1994:15) estimated landed and struck and lost as 15.4 and 4.4 belugas, respectively. Accounting for unknown and non-local hunters (the one-third multiplier 23.1 landed and 6.6 struck and lost) resulted in a total take of 31 whales (text Table 1, text Fig. 2b).

A memorandum from R. Morris (NMFS Field Office Supervisor) to S. Zimmerman (Chief, NMFS Protected Resources Management Division) dated 26 May 1994, included a table with the number of belugas taken in Cook Inlet each year from 1990 to 1993. Morris cited the source of the data as the Alaska and Inuvialuit Beluga Whale Committee (AIBWC). The numbers reported were for whales landed and did not include struck and lost prior to 1993. For 1990, there were 12 belugas, which falls between the raw (7) and corrected (15.4) counts reported by Stanek (1994). Frost and Suydam (1995) reported landings as 7-15 whales for the Anchorage area with no data reported from the Native Village of Tyonek. Therefore, we used the estimate from Stanek (1994), corrected for unknown and non-local hunters, for the 1990 hunting season.

Although Stanek (1994) was unable to conduct surveys in 1991, the memorandum discussed in the preceding paragraph noted the AIBWC reported hunters landed 20 belugas from Cook Inlet that year. However, Frost and Suydam (1995) reported there were no data on number of whales landed by hunters from the Anchorage area or the Native Village of Tyonek. Large numbers of belugas were observed during aerial surveys in late June in areas well known to hunters (Shelden and Mahoney 2016), thus it is unlikely

that no hunting occurred. Minutes from the AIBWC meeting in April 1992 noted there was no information from Cook Inlet but one participant thought that about 20 whales had been harvested but that this should be confirmed by R. Stanek. John Burns also expressed concern that hunters from other regions were going to Cook Inlet, which could be problematic given the small population size (AIBWC 1992).

Stanek (1994) had calculated an average for the period over which surveys were conducted that included the years 1987-1990, 1992 (retrospectively, see below), and 1993. If we used those averaged numbers for 1991, 12 hunting households landed 17.1 belugas and struck and lost 3.8 (Stanek 1994). This is very close to the number in the memorandum and reported at the AIBWC meeting. Including the one-third multiplier (25.7 landed, 5.7 lost), increases the total take in Cook Inlet to 32 whales for 1991 (text Table 1, Fig. 2b).

1992

Similar to 1991, households were not contacted in 1992 due to a lack of research funding (Stanek, 1994). In 1993, eight hunting households surveyed by Stanek (1994) provided retrospective estimates of the number of belugas landed (9) and lost (1) during the hunting season of 1992. Frost and Suydam (1995) reported that nine whales were landed by Anchorage area hunters, and no data were reported from the Native Village of Tyonek. The memorandum by R. Morris noted that the AIBWC reported only three belugas were landed in 1992 but this appears to be an incomplete accounting from the AIBWC meeting, which met in April of that year instead of the fall (AIBWC 1992).

The first Alaska Marine Mammal Stock Assessment Report (hereafter SAR; Small and DeMaster 1995) completed after the U.S. Marine Mammal Protection Act was amended in 1994 (P.L. 103-238), cited Frost and Suydam (1995) as the source for data presented in the Subsistence/Native Harvest Information section of the Cook Inlet stock. However, only an average for the 5-year period (1990-1994) was presented in Small and DeMaster (1995) and for the 3-year period (1993-1995) in the SAR published in 1997 (Hill et al. 1997). It was not until publication of the SAR in 1998 (Hill and DeMaster 1998) that a table was included in the subsistence section with takes listed for each year from 1992 to 1996. For 1992, total take was listed as nine whales with no data available on estimated number of struck and lost (in Hill and DeMaster 1998:table 14b).

NMFS (2016) shows 11 belugas of unknown sex were landed and one lost that year (text Table 1, text Fig. 2a). We believe that two whales of unknown sex that were presented in table 2 in Mahoney and Sheldon (2000) were added to the earlier reports of nine landed whales from Stanek (1994) and Frost and Suydam (1995). This was after noting that males and females from that same table are shown in NMFS (2016) figure 14 (shown here as text Fig. 2a) in later years (i.e., 1994-1998). Adding these two whales in figure 14 (NMFS 2016) also meant assuming they were not among those reported to Stanek (1994).

Records provided by the NMFS Alaska Region (B. Mahoney. NMFS Alaska Region, personal communication via email to S. Moore, NMFS, CAEP Program Leader, 23 Feb. 1999) noted that skeletal remains of whales found in the Susitna Delta were at times classified as hunted (e.g., those found 2 June 1992, 28 Aug. 1992, 13 July 1996, and 1 Aug. 1996). Our review of the SWFSC genetics archive found that six samples (from four individuals: G. O'Corry-Crowe, pers. comm.) collected from August to October were all listed as stranded not hunted whales. The 28 August whale in Mahoney and Sheldon (2000) now has a known age (23 years old); however, in the data set of whales for which age had been determined (see Vos et al. (2020) supplemental table) this whale was listed as a stranding. We included the whales from Mahoney and Sheldon (2000) in text Table 2 but note that these were skeletal remains and cannot confirm they were hunted whales. Therefore, we did not add these whales to the totals for landed or struck and lost.

That left us with the retrospective numbers from Stanek (1994). Half of the households surveyed in 1993 (8 of 16) reported landed and/or lost belugas during the hunt in 1992. Given, on average 12 households participated in hunting each year, we estimated the total hunt by including those four additional households and also included the one-third multiplier. The revised estimates came to 20.3 landed and 2.3 lost for a total of 24 whales after rounding up decimals for landed and lost (text Table 1, text Fig. 2b).

1993

The totals from Stanek (1994) for 16 of the 19 households surveyed were 13 whales landed and 4 lost. These are the same numbers reported in NMFS (2016). Stanek (1994:15) estimated the take was 15.4 landed and 4.8 lost when including the three households that had not been surveyed. Frost and Suydam (1995) listed 13-15 whales landed by hunters

from the Anchorage area, while noting the Native Village of Tyonek reported no whales taken in 1993. In the minutes from the AIBWC meeting in December 1993, there was also mention of a whale that was salvaged after it was found dead near Kenai (AIBWC 1993).

In the memorandum by R. Morris, total take was listed as 17 whales. We believe the 17 whales include landed (13) and lost (4) because the memorandum noted that struck and lost numbers were not reported until 1993. Stanek (1994) also provided a one-third multiplier for unknown, non-local hunters that resulted in a grand total of ~30 whales for 1993. The Alaska Marine Mammal SARs published from 1995 to 2002 (Small and DeMaster 1995; Hill et al. 1997; Hill and DeMaster 1998, 1999; Ferrero et al. 2000a; Angliss et al. 2001, Angliss and Lodge 2002), included this estimated take of 30 whales. To be consistent with our previous estimates, we rounded all decimals up to the next whole number for an estimated take of 24 whales landed, and 8 whales struck and lost, 32 whales total.

As noted in previous sections, male and female whales listed in Mahoney and Shelden (2000) appear to be included in NMFS (2016) figure 14 for the years 1992 and 1994-1998, though this was not the case for 1993 (see text Fig. 2a). The number of unknown sex whales for those years was reduced rather than assuming these whales were not among those reported by Stanek (1994) and others. We believe this assumption is valid for the following reasons. After review of the SWFSC genetics database and the tooth age data set from Vos et al. (2020), we added two more known sex individuals from 1993 (text Table 2). Skin samples had been provided by R. Stanek (ADFG) to the SWFSC; therefore, it is likely that these two whales were among those reported in Stanek (1994:21). Assuming the two males from Mahoney and Shelden (2000) were also accounted for in the projected totals, we reduced the number of unknown sex from 24 to 19 whales and added these four males and one female (text Table 1, text Table 2, text Fig. 2b).

1994

In the meeting minutes from November 1994 (AIBWC 1994), hunters from the Anchorage area reported knowledge of 11 whales taken in Cook Inlet (9 landed and 2 lost). Stanek, who attended the meeting, reported eight additional whales landed and two whales taken by hunters from Kotzebue but did not indicate how many households had been surveyed. Frost and Suydam (1995) reported that hunters from the Anchorage area landed

19 belugas in 1994 (which included the two whales landed by Kotzebue hunters, K. Frost, pers. comm.), while no data were available from the Native Village of Tyonek.

At the AIBWC meeting, Stanek also noted that there were 35-50 households actively hunting in Cook Inlet that included hunters from within and outside the region (AIBWC 1994). Because it was not reported during the meeting how many of these households may have landed whales in 1994, we used the average number of hunting households (8 of 12 responding to surveys) presented in Stanek (1994) from the period 1987-1993. This increased the 17 landed and 2 lost to 26 landed and 3 struck and lost. We then included the one-third multiplier, assuming the two whales taken by Kotzebue hunters were included within that total. The resulting estimated take was 39 landed and 5 struck and lost.

It was noted in the minutes from the 1996 meeting that the Cook Inlet Marine Mammal Council (CIMMC) began helping NMFS to collect samples for genetics and contaminant studies in 1994 (B. Mahoney, pers. comm.) but did not say how many whales were sampled that year (ABWC 1996). Two females and one male reported in Mahoney and Shelden (2000) were included in the Recovery Plan figure (text Fig. 2a). The SWFSC genetics database included additional whales, four females and three males (text Table 2). Genetics confirmed a match between a sample received in 1994 (ID 3790) to a female taken in 1993 (text Table 2); therefore, we removed this whale from the total number of females landed. An article published in the *Anchorage Daily News* on 14 August 1994 featured interviews with subsistence hunters and described a hunt that took place on 8 August (text Fig. 3). A male beluga was landed by hunters that day (text Table 2). We assumed these 9 whales were among those reported as unknown sex and reduced the unknown landed to 29.3 whales, resulting in a total take of 44 whales (text Table 1, text Fig. 2b).

1995

Mahoney and Shelden (2000) noted take totals varied markedly among the sources shown in their table 1 (Hill and DeMaster 1998, 1999; ABWC 1995). After review of the original reports compiled by the CIMMC (1995a, b; 1996) for the 1995 hunting season, we were able to determine why the numbers changed across sources. The meeting minutes (ABWC 1995) contained an error in reporting the total landed for the July-October hunting

period. The ABWC minutes recorded 26 whales landed (ABWC 1995) but CIMMC reported 16 whales landed (CIMMC 1995b). Hill and DeMaster (1998) had also stated that 26 whales were landed, but later corrected the number to 16 whales in Hill and DeMaster (1999). The final report for the July-November hunting period, in which hunters recalled additional whales landed and lost during both hunting periods, was not available until 1 March 1996 (CIMMC 1996). Final tallies from all three reports (CIMMC 1995a, b; 1996) are shown in the table below (Appendix Table 1). Also noted at the meeting, a hunter from Kotzebue reported taking two whales from Cook Inlet that were not included in the CIMMC totals (ABWC 1995). It appears that some if not all of these whales were included in the total take reported in later SARs (Ferrero et al. 2000a, Angliss et al. 2001, Angliss and Lodge 2002).

Appendix Table 1. -- Cook Inlet Marine Mammal Council reported takes of belugas during the 1995 hunting season in Cook Inlet, Alaska (CIMMC 1995a, b; 1996). * = updated totals from the March 1996 report. ND = no data.

Month	Takes		Sex of landed			Skin color of landed			
	Landed	Struck and lost	M	F	ND	White	Gray-white	Gray	ND
April	1	0							
May	9	9							
June	12	4							
Not reported*	3	1							
Apr.-June totals	25	14	9	8	8	16	5	1	3
July	2	4							
August	5*	3							
September	3	1							
October	7	4*							
July-Oct. totals	17	12	5	3	9	7	1	0	9
Grand totals	42	26	14	11	17	23	6	1	12

During the latter half of the hunting season, from July 18th to August 6th, NMFS scientists in collaboration with beluga whale hunters conducted a radio-tagging study. Although hunting pressure was presumably reduced during a portion of the latter half of the hunting period, NMFS personnel (R. Morris and S. Zimmerman) present at the ABWC meeting estimated that about 20% of the total hunt mortality was not reported (ABWC 1995). Concerns were expressed that: "The population is currently estimated at 1,200 and the harvest guidelines are 20-30/1,000. This means the current harvest is more than double the acceptable level." (ABWC 1995:4).

The CIMMC (1996) report noted at least 25 hunters participated in a successful hunt where at least one whale was taken by each hunting crew during the April-June period. Most of the hunters were from the Anchorage, Wasilla, and Palmer areas. Although CIMMC knew of at least 25 hunters who had successful hunts in 1995, participants at the ABWC meeting noted that about 40 hunters reside in the Cook Inlet area (ABWC 1995). CIMMC also reported that a few crews from northern villages visiting Cook Inlet were not successful during that same time period. However, as noted in the ABWC minutes, at least one hunter from Kotzebue did have a successful hunt though this was not mentioned in any of the CIMMC reports. For consistency, we used the multiplier for unknown and non-local hunters of one-third suggested by Stanek (1994). Of the 42 whales landed and 26 struck and lost reported by CIMMC, undocumented hunters added another 21 whales landed and 13 struck and lost. We did not add the two whales taken by the Kotzebue hunter to the total landed as we assumed the estimated undocumented takes included these whales. Overall, this increased the previous estimated take of 70 whales (NMFS 2016) to 102 whales in 1995 (text Table 1, text Fig. 2).

Mahoney and Shelden (2000) provided information on six female belugas and seven males. The Recovery Plan includes seven female belugas and nine males within the number of total whales landed (text Fig. 2a). NMFS was able to coordinate with hunters to collect samples from ten whales during the 1995 hunting season (ABWC 1996), and hunters provided four additional skin samples for the genetics archive (text Table 2). Review of the SWFSC genetics database added one more male beluga to the totals reported in Mahoney and Shelden (2000), though still falling short of the numbers reported in the Recovery Plan. We compared these totals to those reported by the CIMMC. Hunters reported landing eight females and nine males between April-June, and reported that two-thirds of ~50% of whales landed between July-November were males. This suggests that hunters landed at least 11 females and 14 males during the 1995 hunting season (text Table 2). This total does not include a near-term female fetus. We updated totals for male and female belugas landed during the hunt based on the CIMMC numbers (text Table 1, text Fig. 2b), assuming that the numbers reported in Mahoney and Shelden (2000) and the Recovery Plan were included in these totals (text Table 2, text Fig. 2a).

1996

On 19 May 1997, the CIMMC presented a final report for the 1996 hunting season to NMFS (CIMMC 1997). Twelve whaling captains, or members of their crew, were interviewed by four CIMMC representatives. The final tally included 49 belugas landed and an estimate between 1 to 2 whales lost based on direct observation and participation in an unspecified number of hunts. At the ABWC meeting in December 1996, a CIMMC representative had provided a preliminary estimate of 40 whales landed and noted that the Native Village of Tyonek landed two whales in the spring (ABWC 1996). These two whales appear to be included in the CIMMC report as one of the captains resided in Tyonek, two within the Matanuska-Susitna Borough, and the remainder in the Municipality of Anchorage. Whaling captains also reported that three boat crews from non-local communities hunted in 1996 but did not know if they were successful. One captain was responsible for taking about 25 belugas compared to the other 11 captains who landed from one to three whales each. Due to logistics and not having transport to hunting sites, NMFS was only able to necropsy seven whales (ABWC 1996), though skin samples were obtained from three additional whales (text Table 2).

The numbers presented in the Recovery Plan are similar to those previously documented by CIMMC, in the Alaska Marine Mammal SARs, and Mahoney and Shelden (2000). Review of the SWFSC genetics database and Vos et al. (2020) supplementary data, found two more whales not reported in Mahoney and Shelden (2000) and updated age and sex data for others (text Table 2). Multiple attempts to obtain genetic data for one whale failed (text Table 2).

To calculate the total take in 1996, we again assumed that some hunting was not reported and that the struck and lost rate was at least one whale per whale landed. We opted to use this struck and lost estimate versus the average (used in the Alaska Marine Mammal Stock Assessment Reports) or high estimate of two whales lost per whale landed. Whaling captains from Cook Inlet present at the ABWC meeting in November 1997 expressed concern about applying the two whale struck and lost rate to the entire harvest, noting while some younger hunters may have high loss rates, more experienced hunters rarely lose a whale (ABWC 1997). Unreported take by unknown and non-local hunters was calculated using the one-third multiplier suggested by Stanek (1994), as at least three boat

crews from other regions were observed during the hunting season (CIMMC 1997). We also removed the number of known sex whales from the total number of whales landed, assuming these were among the whales reported by the CIMMC. Overall, the final estimated take of 148 whales was higher than past SARs. Interestingly, the struck and lost number remained the same as that reported in the Plan and SARs though the method of calculation changed (text Table 1, text Fig. 2b).

1997

In 1997, the CIMMC formally withdrew as a voting member from the ABWC but representatives attended the meetings to provide updates on hunting occurring in Cook Inlet. Art Nuglene (CIMMC representative) reported that about 35 whales were landed but did not have numbers of struck and lost. Instead, he estimated total killed to be about 65-75 belugas. The Alaska Marine Mammal SARs (Hill and DeMaster 1999, Ferrero et al. 2000a, Angliss et al. 2001, Angliss and Lodge 2002) took the mid-point of the range and estimated that 35 whales were lost (text Table 1). A logbook kept by one of the whaling captains (A. Nuglene) provided a daily list of the number of whales taken by some of the hunters, locations, and vital statistics (Appendix Table 2). The total included one female and 29 whales for which sex was not identified. Of these 30 whales, skin color was described as white for 14 whales, gray for three whales, and not identified for the rest. We were not able to unequivocally match three male whales listed in Mahoney and Shelden (2000) to the list from the logbook (text Table 2). This brought the total number landed to 33 whales.

Appendix Table 2. -- Cook Inlet beluga harvest in 1997 as documented in the logbook of one of the whaling captains (A. Nuglene, Hunter ID#1). Sex shown in parenthesis was documented in Mahoney and Sheldon (2000) but a clear match between the datasets could not be made (see text Table 2). ND = no data. * = hunters were working with two boats.

Month	Day	Color	Sex	Location	Hunter ID#
April	23	white	F	Susitna River	1,2,3
April	26	white	ND	Susitna River	4,5,6
April	27	white	ND	Susitna River	1,3,7
May	3	white	ND	Susitna River	6,8
May	4	gray	ND	Susitna River	3,7,9,10
May	5	ND	ND	Susitna River	11,12
May	5	ND	ND	Susitna River	13,14,15,16*
May	5	ND	ND	Susitna River	13,14,15,16*
May	5	ND	ND	Susitna River	13,14,15,16*
May	9	white	ND	Susitna River	3,7,9
May	22	ND	ND	Little Susitna River	17
May	22	ND	ND	Susitna River	18
May	24	ND	ND	Susitna River	19
May	27	white	ND (M?)	Susitna River	20
June	3	white	ND	Susitna River	3,9,21,22
June	4	white	ND	Susitna River	3,9,21,22
June	15	white	ND (M?)	Eagle River	3,9,10
June	18	ND	ND	Susitna River	23*
June	18	ND	ND	Susitna River	23*
June	28	ND	ND	Susitna River	24
July	19	ND	ND	Susitna River	4
July	24	white	ND	Ivan River	3,9
August	1	ND	ND	Susitna River	25
August	2	gray	ND	Susitna River	26
August	25	gray	ND (M?)	Knik Arm	27,28,29
August	26	white	ND	Knik Arm	30,31
September	6	white	ND	Knik Arm	31,32
September	23	white	ND	Knik Arm	1,2,3
September	28	white	ND	Peter's Creek	1,7,9,22
October	11	ND	ND	Knik Arm	19

The SWFSC genetics database included four males (one of which appears to be a duplicate sample, ID 7400 and 12728) and one female from Cook Inlet, but the female was listed as stranded, not hunted. The Recovery Plan included two females and only one male (text Fig. 2a); however, we were only able to confirm one female based on the whaling captain's logbook, and three males from the SWFSC genetics database (text Table 2). Given that the count of 33 landed whales was close to what was reported at the ABWC meeting, we used the estimate of 35 landed and 35 struck and lost and applied the one-third multiplier for unknown and non-local hunters (text Table 1). Overall, the total estimated

take for 1997 (106 whales) was similar to the 102 whales estimated for the 1995 hunting season (text Table 1, text Fig. 2b). This was not entirely surprising as hunters were collaborating with NMFS scientists on a beluga satellite-tagging project for most of the month of June (Ferrero et al. 2000b), similar to the almost month-long collaboration on the radio-tagging project in 1995.

1998

We found conflicting totals in the Alaska Marine Mammal SARs (Ferrero et al. 2000a, Angliss et al. 2001, Angliss and Lodge 2002) ranging from 21 to 25 whales landed or lost in 1998. At the ABWC meeting in 1998, Carl Jack reported the CIB harvest as 20 confirmed and 20 unconfirmed, plus stuck and lost. It was also noted during the meeting that non-local hunters were still coming to hunt in Cook Inlet. Kathy Frost spoke about ABWC's efforts to get non-local hunters to restrict their hunting of Cook Inlet belugas and to support CIMMC as the co-management body for Cook Inlet belugas through the resolution process (ABWC 1998).

A series of interviews with local hunters took place following the 1998 hunting season, which ran from May to October (Appendix Table 3). The total number of landed whales based on these interviews was 23 whales, which included at least 10 males and 3 females and described skin color as white for 19 whales and gray-white for 4 whales. The timing and locations for the three males reported in Mahoney and Sheldon (2000) coincided with the time-periods and regions mentioned in the hunter interviews (text Table 2). Two females from Mahoney and Sheldon (2000) did not overlap with time-period or region. The SWFSC was able to provide DNA confirmation for the unknown-sex whale from Chickaloon River landed in October. Although this female was killed within the time-period mentioned by two of the hunters, the Chickaloon region was not among any of the areas hunted (Appendix Table 3). Similarly, the female landed in April was before the beginning of the hunting season reported by all of the interviewed hunters. Therefore, at minimum, 5 females and 10 males were landed during the 1998 hunting season (text Table 2).

Appendix Table 3. -- Hunter interviews documenting 1998 landed whales. Note: does not appear to include two females listed in text Table 2 given timing (April) and location (Chickaloon River) which do not match any listed below. ND = no data.

Months(s)	Sex			Skin color		Areas hunted	Source
	M	F	ND	White	Gray-white		
May to Oct.			10	8	2	Susitna River/Beluga River/Little Susitna River/Knik Arm	B. Mahoney (NMFS) interview of C. Eben and F. Anawrok, 3 Dec. 1998
May to Sept.	5			3	2	Susitna River/Beluga River/Eagle River	D. Alex (CIMMC) interview of five anonymous hunters, 30 Sept. 1999
May & Aug.	2	1		3		Susitna River	D. Alex (CIMMC) interview of three anonymous hunters, 30 Sept. 1999
May & Sept.	3	1		4		Susitna River/Eagle River	D. Alex (CIMMC) interview of four anonymous hunters, 30 Sept. 1999
ND		1		1		W. trib. Susitna River	D. Alex (CIMMC) interview of one anonymous hunter, 30 Sept. 1999
Grand total	10	3	10	19	4		

We added the April and October/Chickaloon females to the 23 whales reported by the interviewed hunters for a total landed of 25 whales. Assuming a similar struck and lost rate of 25 whales, and accounting for unknown and non-local hunters (one-third multiplier) produced an estimated take of 76 whales. If we include the unverified report of 20 whales killed in one weekend mentioned in Mahoney and Sheldon (2000), which presumably includes the 20 unconfirmed whales noted at the ABWC meeting, the total take of 96 whales is similar to takes reported in 1995 and 1997 (text Table 1, text Fig. 2b).



U.S. Secretary of Commerce

Gina M. Raimondo

Under Secretary of Commerce for
Oceans and Atmosphere

Dr. Richard W. Spinrad

Assistant Administrator, National Marine
Fisheries Service. Also serving as
Acting Assistant
Secretary of Commerce for Oceans
and Atmosphere, and Deputy NOAA
Administrator

Janet Coit

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Alaska Fisheries Science Center
7600 Sand Point Way N.E.
Seattle, WA 98115-6349