Lowry, L., O'Corry-Crowe, G., and Goodman, D. In press (2006). *Delphinapterus leucas* (Cook Inlet population). In: IUCN 2006. *2006 IUCN Red List of Threatened Species.*

BELUGA WHALE, *Delphinapterus leucas*: Cook Inlet Population
Critically Endangered: C2a(ii)

Population Identity: Based on studies of mitochondrial DNA, Cook Inlet belugas are genetically distinct from the other four beluga populations that occur in western and northern Alaska (O'Corry-Crowe et al. 1997; O'Corry-Crowe, pers. comm.). There have been only two beluga sightings recorded in the region between Cook Inlet and the nearest beluga population in Bristol Bay (Frost and Lowry 1990; Laidre et al. 2000), suggesting that the 900 km long Alaska Peninsula is an effective barrier to movement and that the Cook Inlet population is geographically and reproductively isolated from beluga populations to the west (Figure 1). A thorough review of survey effort in the Gulf of Alaska (Laidre et al. 2000) produced regular sightings of belugas in only two regions, Cook Inlet and Yakutat Bay. The beluga group in Yakutat Bay is very small, probably numbering only 10-20 individuals (Laidre et al. 2000, O'Corry-Crowe et al., 2006). The demographic and genetic relationships between belugas in Cook Inlet and Yakutat Bay are currently poorly known, but since animals are seen in both areas year round (Hubbard et al. 1999; Moore et al. 2000; Laidre et al. 2000) and there have been very few sightings in the intervening 700 km long region (Laidre et al. 2000) it is possible that the Cook inlet population is also isolated from the whales in Yakutat Bay. The occurrence of belugas in Yakutat Bay will not be considered further in this evaluation.

Dedicated aerial surveys for belugas have been conducted mostly in the summer concentration areas, Yakutat Bay and Cook Inlet. However, the adjacent and intervening areas of the Gulf of Alaska are frequently surveyed by marine mammal researchers studying other species, and are regularly traversed by fishermen and other coastal residents who commonly report unusual marine mammal sightings. We consider the lack of reported sightings in these regions to be a reliable indication that the Cook Inlet beluga population is geographically isolated.

Countries of Occurrence: United States of America

FAO Fisheries Area: 67

Historical and Current Range: Resident in Cook Inlet (near Anchorage, Alaska; Figure 2) throughout the year with few sightings in the Gulf of Alaska outside of the Inlet (Laidre et al. 2000). During the 1970s, the summer distribution included the upper, central, and parts of the lower regions of the inlet, and both coastal and offshore waters (Harrison and Hall 1978; Murray and Fay 1979). The current summer distribution is restricted to shallow coastal and estuarine areas in the upper inlet (Rugh et al. 2000; Speckman and Piatt 2000). Although winter sightings have been rare historically, belugas were presumed to move to the lower (i.e., southern) regions of Cook Inlet in winter to avoid heavy ice conditions in the upper Inlet (Calkins 1986). However, recent results from aerial surveys (Hansen and Hubbard 1999; Rugh et al. 2004) and satellite-linked tagging studies (Hobbs et al. 2005) indicate that many if not all belugas remain in the upper Inlet throughout the winter. During 2000-2003 some tagged belugas used Knik and Turnagain arms during all months of the year, and the tagged animals rarely ranged south of the

Forelands. The area of upper Cook Inlet now most used by belugas (stippled region in Figure 2) covers approximately 3,800 km^2, and this figure provides an estimate of the minimum size of the area of occupancy. The portion of central Cook Inlet from the Forelands to Iniskin and Kachemak bays where occasional sightings have been made in recent years (Figure 2) includes an additional area of approximately 7,500 km^2. The current extent of occurrence is therefore on the order of 11,000 km^2. A comparison of distributional information across the records of summer surveys in different years revealed a decrease in sightings of whales in both the offshore areas and the lower regions of the inlet, indicating a reduction in the area of occupancy during this season since the mid-1970s (Rugh et al. 2000).

Habitat: Cook Inlet is a very dynamic environment with large tides, strong currents, and seasonal sea ice cover (Moore et al. 2000). During aerial surveys flown in June and July 1993-2000 beluga whales were seen exclusively in shallow, nearshore, low-salinity waters of upper Cook Inlet, especially off the mouths of large rivers and in Knik and Turnagain arms (Rugh et al. 2000). Belugas are believed to concentrate in those areas to feed on out-migrating salmon smolt and spawning runs of anadromous fishes (Calkins 1984, 1986; Rugh et al. 2000; Moore et al. 2000). Also, the shallow waters of the upper Inlet and coastal zone may provide refuge from predators and suitable habitat for calving and nursing (Rugh et al. 1999; Moore et al. 2000). Satellite-linked telemetry studies showed a tendency for belugas to spend more time in deeper offshore waters of the upper Inlet during winter months, although they continued to use Knik and Turnagain arms (Hobbs et al. 2005).

Population Abundance and Trend: Aerial counts of belugas in Cook Inlet date to the early 1960s (Klinkhart 1966) but those efforts generally produced only minimum counts and/or rough estimates of abundance. The best available estimate of historical population size is based on an aerial survey count of 479 whales made in August 1979 (Calkins 1989), and a correction factor for missed animals of 2.7 that was derived from studies of radiotagged belugas in Bristol Bay, Alaska (Frost et al. 1985). Using those figures NMFS (2003) calculated a minimum abundance estimate of 1,293 whales. Annual systematic surveys to estimate total abundance began in 1993, and the protocols used have been consistent since 1994. Annual estimates of abundance declined from 653 (CV = 0.43) in 1993 to 435 (CV = 0.23) in 2000 and Monte Carlo simulations indicated a 47% probability that there was a decline of at least 50% over the period 1994-1998 (Hobbs et al. 2000). Subsequent abundance estimates have been 386 (CV = 0.09) in 2001, 313 (CV = 0.12) in 2002, 357 (CV = 0.11) in 2003, 366 (CV=0.20) in 2004, and 278 (CV=0.18) in 2005 (D. Rugh and R. Hobbs, pers. comm.).

Differences in survey design and analytical techniques prior to 1994 rule out a precise statistical assessment of trends using the first available population estimate. Simply comparing the estimate of 1,293 in 1979 to 278 in 2005 indicates a 78% decline in 26 years, but with unspecified confidence.

The 1994-2005 surveys were statistically defined, and allow rigorous evaluation of the decline and the underlying population dynamics during the more recent period. A Bayesian inference was conducted on the underlying rate of increase, R_{max}, and the true 1994 population size, using the Taylor and DeMaster (1993) model for density dependent population growth with the conventional shape parameter value z=2.3898, an assumed value of K=1,300 (based roughly on the earliest survey estimate), fitting to the 1994 through 2005 time series of population estimates, reported coefficients of variation of the respective estimates, and the harvest estimates (D. Goodman, unpublished). The results of annual estimates of population size from the model are shown in Figure 3. Comparing the mode of the Bayesian distribution for the 2005 population size (329) to the 1979 estimate indicates a decline of 75% over the 26-year period.

In the present model, R_{max} represents the growth rate that the population would exhibit in the absence of crowding and the absence of harvest, all other things (including favorability of the environmental state) being equal, as revealed from observed growth in the given data set. Thus, R_{max} does not necessarily indicate the potential growth rate under optimal conditions. The Bayesian analysis used broad independent uniform priors for the two unknown parameters, and a normal likelihood for the observation error in the census. The Bayesian analysis yielded a posterior distribution for R_{max} that is abnormally low (Figure 4) compared to the expectation that a small cetacean population should have a value of R_{max} in the range from 2% to 6%, with the average expected to be around 4% (Wade 1999). Based on this analysis the probability is 99% that R_{max} for the Cook Inlet beluga population is less than the expected average normal value, and the probability is 93% that R_{max} is lower than the expected normal range. The probability is 71% that R_{max} is actually negative for this population over the period covered by the data (1994-2005). The modal estimate of R_{max} from the Bayesian inference is -1.2, indicating a population that is declining by about 1% per year. If these underlying dynamics continue, and the future harvest is zero, there is a 22% probability that the population will be further halved from its 2005 abundance within 30 years.

To evaluate taxa based on Red List Criteria, IUCN defines population size as the number of mature individuals. There are no data available on the sex and age composition of the Cook Inlet beluga population or on the age at which animals attain sexual maturity. Such information is available from other harvested beluga populations, and although the data may be subject to biases from non-random distribution of sex/age classes and harvest selectivity it can be used to estimate the number of animals that are mature. Critical to this determination is the ability to accurately determine the age of individuals, which for beluga whales and other toothed cetaceans is typically done by counting growth layer groups (GLGs) in their teeth. For beluga whales it has generally been assumed that two GLGs are deposited each year (Burns and Seaman 1986; Heide-Jørgensen et al. 1994; Suydam 1999). Hohn and Lockyer (1999) questioned that assumption, citing what they regarded as convincing evidence of a one GLG/yr deposition rate. However, examination of teeth from two known age captive animals has confirmed the two GLG/yr assumption (Goren et al. 1987; Heide-Jørgensen et al. 1994) and we will assume that is the true situation. For the eastern Bering and eastern Chukchi seas, Burns and Seaman (1986) estimated the first age of sexual maturity to be 4-7 years old for females. Heide-Jørgensen and Teilmann (1994) produced estimates of 4-7 years old for first age of maturity for females and 6-7 years old for males for West Greenland belugas. Based on the life table in Burns and Seaman (1986), 63% of belugas in western Alaska would be 6 years old and older. However, the proportion capable of reproduction may be somewhat less if reproductive senescence occurs in older females (Burns and Seaman 1986; Suydam 1999). The Bayesian inference procedure described above delivered a posterior distribution for the 2005 population size (Figure 5). This shows a 95% probability that the population is in the interval 278-388. Using the mode of the Bayesian distribution of population sizes (329) and the estimate of 63% mature gives an estimate of 207 mature individuals in the population.

Generation Time: Generation time, estimated as the average age of parents of the current cohort, cannot be calculated directly for Cook Inlet belugas because data on reproductive characteristics and age distribution are lacking for that population. Elsewhere in Alaska, the age of first parenthood for female belugas is 5-8 years (Burns and Seaman 1986). Males probably are physiologically capable of breeding at about the same age (Heide-Jørgensen and Teilmann 1994). Maximum ages recorded by Burns and Seaman (1986) were 35 years for females and 38 years for males. These estimates may be biased low due to tooth wear (Heide-Jørgensen et al. 1994). Based on the life table in Burns and Seaman (1986), the average age of belugas 6 years and older was 16.1 years. We have no way to determine if these vital parameters are similar for Cook Inlet belugas. Nonetheless, we consider 16 years to be the best available estimate of the average age of parents in the Cook Inlet population, and the generation time.

Major Threats: Moore et al. (2000) reviewed potential threats to Cook Inlet belugas from natural catastrophes (fires, earthquakes, and vulcanism) and found no reported negative effects on belugas or their habitat. Availability of prey likely has a strong influence on the Cook Inlet beluga population (Moore et al. 2000). Few data are available on prey abundance except for the commercially harvested salmon species. Speckman and Piatt (2000) speculated that availability of beluga prey species may have changed in the lower Inlet as part of a general regime shift in the Gulf of Alaska. Local residents perceive that there has been a general decline in the abundance of fish in Cook Inlet in recent years (Huntington 2000). It is also possible, if not likely, that climatic warming may change characteristics of the Cook Inlet environment and fauna in ways that will effect beluga whales, but currently there are no data that can be used to evaluate this possibility.

Shelden et al. (2003) reviewed data on killer whale predation in Cook Inlet, and although they accounted for 21 belugas killed by killer whales between 1985 and 2002 they concluded that predation was a small contribution to overall mortality. However, because this population is currently at a very low size, normal fluctuations in prey availability and predation may affect its ability to recover.

Prior to 1972 there were periodic commercial and sport hunts for beluga in Cook Inlet (Mahoney and Shelden 2000; NMFS 2003), but those activities ceased with passage of the Marine Mammal Protection Act (MMPA). Native Alaskans have hunted belugas in Cook Inlet from earliest times (Huntington 2000; Mahoney and Shelden 2000). During much of the last century, subsistence removals appear to have been modest. A number of factors, including rapid human population growth and improvements in equipment, resulted in an increase in subsistence hunting in Cook Inlet during the 1980s. By the mid to late 1990s, the harvest was unsustainable. It has been estimated that an average of 67 whales were removed each year from 1994-1998, and that level was considered sufficiently high to account for most of the decline in abundance observed during that period (NMFS 2003). There was no legal harvest allowed in 1999. Since 2000, NMFS has entered into annual co-management agreements with Alaska Native organizations to allow a limited hunt, and five whales total were harvested during 2000-2005 (Angliss and Lodge 2004; B. Mahoney, pers. comm.). Other factors must be invoked to account for the abnormally low underlying growth rate (R_{max}) exhibited by the population, or to account for the failure to show signs of recovery since the reduction of the harvest to very low levels.

Other factors that could have an adverse effect on Cook Inlet belugas include fishery interactions, contaminants and noise associated with oil and gas exploration and production, vessel traffic, and municipal activities such as waste management and urban runoff (Moore et al. 2000; NMFS 2003). In the course of a review of subsistence harvest management, NMFS concluded that the available evidence could not persuasively attribute much past influence to these non-harvest factors and further asserted that they were unlikely to affect the Cook Inlet beluga population in the foreseeable future (NMFS 2003). The NMFS analysis did not recognize that the population was failing to recover as expected or that the evident R_{max} was abnormally low. The quality and quantity of data for describing impacts or predicting effects of such factors on belugas vary greatly. Levels of heavy metals, PCBs, and chlorinated pesticides are much lower in Cook Inlet belugas than in other beluga stocks in Alaska (Becker et al. 2000). Observer programs and other reports indicate that current incidental take in commercial fisheries is very low (Moore et al. 2000; Angliss and Lodge 2004). However, evaluating the effects of noise is complicated, determining the impact of municipal discharges may not be possible, and no data are available to describe or predict the effects of an oil spill on belugas. Nonetheless, the fact remains that Cook Inlet is no longer a remote, pristine area. Over 350,000 people live in the municipality of Anchorage and the two adjacent boroughs, and there are two large military bases in the area (NMFS 2003). The analysis by NMFS concluded that: "A significant part of the habitat for this species has been modified by municipal, industrial, and recreational activities in Upper Cook Inlet" (NMFS 2003, p. 88). A number of other significant habitat modifications are likely to occur in the near future.

Random demographic, environmental, and genetic factors can accelerate or even cause the extinction of small populations. Catastrophic events such as mass die-offs due to stranding, disease, or acute exposure to toxic substances (e.g., oil spills) could push depleted populations of belugas to extinction (O'Corry-Crowe and Lowry 1997). Mass strandings of belugas are relatively common in the shallow tidal areas of upper Cook Inlet. Although most stranded individuals manage to swim away on the rising tide, some are known to die (Moore et al. 2000). The viability of small populations is further compromised by the increased risk of inbreeding and the loss of genetic variability through drift, which reduces their ability to cope with disease and environmental change (Lacy 1997; O'Corry-Crowe and Lowry 1997). Estimates of genetic variation do not, at present, suggest that Cook Inlet belugas are highly inbred or that a critical amount of genetic variation has been lost through drift (O'Corry-Crowe et al. 1997; G. O'Corry-Crowe, unpublished data), but this population is already in a size range where eventual loss of genetic variability is expected.

Conservation Measures: Belugas, like all marine mammals, are protected in the United States by the MMPA which prohibits all taking. Exemptions to the taking prohibition are allowed for subsistence hunting by Alaska Natives, scientific research, incidental take in commercial fisheries, and a few other activities. In February 1999, the Alaska Region of NMFS recommended that the sale of Cook Inlet beluga products (e.g., skin or muktuk as it is known locally) under the subsistence provisions of the MMPA should be prohibited or that a moratorium on the hunting of Cook Inlet belugas should be imposed. In May 1999, the U.S. Congress passed legislation that prohibited the taking of Cook Inlet belugas for subsistence unless such taking was authorized by a cooperative agreement between NMFS and the affected Alaska Native organization(s), and as a result there was no legal harvest that year. In 2000 a harvest of one whale was authorized by a cooperative agreement, but the hunt did not occur (Mahoney and Shelden 2000). In May 2000, NMFS, having determined that the Cook Inlet beluga stock was below its optimum sustainable population level, designated it as depleted under the MMPA (U.S. Federal Register 65:34590). The depleted listing provided NMFS with the regulatory authority to limit the Alaska Native subsistence harvest. An interim harvest regime was agreed upon through an Administrative Law Judge hearing, whereby the harvest during 2001-2004 would be limited to six strikes. Other provisions limited the hunting season, protected calves and adults with calves, prohibited sales of beluga parts and products, and provided for an emergency suspension of the hunt if an unusual number of non-hunting mortalities occurred (NMFS 2003). Hunting would only be allowed through cooperative agreements between NMFS and Alaska Native organizations.

In June 1991, NMFS added the Cook Inlet beluga population to the list of taxa considered candidates for listing as threatened or endangered under the U.S. Endangered Species Act (ESA) (U.S. Federal Register 56:26797). An ESA status review was initiated in November 1998 (U.S. Federal Register 63:64228). NMFS received two petitions in March 1999 requesting that Cook Inlet belugas be listed as endangered under the ESA. In June 2000, NMFS published a determination that listing the Cook Inlet population under the ESA was not warranted because they believed that no factor other than harvest had been identified at that time as having a significant adverse effect on the population (U.S. Federal Register 65:38778), and that harvest had been dealt with through the ongoing regulation of subsistence hunting.

Rationale for Listing: The Cook Inlet population of beluga whales has experienced a precipitous decline in recent years and currently numbers only in the low to mid hundreds. This decline has been accompanied by a reduction in the population's summer range. Over the period through 1998, overharvest was the major factor responsible for the decline in abundance. Since 1999 the reported harvest has been very small, but the population has failed to show expected signs of recovery. Analysis of the census and harvest data over the entire period of statistically defined surveys (1994 through 2005) shows that over this period the underlying population growth rate has been abnormally low. Based on the available data, the underlying growth rate is so low that there is a 71% probability that, if present conditions persist, the population cannot withstand any take, and will decline in the future. A range of factors other than human harvest could affect this population, either directly by decreasing survival and reproductive rates, or indirectly by affecting the belugas' prey and habitat. Cook Inlet belugas face a suite of risks common to small populations, including those related to demographic, environmental, and genetic stochasticity, amplified by the tendency of belugas to return annually to specific areas and to congregate in compact herds. This population's precarious situation is further exacerbated by our limited knowledge of its ecology, life history, and reproductive potential, and factors that may affect its habitats. However, at least for the present the population is being monitored by regular annual surveys that should allow new evaluations and updates of its status.

Evaluation for Listing as Endangered: The Cook Inlet beluga population qualifies for listing as Endangered under the following IUCN criteria:

- Criterion A2b. Based on an index of abundance showing that the population has likely declined by 75% in the last 26 years (approximately 1.5 generations).

- Criterion D. The population is estimated to number 207 mature individuals, well below the 250 threshold.

Evaluation for Listing as Critically Endangered: The Cook Inlet beluga population qualifies for listing as Critically Endangered under the following IUCN criterion:

- Criterion C2a(ii). The population is estimated to number 207 mature individuals. There is a 71% probability that the growth rate of the population is negative, with the best estimate indicating that the population is declining by 1.2% per year. All of the mature individuals are in one subpopulation.

Based on the information above, the proposed listing is Critically Endangered: C2a(ii). Key to this decision – i.e., to list as Critically Endangered rather than Endangered – is the fact that the population is continuing to decline even after the only identified cause of the decline (excessive hunting) has been controlled. Other factors must be affecting the dynamics of this population, and those factors have not yet been identified.

Consultation and Peer Review: IUCN Cetacean Specialist Group.

Year Assessed: 2005.

Assessors: Lloyd Lowry, University of Alaska, Fairbanks, AK, USA; Greg O'Corry-Crowe, Southwest Fisheries Science Center, La Jolla, CA, USA; Dan Goodman, Montana State University, Bozeman, MT, USA

Evaluators: Randall R. Reeves and Mads Peter Heide-Jørgensen

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Figure 1. Map of Alaska showing the locations of summering concentrations of western Alaska beluga stocks (stippled), Cook Inlet, and Yakutat Bay.

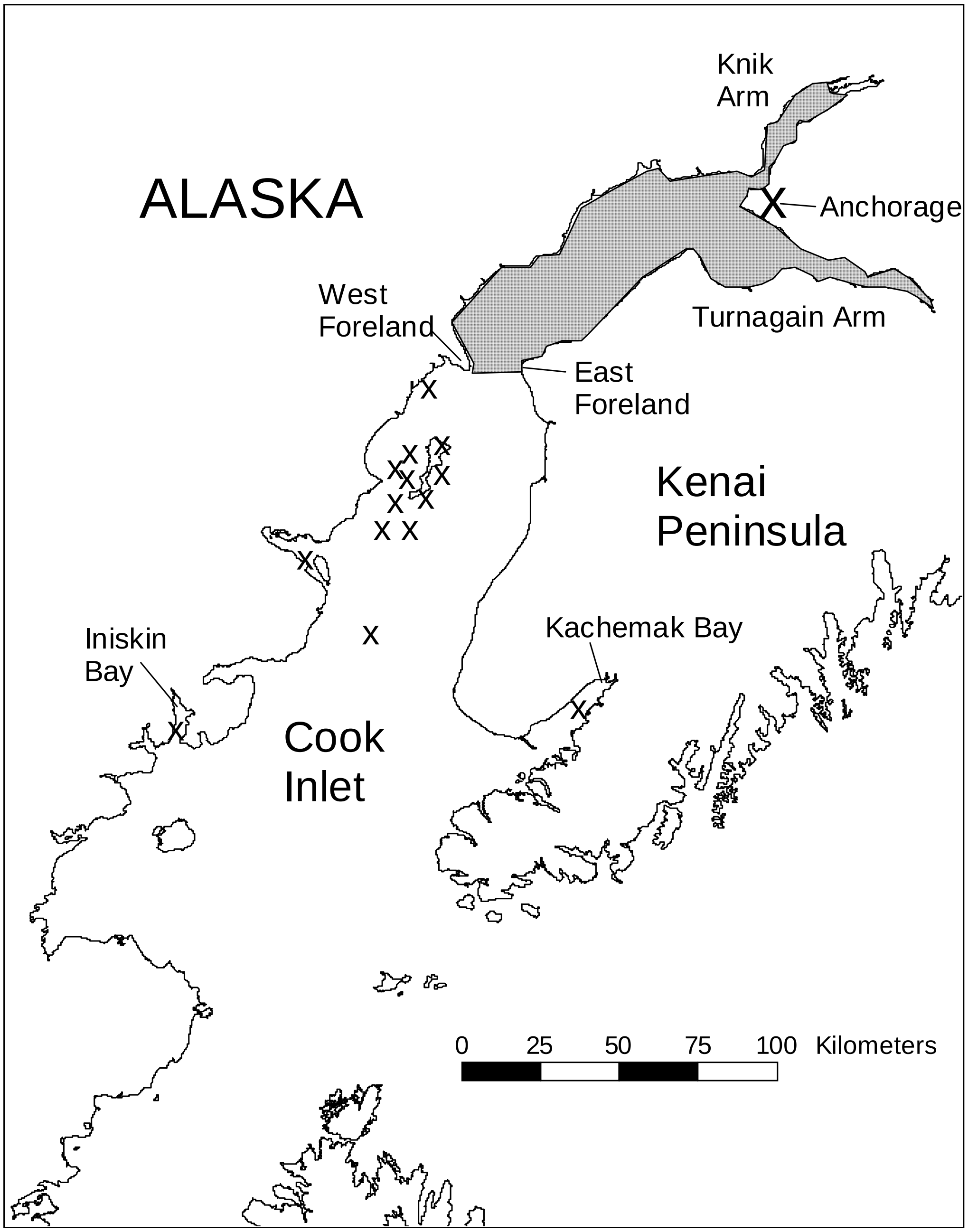

Figure 2. Map showing the main area of occurrence of Cook Inlet belugas (stippled) and other areas where sightings were made during summer and winter aerial surveys, 1993-2000 (dark dots).

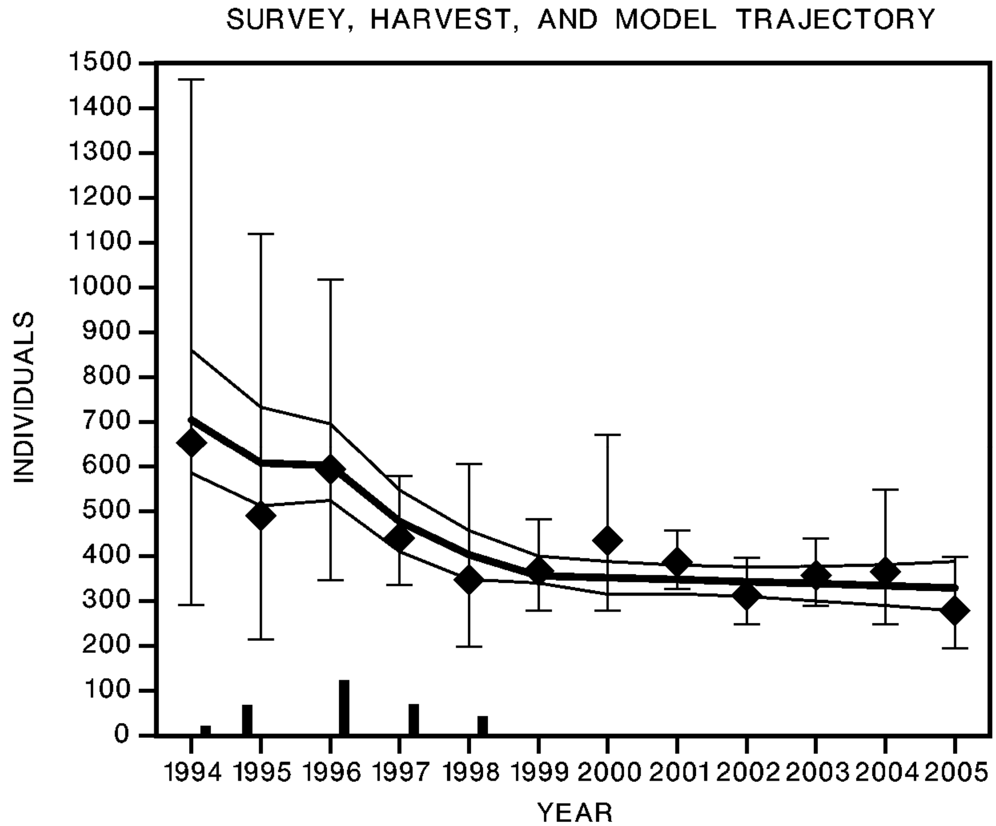

Figure 3. Bayesian inference on the population size of Cook Inlet belugas, 1994-2005. The Bayesian posterior mode, and the posterior 95% interval for the true population size, are shown as the one heavy and the two thin trajectories connecting those quantities for each year. The estimates of harvest landed plus struck and lost are shown as vertical bars from the x axis. The NMFS survey population estimate for each year is shown as a diamond, and the vertical thin bars show the survey 95% confidence intervals.

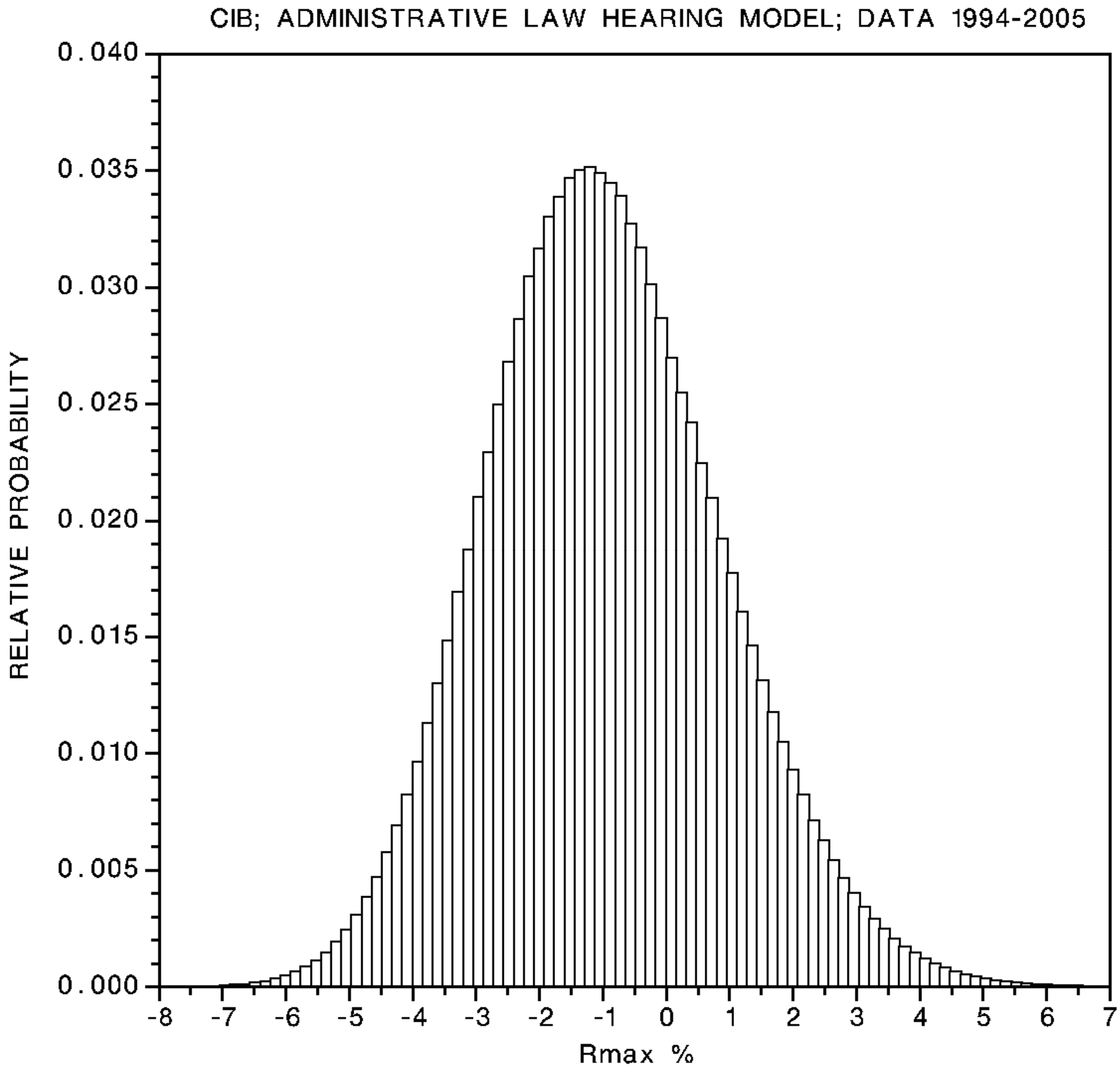

Figure 4. Bayesian inference on the underlying population growth rate of Cook Inlet belugas from fitting a density dependent growth model to the 1994-2005 population and harvest data.

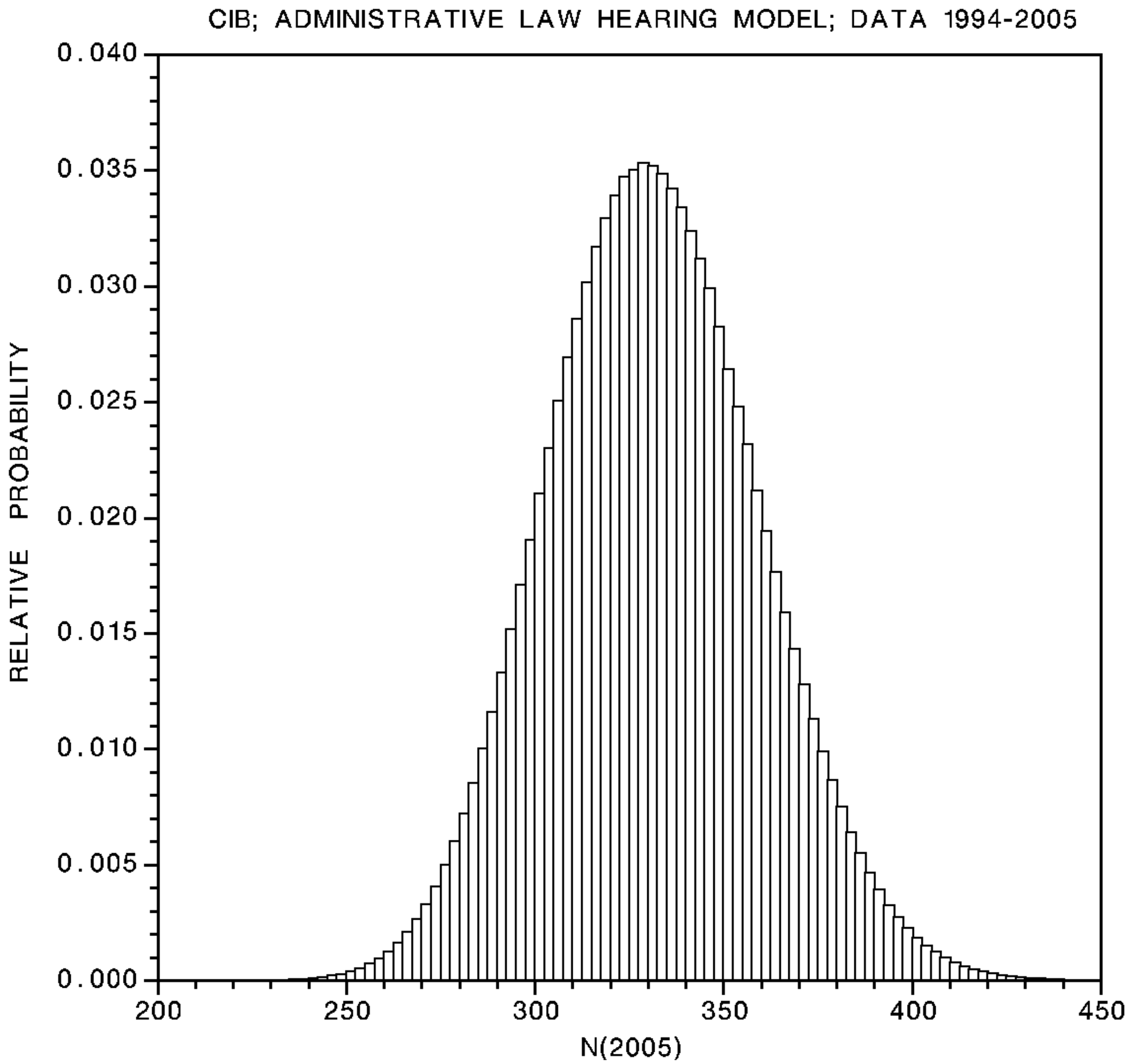

Figure 5. Bayesian inference on the 2005 population size of Cook Inlet belugas from fitting a density dependent growth model to the 1994-2005 population and harvest data.