Beluga Whale (*Delphinapterus leuca* Cook Inlet subpopulation)

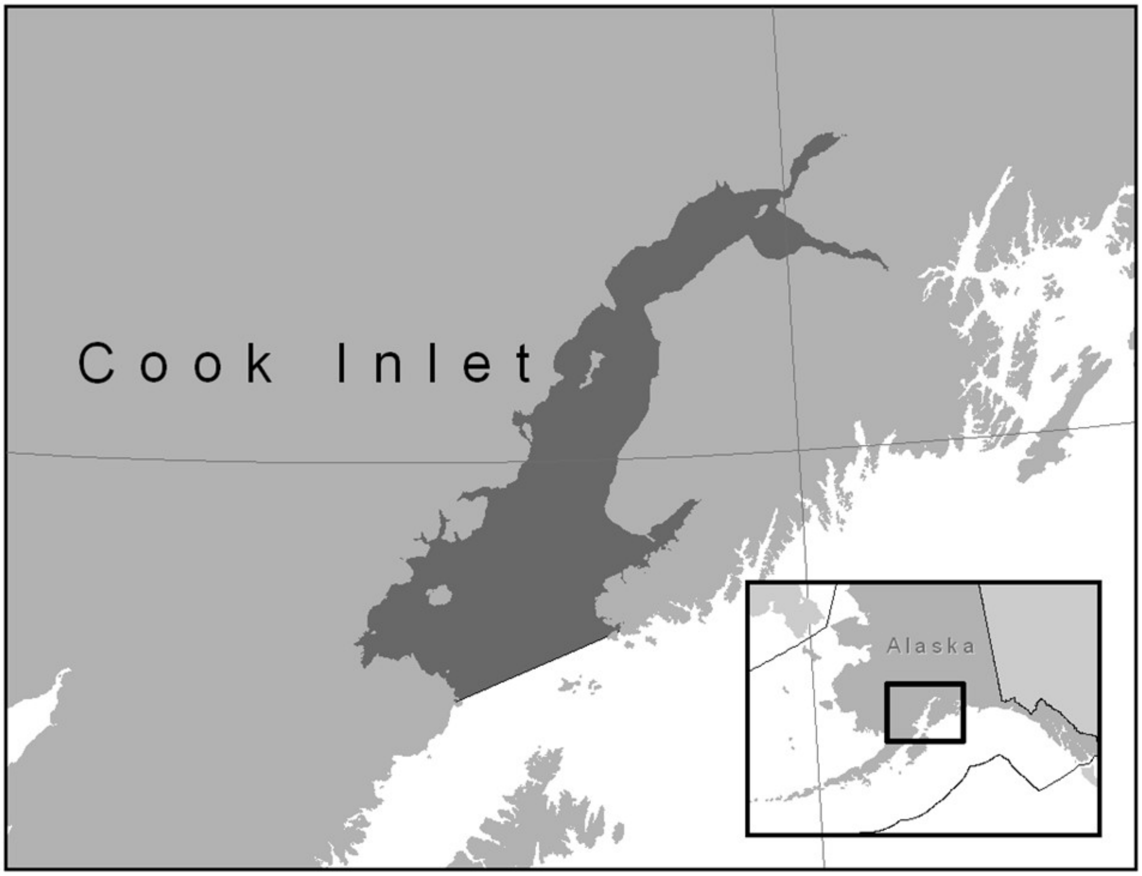

Figure 1. Range of Cook Inlet Belugas, from Muto *et al.* 2016.

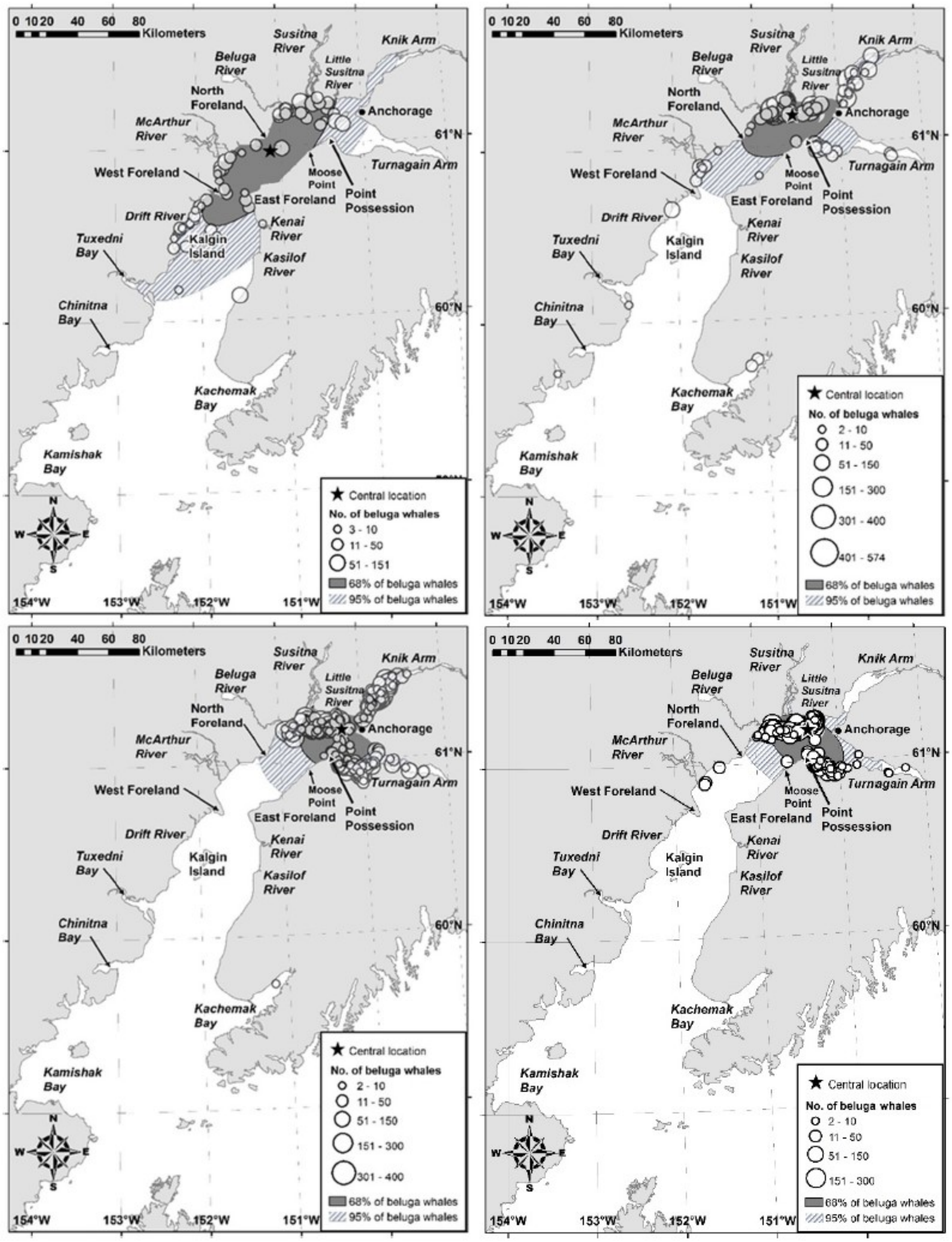

Figure 2. Observed distribution of Belugas in Cook Inlet, Alaska, during systematic aerial surveys in June and July during 1978–79 (upper left panel), 1993–97 (upper right panel), 1998–2008 (lower left panel), and 2009–16 (lower right panel). The star is the geographic center of the distribution, the dark gray region is the central 68%, and the striped region is the central 95% of the population. The open circles represent locations and sizes of individual groups of belugas sighted during surveys. The area occupied

during 2009-2016 is only 29% of the area occupied during 1978-1979 (from Figure 20 in Shelden *et al.* 2017; see Shelden *et al.* 2015 for details of analysis).

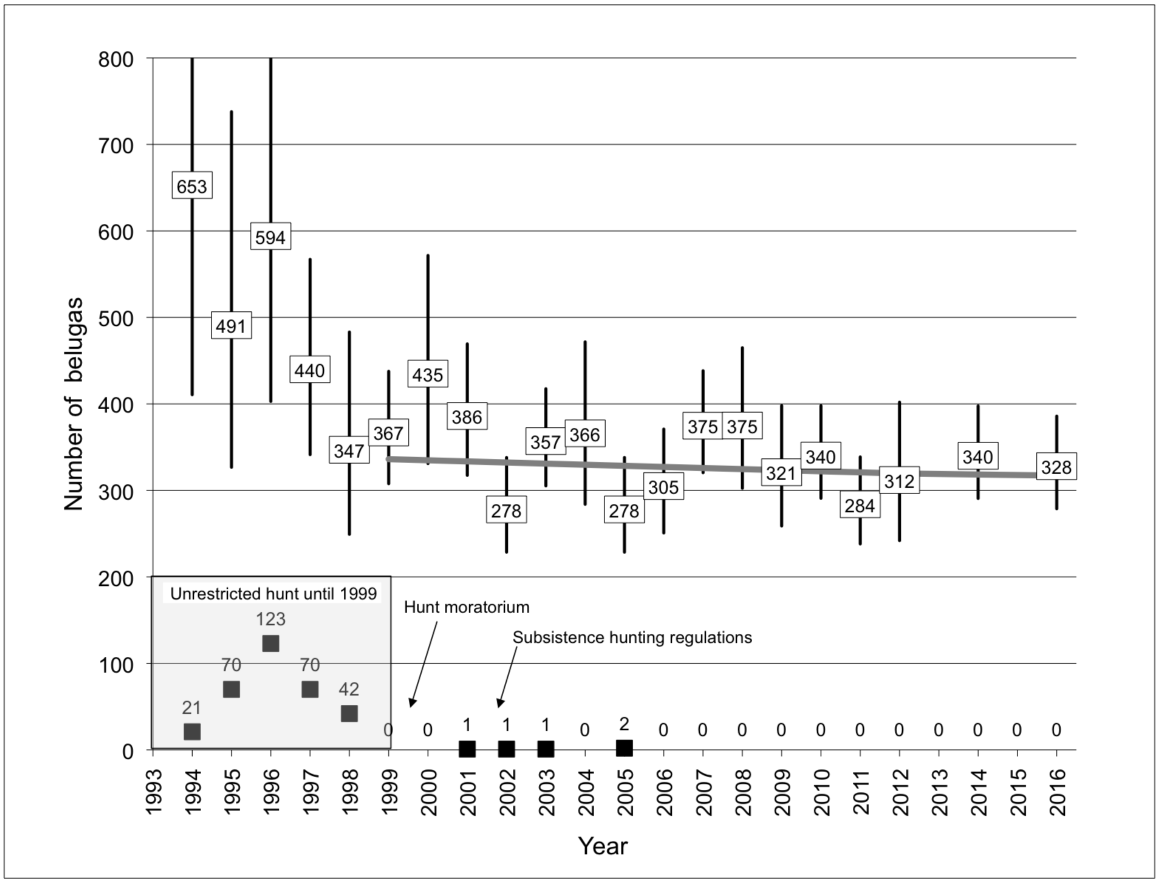

Figure 3. Abundance estimates and one standard error (SE; vertical line) from aerial surveys of Cook Inlet Belugas in the summer of 1994-2012, 2014, and 2016. The gray line is the trend from 1999-2016 which has a declining rate of -0.4%/yr (SE = 0.6%). Solid squares indicate the years that hunts occurred with digits indicating estimated removals (Shelden *et al.* 2017).

Estimating generation time and the number of mature individuals

Critical to the estimation of life history parameters is the ability to accurately estimate the age of individuals, which for Belugas and other toothed cetaceans is typically done by counting growth layer groups (GLGs) in their teeth. For Belugas it has been demonstrated that one GLG is deposited each year (Stewart *et al*. 2006, Lockyer *et al*. 2007, Waugh *et al*. 2018), however, prior to these analyses it had generally been assumed that two GLGs are deposited each year (Burns and Seaman 1986, Heide-Jørgensen *et al*. 1994). Hohn and Lockyer (1999) questioned the assumption of two GLGs/year, citing what they regarded as convincing evidence of a one GLG/yr deposition rate. Stewart *et al*. (2006) used radio isotopes from atomic bomb tests deposited in teeth as year markers to show that the one GLG/yr rate was the best fit to the age data. Recently this annual GLG deposition rate was confirmed by examining microstructure within the teeth, which revealed that there are roughly 365 incremental lines representing daily pulses of dentin mineralization (Waugh *et al*. 2018). Using the earlier assumption of two GLGs/yr for estimating life history parameters, Taylor *et al*. (2007) calculated a generation length of 14.9 years for Belugas. We recalculate this below using one GLG/yr.

We draw on a thorough investigation of life history parameters for Belugas in western Alaska (Burns and Seaman 1986) for age-dependent annual birth and survival rates. We use the Generation Length tool, an Excel spreadsheet provided on the IUCN webpage[1] modified with annual survival and reproductive rates for Belugas. To the original spreadsheet, we have added the capability to estimate the fraction of reproductive adults in the population at the current growth rate, and the growth rate for the population with the given birth and survival rates using the Lotka equation (Lotka 1907, Pielou 1969). We use birth rates by age class adapted from Burns and Seaman (1986) (Table 2, Hobbs *et al*. 2015) by assuming that each GLG represents a year. Suydam (2009) estimated average age at maturity for females to be 8.25 years and average age at first conception to be 8.27, indicating that most females become pregnant in the first year of maturity. Assuming that 1/3 are mature the year before and 1/3 mature the year after the mean then 1/3 of females would become pregnant during age 7 and give birth at age 9. We use age at first birth of 9 years extending the 12-21 age class of Burns and Seaman (1986) to 9-21 so that the birth rates by age, B(age), are: 0–8 GLGs (0), 9–21 GLGs (0.326), 22–45 GLGs (0.333), 46–51 GLGs (0.278), 52–57 GLGs (0.182), 58–77 GLGs (0.125).

Annual survival, S(age), survival to age (i+1) from age i, was drawn from Table 7 of Burns and Seaman (1986). That table provides estimated annual mortality for age classes based on the two GLG/yr assumption. We expand this to annual survival assuming one GLG/yr as $S(2x) = S(2x+1) = \mathrm{sqrt}(1-q(x)/1000)$, where x is the age given in Table 7 and q(x) is the deaths per 1000 animals of age x given in Table 7. The oldest aged animal in the Burns and Seaman (1986) study was age 79 so we use that as the maximum age.

Inserting S and B into the Generation Length tool yields a generation time of 28 years. The growth rate for the population represented by the S and B age-dependent annual

[1] Generation_length.xls. Available at http://www.iucnredlist.org/technical-documents/red-list-training/red-list-guidance-docs. Downloaded 20-August-2018.

survival and birth rates is 1.033. To estimate the fraction mature we note that the oldest reproductive female age class ends at age 77 and that there is a substantial decline in birth rates after age 51 years. A typical birth interval for belugas is thought to be 3 years (Burns and Seaman 1986) for a birth rate of 0.333, assuming that birth rates lower than 0.333 of older females result from reproductive senescence of some individuals (Burns and Seaman 1986, Suydam 1999). The fraction of reproductive adult females in each age class of the population is B(age)/0.333, thus excluding females that are non-reproductive due to immaturity or senescence. There is no evidence of senescence among males so the fraction of reproductively active adult males in the population is assumed to be all males older than age 8.

The population growth rate for Cook Inlet Belugas is reduced to 0.996 (trend 1999-2016 of -0.4%, Shelden *et al.* 2016) to estimate the fraction mature = 0.70. The estimated number mature is 231 (95% confidence interval 194 to 273), with an 82% probability that there are fewer than 250 reproductive adults in the population.