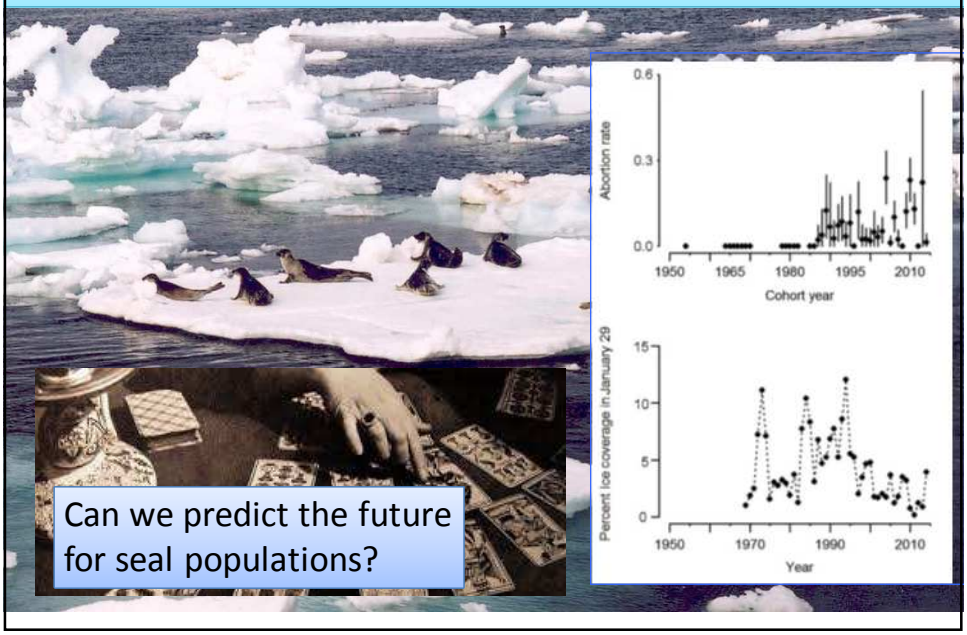
## So What? Seals and Environmental Drivers



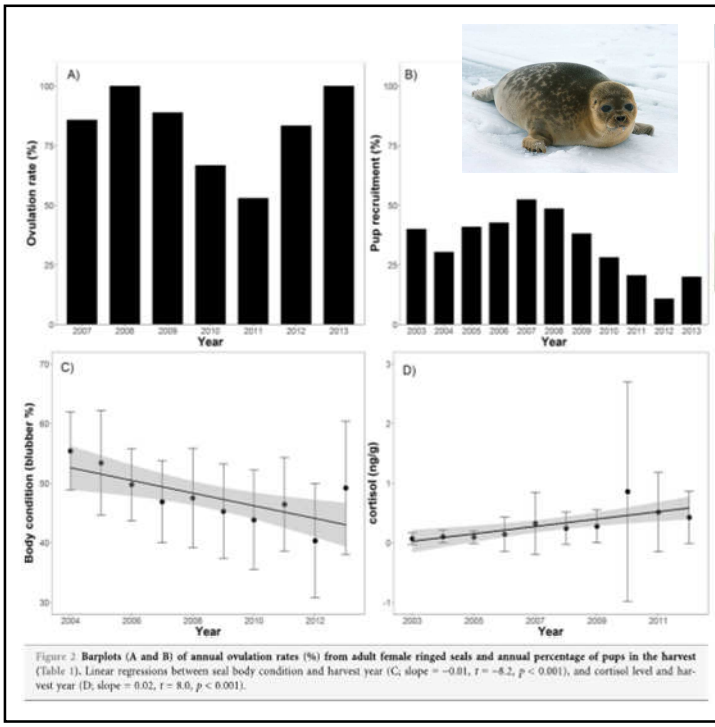
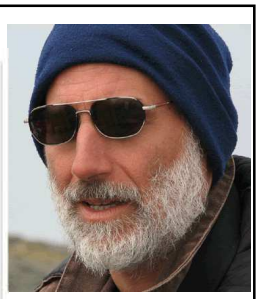




Figure 2. **Barplots (A and B) of annual ovulation rates (%) from adult female ringed seals and annual percentage of pups in the harvest** (Table 1). Linear regressions between seal body condition and harvest year (C; slope = −0.01, $t = -8.2$, $p < 0.001$), and cortisol level and harvest year (D; slope = 0.02, $t = 8.0$, $p < 0.001$).





Based on measures of individual seals, we find considerable temporal variation in characteristics such as condition (blubber thickness) and cortisol (stress hormones). WHY?

# Objectives

1. Historical data sets on body condition and vital rates of harp and ringed seal stocks will be related to environmental covariates using statistical models
   - Body condition (blubber thickness)
   - Pregnancy rates and maturation (necropsy, ovaries); abortion rates.
   - Survival

Response variables

# Objectives

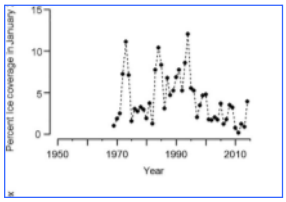
1. Historical data sets on body condition and vital rates of harp and ringed seal stocks will be related to environmental covariates using statistical models
   - Body condition (blubber thickness)
   - Pregnancy rates and maturation (necropsy, ovaries); abortion rates.
   - Survival
   - Diet

Response variables

# Objectives

2. The environmental covariates will come from
   - remote sensing (e.g. sea ice dynamics, surface temperature and productivity, M3b),
   - modelling (e.g. depth resolved temperature and productivity, circulation patterns, water mass pathways, M3b)
   - field datasets (e.g. decadal change in the isoscape and **trophic position inferred from seal archives**, M3a)

Explanatory variables




# Objectives

3. Identify the key environmental factors that are driving historical changes in seal population dynamics.

Response variables ~ Explanatory variables

e.g.

Abortion rate ~ Ice cover + population size

A model of abortion rates as a function of environment (ice cover) and harp seal population size (competition)

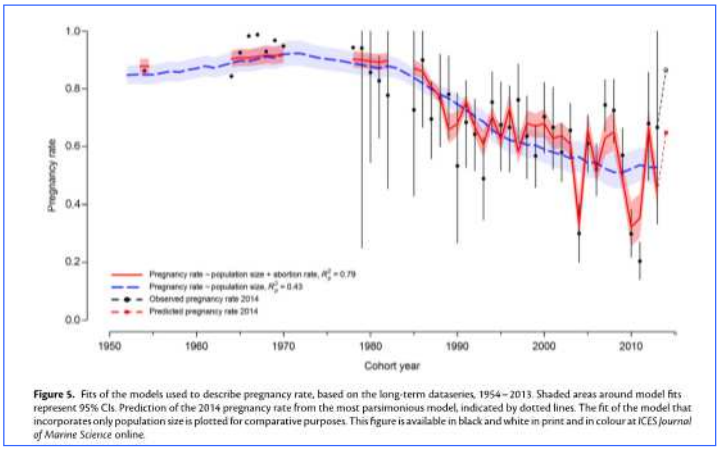



**Figure 5.** Fits of the models used to describe pregnancy rate, based on the long-term dataseries, 1954–2013. Shaded areas around model fits represent 95% CIs. Prediction of the 2014 pregnancy rate from the most parsimonious model, indicated by dotted lines. The fit of the model that incorporates only population size is plotted for comparative purposes. This figure is available in black and white in print and in colour at *ICES Journal of Marine Science* online.

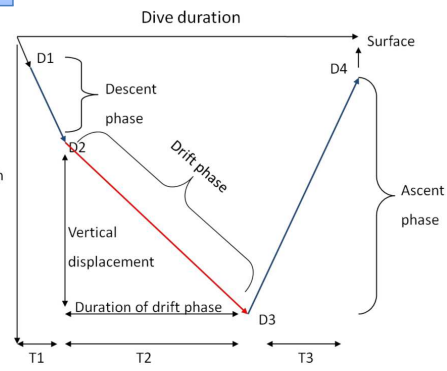
## Methods and problems to solve

### Response variables ~ Explanatory variables

- ANOVA for differences between decades, simple exploratory plots, linear regression.
- Care needed in case of co-linear explanatory variables e.g. prey abundance might be correlated with ice. If so, pick just one of these two to try in the model.
- Might need to move from simple linear regression to models that can cope with non-linear relationships, and/or different error structure in the data (such as count, proportions). GLMs, GAMs
- Include covariates that improve either the model's AIC score or its predictive power (cross-validation score).
- Spatial and temporal matching: causes must match effects
- **Correlation does not necessarily imply causation** so important to propose plausible models and interpret them carefully.

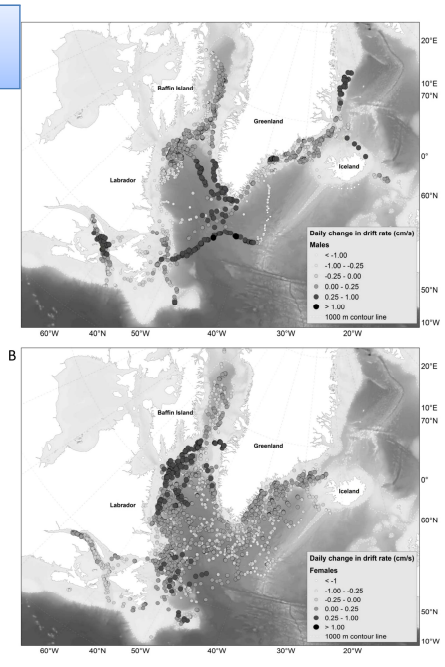
# The cost of living

- The energetic costs of migration and foraging may affect survival and fecundity.
- Telemetry data…
  - How hard do animals have to 'work' to get food? Diving patterns, length of migration, proportion of time spent 'foraging' and 'travelling'
  - How does animal condition change with time?
- Previous studies: hooded seals, terminal velocity during dives to calculate body density in hooded seals.

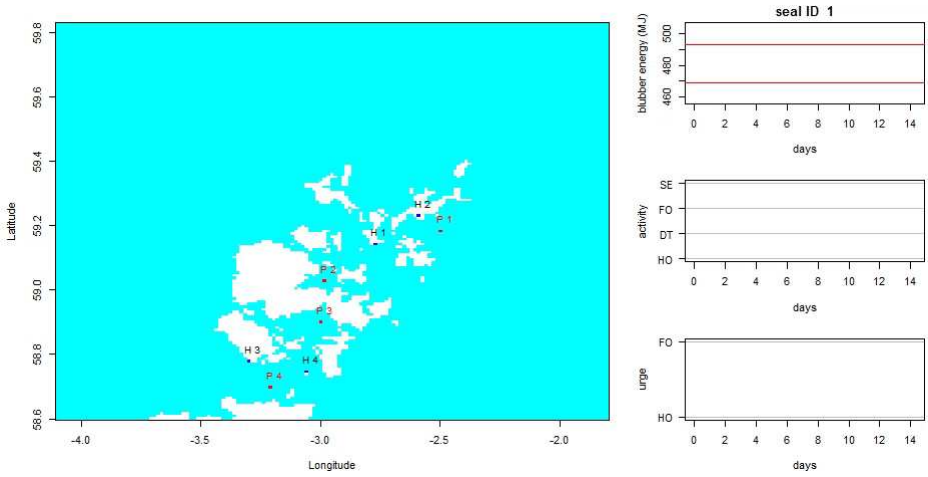



# The cost of living

- Previous studies **estimated condition of hooded seals based on terminal velocity during dives** (indicates body density).
- Remote sensing associates foraging with habitat.
- Could this be done with harp seals?



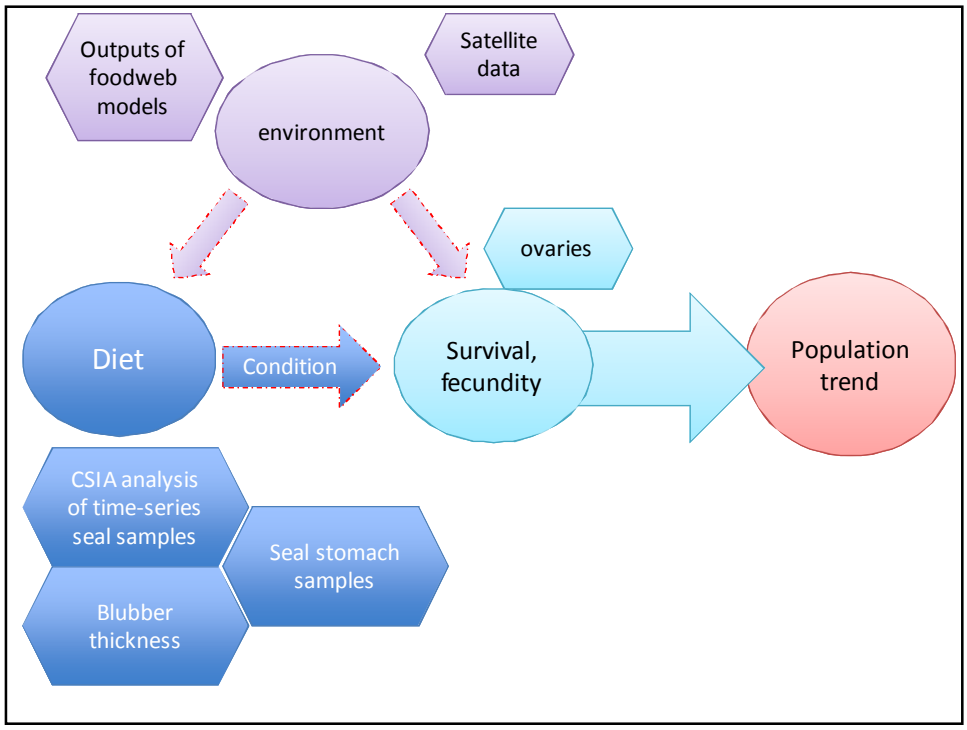
## The cost of living




**Individual based models**, combined with data from previous captive studies about the energetic consumption by seals during different activities

## Summary

1. Historical data sets on body condition and vital rates of harp and ringed seal stocks will be related to environmental covariates using statistical models
2. Environmental covariates based on remote sensing (e.g. sea ice dynamics, surface temperature and productivity, M3b), modelling (e.g. depth resolved temperature and productivity, circulation patterns, water mass pathways, M3b), field/lab datasets (e.g. decadal change in the isoscape and **trophic position inferred from seal archives**, M3a)
3. Identify the key environmental factors that are driving historical changes in seal population dynamics through statistical modelling
4. Spatially explicit approaches might involve additional analysis of dive data to infer changes in condition; individual based modelling.


Outputs of foodweb models
Satellite data
environment
ovaries
Diet
Condition
Survival, fecundity
Population trend
CSIA analysis of time-series seal samples
Seal stomach samples
Blubber thickness