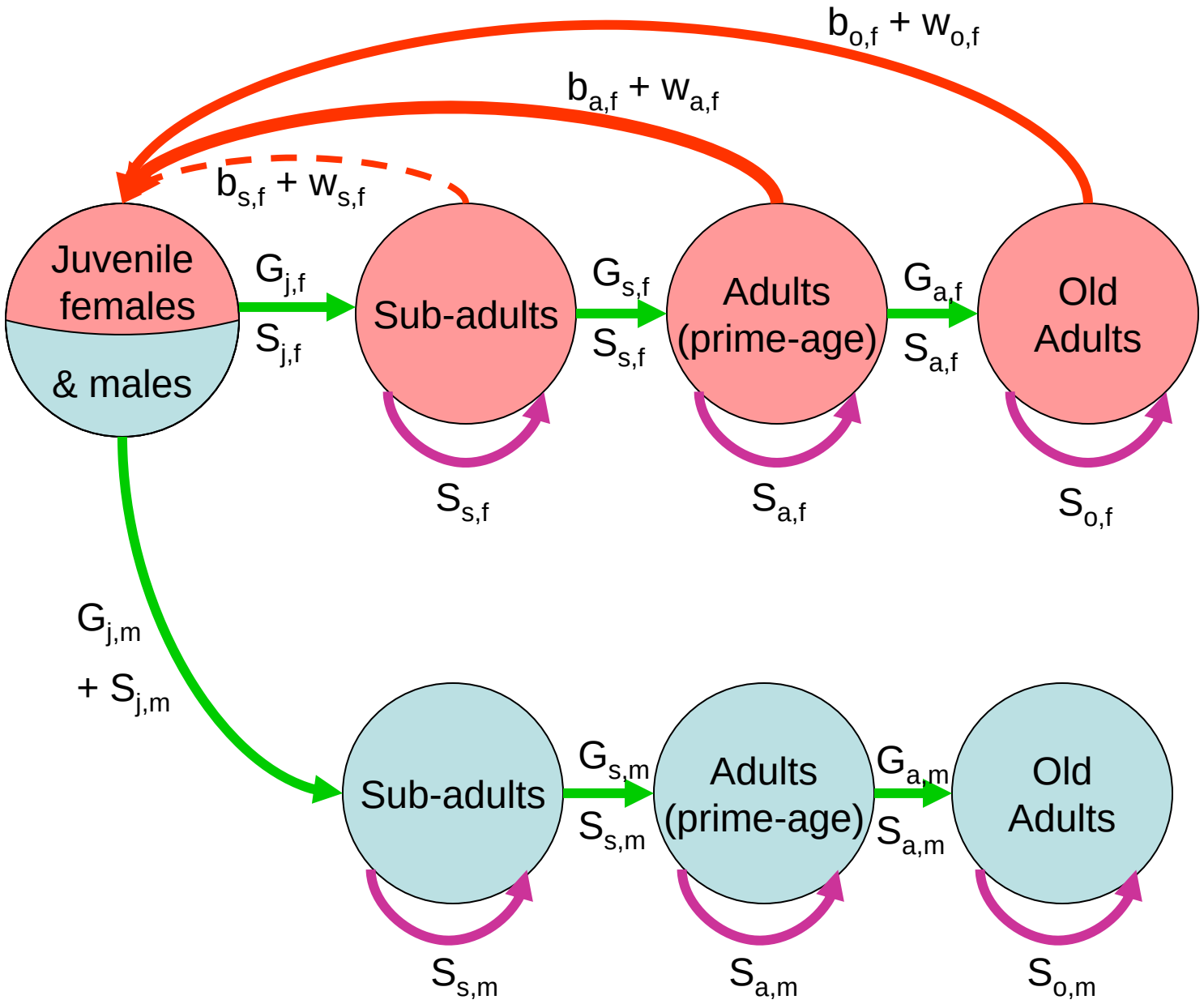
Developing a PVA model for SW Alaska sea otters

A first stab at a general framework

What type of model?

- Count based PVA vs. demographically explicit matrix-based model?
  - We have data on age/sex structure & vital rates → these could be important given small pop'n sizes, so use matrix model
- Spatially-structured: multiple sub-populations (Islands, mainland regions) linked by dispersal
- Level of realism? Start with simple, conceptual model (for sensitivity and exploratory analyses)


$b_{o,f} + w_{o,f}$
$b_{a,f} + w_{a,f}$
$b_{s,f} + w_{s,f}$
Juvenile females & males
$G_{j,f}$
$S_{j,f}$
Sub-adults
$G_{s,f}$
$S_{s,f}$
Adults (prime-age)
$G_{a,f}$
$S_{a,f}$
Old Adults
$S_{s,f}$
$S_{a,f}$
$S_{o,f}$
$G_{j,m}$
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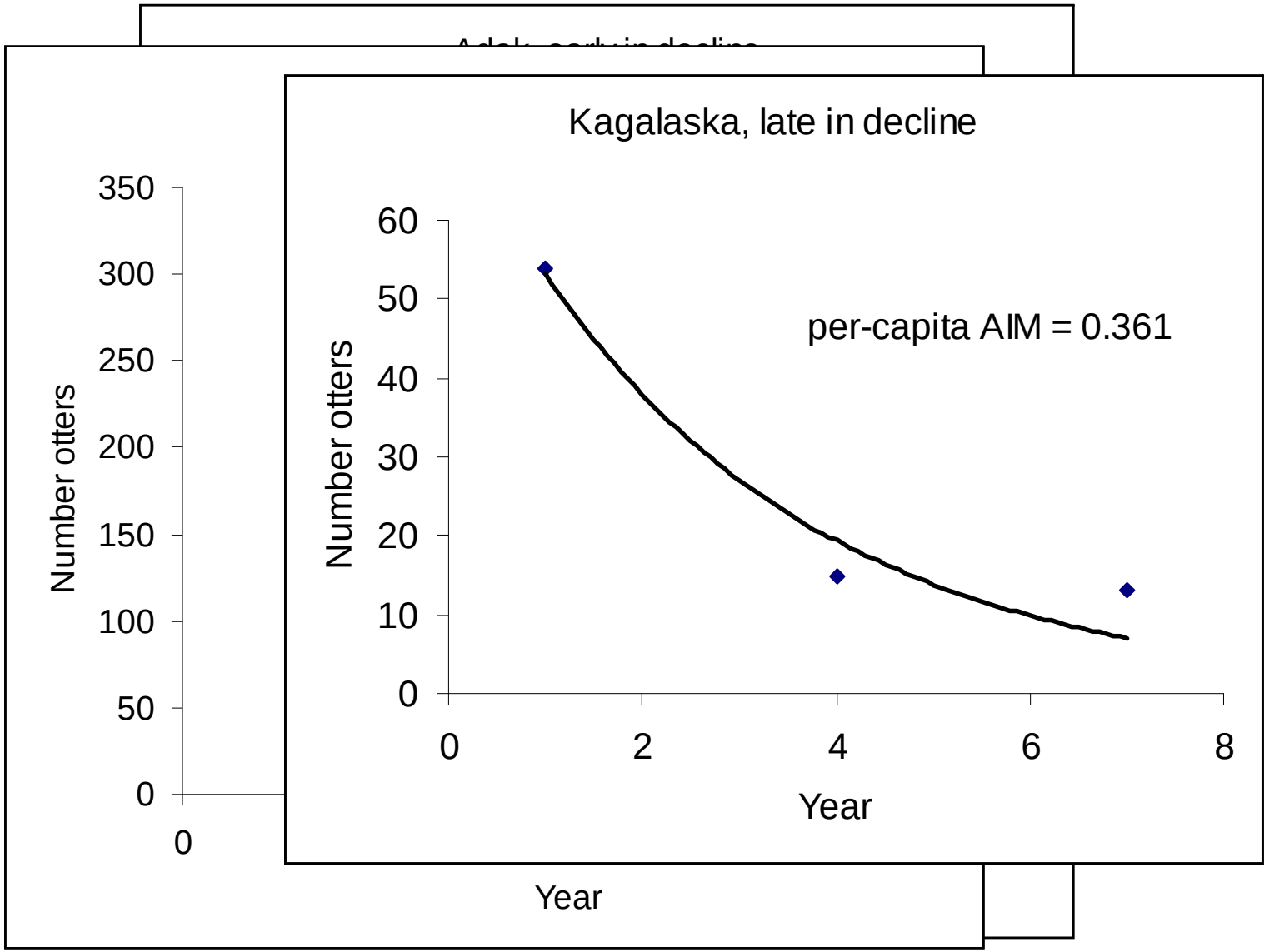
Sub-adults
$G_{s,m}$
$S_{s,m}$
Adults (prime-age)
$G_{a,m}$
$S_{a,m}$
Old Adults
$S_{s,m}$
$S_{a,m}$
$S_{o,m}$

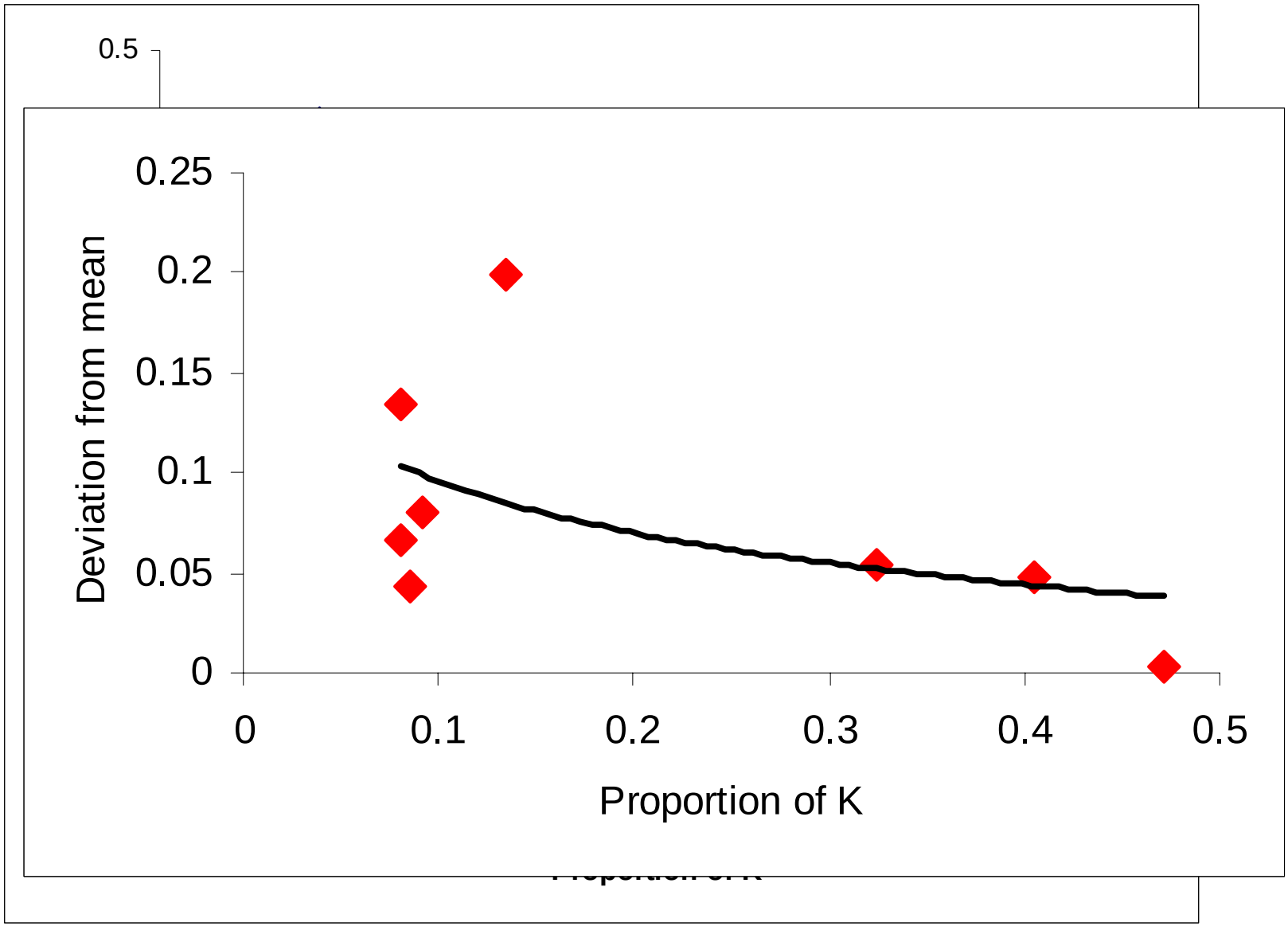
Parameterizing transition rates

- Estimates of age/sex-specific vital rates from various telemetry studies
- Recent analysis of pop'n age-structure (Laidre et al 2006) indicates that age-biased mortality "relaxed" early-on in decline: the increased mortality that caused decline was primarily age-independent mortality (AIM = predation or…)
- Approach: use MLE techniques with skiff survey time series data to find rate of per-capita AIM necessary to cause observed declines

In other words…



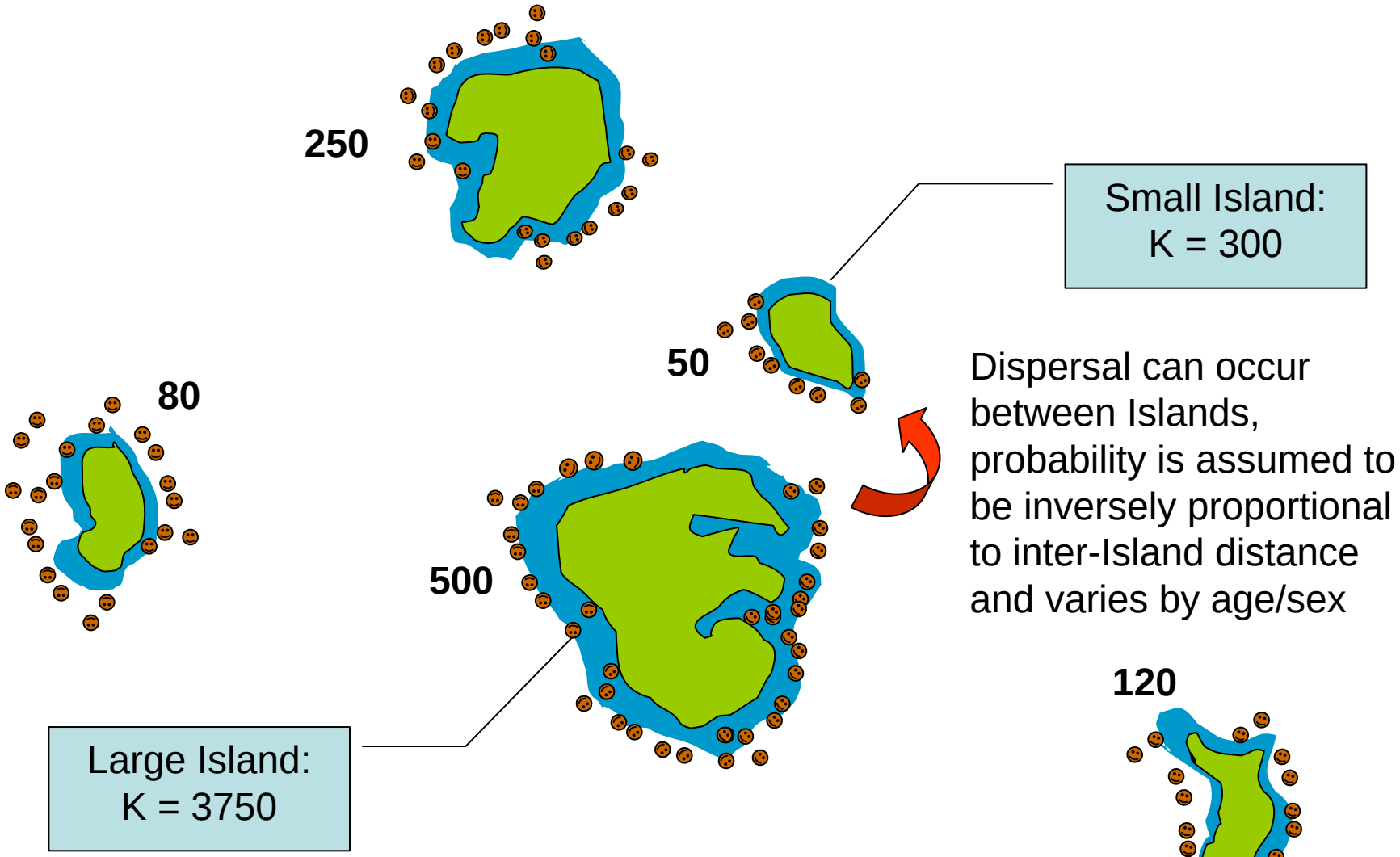
Not surprisingly, high AIM



Simulation model: layout

- Dynamics tracked on annual time-step for each distinct sub-population: vital rates are density dependent (theta-logistic model, assume $\lambda = 1.12$ at low density) with environmental & demographic stochasticity
- Additional mortality from predation (or other AIM) drawn randomly from MLE-fitted sampling distribution
- Dispersal between sub-populations also modeled as a stochastic process

Simulation model: example



TOTAL POP'n at Year 0 = 1000 (~ 15% of K)

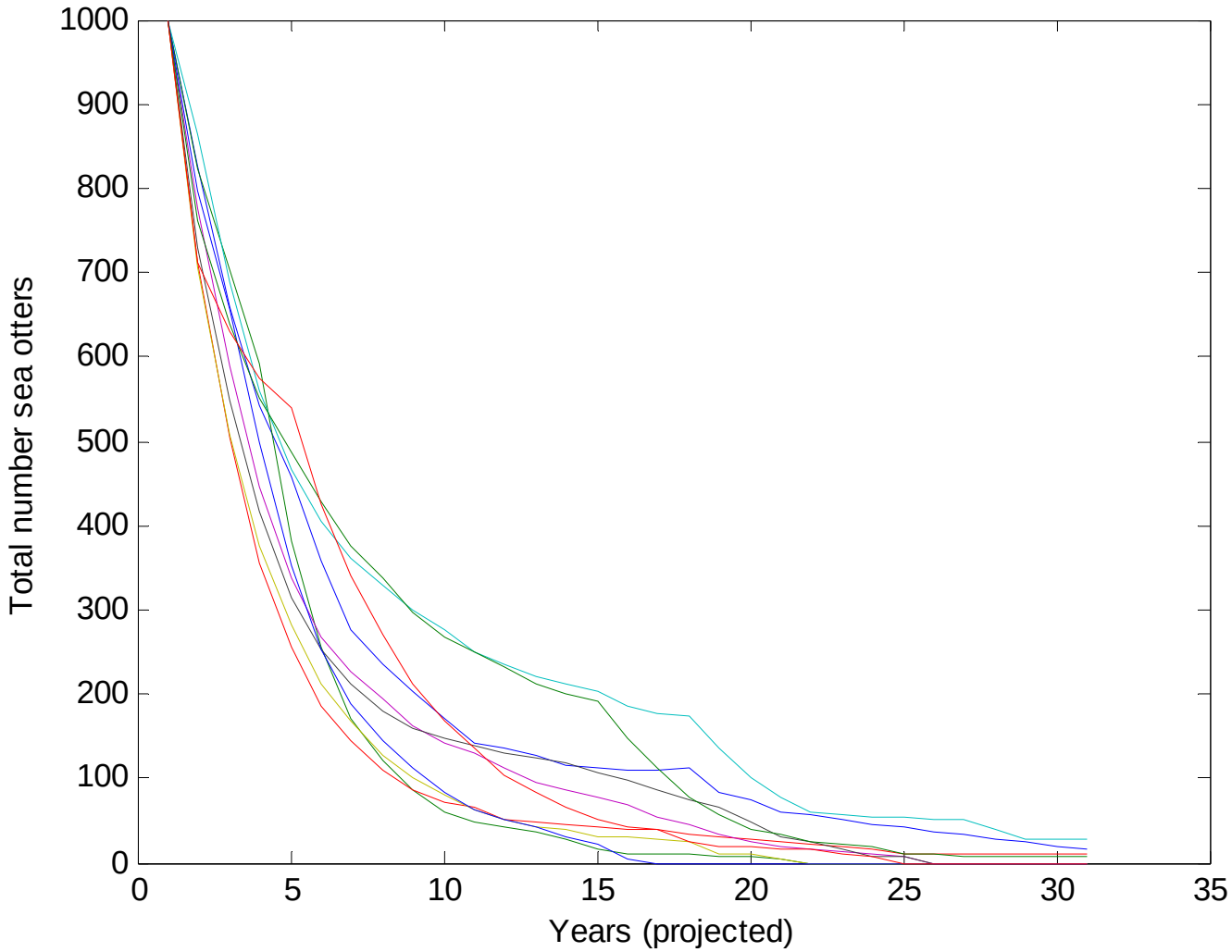
Simulation model: methods

- Monte Carlo simulations: all stochastic processes modeled by drawing randomly from appropriate distributions
- Handling uncertainty: vary all input parameters within “reasonable ranges” over many iterations
- Model output: total pop’n size over time (# years to extinction)
- More importantly: which parameters have strongest effect on results?

Some preliminary results

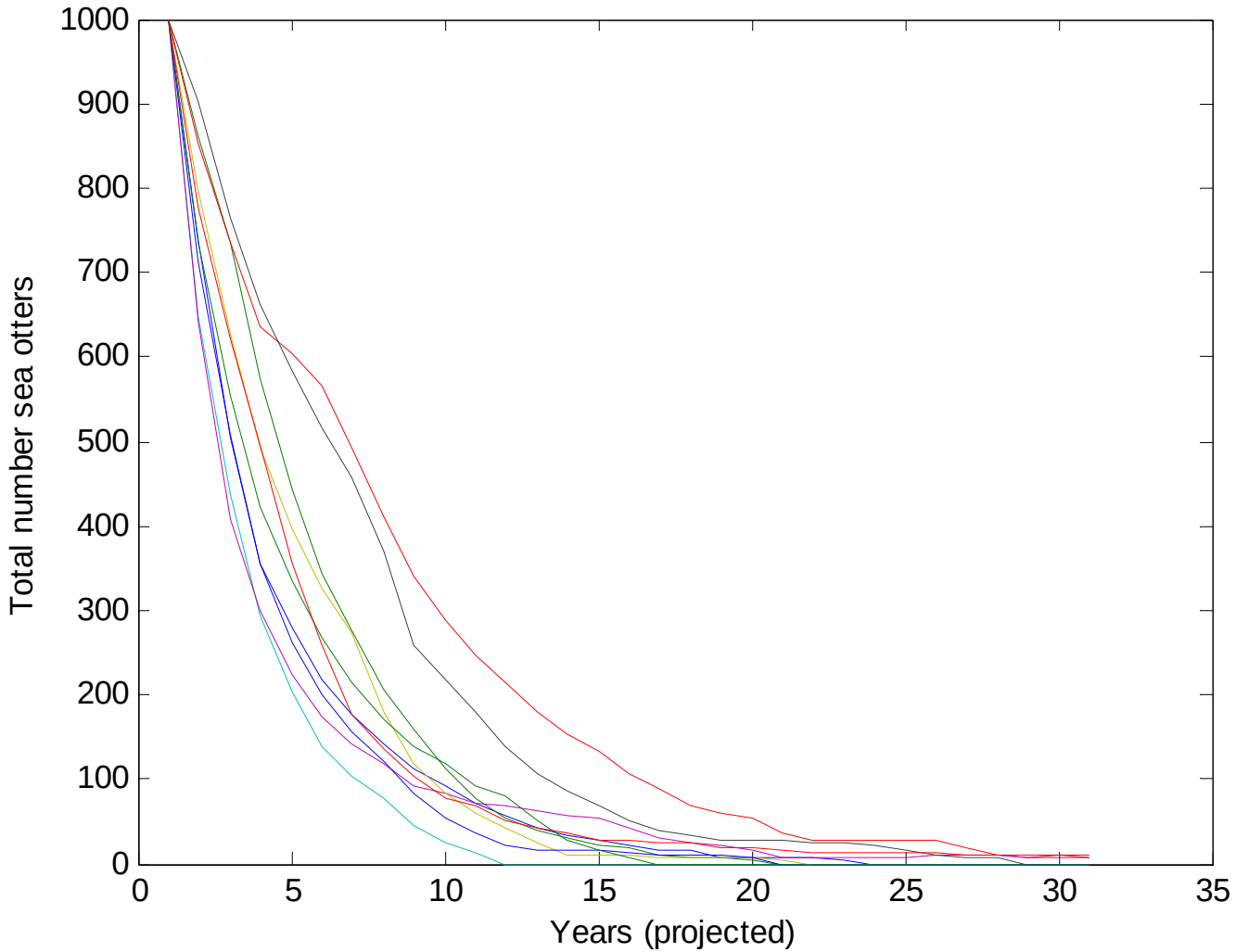
Low dispersal, random predation rate

Per-capita dispersal = 0.00037



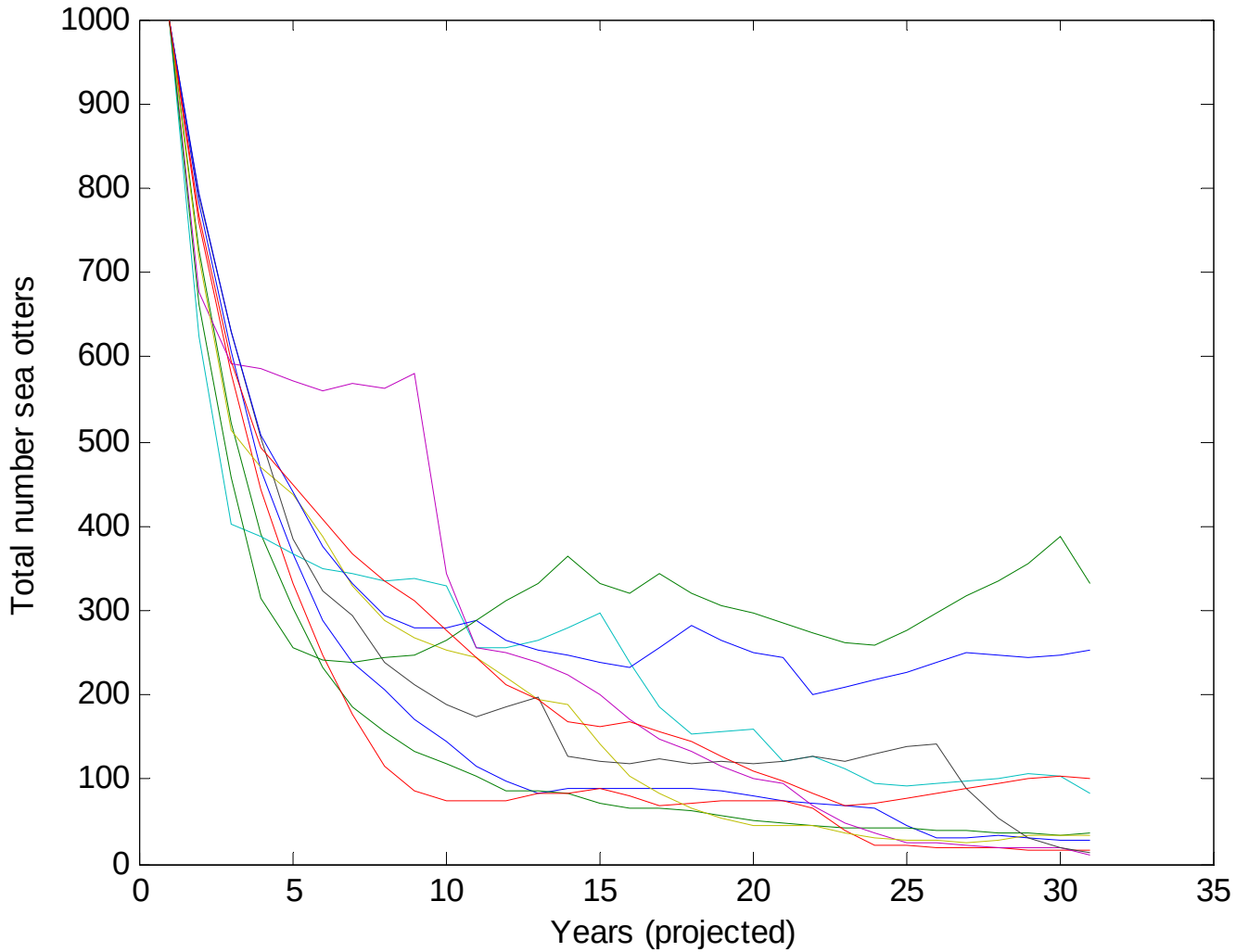
High dispersal, random predation rate

Per-capita dispersal = 0.00867, or 23x greater than low-dispersal sims



Low dispersal, non-random predation

Some islands buffered from predation at low density, but same overall mean



What next?

- Discuss model with recovery team:
  - Is this approach useful (providing a theoretical framework for evaluating quantitative Qstn's)?
  - How to handle uncertainties (e.g. dispersal)
  - What level of realism? Heuristic vs. predictive?
- Further parameterization: need data from eastern M.U.s (aerial data, TASSC skiff surveys?)
- Preliminary results highlight the need to better understand spatial dynamics, especially potential for "refuges" (habitat characteristic model?)