Causal inference corroborates presumed drivers of North Atlantic seabird declines

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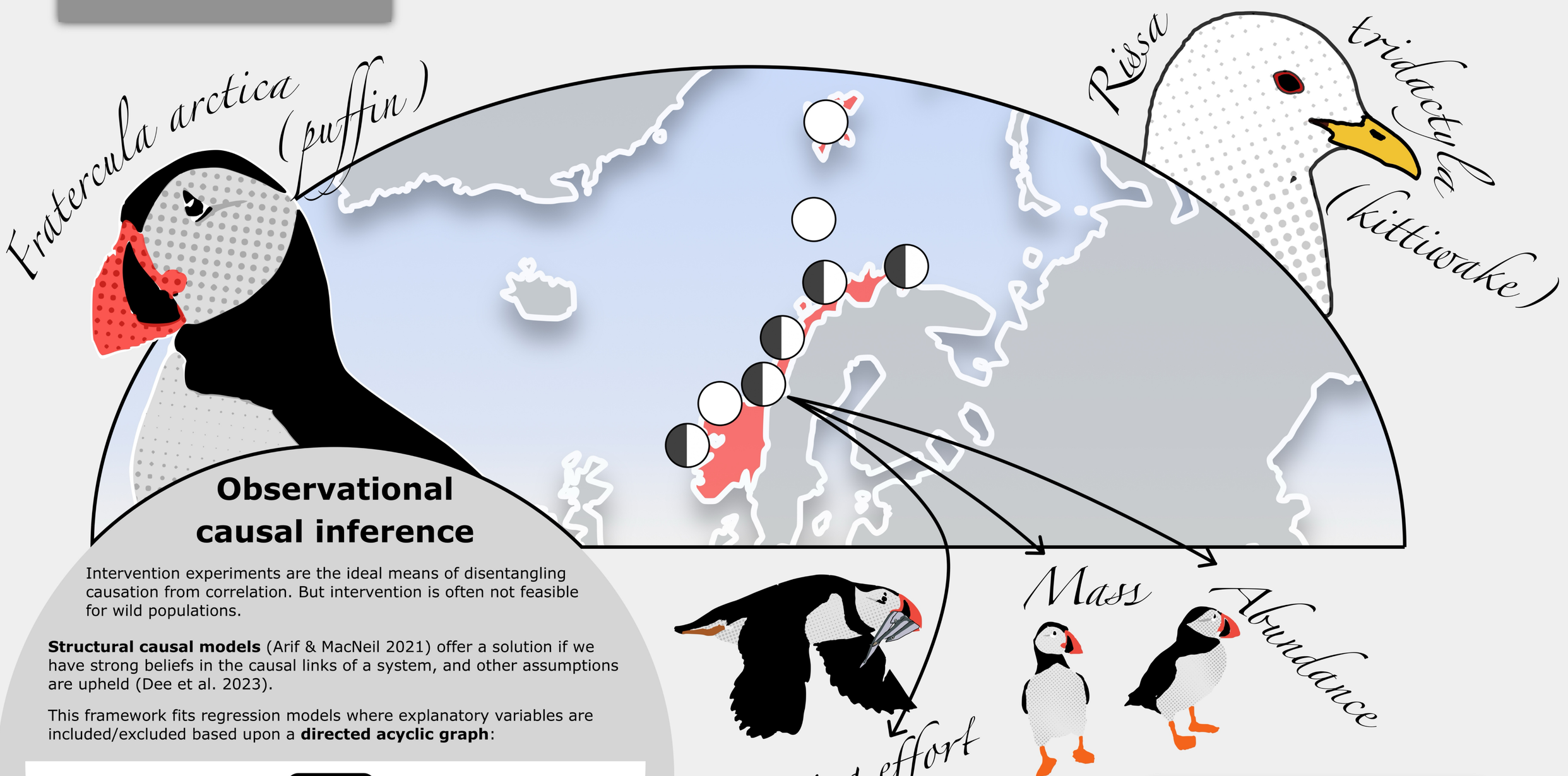
Identifying drivers of seabird change is critical to preventing their extinction but is challenging to achieve from non-experimental data.

Developments made in economics, psychology and medical sciences have improved guidance for assessing causality from observations.

Here, we apply these techniques to reveal time-lagged causal relationships between sea surface temperature (SST) and seabird characteristics such as foraging effort, mass and population size.

Rationale

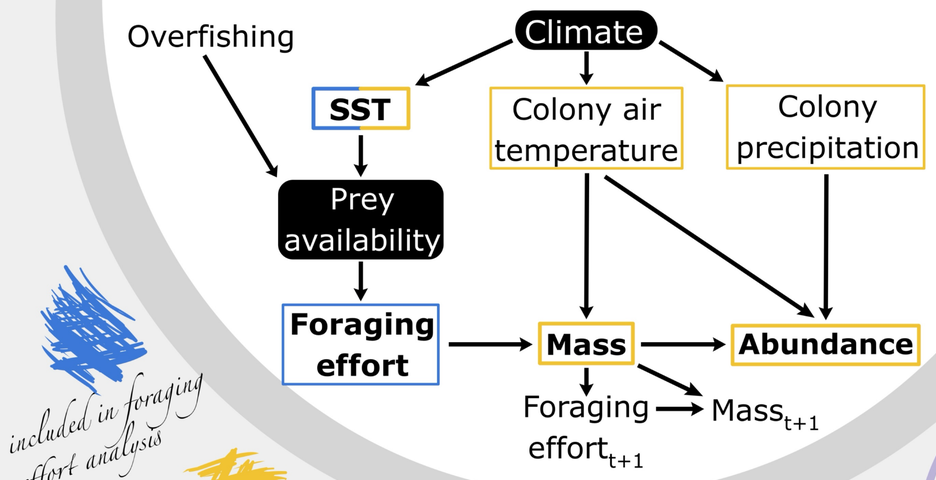


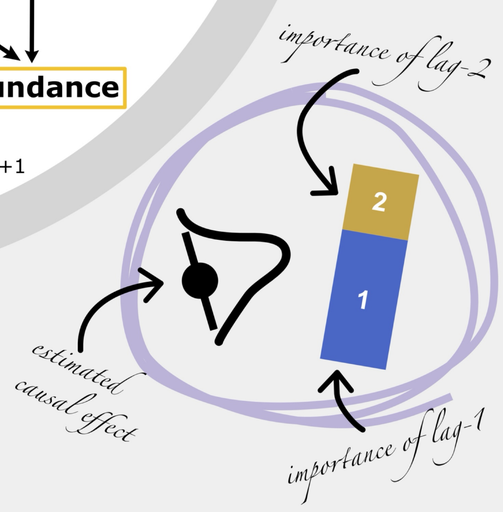
Observational causal inference

Intervention experiments are the ideal means of disentangling causation from correlation. But intervention is often not feasible for wild populations.

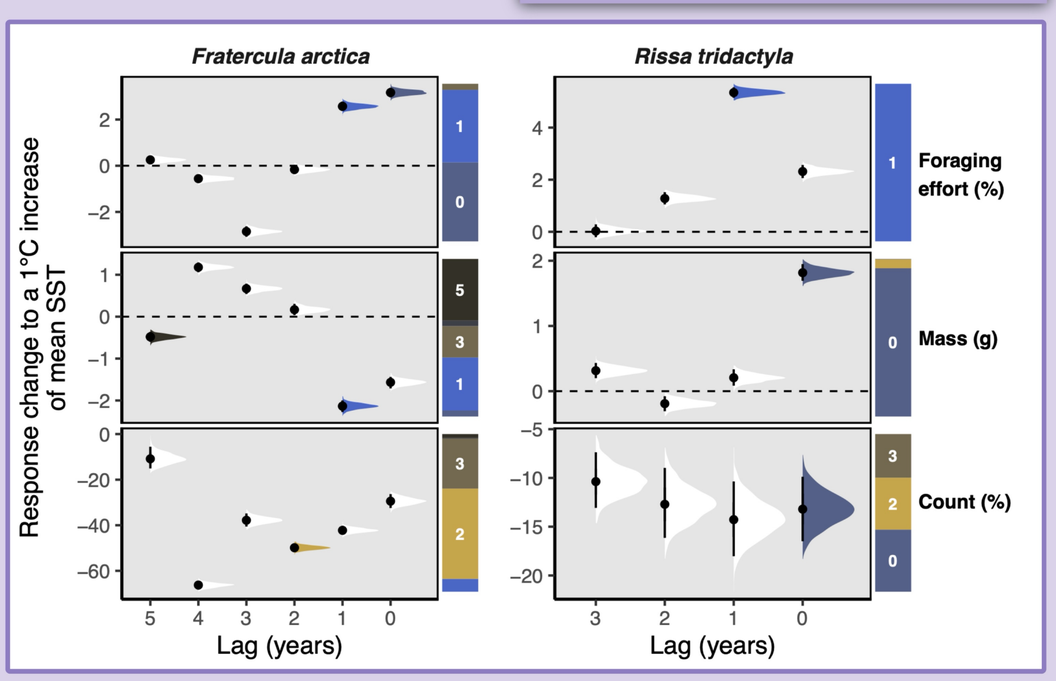
Structural causal models (Arif & MacNeil 2021) offer a solution if we have strong beliefs in the causal links of a system, and other assumptions are upheld (Dee et al. 2023).

This framework fits regression models where explanatory variables are included/excluded based upon a **directed acyclic graph**:





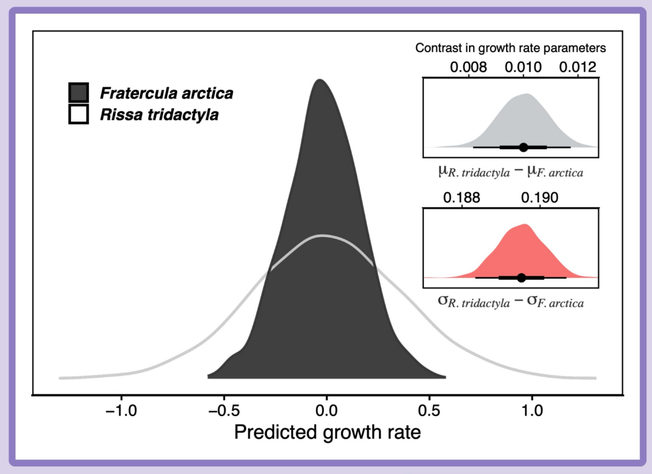
Results



Majority of assumed causal relationships are supported
Behaviour increases, while mass and population decrease in response to a 1°C increase in SST.

Puffins display time delayed effects whereas kittiwakes respond instantaneously

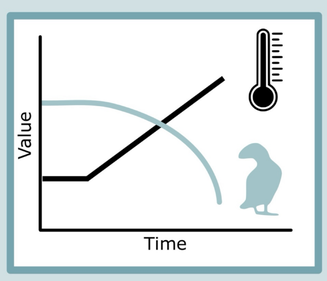
These delayed effects in puffins arise from increased demographic buffering
Kittiwake growth rate variability (σ) is larger than in puffins.



Conclusion

Current understanding of seabird ecology is robust to stricter modelling assumptions - The established belief that climatic changes detrimentally impact seabirds is upheld.

Puffins and kittiwakes are both vulnerable to future climatic change - Very large declines in population size are predicted for future SST increases.



Kittiwakes have less capacity to buffer environmental conditions - As kittiwake growth rate is more variable than puffins, this implies they respond rapidly to the environment.

Time lagged effects are ubiquitous - Ecology must account for these time delays when designing management interventions or 'extinction debts' will become commonplace.

Info

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References: Arif & MacNeil 2021 *Ecol. Monogr*; Dee *et al.* 2023 *N. Commun*; Dias et al. 2019 *Biol. Conserv.*