SYNTHESIS OF AVAILABLE INFORMATION ON THE COOK INLET STOCK OF BELUGA WHALES

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ABSTRACT

On 19 November 1998, the National Marine Fisheries Service initiated a status review of the Cook Inlet beluga whale (*Delphinapterus leucas*) stock to determine whether designation under the Marine Mammal Protection Act or a change in listing classification under the U.S. Endangered Species Act was warranted (63 Federal Register page 64229; 19 Nov. 1998). The National Marine Fisheries Service undertook a review in conjunction with the Alaska Beluga Whale Committee (ABWC) and the Cook Inlet Marine Mammal Council (CIMMC). The status review consisted of a period (19 November 1998 to 19 January 1999) wherein NMFS requested public comment and pertinent information, followed by a workshop for presentation of scientific information and the collection of additional public comments held 8-9 March 1999 in Anchorage, Alaska. The scientific review was focused on the current status of Cook Inlet belugas: distribution, abundance, trends in abundance, and habitat. The effects of the Alaska Native subsistence harvest and the potential effects of other anthropogenic impacts, as well as beluga natural mortality were also examined. Results of the scientific review confirm that this stock of beluga whales is geographically and genetically isolated from all other stocks. It is now evident that their distribution within Cook Inlet is shrinking, and that there are no large, persistent groups of beluga whales in the Gulf of Alaska. Habitat factors are being examined, including physical, ecosystem and anthropogenic factors. Samples from belugas in Cook Inlet had lower contaminant and heavy metal levels (except copper) than did other stocks of belugas in Alaska. The abundance of beluga whales in Cook Inlet has declined by nearly 50% between 1994 and 1998. The latest abundance estimate, from the June 1998 aerial counts, was 347 whales (SE = 101, CV = 0.29). This estimate includes corrections for surface timings (calculated from suction-cup attached VHF transmitters) and sighting rates (calculated from video analysis). An annual take of approximately 72 whales (averaged for the years 1994-96) has been excessive for this small stock. Options for reducing the harvest levels and increasing the efficiency of the hunt are being developed in cooperation with local hunters.

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1.0 INTRODUCTION

Beluga whales occur in five stocks around Alaska (Hill and DeMaster 1998), the most isolated of which is the Cook Inlet population (O'Corry-Crowe et al. 1997). The geographic and genetic isolation of this stock, in combination with their tendency toward site fidelity in summer (Rugh et al. 1999), makes this population vulnerable to deleterious impacts from large, persistent harvests or other localized mortality events. Results from annual aerial surveys conducted by the National Marine Fisheries Service (NMFS), starting in 1993, indicated that the beluga whale distribution within Cook Inlet has shrunk relative to records collected in previous decades (Rugh et al. 1999) and that the beluga abundance had declined by nearly 50% between 1994 and 1998 (Hobbs et al. 1999). The abundance estimated from the June 1998 aerial counts was 347 whales (CV = 0.29), compared to 653 (CV = 0.43) in 1994 (Hobbs et al. 1999). The average reported take of beluga whales in Cook Inlet from 1994 through 1996 (72 whales; Hill and DeMaster 1998) was 21% of the best estimate of abundance. This meant the harvest was approximately 5 times the calculated Potential Biological Removal (PBR) of 14, which was calculated using an earlier abundance estimate (N_{min} = 712), half of the maximum theoretical net productivity rate (0.02), and a recovery factor of 1.0 (Hill and DeMaster 1998). The Alaska Scientific Review Group (AKSRG), the Alaska Beluga Whale Committee (ABWC), the Cook Inlet Marine Mammal Council (CIMMC), various components of NMFS (in particular the Alaska Regional Office (F/AKR), the Office of Protected Resources, the Alaska Fisheries Science Center (AFSC), and the National Marine Mammal Laboratory (NMML)), and several Non-Government Organizations (NGOs) all expressed concern about the high level of harvest from this small, isolated population of beluga whales. Furthermore, "the AKSRG has concluded that the Cook Inlet beluga situation is one of the most pressing conservation issues facing Alaskan marine mammals at this time."[1]

Accordingly, NMFS, which (under the Marine Mammal Protection Act (MMPA)) is responsible for management and protection of beluga whales in Alaska, initiated a formal review of the status of the Cook Inlet beluga whale stock through a cooperative process with the ABWC and the CIMMC (63 FR page 64229; 19 Nov. 1998). This status review process was initiated at the same time workshops were held by the ABWC (16-17 November 1998) and the AKSRG (18-20 November 1998) in Anchorage, Alaska. These workshops provided an avenue for scientific presentations to interested parties, such as hunters, administrators, and researchers. To ensure that the status review was comprehensive and based on the best available data, NMFS solicited information and comments from any interested person concerning the status of Cook Inlet beluga whales. The comment period extended from 19 November 1998 through 19 January 1999 and was followed by a NMFS' sponsored workshop ("The Cook Inlet Beluga Whale Status Review Public Meeting") held at the Sheraton Hotel in Anchorage on 8-9 March 1999. This provided a review of relevant scientific information and an

[1]Letter dated 27 July 1998 from Lloyd Lowry, Chair, AKSRG, to Dan Alex, Chair, CIMMC.

avenue for additional public comments and information. The following abstracts represent the most pertinent components of each presentation at the workshop. Also included are abstracts and materials prepared in response to some of the questions raised at the meetings. Final papers will be published in a special issue of the scientific journal *Marine Fisheries Review* in the near future following the formal peer-review process.

1.1 Workshop objectives

The specific objectives of the workshop were to review relevant scientific information regarding the status of the Cook Inlet beluga whale stock and to receive additional public comments relevant to listing the population as depleted under the MMPA, or as threatened or endangered under the U.S. Endangered Species Act (ESA). An additional incentive to conduct this review in a timely fashion was the International Whaling Commission's (IWC) focus on small cetacean takes and on beluga whales at their May 1999 meetings.

2.0 POPULATION ECOLOGY

2.1 Distribution of beluga whales in Cook Inlet during June/July 1993-98

by D.J. Rugh[1], K.E.W. Shelden[1], and B.A. Mahoney[2]

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Aerial surveys of the isolated stock of beluga whales in Cook Inlet, Alaska, were flown during June/July of 1993-98. The surveys provided a thorough, annual coverage of the coastal areas of the inlet (1,388 km) and have included up to 1,500 km of offshore transects. Coastal transects were flown 1.4 km (0.7 nmi) from the tideline, covering most of the area within 3 km of shore(Fig. 1). Therefore, 100% of the coastal areas were surveyed most years, and along with offshore transects, systematic searches encompassed 13-29% of the entire inlet. All of the surveys were flown in a twin-engine, high-wing Aero Commander or Twin Otter aircraft at an altitude of 244 m (800 ft) and at a speed of approximately 185 km/h (100 knots). Nearly all of the beluga whales seen in Cook Inlet in June/July were concentrated in a few dense groups in shallow areas near river mouths. The largest concentration (generally 120-300 whales by aerial count) was in the northern portion of upper Cook Inlet, either in the Susitna River Delta or Knik Arm. Another group (10-50 whales) was consistently found between Chickaloon River and Point Possession. Smaller groups (generally <20 whales) occasionally occurred in Turnagain Arm, Kachemak Bay, Redoubt Bay (Big River), and Trading Bay (McArthur River). Some dispersal may have begun in July relative to June, but by September the dispersal was evident. Over the past three decades, there has been a consistent decline in sightings of beluga whales both in offshore areas and in lower Cook Inlet (Figs. 2 and 3). Currently, aerial surveys show that belugas occur in significant numbers only in the upper reaches of the Inlet in June/July compared to the wider distribution throughout the Inlet seen during vessel and aerial surveys in the 1970s and 1980s.

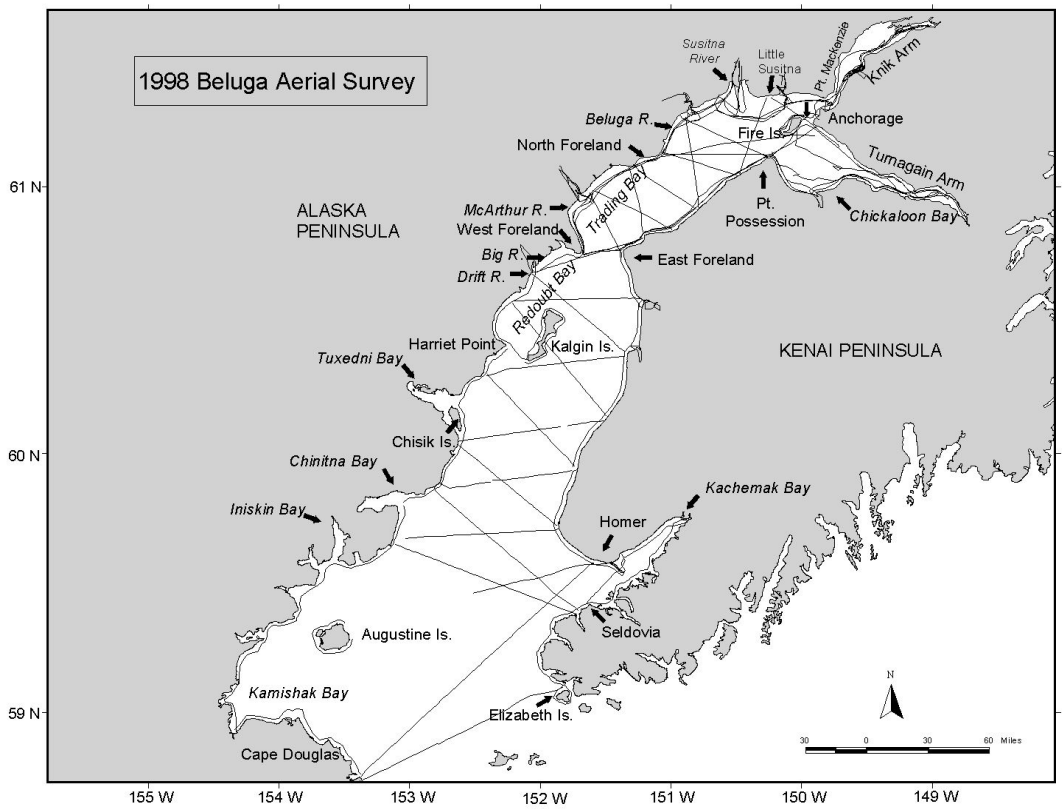

Figure 1. Coastal and offshore tracklines used to survey beluga whales in Cook Inlet, Alaska, in June 1998, considered a representative survey for other surveys conducted in 1993-98.

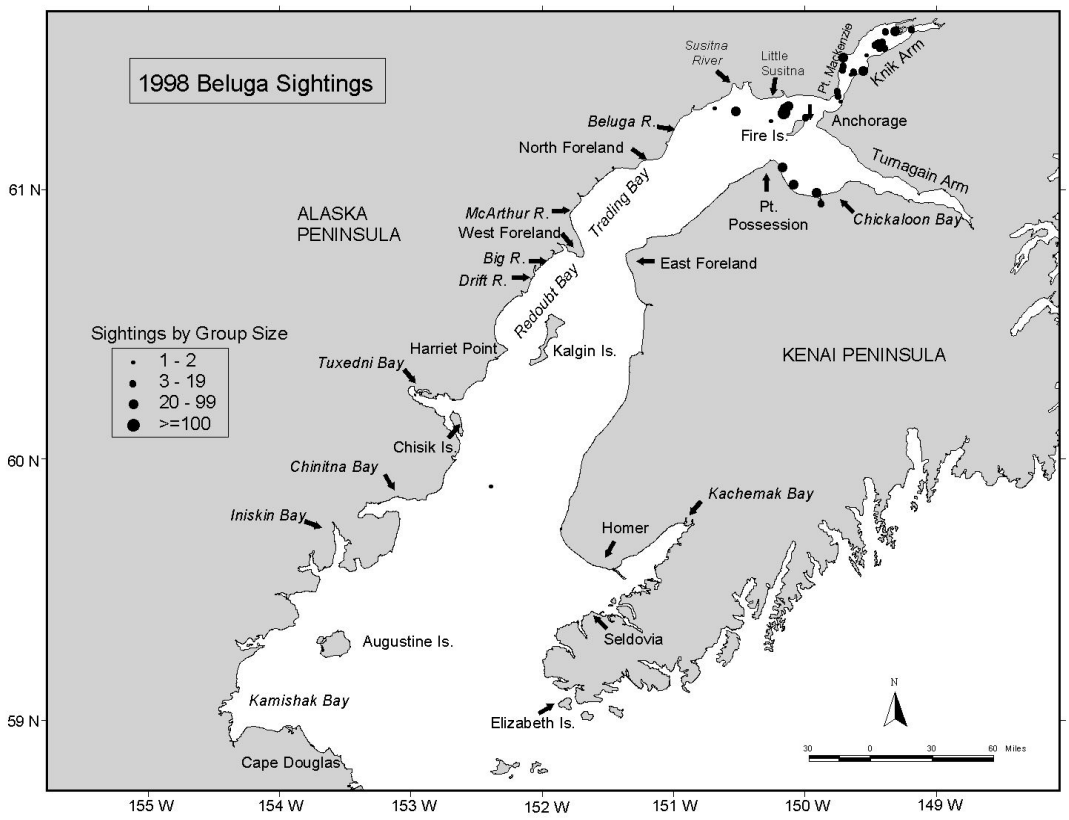

Figure 2. Beluga whales sightings made during systematic aerial surveys in Cook Inlet, Alaska, in June 1998. Sighting locations have been consistent in June/July 1993-98 except that there were more sightings in the lower inlet in the earlier years (prior to 1995). The one sighting made in the lower inlet in 1998 was of a dead beluga. Note that each group of whales may be represented here as many as four times because of the multiple flights made in a survey season.

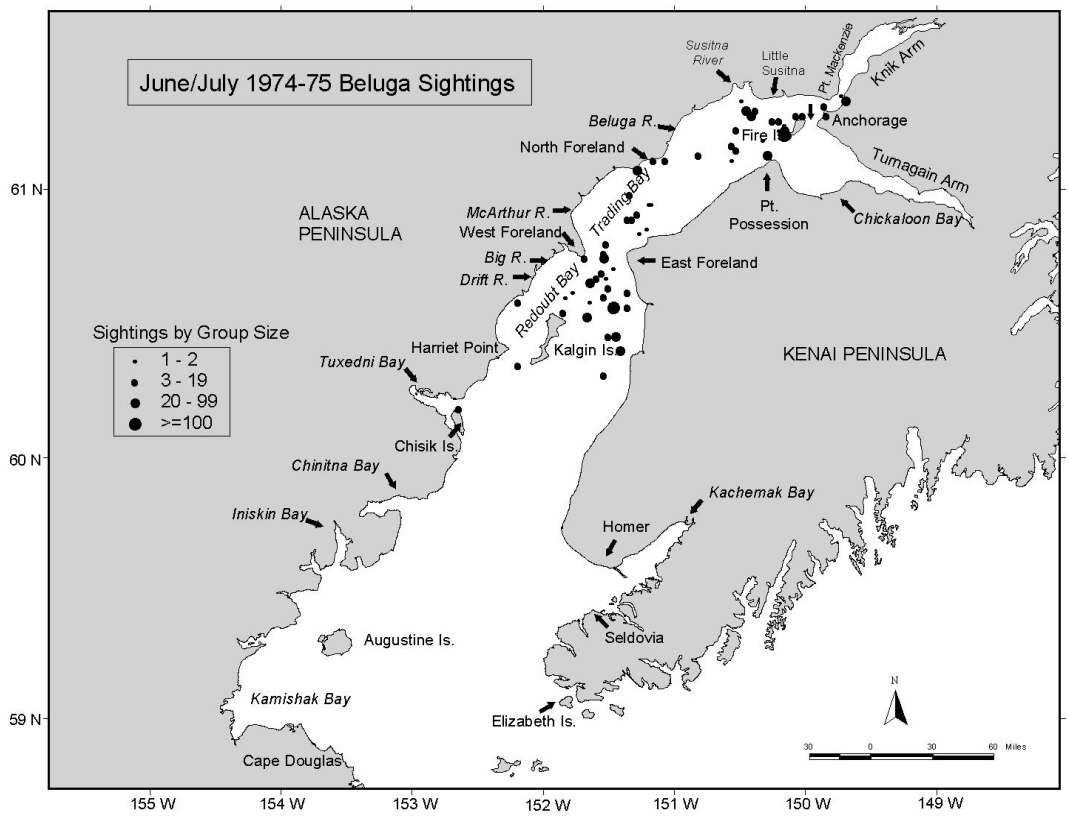

Figure 3. Beluga whale sightings made during hydrographic surveys in June and July 1974-75. Note that most of the sightings were well offshore, and many sightings occurred in lower Cook Inlet, in contrast to sightings made in the 1990s. Nearshore waters frequented by belugas are too shallow for the hydrographic survey vessels, so the lack of coastal sightings in this map does not necessarily indicate the absence of belugas.

2.2 Distribution of beluga whales and survey effort in the Gulf of Alaska

by K.L. Laidre[1], K.E.W. Shelden[1], D.J. Rugh[1], and B.A. Mahoney[2]

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Beluga whale distribution in the Gulf of Alaska and adjacent inside waters was examined through a review of surveys conducted as far back as 1936. Although sightings of belugas have occurred on almost every marine mammal survey through northern Cook Inlet (each of 20 surveys reported here), beluga sightings have been rare outside of the inlet in the Gulf of Alaska. To date, there have been 28 sightings: 7 near Kodiak Island, 8 in or near Prince William Sound, 12 in Yakutat Bay, and 1 anomalous sighting south of the Gulf near Tacoma, Washington (Fig. 4). These sightings are associated with different data sources: 1) 4 sightings (5 belugas) were observed during more than 150,000 km of dedicated survey effort in the Gulf of Alaska which resulted in sightings of over 23,000 other cetaceans; 2) 5 sightings (39 belugas) were reported in the National Marine Mammal Laboratory's Platforms of Opportunity database which contains sightings of nearly 100,000 cetaceans in the Gulf of Alaska; and 3) 19 sightings (276 belugas) were reported during surveys for wildlife other than marine mammals, during U.S. Coast Guard operations, or by recreational boaters. Commercial whaling records show belugas were taken only in Cook Inlet. In addition, there is no conclusive evidence of belugas in archaeological sites outside of Cook Inlet. Considering the extensive survey effort and lack of whaling and archaeological evidence, it appears there are no large, persistent groups of beluga whales in the Gulf of Alaska or adjacent inside waters other than in Cook Inlet.

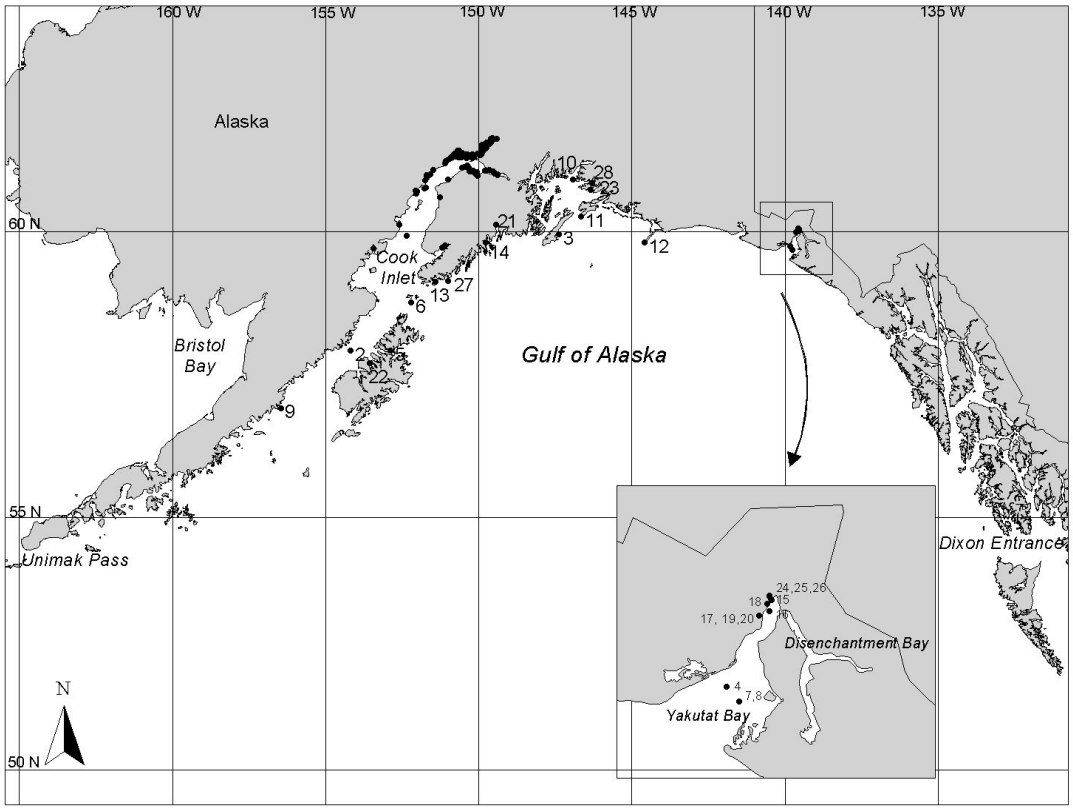

Figure 4. Beluga whale sightings in the Gulf of Alaska (not including sightings in Cook Inlet) as recorded over the past 25 years. Numbers in this map refer to sighting identifications used in Laidre et al. (In press.)

2.3 Molecular genetic analysis of beluga whale, *Delphinapterus leucas*, population structure and movement patterns in Alaska and Canada with special reference to Cook Inlet

by G. O'Corry-Crowe and A.E. Dizon

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This study used a molecular genetic approach to investigate the recent evolutionary history, population structure, and movement patterns of beluga whales in Alaska and northwest Canada. Specifically, separate management stocks of beluga whales were identified based on the degree of dispersal and gene flow occurring among geographically separate concentrations of beluga whales, which were estimated from an analysis of patterns of variation within the mitochondrial genome (mtDNA) and eight hypervariable microsatellite (nuclear) loci.

To date, samples from 470 whales collected from 35 separate locations in Alaska and Canada, including 64 animals from Cook Inlet, have been analyzed for sequence variation in the mtDNA control region (Fig. 5). Phylogenetic relationships among mtDNA haplotypes were reconstructed from parsimonious networks, and genetic subdivision was examined using haplotype frequency-based indices and an analysis of variance method modified for use with interhaplotypic distance data. The mtDNA phylogeny is characterized by a series of star-like phylogenies which, when viewed in conjunction with information on haplotype frequency and distribution, suggest a rapid radiation of beluga whales into the western Nearctic following the Pleistocene and an early divergence of the Beaufort Sea from the Chukchi and Bering Seas stocks. We have found that the beluga whales from Cook Inlet, Bristol Bay, the eastern Bering Sea, the eastern Chukchi Sea, and the Beaufort Sea are all significantly differentiated from each other ($\Phi st = 0.33$). Cook Inlet was found to be genetically the most distinct of all five areas, suggesting that the whales in this area have been effectively isolated from the other stocks to the west for a long period, perhaps several thousand years. These findings indicate that beluga whales tend to return to the same summering grounds year after year and generation after generation. Because of the limited movement among summering areas, we conclude that each summering area is a demographically distinct unit and recommend that each of the five major summering areas should be treated as separate management stocks. Further analysis revealed that when dispersal does occur, it is primarily done by adult males, a characteristic that may be related to breeding behavior.

Preliminary findings from the microsatellite analysis support much of the mtDNA analysis and reveal significant differences among summering areas. This indicates that, as well as limited dispersal, there may be limited interbreeding among separate stocks. Both the microsatellite and the mtDNA analysis show that the Cook Inlet stock is the most distinct. In an assignment test, over 90% of samples collected from Cook Inlet were correctly assigned to that population, confirming that the genetic composition of this stock is distinct from that of beluga whale stocks further to the west. Overall, the patterns of mtDNA variation in beluga whales indicate that discrete stocks are

demographically if not evolutionarily distinct, that population structure appears to be maintained by geographic barriers and natal homing behavior, while asymmetry in dispersal may be associated with the type of mating system. The combined mtDNA-microsatellite data indicate that the Cook Inlet stock is both demographically and reproductively isolated from other groups in Alaska and northwest Canada and possibly has been for several thousand years. Therefore, it should be treated as a separate management stock. At present we are continuing to examine genetic variation among beluga whales to clarify the relationships among some areas (e.g., Kotzebue Sound vs. Point Lay, northern vs. southern Norton Sound, Alaska vs. Russia), and to learn more about beluga whale group structure and breeding patterns.

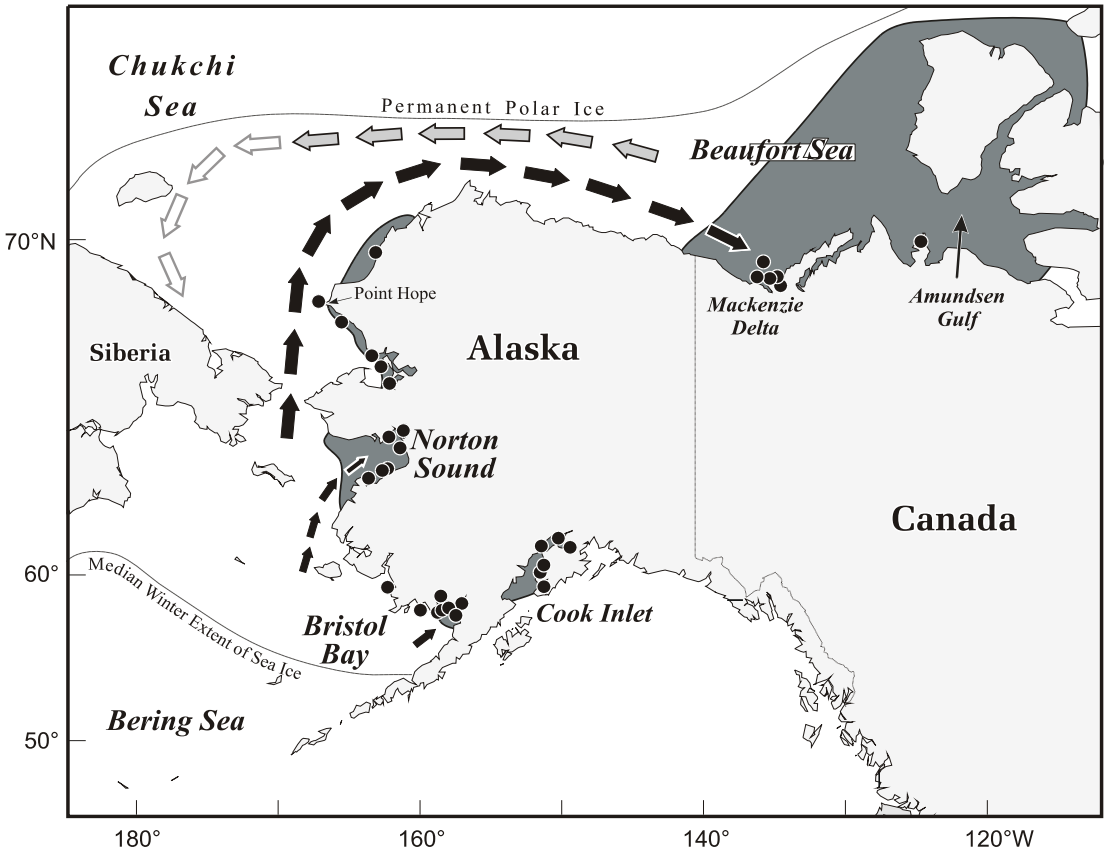

Figure 5. The five major summering areas of beluga whales in Alaska and Northwest Canada indicated with dark shading (O'Corry-Crowe et al. 1997). Dark arrows show the prominent direction of springtime migrations; lighter arrows show the fall migration of the Beaufort stock.

3.0 COOK INLET HABITATS

3.1 Beluga whale habitat associations in Cook Inlet

by S.E. Moore[1], D.J. Rugh[1], K.E.W. Shelden[1], and B.A. Mahoney[2]

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A review of habitat associations for beluga whales resident in Cook Inlet was undertaken to complement population assessment surveys conducted from 1993 to 1998. The summer distribution of beluga whale groups within the Inlet was used to delineate areas of high (Region 1), moderate (Region 2) and low (Region 3) concentration (Fig. 6). Physical, ecosystem, and anthropogenic factors that may affect beluga whale distribution were summarized from the available literature and tabulated for each Region (Table 1). Physical factors include bathymetry, substrate, surface currents, tidal range, salinity, and ice cover. Ecosystem factors include prey variability, predator variability, strandings, and disturbance events (e.g., volcanoes and fires). Anthropogenic factors include commercial and sport fishing, oil and gas activities, water quality, transportation, and tourism. Much of the available literature is descriptive in nature and could be greatly improved by integration of quantifiable measures of habitats associated with beluga whales. Recommendations include: 1) obtaining data on seasonal runs of fish in rivers used by beluga whales, and 2) measuring anthropogenic factors (such as fishery bycatch and underwater noise) within and outside of beluga whale concentration areas.

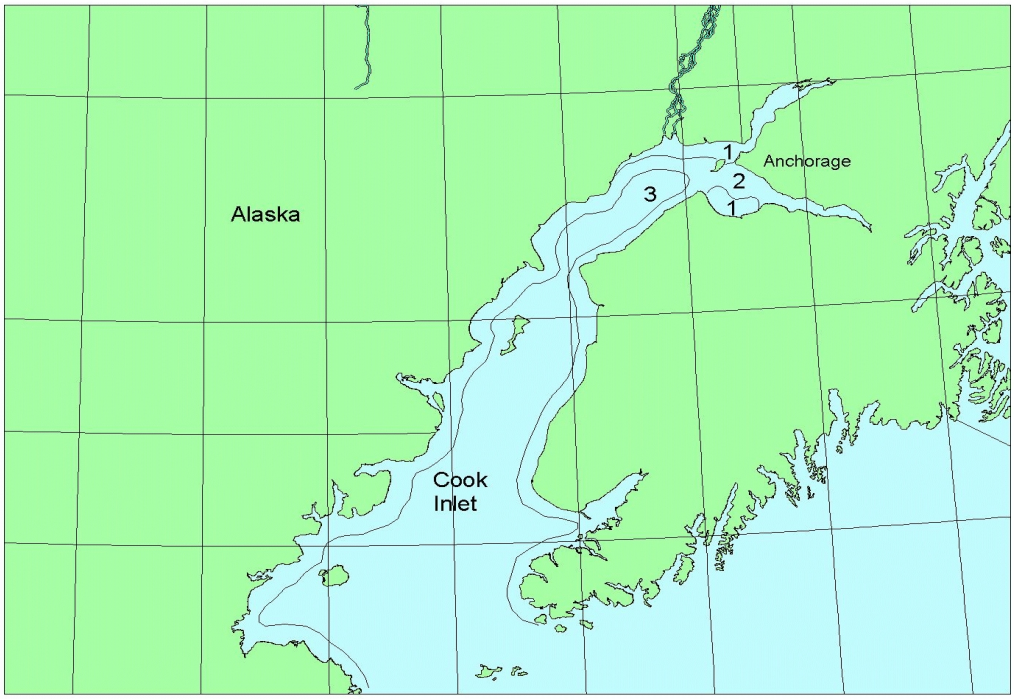

Figure 6. Provisional Cook Inlet regions based upon areas of high (Region 1), moderate (Region 2), and low (Region 3) occurrence of beluga whales during summer aerial surveys. Region 1 includes the shoreline from the Beluga River extending into Knik Arm and the shoreline from Pt. Possession to Chickaloon Bay. Region 2 includes Turnagain Arm and the rest of the shoreline of the upper and lower inlet. Region 3 includes central waters of the upper and lower inlet.

Table 1. Physical, ecosystem, and anthropogenic factors that may affect beluga whale distribution in three regions of Cook Inlet.

	Region 1	Region 2	Region 3
Beluga Distribution			
Summer	High	Moderate	Low
Winter	Occasional	Occasional	Moderate
Physical Factors			
Bathymetry	Shoals/shallow	Shallow	Shallow/channels
Tides and Currents	Extreme and variable	Extreme and variable	Moderate and channeled
Salinity and Sea Ice			
Summer	Fresh water and no ice	Fresh water and no ice	Fresh/saline and no ice
Winter	Unknown and ice-covered	Unknown and brash ice	Unknown and ice-free
Ecosystem Factors			
Prey Variability	Concentrated fish runs (?)	Fish runs (?)	Dispersed fish runs (?)
Predators	Low	Low	Moderate? (Lower Inlet)
Strandings	High	High	Low
Disturbance Events	Unknown	Unknown	Unknown
Anthropogenic Factors			
Fishing/bycatch	Low	Low	Low
Oil and Gas	Low	High - West Side	High - West Side
Transportation	High - Anchorage	Low	High
Water Quality	Poor	Poor	Moderate

3.2 Concentrations of chlorinated hydrocarbons, heavy metals, and other elements in beluga whale tissues banked by the Alaska Marine Mammal Tissue Archival Project

by P.R. Becker

National Institute of Standards and Technology, U.S. Dept. Commerce, Charleston Laboratory, 219 Fort Johnson Road, Charleston, SC 29412

Tissues from three of the Alaskan stocks of beluga whales (Beaufort Sea, Eastern Chukchi Sea, and Cook Inlet) that were archived by the Alaska Marine Mammal Tissue Archival Project (AMMTAP) have been analyzed for polychlorinated biphenyls (PCBs), chlorinated pesticides, heavy metals, and other elements. Blubber of animals from these Alaskan stocks contained PCB congeners, DDT, chlordane compounds, hexachlorobenzene (HCB), dieldrin, mirex, toxaphene, and hexachlorocyclohexame (HCH) concentration ranges similar to those found in belugas from the Canadian Arctic and much lower than those in belugas from the highly contaminated St. Lawrence River. Females of each stock had lower mean concentrations than did males, a result attributable to the transfer of these compounds from mother to calf during pregnancy and during lactation. The Cook Inlet stock had the lowest levels of these compounds of the stocks examined. This result might be due to differences in tissue sources, ages of the animals sampled, or differences in the species, structure, or contaminant levels within the local food web. Liver concentrations of cadmium and mercury were also lower in the Cook Inlet stock (Figs. 7a and 7b), but copper levels were substantially higher in the Cook Inlet animals than in either the Beaufort Sea or Eastern Chukchi Sea stocks (Fig. 7c). Although total mercury levels were lowest in the Cook Inlet stock, methyl mercury concentrations were similar among the stocks, with those in animals in Cook Inlet ranging from 0.09 mg/kg wet weight in a fetus to 2.11 mg/kg wet weight in a large male (median levels were 0.5 for females and 1.5 for males).

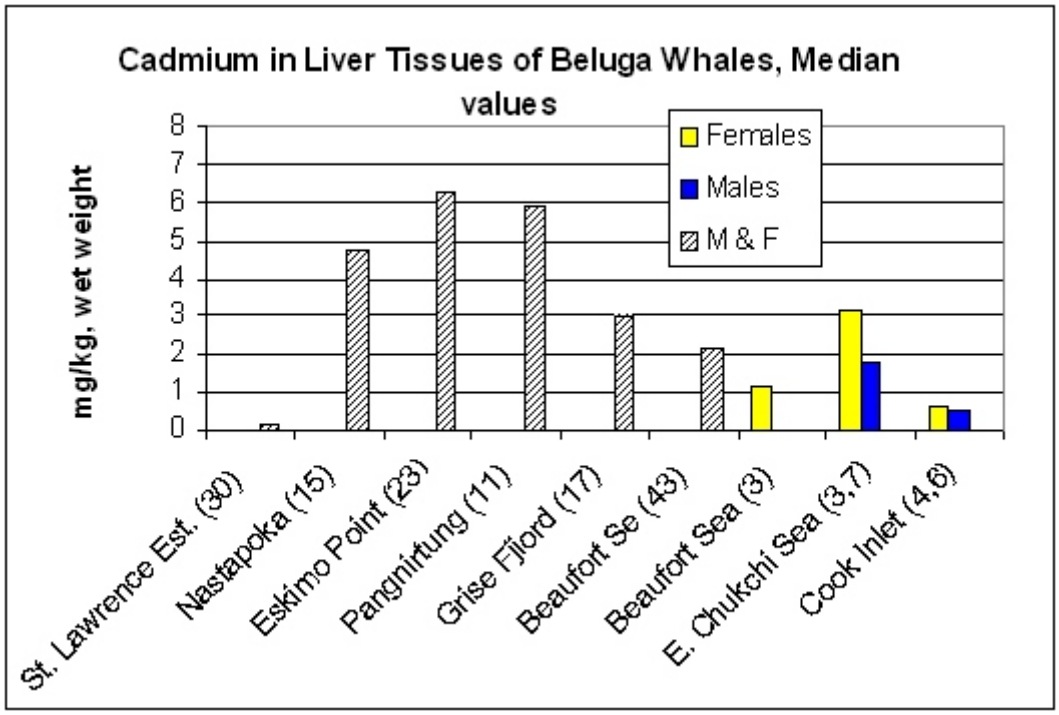

Figure 7a. Cadmium concentrations in beluga whale liver tissues (number of females and males are in parentheses).

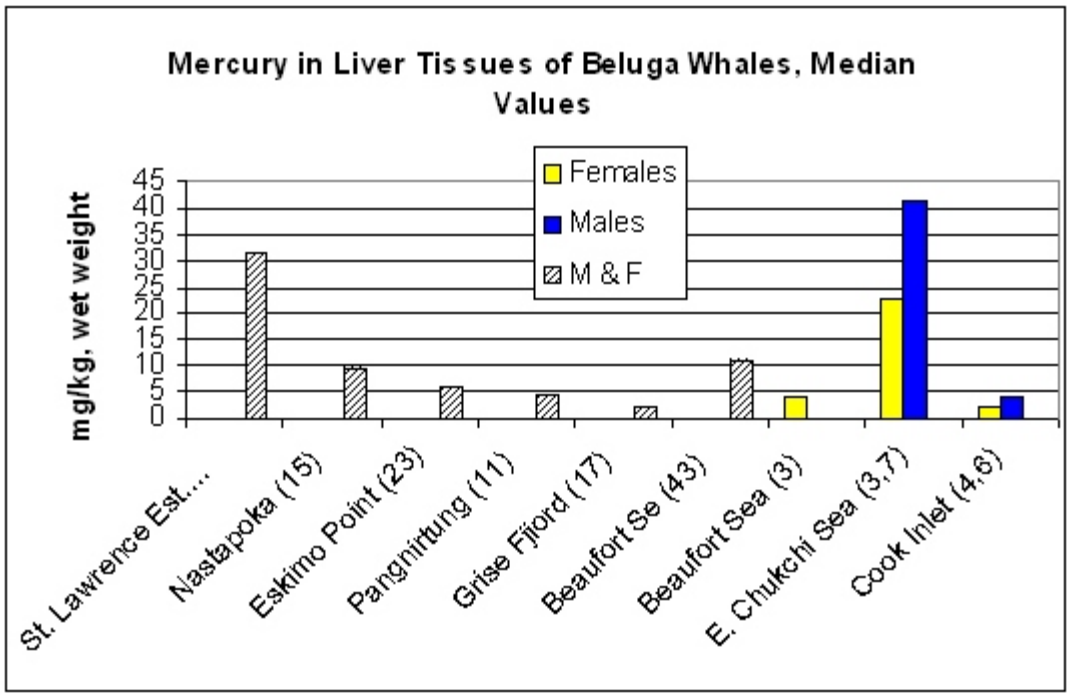

Figure 7b. Mercury concentrations in beluga whale liver tissues (number of females and males are in parentheses).

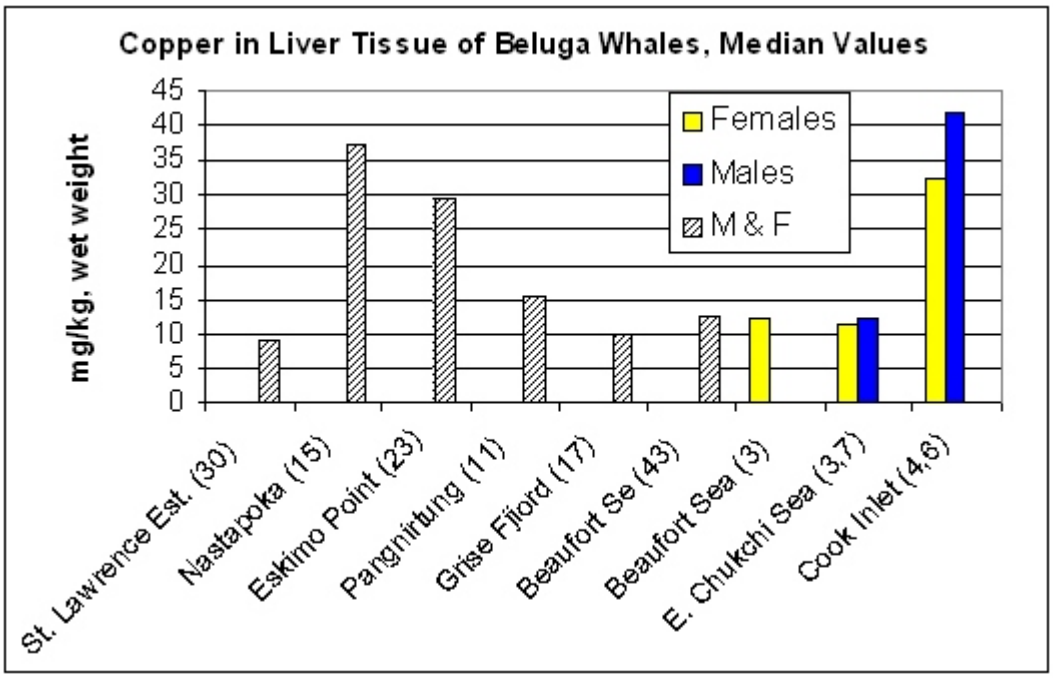

Figure 7c. Copper concentrations in beluga whale liver tissues (number of females and males are in parentheses).

4.0 ABUNDANCE ESTIMATION

4.1 The surfacing behavior of beluga whales in Cook Inlet: results from suction-cup attached VHF transmitter studies

by J.A. Lerczak, K.E.W. Shelden, and R.C. Hobbs

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Suction-cup attached VHF radio transmitters were deployed on beluga whales in Cook Inlet in 1994 and 1995 to characterize the whales' surfacing behavior. Data from video recordings were also used to characterize behavior of undisturbed whales and whales actively pursued for tagging. Statistics for dive intervals (time between the midpoints of contiguous surfacings) and surfacing intervals (time at the surface per surfacing) were estimated. Operations took place on the tidal delta of the Big and Little Susitna Rivers. A total of eight whales were successfully tagged. Five tags remained attached for >60 minutes, and data from these were used in the analyses. The mean dive interval was 24.1 sec (inter-whale SD = 6.4 sec, n = 5). The mean surfacing interval, as determined from the duration of signals received from the radio transmitters, was 1.8 sec (SD = 0.3 sec, n = 125) for one of the whales. However, the time that a whale was visible at the surface was longer than the time that the radio transmitter was at the surface because the radio transmitter represented one point on the whale, and no more than half of the whale was visible at a time during a slow roll. Video-taped behaviors were categorized as "head-lifts" or "slow-rolls." Beluga whales were more likely to head-lift than to slow-roll during vessel approaches and tagging attempts when compared to undisturbed whales. In undisturbed groups, surfacing intervals were significantly different between head-lifting ($\bar{x}$ = 1.02 sec, SD = 0.38 sec, n = 28) and slow-rolling whales ($\bar{x}$ = 2.45 sec, SD = 0.37 sec, n = 106). Undisturbed juveniles exhibited shorter slow-roll surfacing intervals ($\bar{x}$ = 2.25 sec, SD = 0.32 sec, n = 36) than adults ($\bar{x}$ = 2.55 sec, SD = 0.36 sec, n = 70). Reactions to disturbance were consistent with those observed in other studies of beluga whales. Beluga whales did not exhibit strong reactions to suction-cup tags. This tagging method shows promise for obtaining surfacing data for durations of a day or less from a large sample of beluga whales, particularly in environments like Cook Inlet where capturing whales for the attachment of long-term tags is very difficult.

4.2 Estimates of beluga whale group sizes in Cook Inlet from aerial video recordings

by R.C. Hobbs and J.M. Waite

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Videotapes of beluga whale groups were collected concurrently with counts made by observers during annual aerial surveys of Cook Inlet from 1994 to 1998. From these aerial video tapes, 165 counts of 54 whale groups were made. The McLaren Formula was used to account for whales missed underwater (average correction factor = 1.94; SD = 0.60). A correction for whales missed due to video resolution was developed by using a second video camera with a telephoto lens focused on a portion of the field of view obtained by the counting video. Whale images in this magnified view were matched to whales in the counting video, and the missed whales were noted. Whales were missed either because their image size fell below the resolution of the video or because two whales surfaced so close to each other that their images ran together. The correction method that resulted depended on knowing the average whale image size in the counting videos. Image sizes were measured for 1,218 whales from 70 different passes over whale groups. Groups for which the average image size was not measured were given the average correction factor from the other groups (average correction = 1.17; SD = 0.04). Group sizes were estimated as the product of the count, the correction factor for whales missed underwater, and the correction factor for whales missed due to video resolution. These estimated group sizes were used in annual abundance estimates (see Section 4.3).

4.3 Abundance of beluga whales in Cook Inlet, 1994-98

by R.C. Hobbs, D.J. Rugh, and D.P. DeMaster

National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way N.E.,Seattle, WA 98115-0070.

Annual abundance estimates of beluga whales in Cook Inlet were calculated based on counts made by aerial observers and group sizes estimated from aerial video recordings. Whale group sizes examined in the videos were corrected for subsurface animals (availability bias) and animals that were at the surface but were missed (detection bias). A formula for estimating group sizes from counts by aerial observers was developed by regression of the counts and an interaction term based on encounter rate (whales per second during counting of a group) against the group sizes estimated from the video recordings. Logistic regression was used to estimate the probability that entire groups were missed during the systematic surveys. It was estimated that some whale groups may have been missed by both primary observers, but these would have constituted only 1.5% of the total abundance estimates. Abundance at the time of the June 1998 survey was estimated at 347 whales (SE = 101, CV = 0.29, N_{min} = 273; Fig. 8). Monte Carlo simulations indicate a 47% probability that the June 1998 abundance of the Cook Inlet stock of belugas was depleted to 50% of the abundance in June 1994 (Fig. 9).

Prior to November 1998, NMFS had used an abundance estimate of 881 whales for 1994 (cf. Hill et al. 1997). This was based on a preliminary estimate of 747 whales (CV = 0.19; Hobbs et al. 1995) multiplied by a correction factor (1.18) to account for small gray-colored whales that were probably missed by observers. The estimate of 747 whales was based on counts and video recordings from the June 1994 survey. At the time there was not enough data to estimate the fraction of the population in groups that were missed by the observers. Consequently the largest single-day abundance estimate was used as the seasonal abundance estimate. As more data became available, the fraction of the population in groups that were missed was estimated to be 1.5%. With this fraction estimated, the average abundance was substituted for the largest single-day estimate and used in the final abundance estimate (653) for 1994.

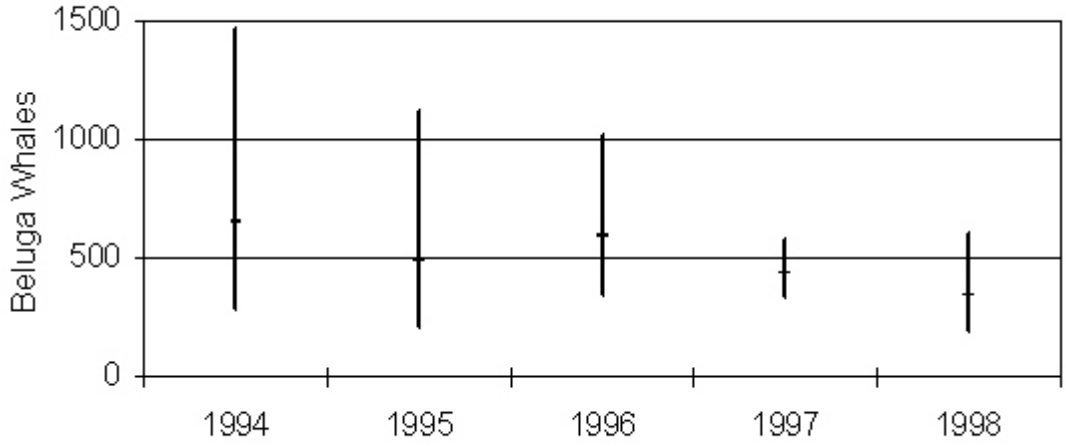

Figure 8. Estimated abundance of beluga whales in Cook Inlet. Cross bars show the best estimate of abundance of each year; vertical bars represent the 95% confidence intervals.

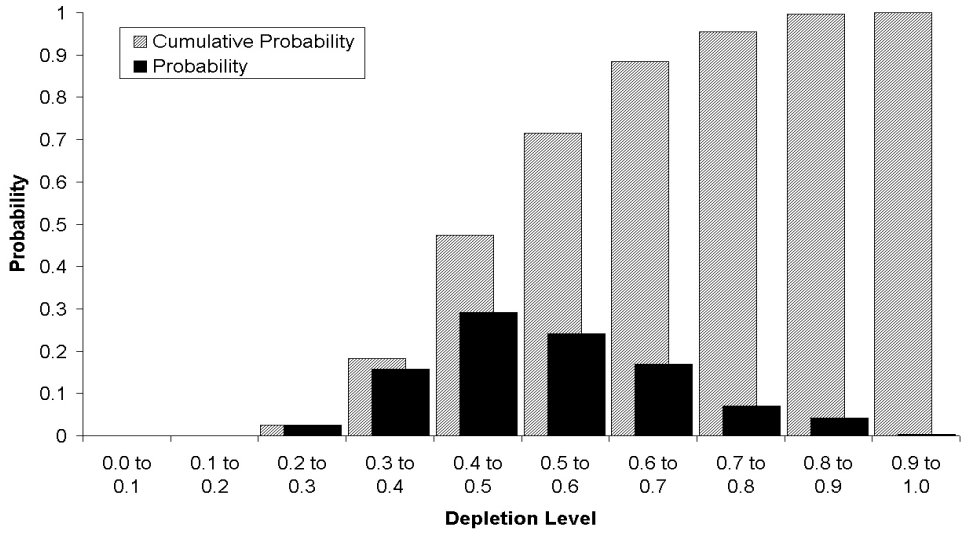

Figure 9. Probability distribution of depletion level at the time of the June 1998 aerial survey. The cumulative probability represents the probability that the depletion level is less than the upper bound of the interval represented.

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