Estimation of survival rates for branded Steller sea lions on the Kuril Islands, Russia

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Introduction

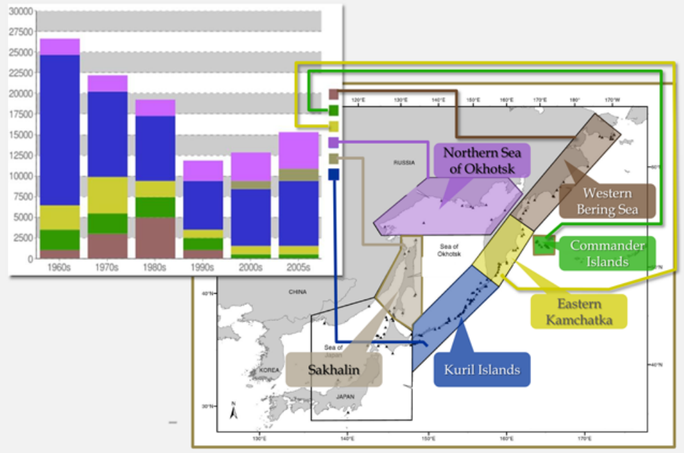

Figure 1. Geographical regions and reconstructed Steller sea lion abundance along the Asia coast

For abundance monitoring purposes, distribution of Steller sea lions along the Asian coast was divided into seven geographical regions (Fig. 1). The barplot shows changes in Steller sea lion abundance along the Asian coast during the breeding season. Although a decline started in the 1970s, the trends were not uniform among the different regions. This suggests that the Asian population might contain three relatively isolated stocks: northern Sea of Okhotsk and Sakhalin; the Kuril Islands; and Eastern Kamchatka. The Steller sea lions breeding in the Commander Islands belong to the Western population.

We examined demographic data from 8 years of observations in the Kuril Islands to determine whether these differences might be due to changes in reproductive success, survival, or perhaps immigration.

Materials and Methods

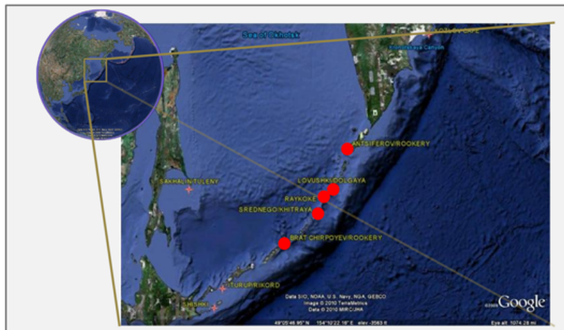

Figure 2 Observation area

The Steller sea lion rookeries in the Kuril islands are noted with red points (Fig. 2). We used hot-iron branding to mark pups born on all five major rookeries since 1989 (Fig 3). We have collected observations of marked sea lions from field camps on four of these rookeries annually since 2002. Similar work was conducted at the rookeries in the Northern Okhotsk Sea, the Commander Islands, and Eastern Kamchatka.

We used 4,794 resight (recapture) events of 3,547 branded Steller sea lion pups from four rookeries in the Kuril Islands and mark/recapture analysis to estimate survival rates.

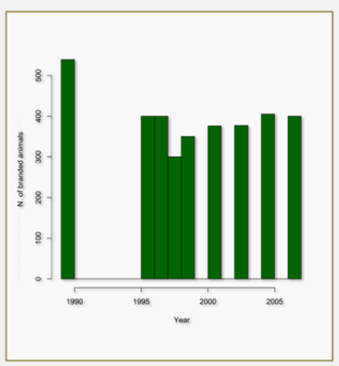

Figure 3. Branding history

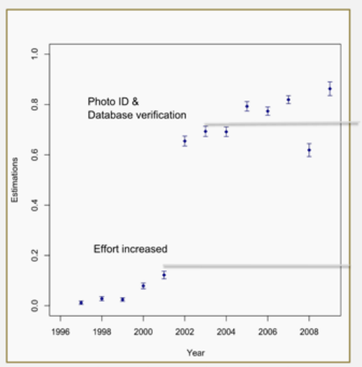

Figure 4. Recapture rate estimation

Figure 4 plots the recapture probability since 1996. A low survey effort between 1990 and 2001 is reflected by the low probabilities.

Recapture probabilities have improved since 2002 due to increased observation effort and the initiation of photo identification. The dip in recapture rate in 2008 results from a decrease in resight effort due to limited funding, when we could not collect data on one of the four rookeries (Brat Chirpoev I.)

We have used CJS models to estimate survival rates, and multistate models to estimate migration rates. All calculations was performed in MARK (via RMark).

Results: Survival Estimations

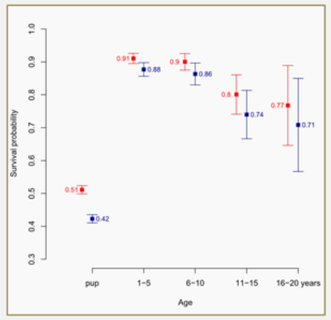

Figure 5. Estimations of survival rates for different ages

Steller sea lion pups had lower survival rates than other ages (Fig. 5) and sea lions between 3 - 10 years of age had the highest survival rates (0.8-0.9). Females (red line on plot) had higher survival probabilities than males.

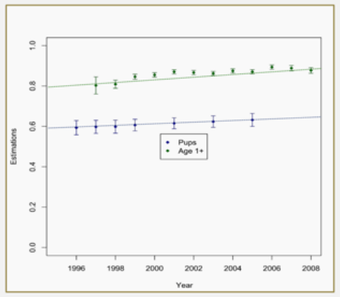

Figure 6. Survival rate estimation on the time scale

Survival rates of all age groups haven't changed significantly over the past 8 years. However, there has been a slightly positive trend (Fig. 6).

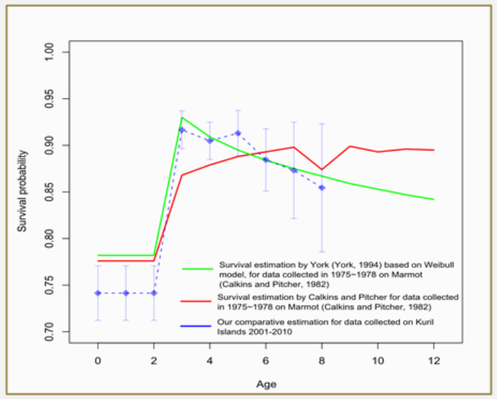

Figure 7. Comparison of survival rate estimation

We compared estimates of survival rates for Alaskan Steller sea lions prior to the population decline with our estimation for the Kuril Islands (Fig. 7). We found lower survival rates for sea lions <3 years of age but similar for older ages.

Results: Reproductive Contribution and Migration Rates

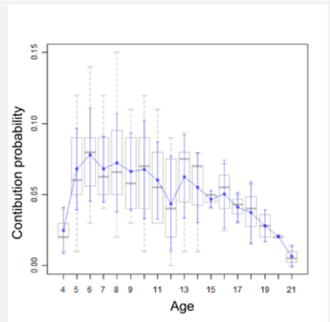

Figure 8. Reproductive contribution

We also estimated the birth rate of females by simply dividing the number of females that gave birth by the total number of females of each age sighted on the rookeries. The proportional reproductive contribution of females by age was calculated by multiplying the birth rates by the total estimated proportion of females of each age in the population (Fig. 8)

Middle-aged females had the highest birth rates (Fig. 8). The trend has increased slightly over the past 9 years (Fig. 9), but there were no differences among rookeries within the Kuril Islands.

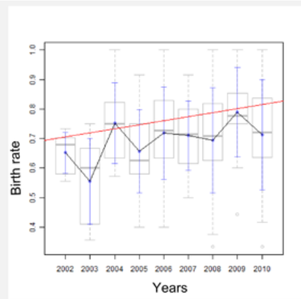

Figure 9. Changes in birth rates of mid-age females in Kuril Islands, 2002-2009

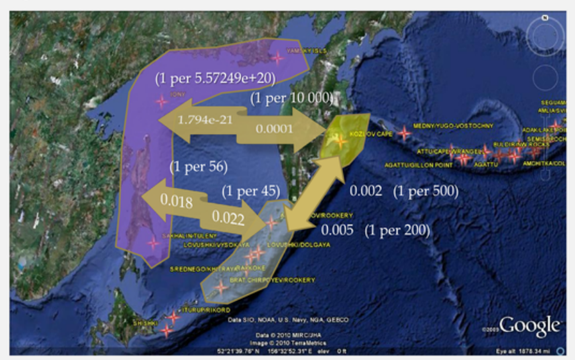

Figure 10. Migration rates estimation

Migration rates between the Northern Sea of Okhotsk area and the Kurils area are very similar; about 1 sea lion per 50 migrate between the areas (Fig. 10).

Migration rates estimates between the Kurils area and Eastern Kamchatka are much lower however; approximately 1 sea lion per 500 migrate from the Kurils to Eastern Kamchatka and 1 per 200 in opposite direction.

The probability of migration between the Northern Sea of Okhotsk and Eastern Kamchatka, is extremely low; approximately 1 sea lion per 10,000.

Conclusion

The low immigration rates and lack of change in the birth rates observed in the Kuril Islands suggests that the increased abundance of Steller sea lions is most likely due to an increase in survival rates of both pups and adult females. Our survival estimations combined with observed reproductive rates and abundance trends suggest a slowly population growth in the Kuril Islands in the near future.