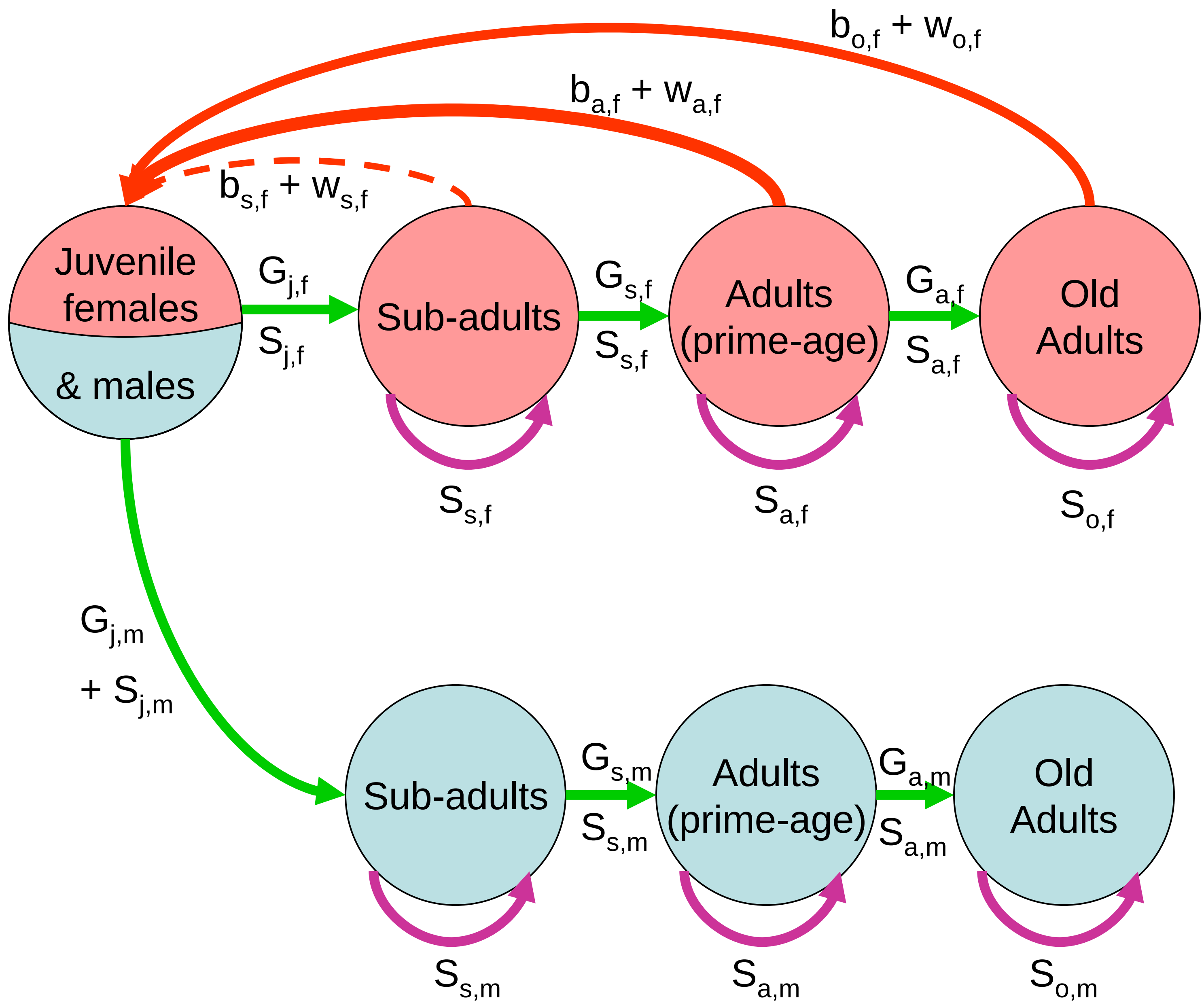
PVA model
for SW Alaska sea otters

A progress report

Overview of PVA

- Demographic model structured by age (juv, sub-adlt, adult, aged adult) and sex
- Also accounts for spatial structure: multiple sub-populations (Islands, or mainland regions) linked by dispersal
- Forecasts of population dynamics made by simulating variation in survival rates according to observed range and patterns of variation from existing data



$b_{o,f} + w_{o,f}$
$b_{a,f} + w_{a,f}$
$b_{s,f} + w_{s,f}$
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
$S_{s,f}$
$S_{a,f}$
$S_{o,f}$
$G_{j,m}$
$+ S_{j,m}$
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
- 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…

- How much unexplained AIM (in addition to “baseline” age-dependent mortality from all other sources) was needed to cause the observed decline trajectories?
- Was per-capita rate of AIM constant, or has it varied as a function of sea otter density (↑ or ↓ over the course of the decline)

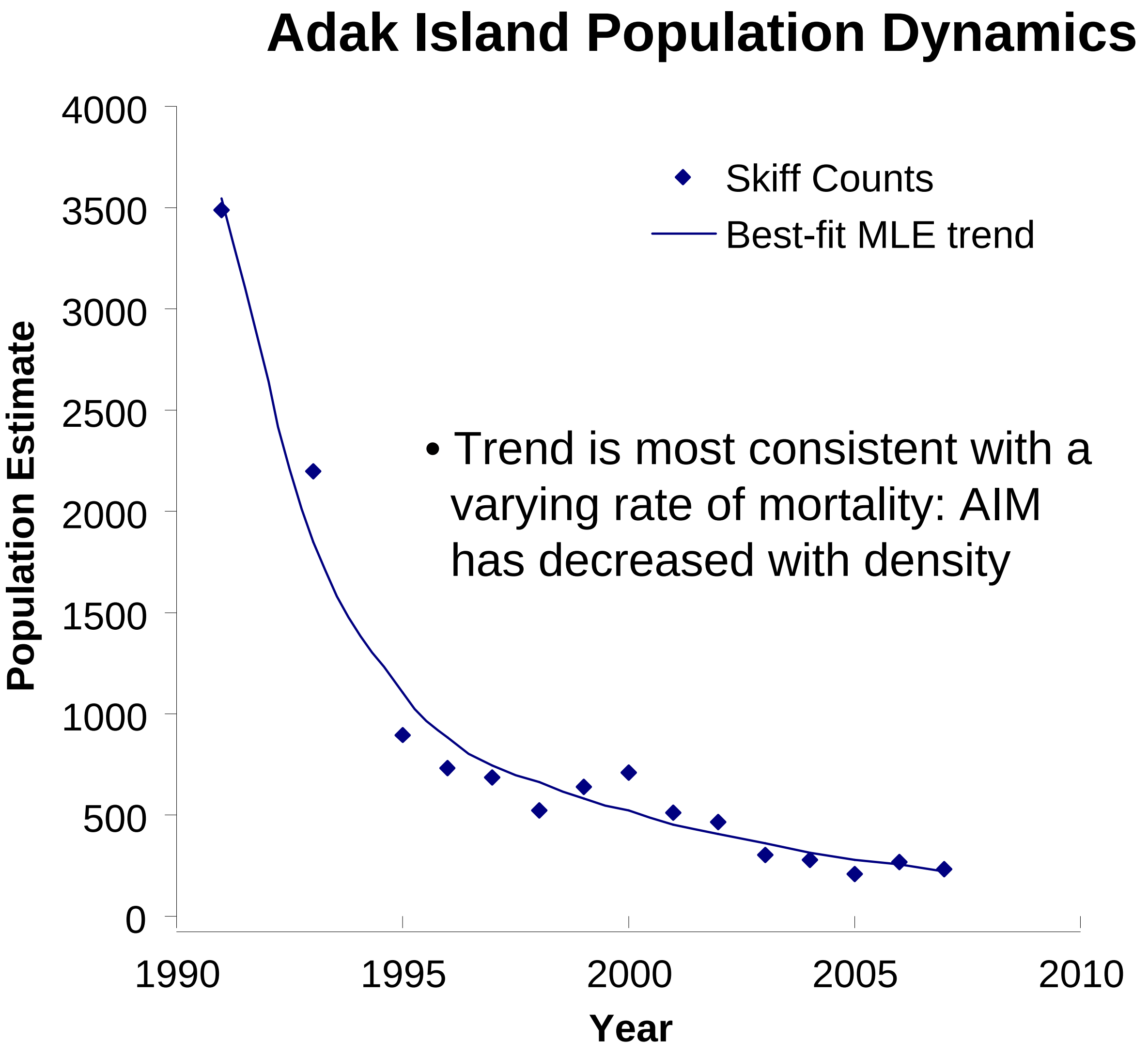
Alternate functions evaluated

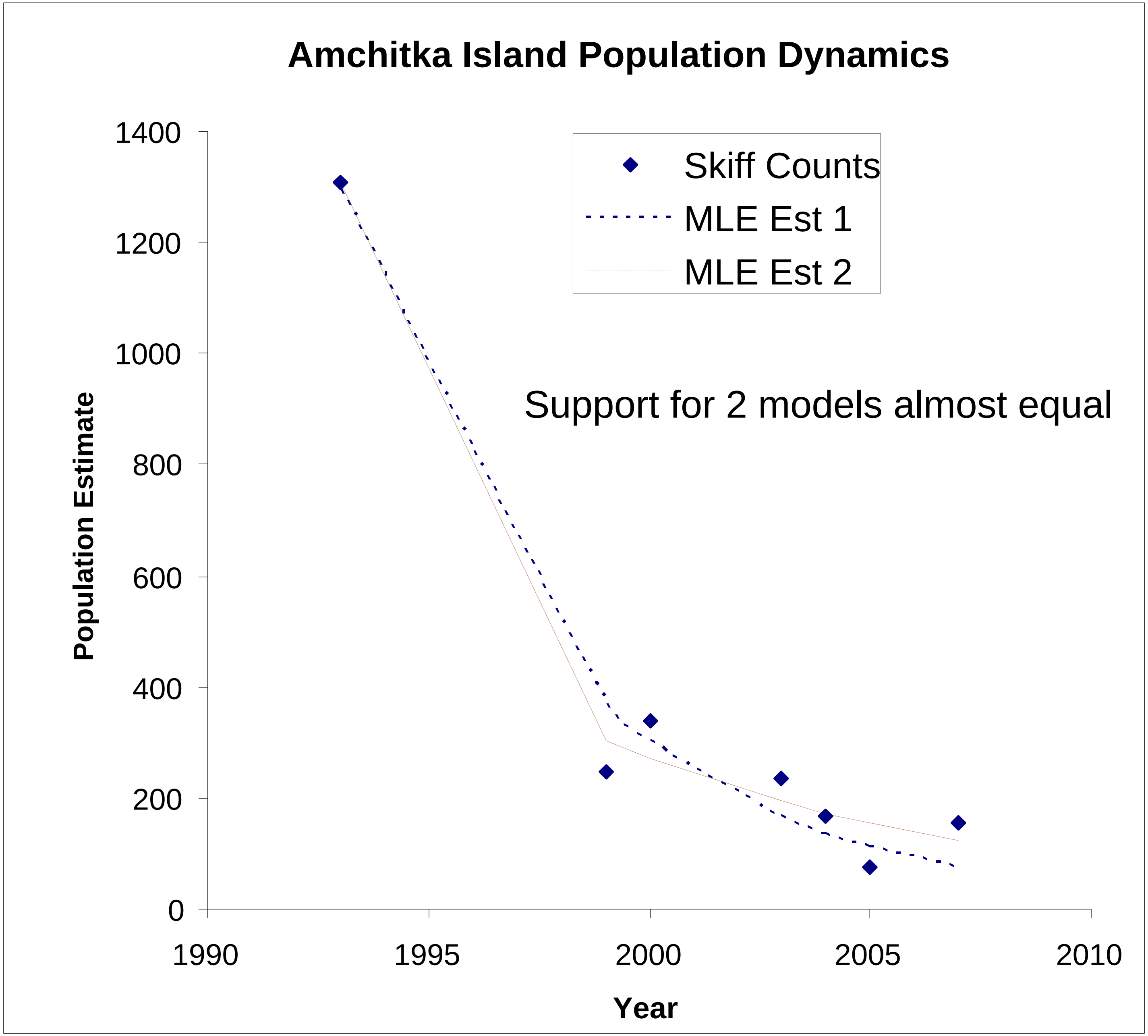
1. Rate of mortality shows no directional change (varies randomly, with constant average)

2. Time-varying or density-varying mortality: per-capita rate AIM increases or decreases as otter numbers drop: 3 additional parameters needed to fit this function

- AIC used to select most parsimonious model form (penalizing for additional parameters)

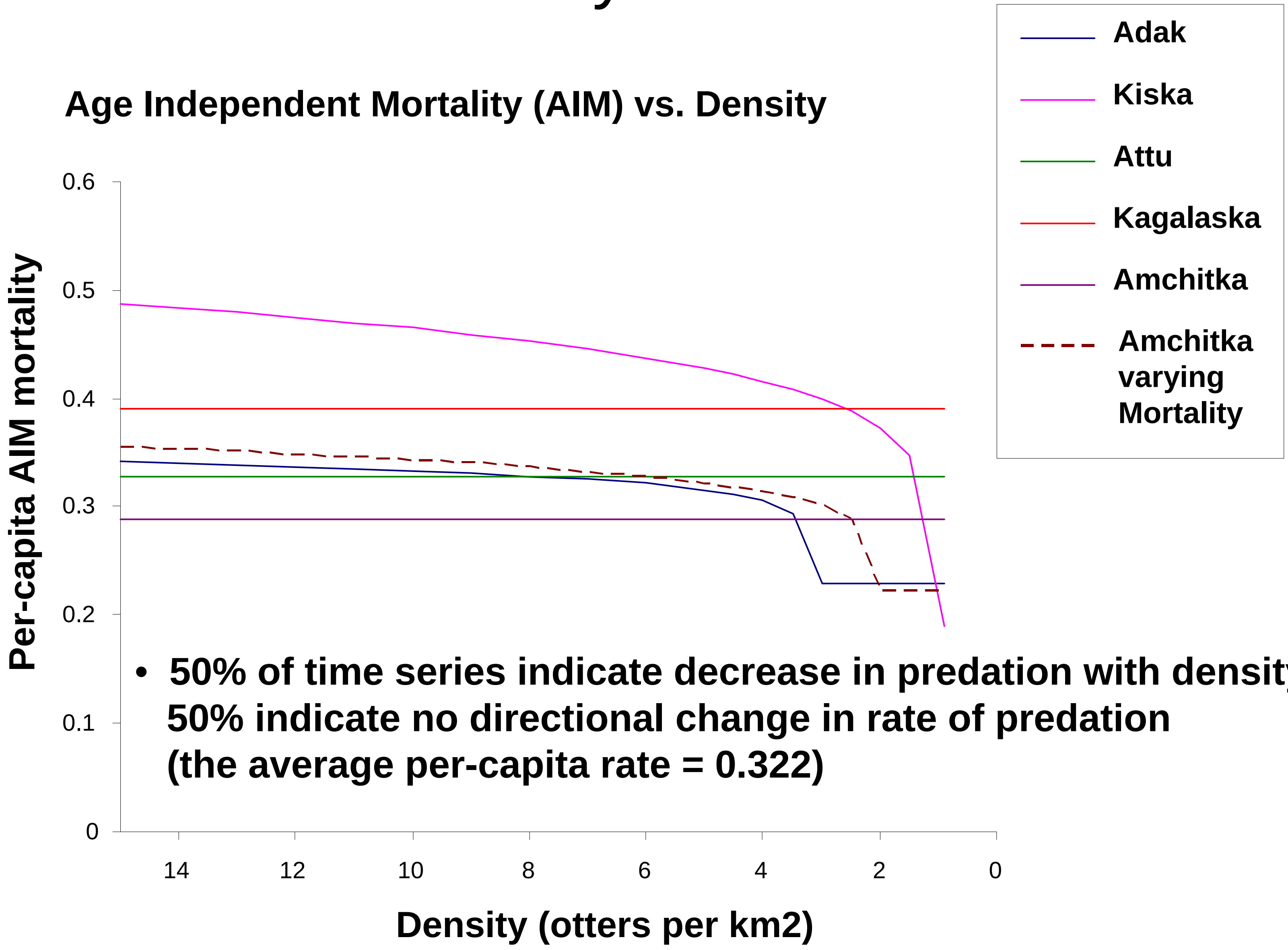
Raw data: skiff survey time series





Amchitka Island Population Dynamics
Population Estimate
Year
0
200
400
600
800
1000
1200
1400
1990
1995
2000
2005
2010
Skiff Counts
MLE Est 1
MLE Est 2
Support for 2 models almost equal

Summary of Trends



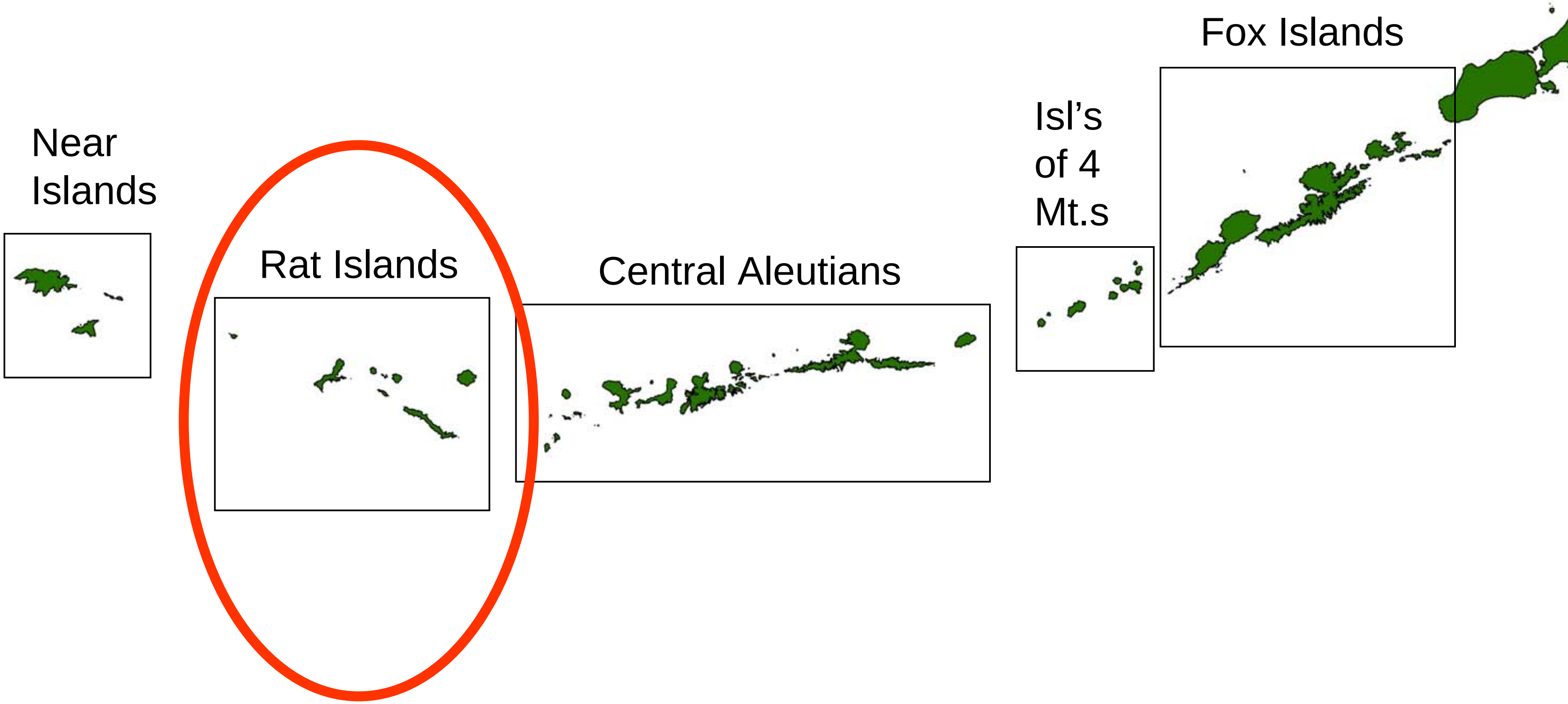
- **50% of time series indicate decrease in predation with density, 50% indicate no directional change in rate of predation (the average per-capita rate = 0.322)**

PVA model: methods

- Dynamics tracked on annual time-step for each distinct sub-population: vital rates are density dependent (theta-logistic model, assume $\lambda = 1.15$ at low density), with env. & demog. stochasticity
- Additional mortality from predation (or other AIM) drawn randomly from MLE-fitted distributions: rate of AIM assumed to be independent of density at some Islands (50%), density-dependent at others
- Dispersal between sub-populations also modeled as a stochastic process

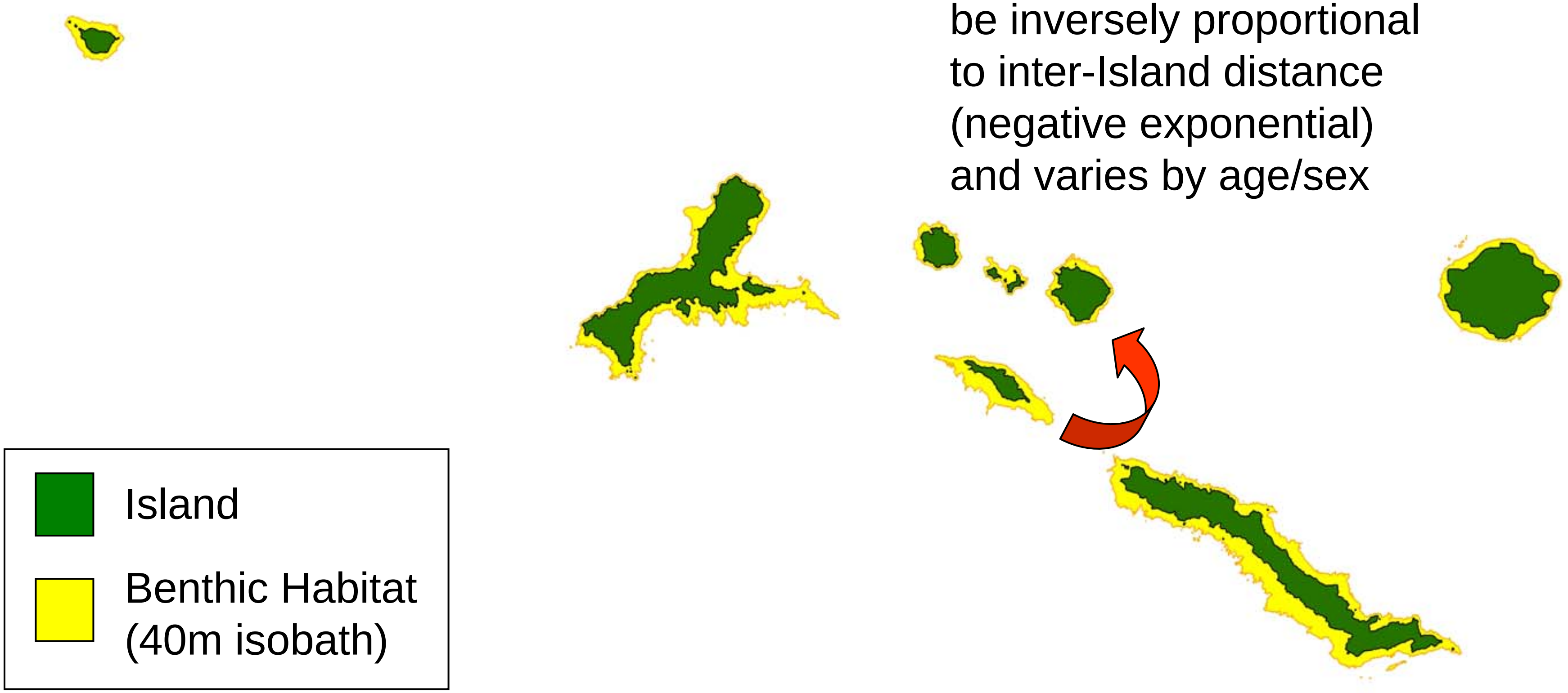
Geography Review: Aleutian Islands

- **Population dynamics tracked for five main Island Groups**



Rat Island Group

Dispersal can occur between Islands, with probability assumed to be inversely proportional to inter-Island distance (negative exponential) and varies by age/sex

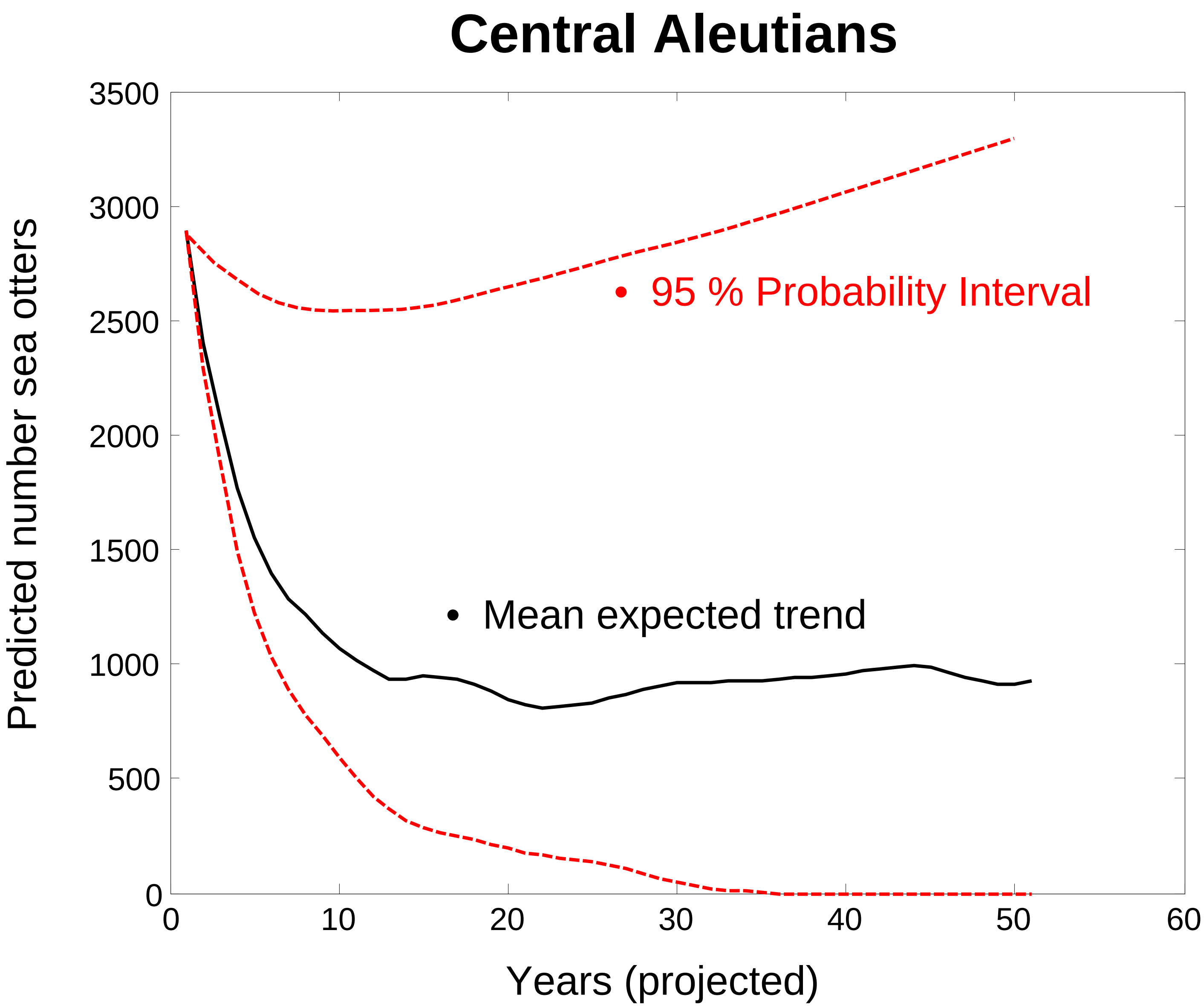


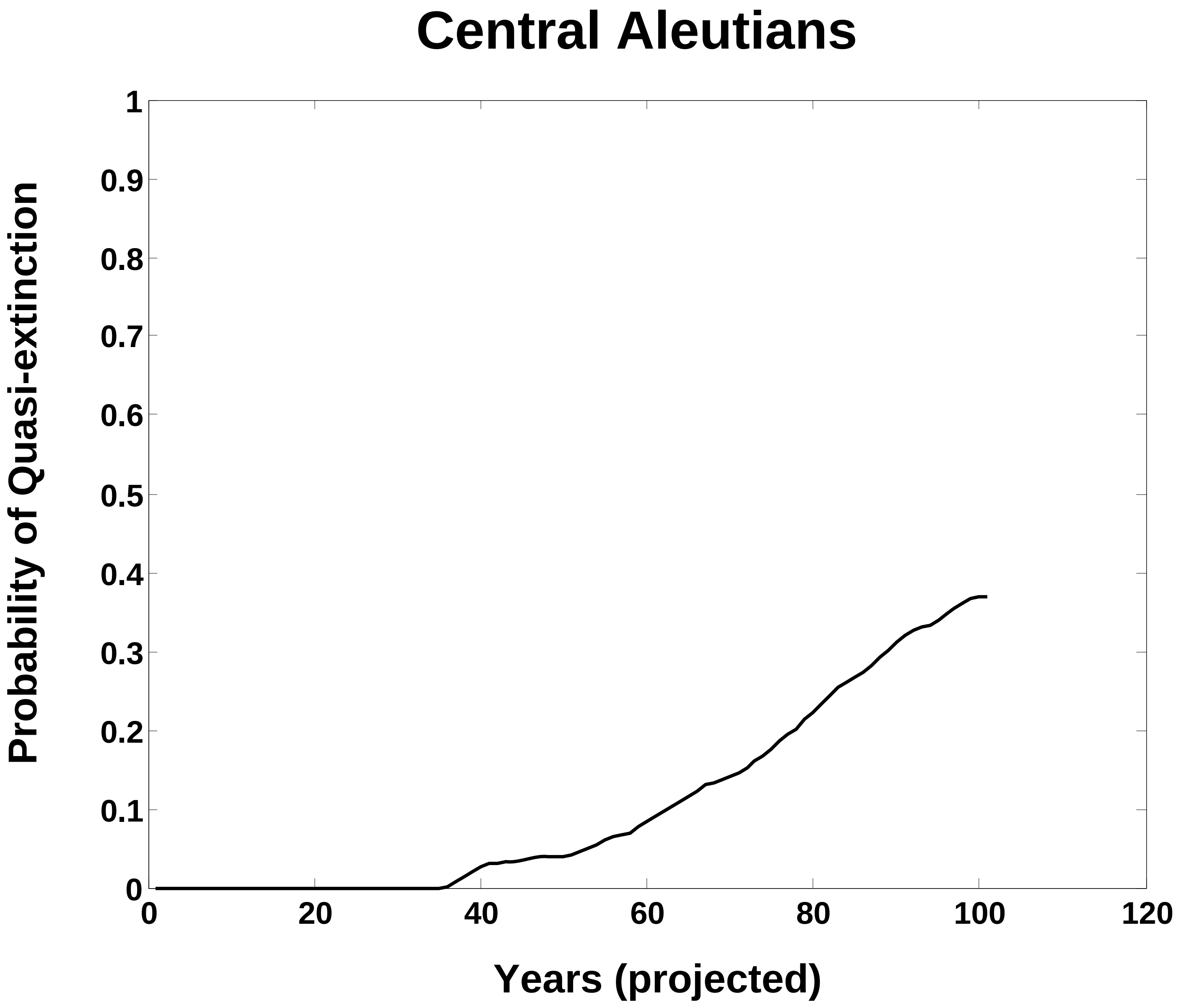
- **Density at each Island measured as otters per km^2 of habitat**
- **Total Population size in 2000 (Yr 0) = 600, ~ 5% of K**

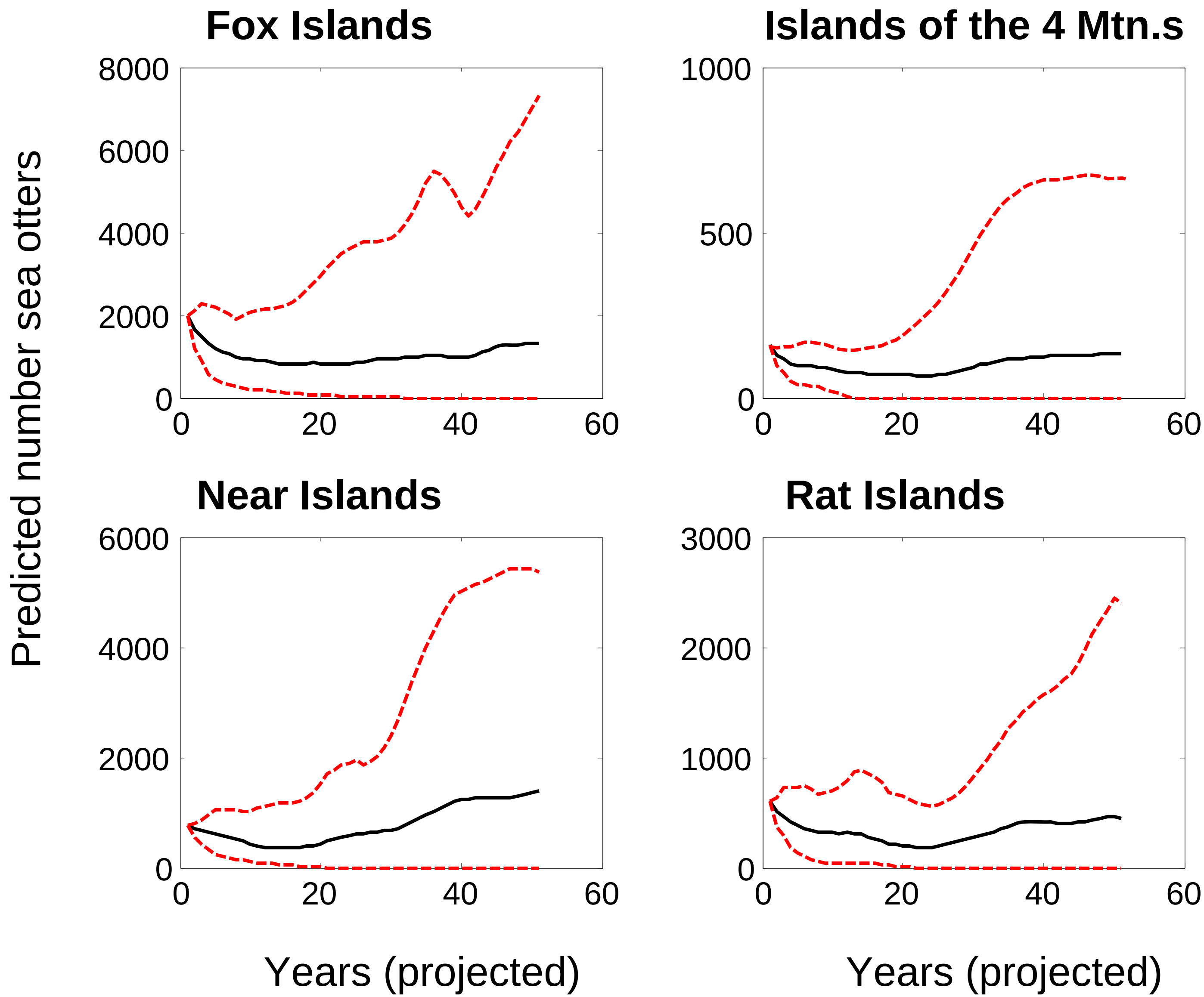
PVA model: more methods

- Monte Carlo simulations: all stochastic processes modeled by drawing randomly from appropriate distributions
- Model parameters vary within “reasonable ranges” over many iterations
- Model output: total pop’n size over time and probability of extinction at year T

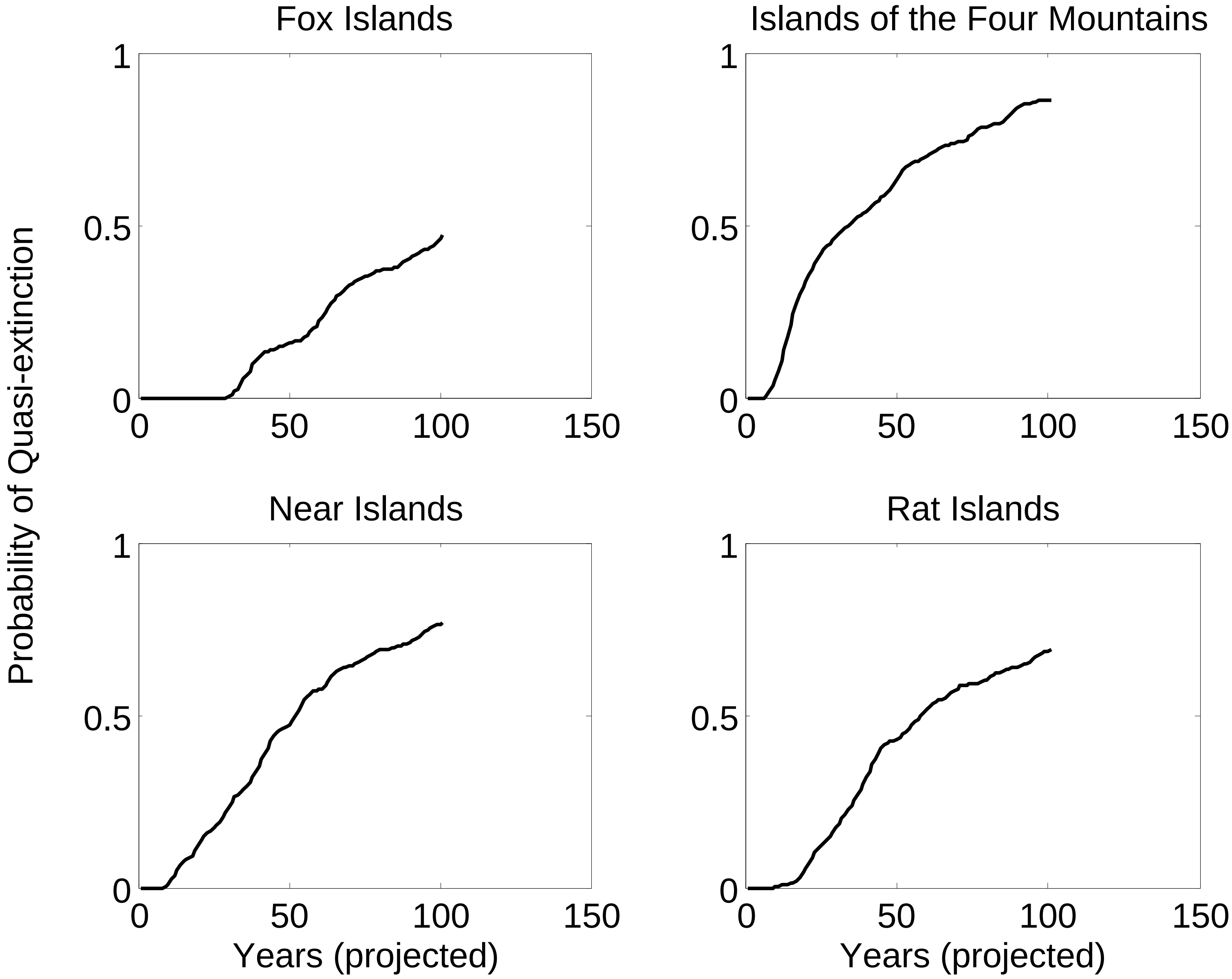
Some preliminary results




Central Aleutians
Probability of Quasi-extinction
Years (projected)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
20
40
60
80
100
120



Fox Islands
Islands of the 4 Mtn.s
Near Islands
Rat Islands
Predicted number sea otters
Years (projected)
Years (projected)
8000
6000
4000
2000
0
1000
500
3000
1000
0
20
40
60



Fox Islands
Islands of the Four Mountains
Near Islands
Rat Islands
Probability of Quasi-extinction
Years (projected)
Years (projected)
0
0.5
1
0
50
100
150

Conclusions

- Adding 2007 data points was crucial: allowed detection of varying decline rates
- Prognosis still grim, but depends on assumptions about variation in mortality
- Preliminary results highlight the need to better understand spatial dynamics, especially potential for “refuges” (habitat characteristic model)
- Further parameterization needed before applying model to eastern M.U.s

Version 1: probability of Islands showing D-D mortality vs. random AIM is not related to habitat area

Version 2: probability of Islands showing D-D mortality vs. random AIM is greater for big Islands

Version 3: variation in rate of mortality is time-dependent rather than density-dependent