MATRIX POPULATION MODELLING OF THE STELLER'S SEA EAGLE IN RUSSIAN FAR EAST: DETERMINISM VS. STOCHASTICITY

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To assess the sustainability of two populations of the Steller's Sea Eagle (*Haliaeetus pelagicus*) we have developed matrix population model of the Lefkovitch type. The field studies were performed in 2004–2017 on the NE Sakhalin Island and in the Lower Amur region (Russian Far East). During this period, productivity of both populations was highly unstable and averaged 0.53 and 0.61 fledglings / occupied territory / year, respectively, which is fairly low in comparison to previous decades (about 1 fledgling per occupied territory per year. The parameter of fecundity (N of fledglings / adult individual including floaters) equals to 0.19 and 0.24 fl/ad/yr. The survival of age classes was estimated indirectly, with help of Weibull's ageing model, and also by their age ratio. According to our estimations, only 13–17% of birds survive to maturity, which is also extremely low for large eagles.

The model predicts a decline of both island and mainland populations, these being halved in 89 and 70 years respectively. Apart of the main scenario (1), we considered alternative scenarios of populations development: cessation of predation of brown bears (2), and enabling of the population reserve by allowing floater reproduction (3). On Sakhalin, increasing the fecundity to 0.241 fl/ad/yr could stabilize the population, while on the mainland the stabilization requires fecundity increase to 0.33 fl/ad/yr.

If the environmental conditions are unstable, the age structure of a population at each time step deviates from the stable one, so the population exists in a regime of so-called 'transient dynamics', and its growth rate may differ from the one predicted by deterministic model. Stochastic modelling supports the main conclusion of population decline, but generally its predictions are more optimistic. In some cases, this difference leads to qualitatively different conclusions. Thus, on Sakhalin the deterministic model shows that even with the cessation of bear predation, rate of the population growth remains slightly negative; the stochastic model predicts a positive growth rate. In the Lower Amur region, according to the deterministic model, the population reserve is not sufficient to stabilize the population; the stochastic model disproves this conclusion and the population stabilizes at the level of 94% of the initial number.

Therefore, though admitting the secondary importance of fecundity in large raptors as compared to adult survival, we suggest that it can vary in broader limits and, if at a poor level, can alone lead to population decline. On the other hand, this parameter is more amenable to management, so that efforts should be focused on raising it to richer levels. Stochastic effects can have major effects on the dynamics of the population and should be taken into account while modelling.