Ringed seal demography in a changing climate

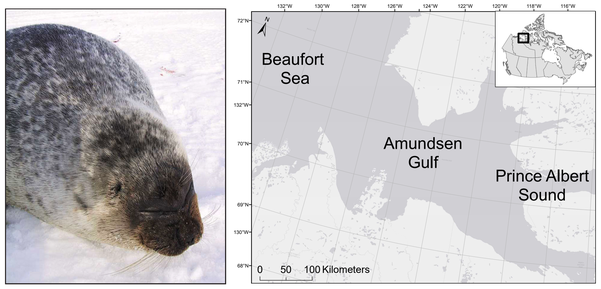
Jody R Reimer[1], Hal Caswell[2], Andrew E Derocher[1], and Mark A Lewis[1]
(1) University of Alberta,Canada (2) University of Amsterdam, Netherlands

Key findings

- Changes in spring snow depth and sea ice breakup date may lead to declines in ringed seal population size ranging from 50 to 99% by year 2100.
- Substantial changes in population structure correspond to these declines.
- Current monitoring may only reliably detect these changes by mid-century.

1. Introduction

Changes in the health of Arctic marine ecosystems may be signaled by changes in the health of indicator species, such as ringed seals (*Pusa hispida*) [1]. We study population growth and structure, past and future, of ringed seals in western Canada.



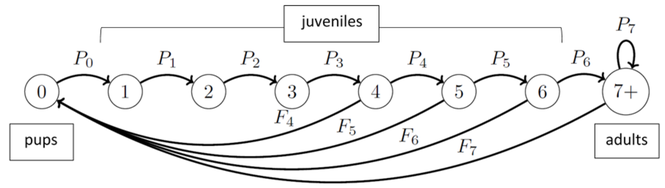
(Left) Adult ringed seal; (Right) Study area: Amundsen Gulf and Prince Albert Sound, Canada.

Questions:

- What are the historical population growth rate and population structure?
- How may this change under forecasted climatic conditions?
- How effective are current monitoring practices at detecting expected population changes?

2. Methods

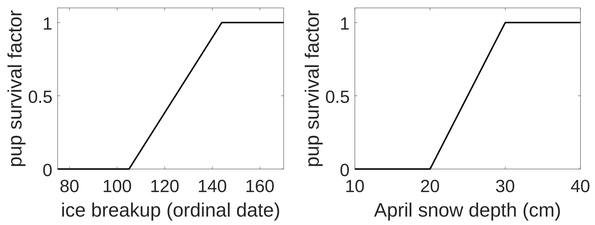
1. Create matrix population model for ringed seals



Ringed seal life history. $\mathbf{P_i}$ is annual survival of an age i seal. $\mathbf{F_i}$ is annual fertility. This is the structure of the matrix population model.

2. Estimate historical population growth and structure using the population model

3. Formalize hypothesized future relationships between reduced spring snow depth, earlier sea ice breakup, and ringed seal survival

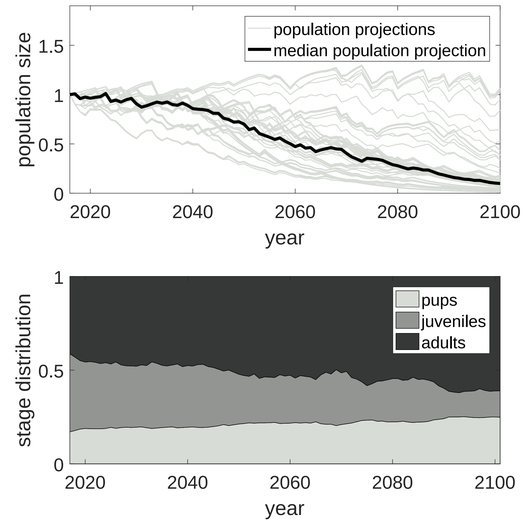


Relationships between early ice breakup, shallow April snow depth, and ringed seal pup survival. Annual pup survival is multiplied by each scaling factor for each year.

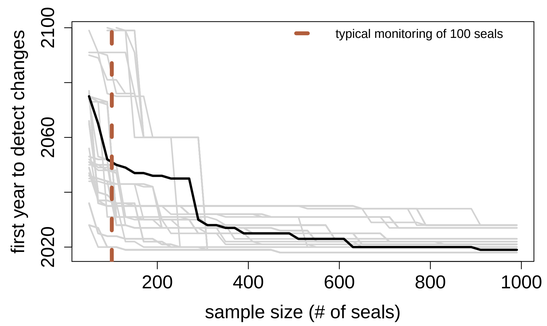
4. Project population forward using climate projection data available from the Coupled Model Intercomparison Project Phase 5 [2]

5. Look at our ability to detect the projected population changes. Ringed seal monitoring often includes of estimates of population structure (rather than size), so we perform a power analysis for comparisons between historical and projected population structures.

3. Results



(Top) Projections of ringed seal population size (scaled) from 2017-2100. Grey lines are population projections for each ice and snow model. Black is the median projection. (Bottom) Mean population stage structure, corresponding to projections above.



First year we reliably detect differences in population stage structure between the historical structure and our projections (i.e., first year the statistical power of a chi-squared test = 0.8), for varying sample sizes. Black line considers the mean projected stage structure seen above.

References

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[2] K. E. Taylor, R. J. Stouffer, and G. A. Meehl. An overview of CMIP5 and the experiment design. *Bull. Am. Meteorol. Soc.*, 93(4):485–498, 2012.

Acknowledgements

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Contact

Email jrreimer@ualberta.ca
Phone +1 (780) 983 7941
Web math.ualberta.ca/~mlewis/