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Integrated Population Models

A Framework and Lobster Case Study

Trevor Avery Ph.D., P. Stat.
Associate Professor, Acadia University, Biology and Mathematics & Statistics

Project Goal

- Develop a framework for monitoring cumulative (long-term) and far-field (spatial) effects (on fisheries)
- Simulate scenarios of uncertainty to identify areas for improved monitoring
  - Examples: sample size, spatial extent, differences in occupancy or survival, etc.
- Incorporate real fisheries data
- Better quantify the uncertainty of parameters of interest
  - Example: survival at various life stages

What is an IPM?

"Typical IPMs combine one or more time series of counts with another data set that is directly informative about survival probabilities such as capture recapture. However, many other sources of demographic information may be envisioned instead or in addition, including age-at-death data, occupancy or replicated point count data."

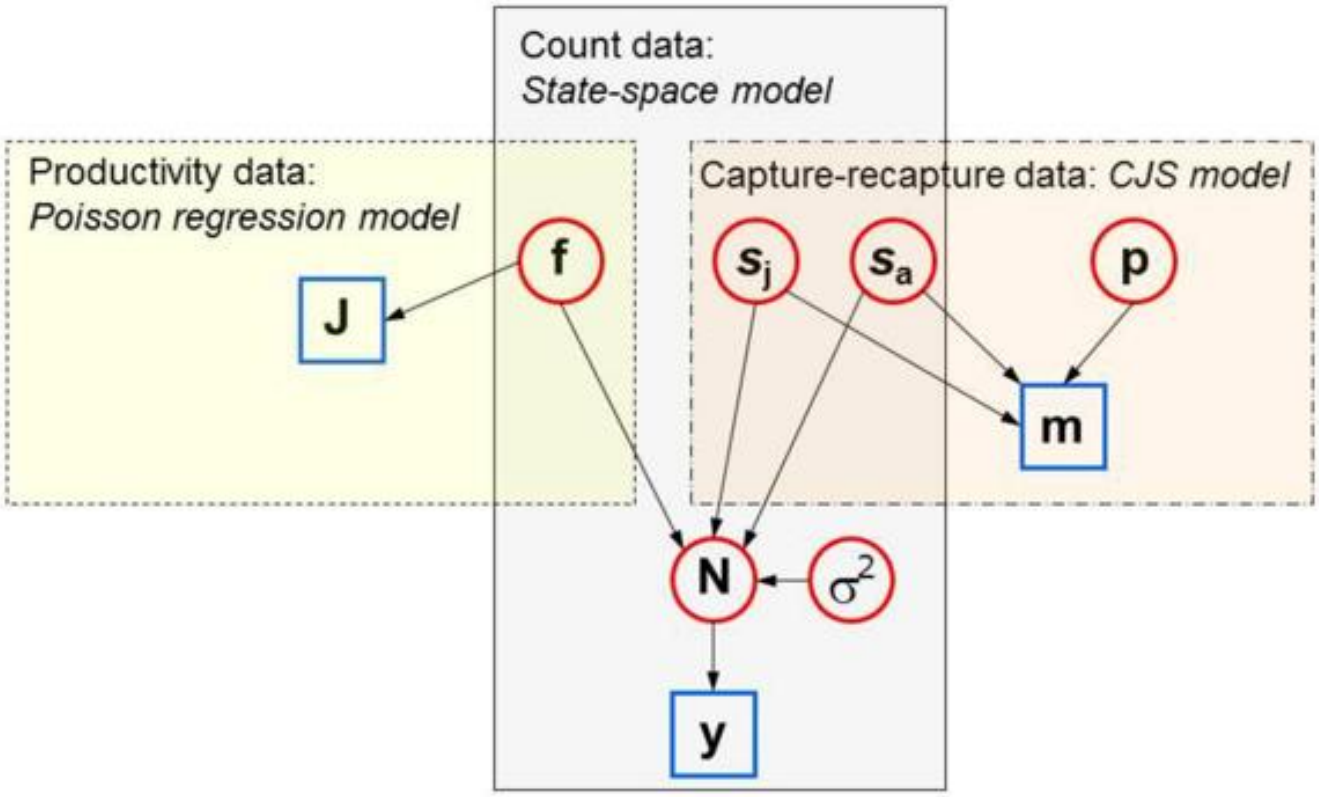
- -- Michael Schaub & Marc Kéry

What is an IPM?

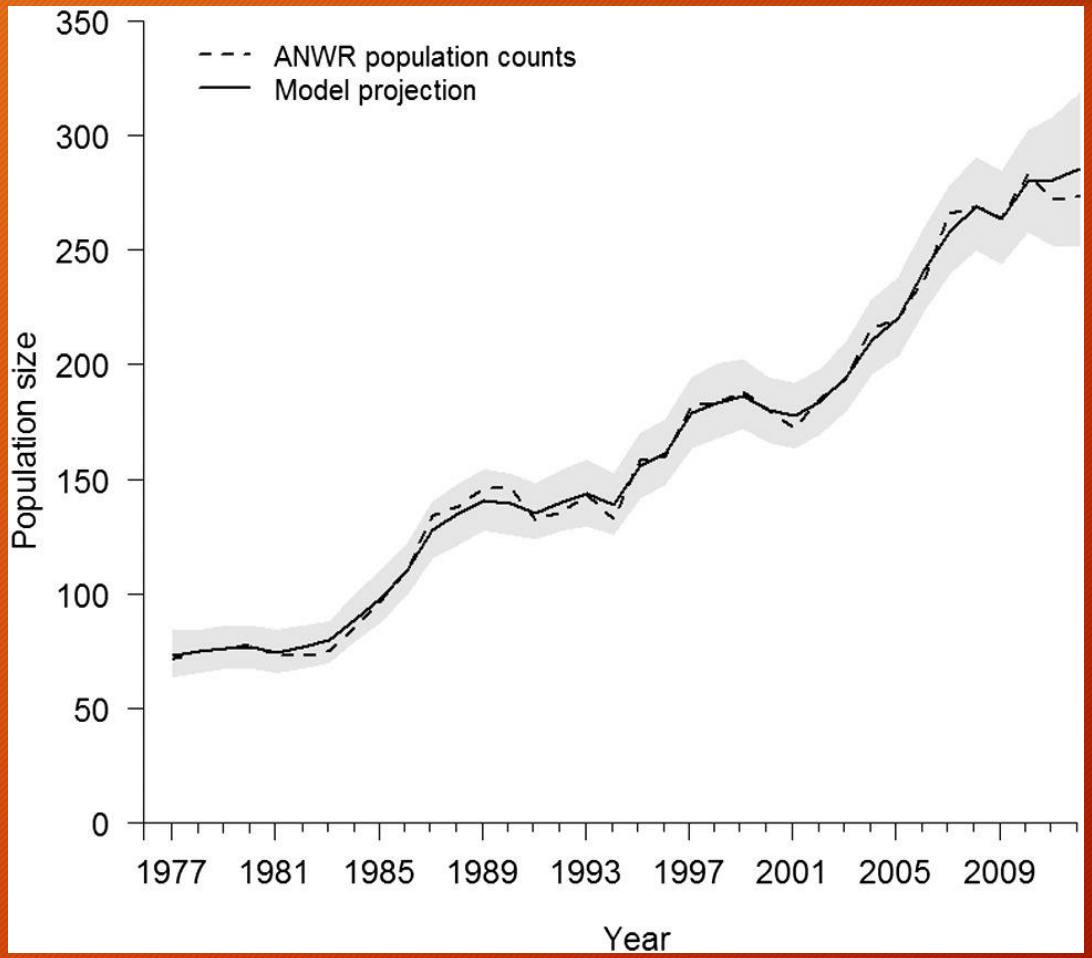
1. Combines multiple pieces to help with ‘figuring out’ and ‘accounting for’ uncertainty
2. Incorporates both observation uncertainty and process error
   - *Process Error* = Uncertainty that arises from modelling a simplification of reality
3. Flexible framework for incorporating all sorts of spatial and temporal factors

IPM

"Nothing more than a series of simple deterministic and stochastic relationships"



IPM Output



A typical model output resembles a trend line with associated error (blue-grey area).

WIlson et al. 2016 Integrated population modeling to assess demographic variation and contributions to population growth for endangered whooping cranes

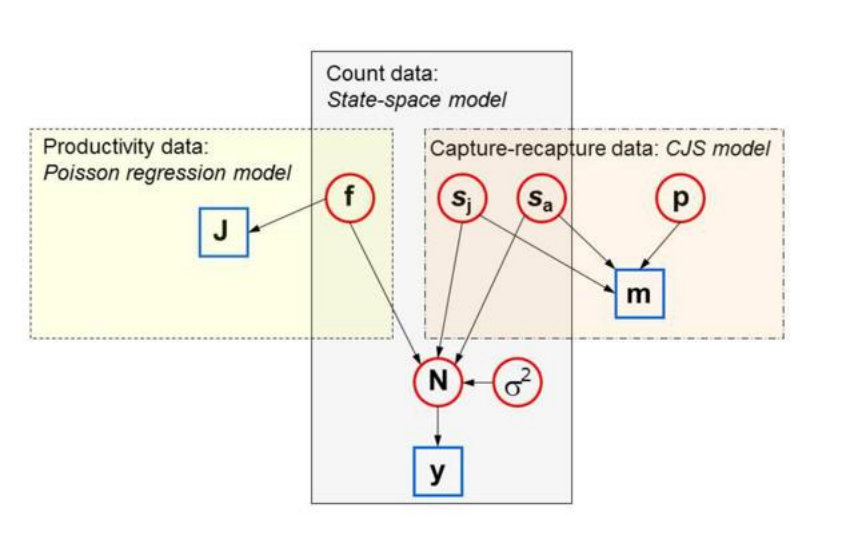
Why a Bayesian IPM?

- ✓Incorporating stochasticity in a BIPM is ‘trivial’
  - Traditional/historical/frequentist models typically follow a ‘deterministic’ approach where the outcome does not adequately consider stochastic processes i.e. random effects
- ✓Estimates are exact for any sample size.
  - Even with sparse data, predicted values and uncertainties are unbiased.
- ✓Calculation of the uncertainties of derived parameters is ‘trivial’
- ✓High Performance Computing necessary for Bayesian methods analysis
- ✓Prior information/probabilities can be considered

IPM Parts

State-space models incorporate both observation and process error explicitly

Historical and known productivity

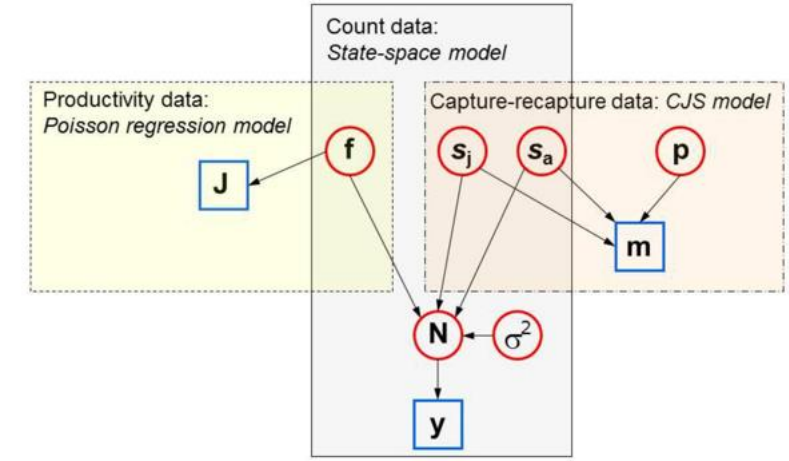


Mark-Recapture model/data or Simulations

Lobster

‘On the ground’ count data from fisheries contributions

Historical and known productivity



Mark-Recapture model/data or Simulations

Simulations

- Simulations using parameters (information) from similar populations is possible for exploration
  - Example: If specific population information is lacking
- Simulations are powerful tools, but require powerful computers
  - Compute Canada and AceNet resources
- Bayesian IPM are adaptable to *any* population!
  - Example: Adoption to fish species or long-term monitoring of identified indicator species

Acknowledgements

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