

## Modelling of polar bear populations by the Leslie matrix population model

Comments on a paper by Nils Are Øritsland and Ray Schweinsburg in *Polar Research 1 n.s. No. 3*, pp. 241–247

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Some general doubts have been voiced regarding the soundness of using a Leslie matrix population projection on polar bear populations. Øritsland & Schweinsburg's APL-programme includes the option that hunting is included as a mortality factor in addition to natural mortality. This programme model has distributed the events of natural and hunting mortalities and the production of offspring in a lifetable or cohort model, which is reasonable and sound. The main criticism that can be raised is that the model treats cubs and females as independent units. This is valid for species where offspring are independent of their mothers at an early age (fish, seals, etc.), but not for polar bears, where offspring follow their mothers for more than two years. Their survival is partly a function of their mothers' survival. Females with offspring are not available for breeding before their offspring are weaned or lost. Consequently, if the majority of mature females breed at the age of 5, there will be relatively fewer for breeding at the age of 6 and 7, while 8-year-olds have weaned their cubs and are entering the breeding pool again. Thus, the productivity rate may differ between cohorts. Because it is very difficult to determine the productivity rate for each cohort, averages for all cohorts older than 4 years are therefore used in most population projections. Øritsland &

Schweinsburg have used an average productivity rate of 0.388 cubs/female/year, which we accept.

Any model will include certain approximations and assumptions. The quantitative effects of such approximations cannot be evaluated with the present information available on population biology parameters. But qualitatively, 'errors' in predictions of population development may become serious if the hunt is taking a large proportion of the females of the population.

Øritsland & Schweinsburg's model does not contain any estimation procedures for the input parameters, and thus requires that the user judiciously evaluates the soundness of his input. In Øritsland & Schweinsburg's paper, it is stated that 'the initial age frequencies . . . are in accord with field observations . . .' (p. 243, Discussion). In the projections, the authors have used age frequencies of 88.94 for coys and 85.20 for yearlings, with consequent survival rates of 0.958 and 0.956, respectively, which we consider too high. A subjective estimate, based on findings from many areas and from discussions at the Polar Bear Technical Committee no. 15 in Vancouver, Canada, in January 1984, suggests coy and yearling survival to be at least as low as 0.6 independent of their mother's survival. Furthermore, the projections in the paper assume that all females breed at the age of 4 and have their first offspring

at the age of 5, with an equal opportunity in following years. This assumption is not consistent with biological information. We believe that few females breed at the age of 4, and the majority at the age of 5.

We have made a projection on Øritsland & Schweinsburg's Leslie matrix model, where the coy and yearling survival rate is 0.6, where the adult natural mortality is 0.05 between ages 3 and 17, gradually increasing to 0.08 at the age of 24. Maximum age is 25 years. Females do not enter the breeding pool until they are 5 years old, and have their first offspring at the age of 6. Population size and productivity rates are the same as in the Øritsland/Schweinsburg paper. Whilst Øritsland & Schweinsburg's projection gave a population increase from 1100 to 1559 animals in 10 years, our projection gave a population decline from 1100 to 950 bears in the same period.

Our population projection is probably not correct. It is reasonable to expect an unharvested polar bear population to be growing. Some of our input parameters are probably too conservative. But the very different trends in the two projections show that the predictions are sensitive to the input data. Any model population projection will reflect the quality of the input parameters. The management of polar bears is debated in many Arctic countries. Hunters as well as conservationists use scientific findings and publications as a platform for their arguments, either for increased hunting, or for stricter protection measures. Scientists should therefore be extremely cautious when publishing data which are used in population projections, and make their reservations clear when data are insufficient or questionable.