ABUNDANCE, TRENDS, AND POPULATION VIABILITY OF HARBOR SEALS IN ILIAMNA LAKE

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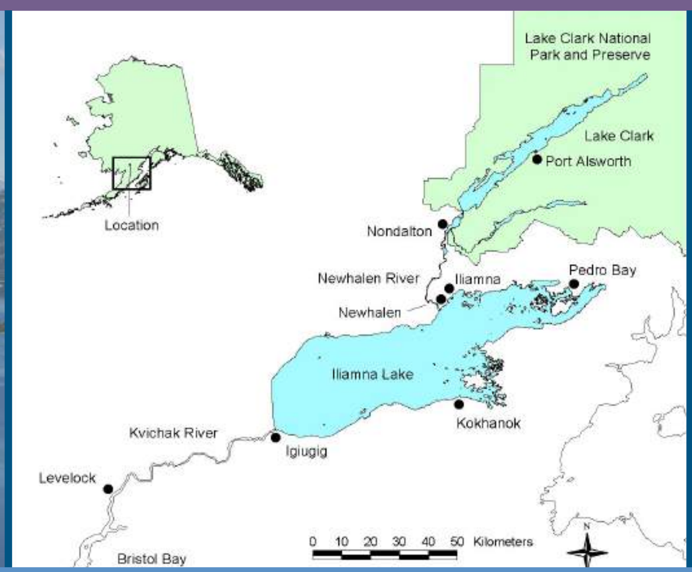


Abstract

Harbor seals living in the freshwater of Iliamna Lake, Alaska, have recently become the focus of concern about impacts from minerals development in the Iliamna watershed and from climate-related changes in Bristol Bay salmonids that are important prey for the seals. To determine the recent abundance and trends of the seals in the lake, and to help assess their future prospects, we constructed a population viability analysis model (PVA). The PVA uses a simple demographic model to combine survey counts of pups and non-pups with vital rates and subsistence harvest levels, yielding posterior probability distributions for current abundance and recent trends. The Bayesian hierarchical framework of the model ensures that the uncertainty stemming from the relatively sparse data set is reflected in the results. By comparing posterior and prior distributions, the model results can easily be scrutinized to identify which parameter estimates are supported by the data and which are largely dependent on prior information (e.g., vital rates). The model also allows forward projection of the population under various threats scenarios to evaluate conditional extinction risks. A key result of the model is that the population has likely been increasing during the past 10 years.

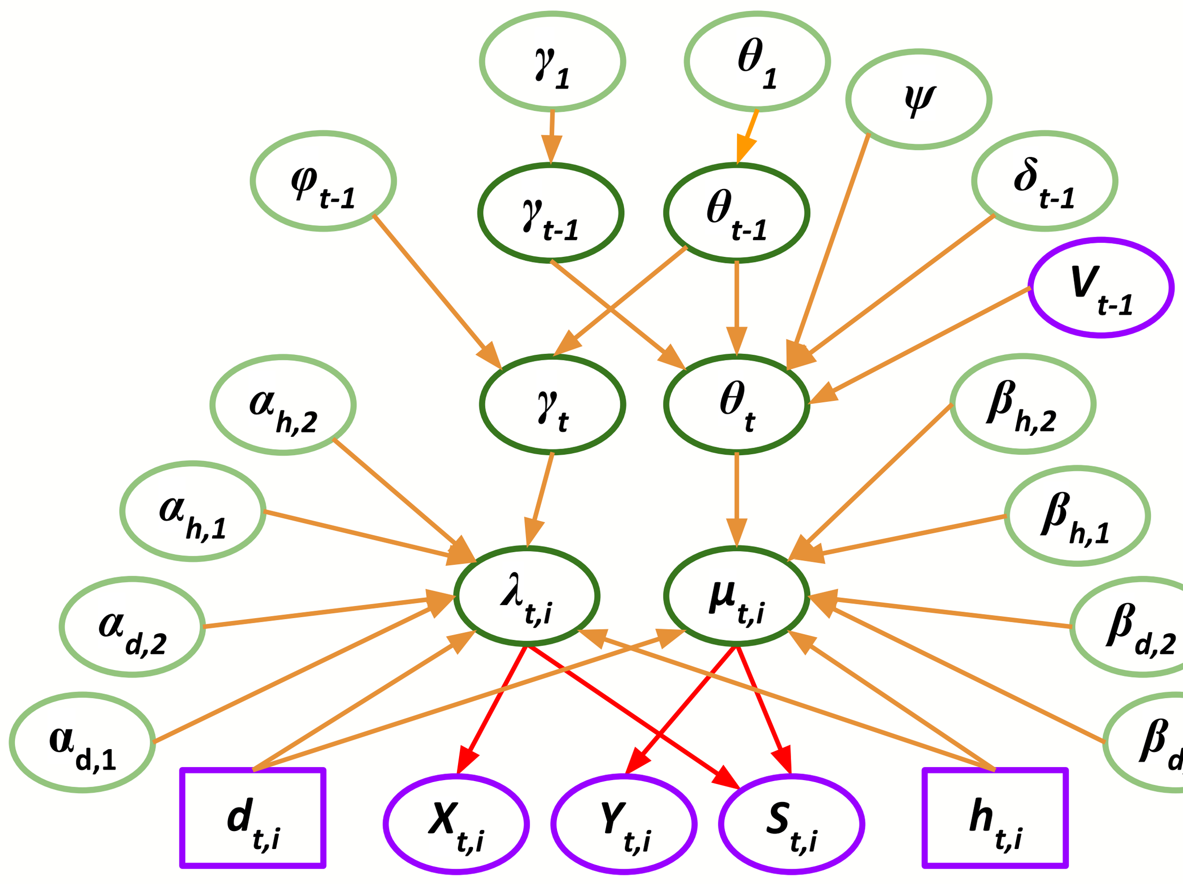
Background

- The seals have been surveyed sporadically by several organizations since the 1980s.
- The counts of seals hauled out on the shore, islets, bars, and ice (in winter) tend to be highly variable, as is common for harbor seals.
- To extract as much information as possible for estimating abundance and trends from the sparse and variable counts, we developed a model that relates counts in one year to the previous years' counts via simple population dynamics, including harvest removals by Alaska Native hunters.
- By including model parameters for day of the year, and time of day, we were able to derive estimates for abundance, trend, timing of peak numbers of seals ashore, recruitment, and survival.
- The model also serves as a framework for evaluating the viability of this small population under various future scenarios, but this use has not yet been extensively explored.

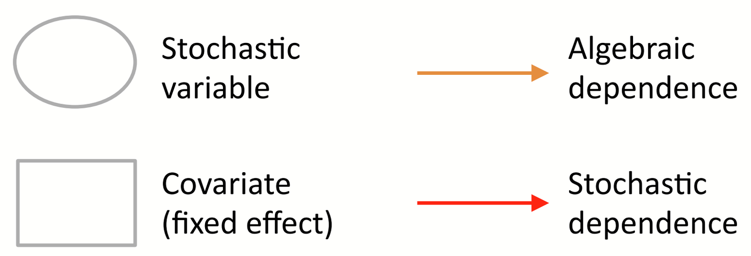
The Model

We constructed a Bayesian hierarchical model for survey count data, including:

- A simple underlying population of pups and non-pups. Each year a portion of the non-pups survive to the following year (termed survival); some portion of the the non-pups produces pups that survive and enter the non-pup population the following year (termed recruitment). A density-dependent subsistence harvest is taken from the non-pups;
- A process model for the number of seals on shore and available for counting, which depends on day of the year and hour of the day;
- A data model for the random variation in counting seals from aerial surveys; and
- A correction factor for seals missed during surveys because they were in the water or away from known haul-out sites; a distribution for this factor was constructed by expert judgment and not updated by the model.
- The model was fitted using standard Markov Chain Monte Carlo (MCMC) methods.



Key to Model Relationships



Key to Model Variables

Observables (data):

- $X_{t,i}$ *i*th pup count in year *t*
- $Y_{t,i}$ *i*th non-pup count in year *t*
- $S_{t,i}$ *i*th count in year *t* year (when pups not counted separately)
- $d_{t,i}$ day of year for the *i*th count in year *t*
- $h_{t,i}$ hour of day for the *i*th count in year *t*
- V_{t-1} harvest in year *t-1*

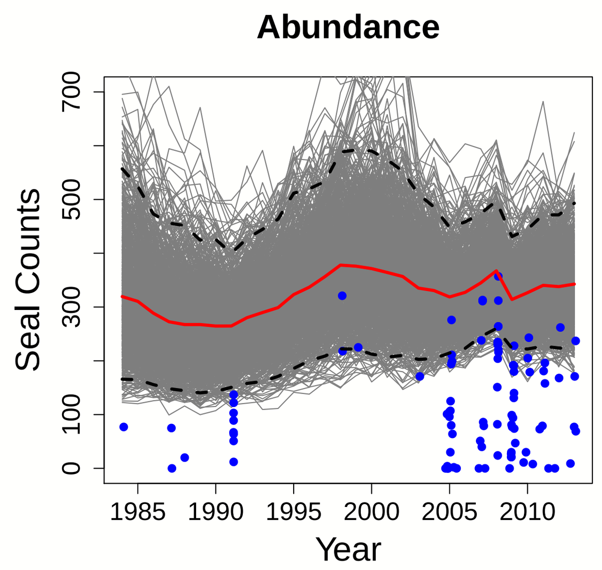
Latent variables, defined algebraically:

- γ_t underlying population (mean expected count) of pups in year *t*
- θ_t underlying population (mean expected count) of non-pups in year *t*
- $\lambda_{t,i}$ covariate-adjusted, expected pup numbers in the *i*th count in year *t*
- $\mu_{t,i}$ covariate-adjusted, expected non-pup numbers in the *i*th count in year *t*

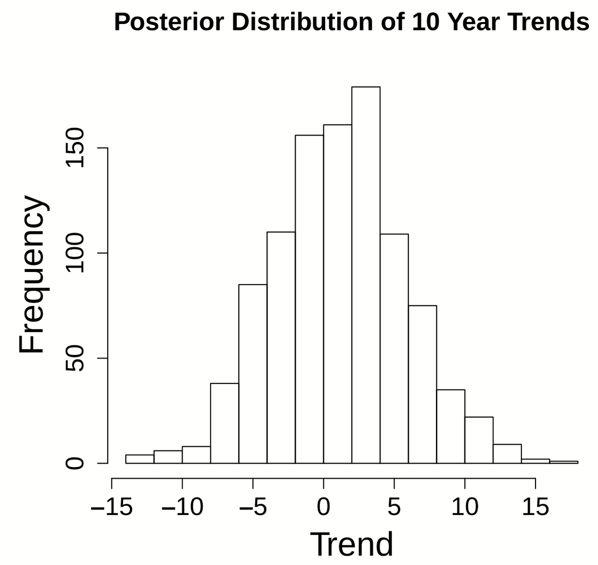
Latent variables, with prior distributions:

- $\alpha_{h,\cdot}$ hour of day effect on pup counts, linear and quadratic
- $\alpha_{d,\cdot}$ day of year effect on pup counts, linear and quadratic
- $\beta_{h,\cdot}$ hour of day effect on non-pup counts, linear and quadratic
- $\beta_{d,\cdot}$ day of year effect on non-pup counts, linear and quadratic
- δ_{t-1} survival rate (non-pups)
- φ_{t-1} recruitment rate (includes pup survival)
- ψ correction for seals missed in surveys

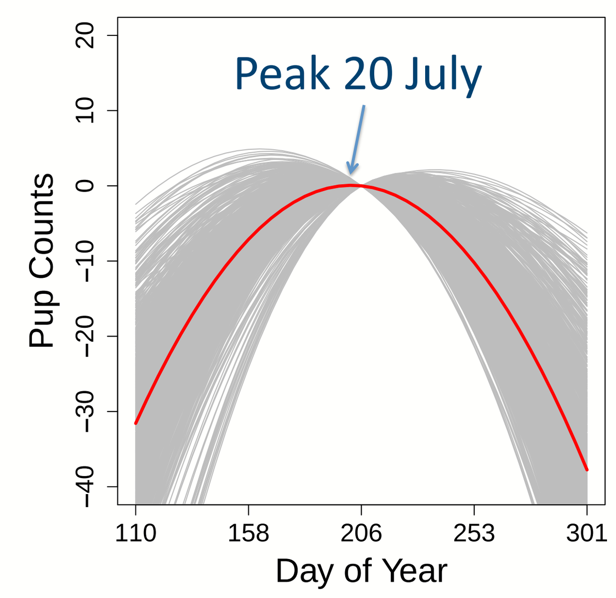
Results



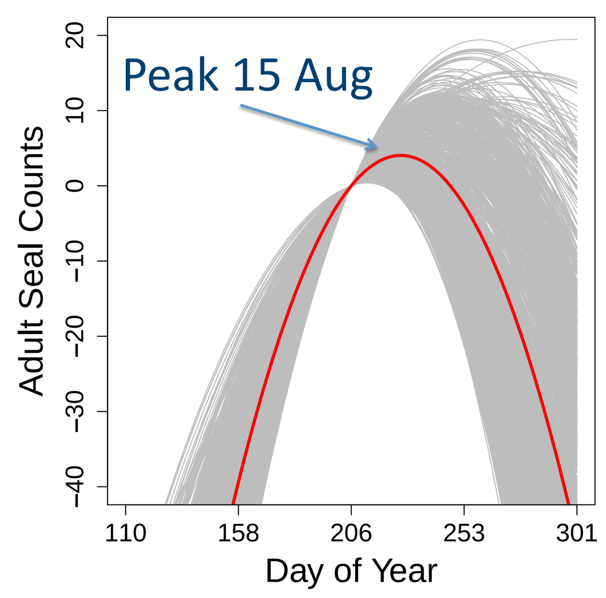
Fitted abundance estimates from 1000 MCMC samples (gray lines). The dashed lines show 2.5% and 97.5% credible intervals and the red line shows the average abundance. The blue points are the data (counts).



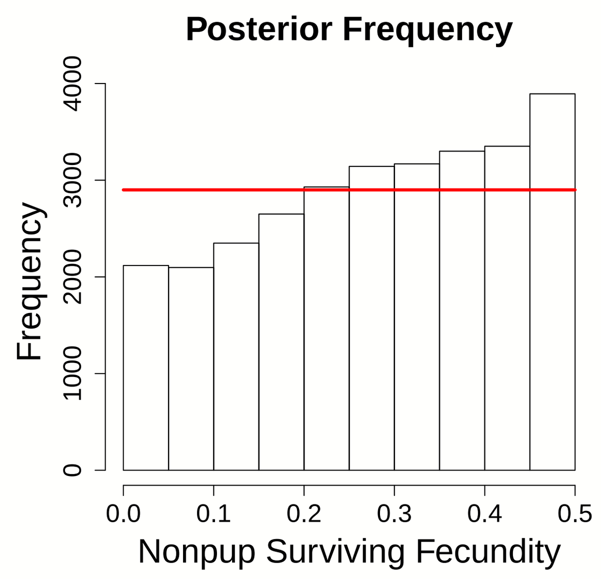
Histogram of recent 10-year trends using 1000 samples from the posterior distribution. The posterior probability of a negative trend was 0.41, indicating slightly more evidence for an increase than a decrease.



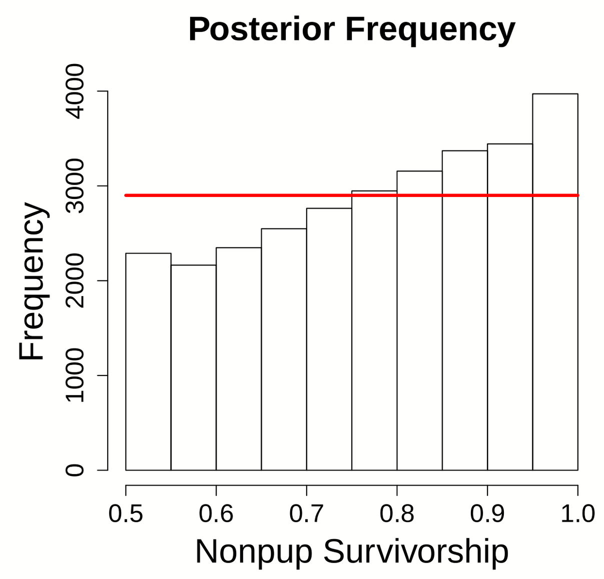
The effect of day-of-year on pup counts using 1000 samples from the posterior distribution. The red line is the average value at each date.



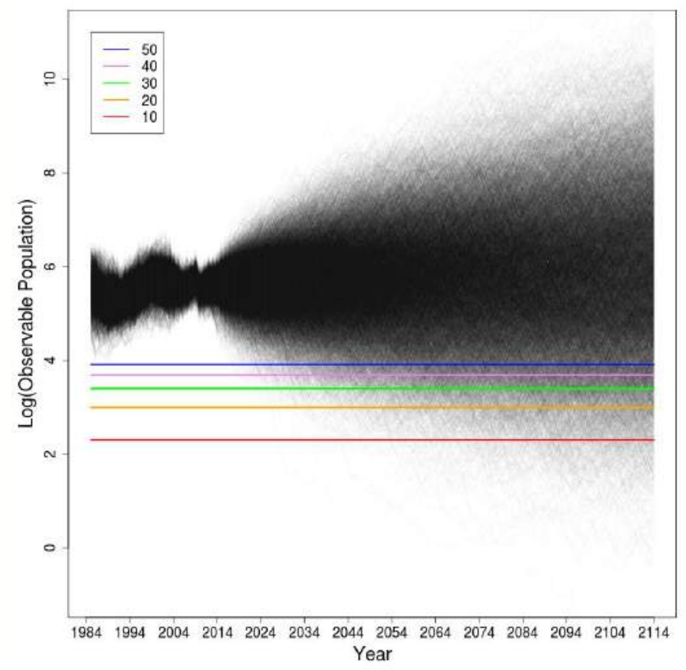
The effect of day-of-year on non-pup counts using 1000 samples from the posterior distribution. The red line is the average value at each date.



Histogram of the recruitment parameter from the posterior distributions of 1000 MCMC samples. The posterior mean was 0.28. The red line is the prior distribution of frequencies.



Histogram of the survival parameter from the posterior distributions of 1000 MCMC samples. The posterior mean was 0.78. The red line is the prior distribution of frequencies.



Simulated abundance values from the posterior distribution, with 10,000 trajectories for 100 years beyond 2013. Colored lines show how various low population thresholds could be used in a population viability analysis.

Conclusions

- We estimate that the abundance of seals in Iliamna Lake has fluctuated between 300 and 400, with slight evidence of an increase over the past 10 years.
- The best dates for counting pups and non-pups are 20 July and 15 August, respectively.
- There was very little information in the survey data for estimating the demographic parameters, but the flat priors for recruitment and survival were modified slightly toward sensible values by the influence of the data.
- Projecting the model forward for 100 years gives a sense of the utility that such a model may have for testing the effects of various scenarios for future risks such as climate change or minerals development in the Iliamna Lake drainage.

Acknowledgments

Our understanding of harbor seals in Iliamna Lake depends heavily on the local and traditional knowledge shared by the people in communities around the lake. We are grateful to Jennifer Burns, James Van Lanen, and Davin Holen for making data available from the study, "Burns, J., J. Van Lanen, D. Withrow, D. Holen, T. Askoak, H. Aderman, G. O'Corey-Crowe, G. Zimpelman, and B. Jones. 2013. Integrating local traditional knowledge and subsistence use patterns with aerial surveys to improve scientific and local understanding of the Iliamna Lake seals. Report to the North Pacific Research Board Final Report 1116. 189 p.