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# Estimation by a computer simulation of population trend of Steller's Sea Eagles

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**Abstract**. The population trend of Steller's Sea Eagles *Haliaeetus pelagicus* was estimated using a computer simulation model. The simulation was conducted using an "individual based model". The simulation breeding success was estimated from 308 nests in the Amur River basin 1996-1998 and mortality of each age class estimated from the number of eagles in each age class in Hokkaido 1997-1999 ($N$ = 332) to the simulation model. The model predicts that the Steller's Sea Eagle population will slowly decrease, and that adult mortality has the strongest affect on the population trend. The result suggests that lead poisoning in Hokkaido is a major factor in the predicted population decrease.

## INTRODUCTION

In order to conserve endangered species, it is important to understand what are important factors that might cause population decline. This information is important when constructing an effective management plan. Population models are an effective method to better understand the factors that might cause population decline. For raptor species, population models have been constructed for Northern Spotted Owls *Strix occidentalis* (Lande 1988), White-tailed Sea Eagles *Haliaeetus albicilla* (Green *et al*. 1996), and Bonelli's Eagles *Hieraaetus fasciatus* (Real & Manosa 1997). In this paper, we estimate the population trend of Steller's Sea Eagles *Ha. pelagicus* by computer simulation model.

## METHODS

The population trend of Steller's Sea Eagles was estimated using a computer simulation run for a 100 years time span. The wintering population of Steller's Sea Eagles in Hokkaido, northern Japan has been estimated 1,500 to 2,000 individuals (WGWS 1996). The simulation was started from 1,500 individuals.

The simulation used an "individual based model". This model uses the mean probability of life history factors, such as breeding success and mortality rates, and a table of random

Table 1. Demographic parameters used for simulation of population trend of Steller's Sea Eagles.

| | |
|---|---|
| Breeding success | |
| Percentage of pairs with no fledgling | 47.1% |
| Percentage of pairs with a fledgling | 26.8% |
| Percentage of pairs with two fledglings | 26.1% |
| Mortality rate | |
| First year | 68.7% |
| Second year | 24.8% |
| Third year | 21.5% |
| Thereafter | 6.6% |

numbers. Life expectancy of each individual within was decided by the table and the probability. For example, if the annual mortality rate was 20%, a random number between 0 and 100 would be generated and assigned to each individual bird, and those individuals who assigned number was < 20 would survive, which those ≥ 20 would die in a given year. Assembling the results of annual mortality on individuals over many years the trend of the total population was determined. This model is suitable to show the trend of a small population because it includes the chance fluctuations in probability, such as successive hatching of one of the sexes (Horino & Miura 1997).

Parameters used in this simulation model were mean breeding success, and mortality rate of each age class.

Steller’s Sea Eagles wintering in Japan are mainly summering in north Sakhalin, lower Amur region, Shantar Islands to Magadan (Ueta *et al.* 2000, McGrady *et al.* 2000). The mean breeding success was estimate from 308 nests in Amur in 1996-1998. The Amur River basin was surveyed mainly by small boat. Because almost all large nestlings (≥ 8 weeks of age) will fledge (Masterov unpublished data), we assumed 100% survival of them to fledging.

To estimate mean mortality rate of each age class, a survey was conducted on the wintering grounds on Hokkaido. We assumed there are no age-specific wintering areas. The identification method of age was depending on Morioka *et al.*(1995) and Morioka (2000). We counted the number of individuals of each age within about 200 m of observation points because we could not confidently determine age from long distance. The survey was conducted on Nov. 23 1997, Dec. 17-18 1997, Jan. 16-20 1998, Jan. 18 and Feb 21, 1999. If the exact age could not be determined, these birds were put into grouped age classes (e.g. 1-2 years old). At the end of the count, the numbers of individuals in these groups were shared between the ages they included according to the ratio of known age birds.

## RESULTS AND DISCUSSION

### *Breeding success and mortality rate*

Table 1 summarizes breeding success and mortality estimation used in the simulation. Breeding success was recorded for 121 nests in 1996, 91 nests in 1997, and 96 nests in 1998. It

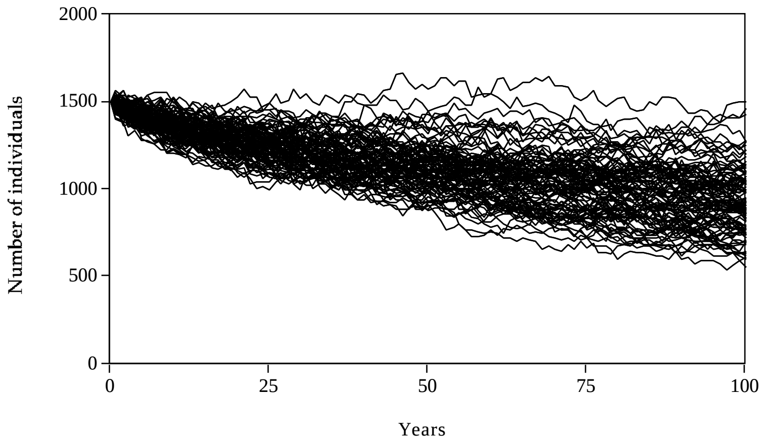


Fig. 1. Computer simulation of Steller's Sea Eagles population. Lines show each 100 times simulations data.

was estimated that 47.1% of pairs raised no fledgling, 26.8% raised a single fledgling, and 26.1% raised two fledglings.

In total, 433 individuals were observed in Hokkaido. The percentage of first winter eagles was 23.3%, 7.3% second winter eagles, 5.5% third winter eagles, 4.3% fourth winter eagles, and 59.7% older than fifth winter eagles. From this, we estimated annual mortality rate as: 68.7% for first year, 24.8% for second year, 21.5% for third year, and 6.6% thereafter. Because we counted the number of individuals in each age class in winter, mortality between fledging to first winter could not be determined. Therefore, first year mortality was probably underestimated. We do not believe the underestimation to be great because in the period from late summer when eagle fledge to autumn, food for eagles is abundant, because there are many dead salmon on the river, and because the results of satellite-tracking (McGrady *et al.* 2000), suggest low mortality. Therefore the underestimation of first year mortality is not thought to be great.

That mortality rate of young eagles is high and low in adult eagles has been shown in species closely related to Steller's Sea Eagles. The mortality of Bald Eagles *Ha. leucocephalus* in the Aleutians was estimated at around 95% up to the acquisition of adult plumage in the forth to sixth year, and at around 5% per year thereafter (Sherrod *et al.* 1977). In this study, mortality was 81.5-82.7% up to the acquisition of adult plumage in the forth to fifth year, and 6.6% thereafter.

***Simulation of population trend***

The results from running the simulation 100 times are shown in Figure 1. Within the 100 year time period, there was no case of the simulation showing a population increase, and all simulations showed population declines. The mean simulated population size 100 years in the future was 934.6. A slow decline of population that predicted by the simulation agree with

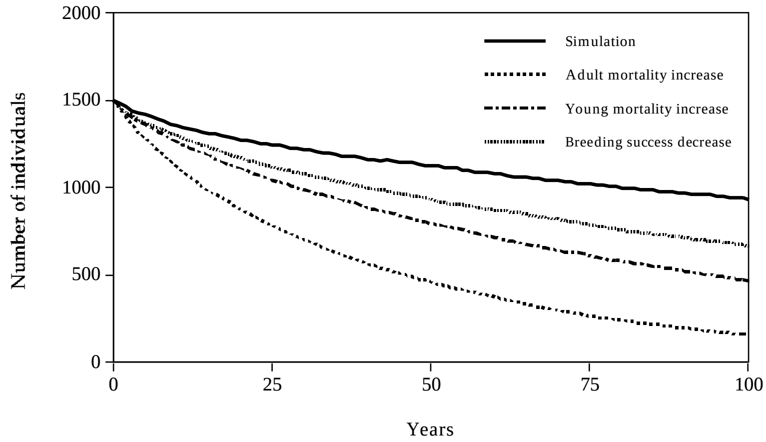


Fig. 2. Computer simulation of Steller's Sea Eagles population under different rates of mortality and breeding success. Lines show averages of 100 simulations. Solid line show the mean simulation using parameters shown in Table 1. "Adult mortality increase" shows the simulation with adult mortality rate increased 2%. "Young mortality increase" shows the simulation with 1-3 years old mortality rate increased 2%. "Breeding success decrease" shows the simulation with 51.1% of pairs failing to breed, 24.8% producing a single fledgling, and 24.1% producing two fledglings.

observed results in Magadan area (Potapov *et al.* 2000).

In order to illustrate which factor affects the population trend most, we simulated the population trend increasing adult mortality by 2% (add 2% mortality to older than 5 years old birds), again by increasing sub-adult and juvenile by 2%, and again by decreasing breeding success (51.1% of pairs failing to breed, 24.8% producing a single fledgling, and 24.1% producing two fledglings). The mean population trends from 100 simulations are shown in Figure 2. These simulations suggest that adult mortality has the biggest effect on the population trend. A similar result has been shown in Bonelli's Eagle (Real & Manosa 1997).

In Hokkaido, Steller's Sea Eagles and White-tailed Sea Eagles are exposed to the threat of lead poisoning (Kim *et al.* 1999). In the winter of 1997-98, 18 Steller's and three White-tailed Sea Eagles were found dead from lead poisoning in Hokkaido, due to ingestion of bullet fragments from hunted deer (Kurosawa 2000). In the winter of 1998-99, 16 Steller's and nine White-tailed Sea Eagles were found dead from lead poisoning in Hokkaido (Kurosawa 2000). The number of dead eagles is almost one percent of the wintering population of Steller's Sea Eagles in Japan. We don't know what percent of total lead poisoned eagles we find but it is thought to be low. For the Red-crowned Crane *Grus japonensis*, it was estimated that 18.2% of dead cranes were found (N. Kurosawa per. comm). Because of the large body size and color of Red-crowned Cranes, it likely that they are be easier to find than dead eagles. It seems reasonable that perhaps over 5% of the Steller's Sea Eagle that winter in Hokkaido may be dying of lead poisoning.

Of further concern is the age structure of dead eagles. Of all eagles killed by lead, percentage of first winter eagles was 23.8%, 14.3% for sub-adult birds, and 61.9% for adult birds (N. Kurosawa personal comm.). Because sub-adult birds are second and third winter eagles, and adult eagles are older than forth winter, the age structure of dead eagles is similar to population structure, and suggests that mortality by lead poisoning affects all age classes equally. Lead poisoning's effect of increased juvenile mortality is likely to cause a slow decline in the population, but an increase in adult mortality will likely cause a rapid decline in the population.

The Hokkaido Local Government will forbid to use lead bullet for hunting of deer from on November 2000 in Hokkaido. Although this is welcomed and is positive in conservation terms, we need further effort to reduce the mortality by lead poisoning.

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