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Appendix B Calculation of fertility

In this model, fertility appears as the number of independent cubs surviving from a yearling litter. The calculation of that probability requires several steps, starting from the survival probability of a cub of the year litter, σ_{L0} .

The size distribution of a litter cubs of the year in stage 5 was set to

$$\mathbf{c} = \begin{pmatrix} 0.276 & 0.724 \end{pmatrix} \quad (\text{B-1})$$

where c_i is the probability of a litter of size i . These values were calculated from capture data collected in 2001–2006 in the Southern Beaufort Sea management unit. We included only one- and two-cub litters because triplets are rare for polar bears in the Arctic basin (Amstrup 2003). We did not investigate variation in this parameter.

The probability of survival of a cub of the year litter satisfies

$$1 - \sigma_{L0} = (1 - s)c_1 + (1 - s)^2 c_2 \quad (\text{B-2})$$

where s is the probability of survival of a cub of the year. That is, a cub of the year litter is lost if it consists of one cub which dies, with probability $1 - s$, or two cubs both of which die, with probability $(1 - s)^2$. Given \mathbf{c} and an estimate of σ_{L0} , we solve (B-2) for s .

Conditional on not losing the cub of the year litter, the size distribution of a new yearling (stage 6) litter is

$$y_1 = [c_1 s + 2c_2 s(1 - s)] / \sigma_{L0} \quad (\text{B-3})$$

$$y_2 = c_2 s^2 / \sigma_{L0} \quad (\text{B-4})$$

The probability of loss of the yearling litter between stage 6 and stage 1 depends on the probability of survival of a yearling cub. Assuming that this probability equals that of a 2-year old bear in stage 1 (σ_1), then

$$1 - \sigma_{L1} = (1 - \sigma_1)y_1 + (1 - \sigma_1)^2 y_2 \quad (\text{B-5})$$

Conditional on not losing the yearling litter, the size distribution of the litter arriving at stage 1 is then

$$z_1 = [y_1 \sigma_1 + 2y_2 \sigma_1(1 - \sigma_1)] / \sigma_{L1} \quad (\text{B-6})$$

$$z_2 = [y_2 \sigma_1^2] / \sigma_{L1} \quad (\text{B-7})$$

The expected number of new stage 1 bears, conditional on not losing the yearling litter, is then

$$f = z_1 + 2z_2. \quad (\text{B-8})$$

Multiplying f by the survival of the mother and the probability of not losing the litter, and dividing by 2 to account for the sex ratio, gives the fertility $\sigma_6 \sigma_{L1} f / 2$.

LITERATURE CITED

- Amstrup, S.C. 2003. Polar bear, *Ursus maritimus*. pp. 587–610 in G.A. Feldhamer, B.C. Thompson, and J.A. Chapman, editors. Mammals of North America: biology, management, and conservation. Johns Hopkins University Press, Baltimore, Maryland, USA.