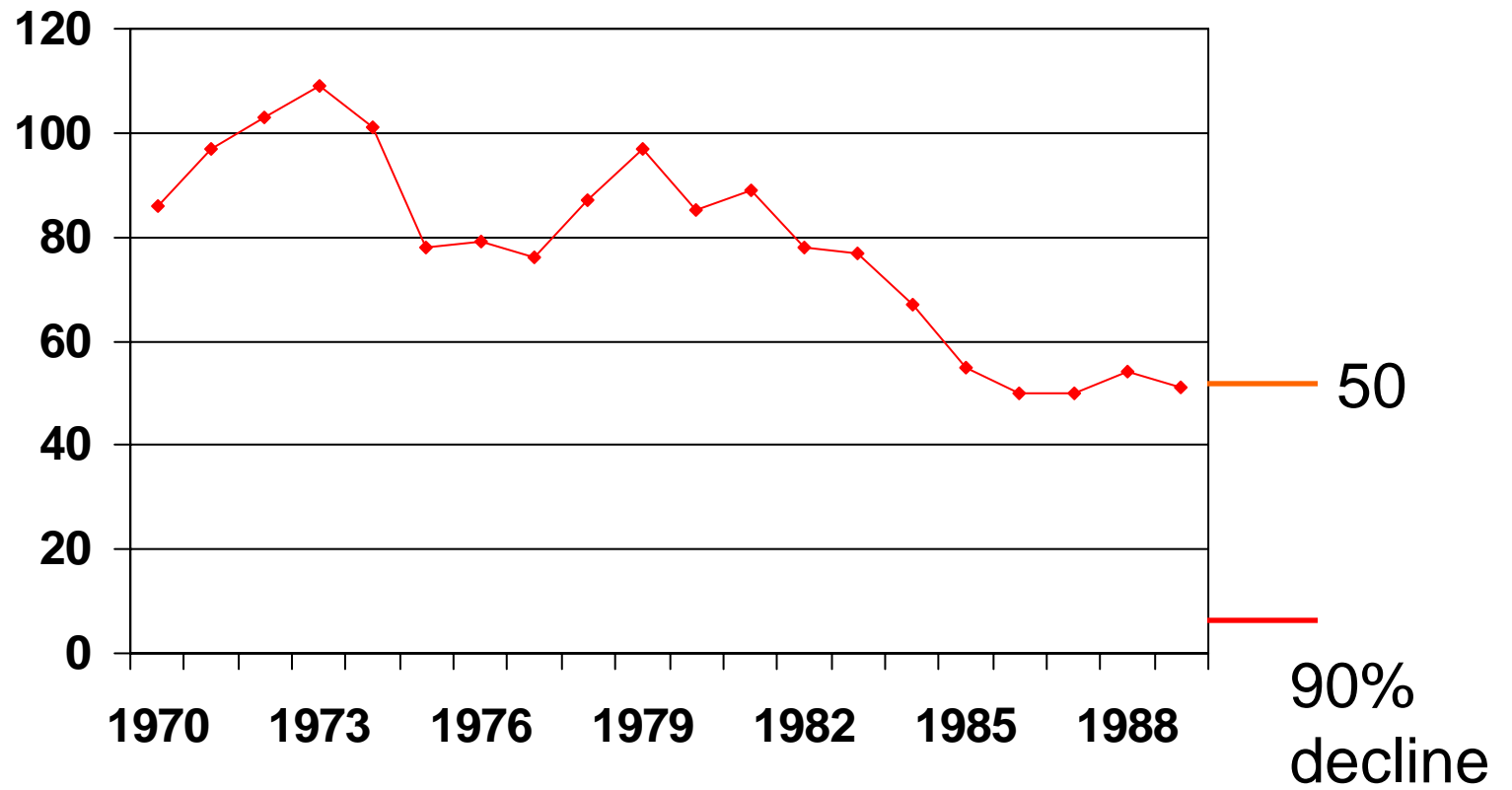


From theory to application:
diffusion approximations for
Population Viability Analysis

E. E. Holmes
National Marine Fisheries Service

Quasi-extinction risk



Using diffusion approximations for estimating quasi-extinction risks

- Some of the problems with count data on species of conservation concern and how these problems affect DA PVA, especially parameterization
- Cross-validation of DA PVA using real data

- **Salmon:**
 - Leslie matrix model of Snake R. spr/sum chinook
 - Has density dependence
 - Has environmental autocorrelation
- **Petrel:**
 - Leslie matrix model of the Hawaiian Dark-rumped Petrel (Simons 1984);
 - Long-lived; census is of mature breeders
 - environmental autocorrelation
- **Sea Turtle:**
 - Leslie matrix model of the Loggerhead Sea Turtle (Crowder et al. 1994);
 - Long-lived; census is of eggs which is highly variable
 - environmental autocorrelation

A really simple DA model can predict quasi-extinction in age-structured models

$$\log(N_{t+1}) = \log(N_t) + \varepsilon_{t,p}$$

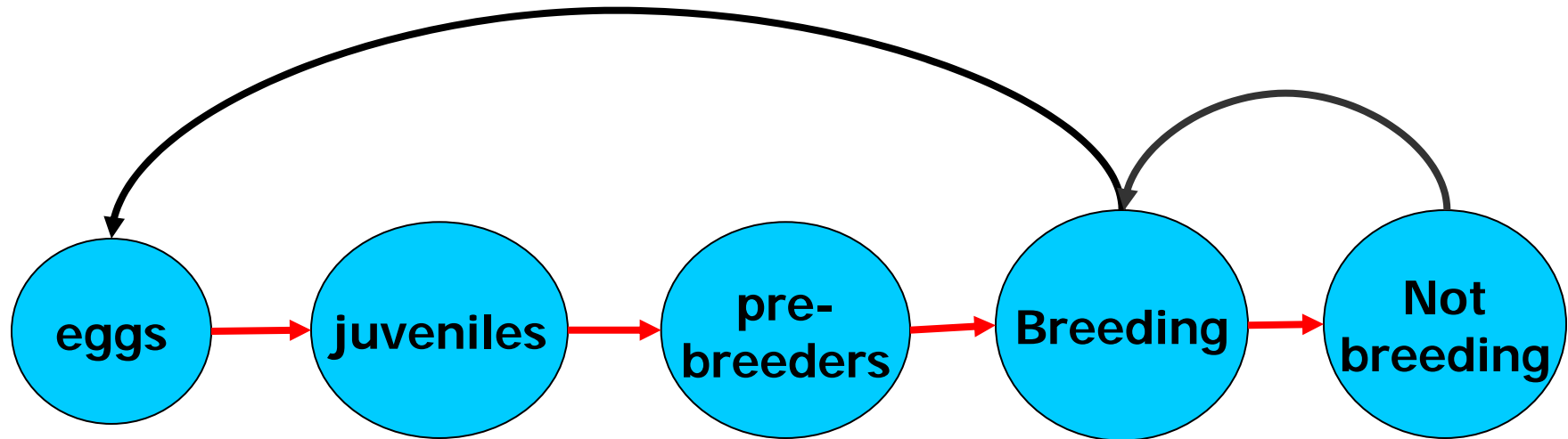
$$\varepsilon_{t,p} \sim \text{Normal}(\mu, \sigma_p^2)$$

Long-term population growth

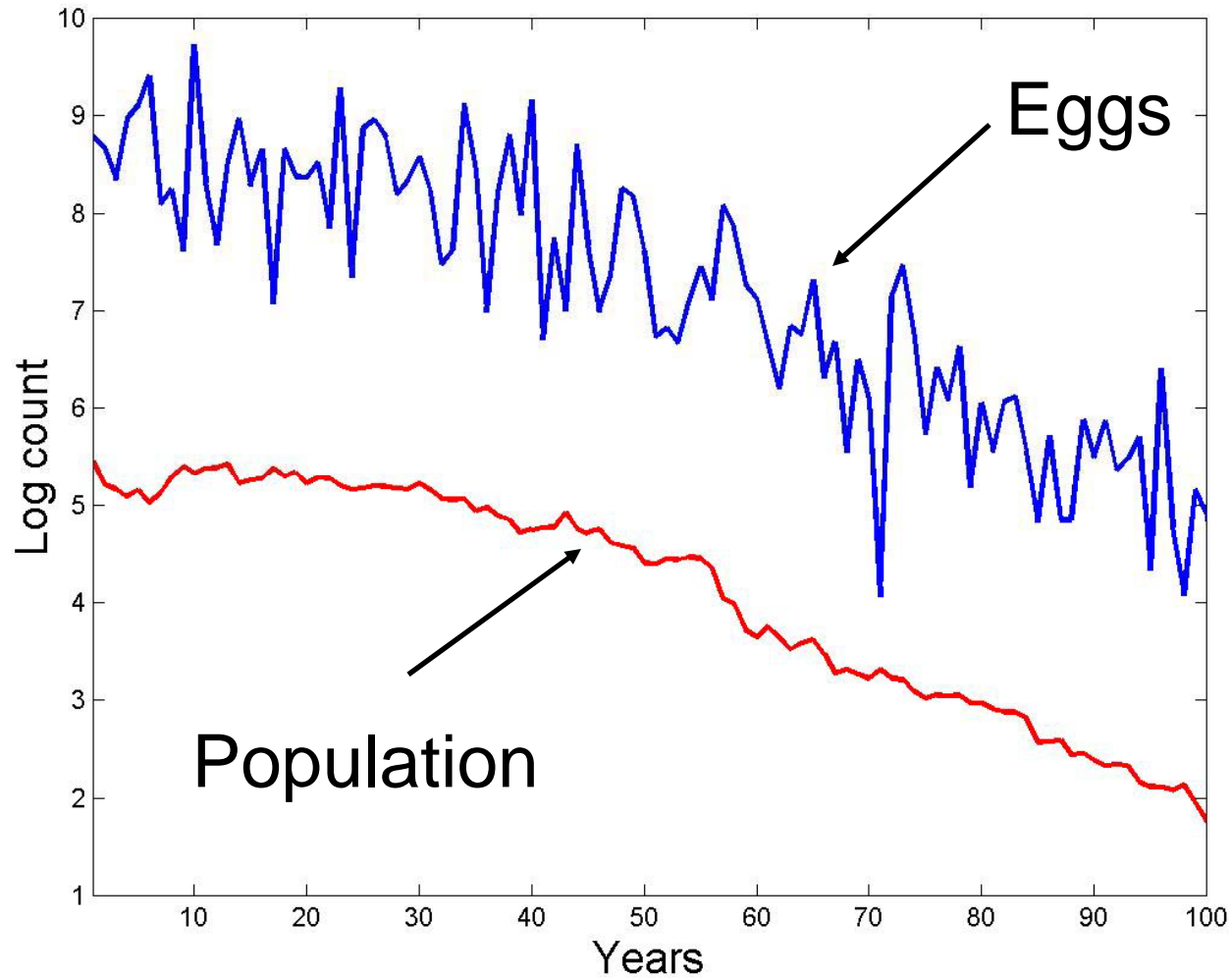
Process Error

$$\log(N_{t+\tau}) - \log(N_t) \sim \text{Normal}(\mu\tau, \sigma_p^2\tau)$$

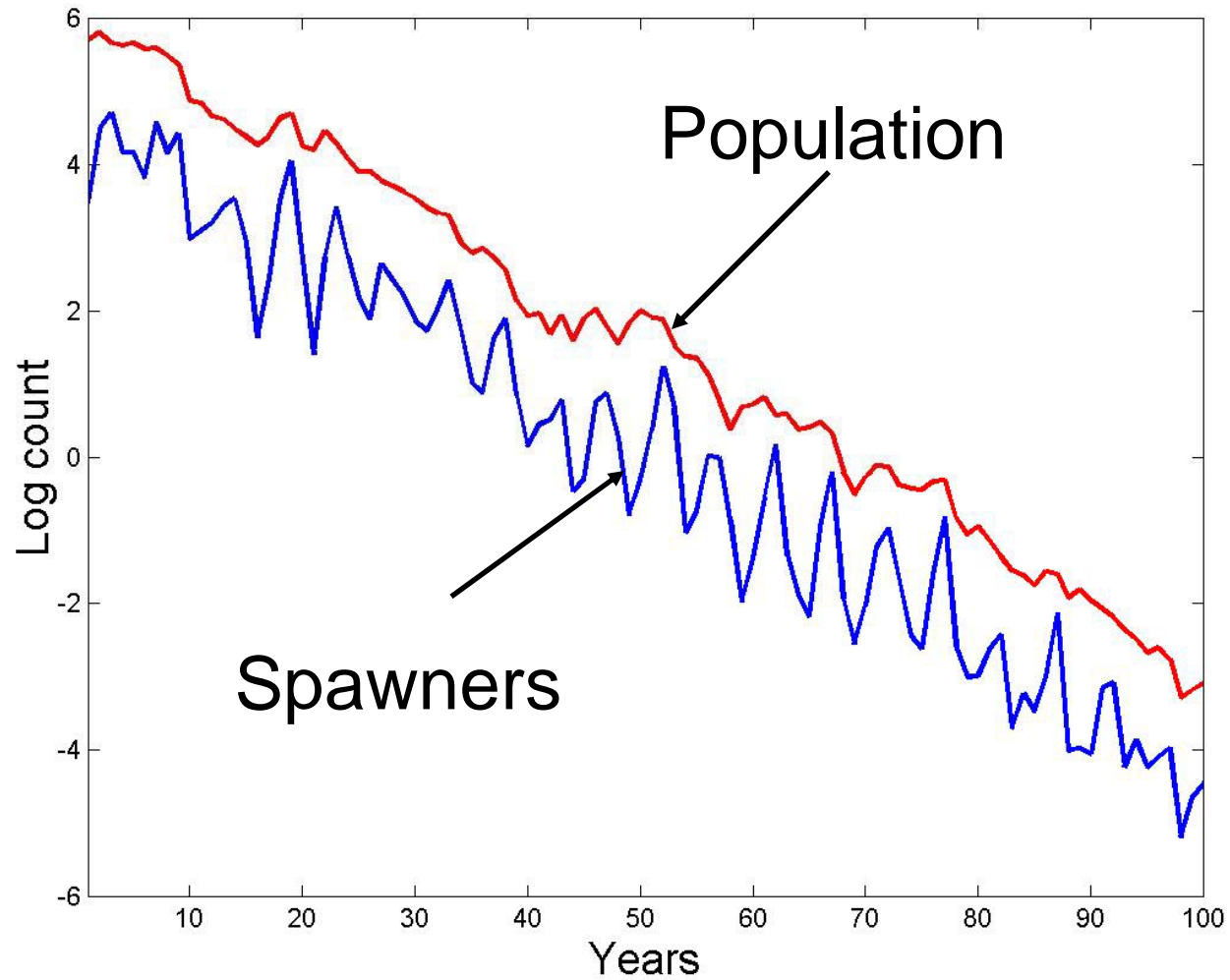
Monitoring data is often stage specific



Example with sea turtles



Example with salmon



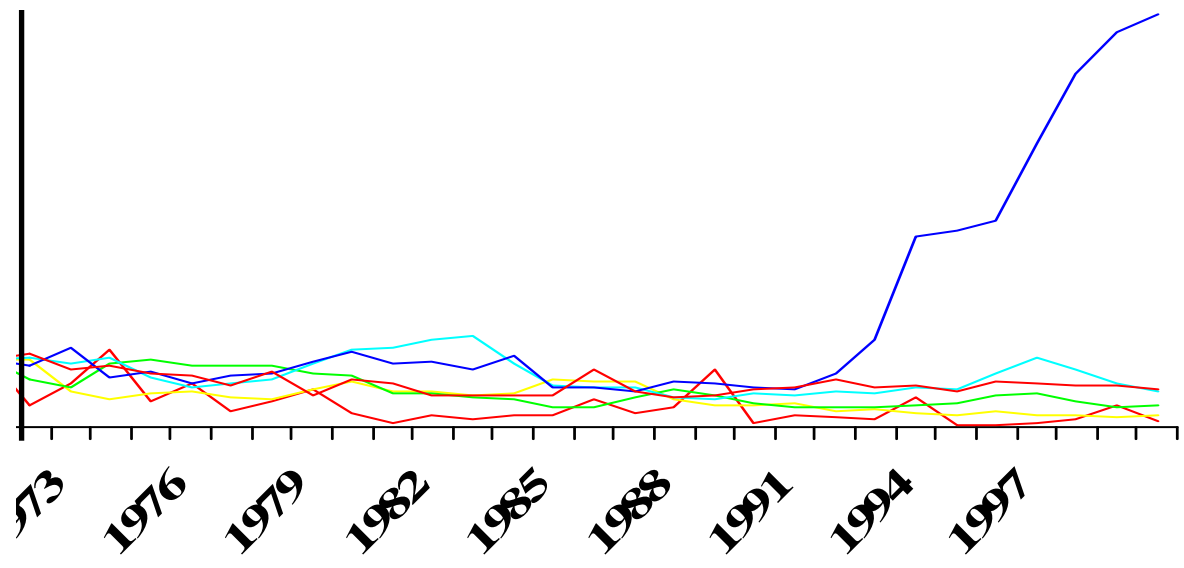
Good news: a state-space model does
a good job of modeling age-specific
counts:

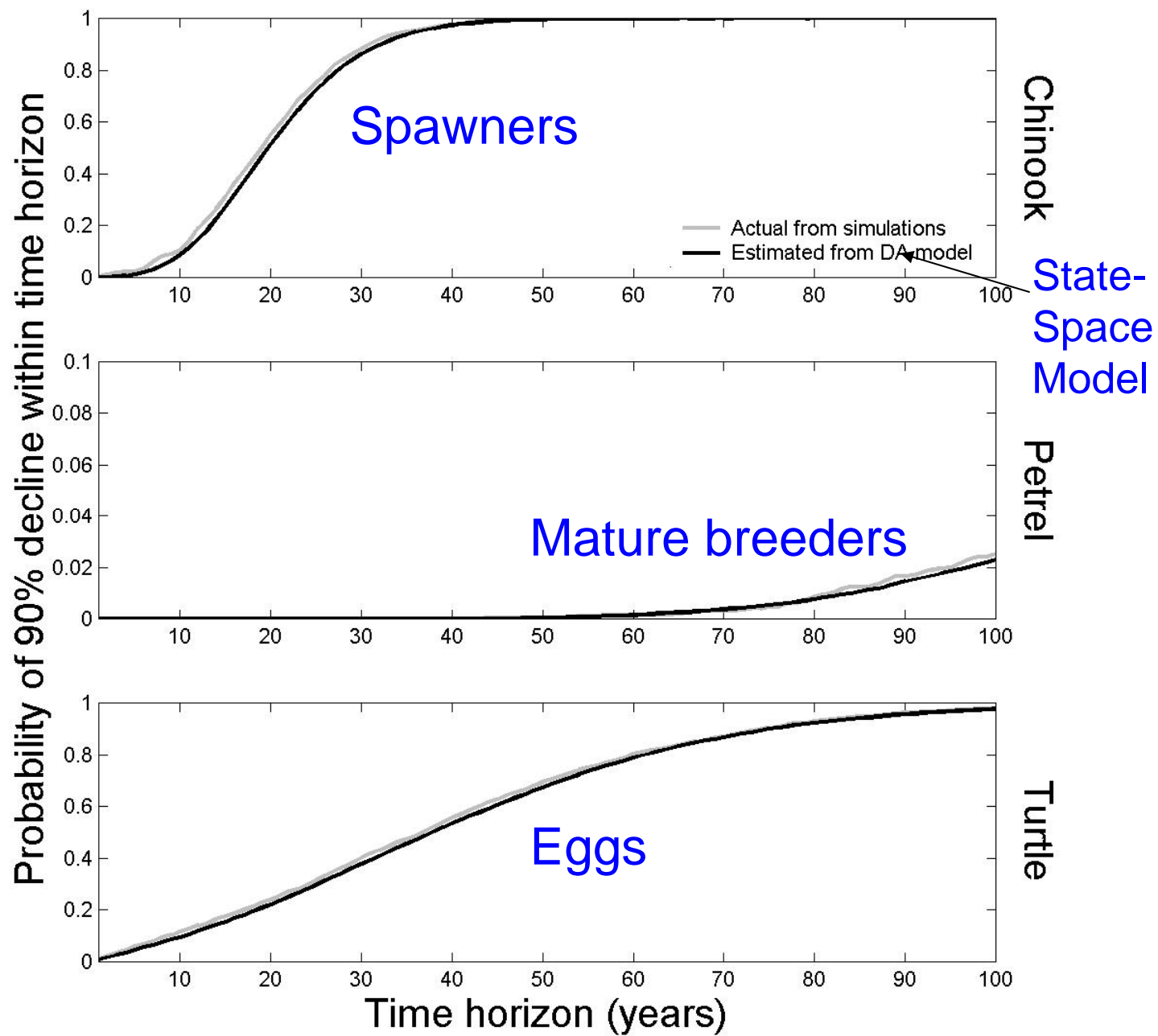
$$\log(N_{t+1}) = \log(N_t) + \varepsilon_{t,p}$$

$$\log(a_{t+1}) = \log(N_{t+1}) + \varepsilon_{t+1,np}$$

$$\varepsilon_{t,p} \sim \text{Normal}(\mu, \sigma_p^2)$$

$$\varepsilon_{t,np} \sim f(\beta, \sigma_a^2)$$



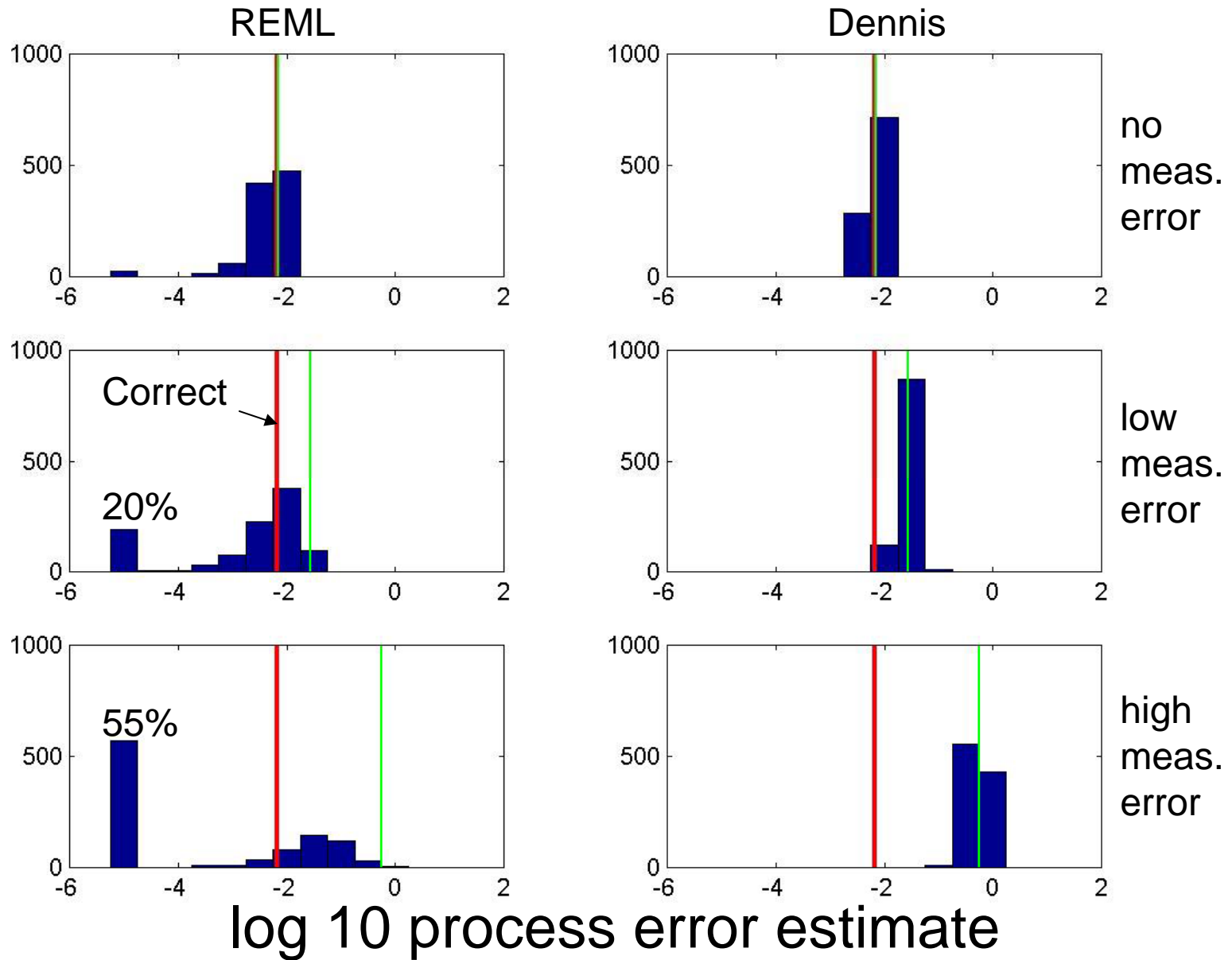


Bad news: this high non-process error makes parameterization difficult

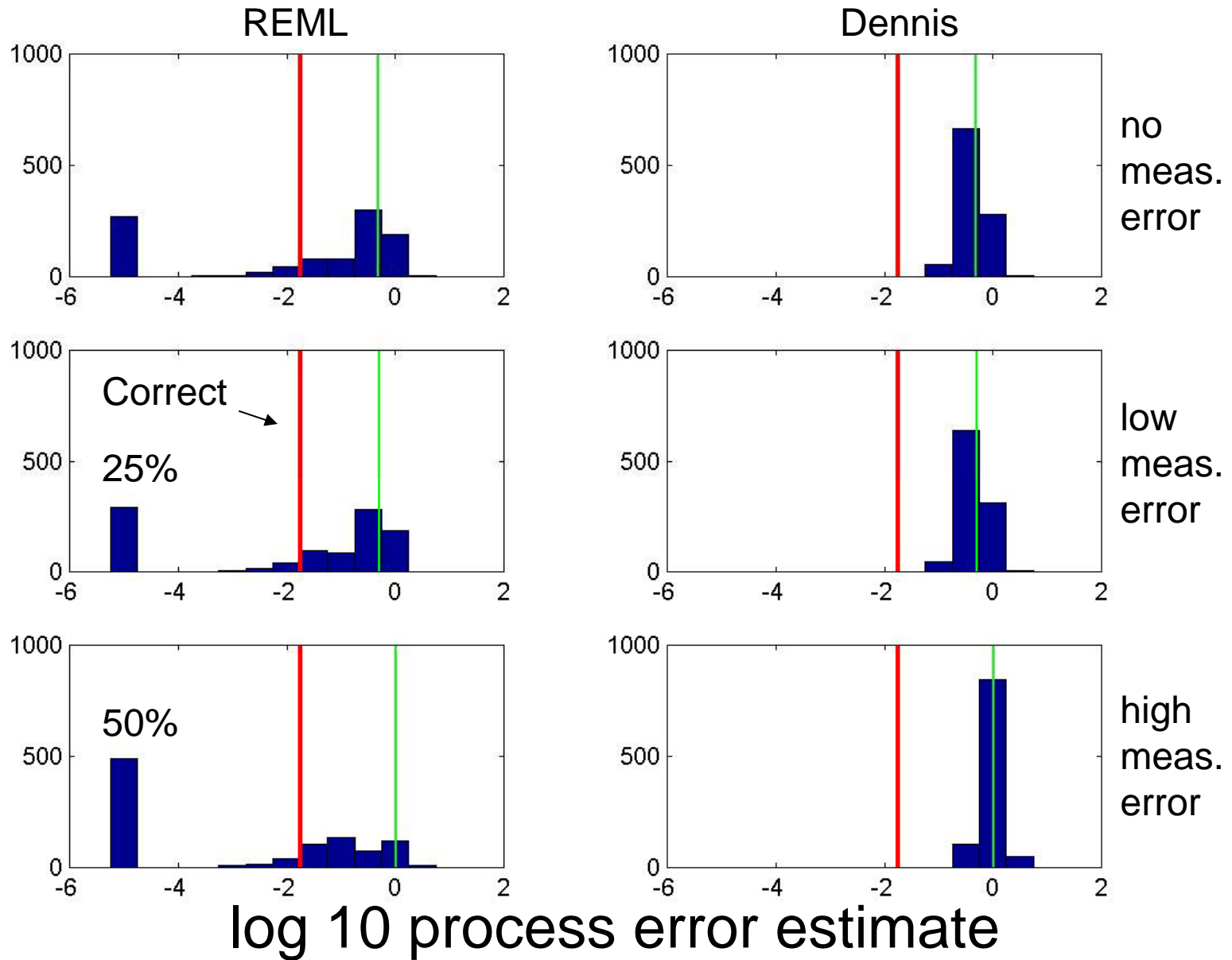
Estimation of σ^2 (process error).

- “REML”: Restricted ML estimation (Staples et al. 2004)
- Regression estimating the increase in variance in $\log N_{t+\tau}/N_t$ with τ (Holmes 2001)
- Kalman filter (Lindley 2003)

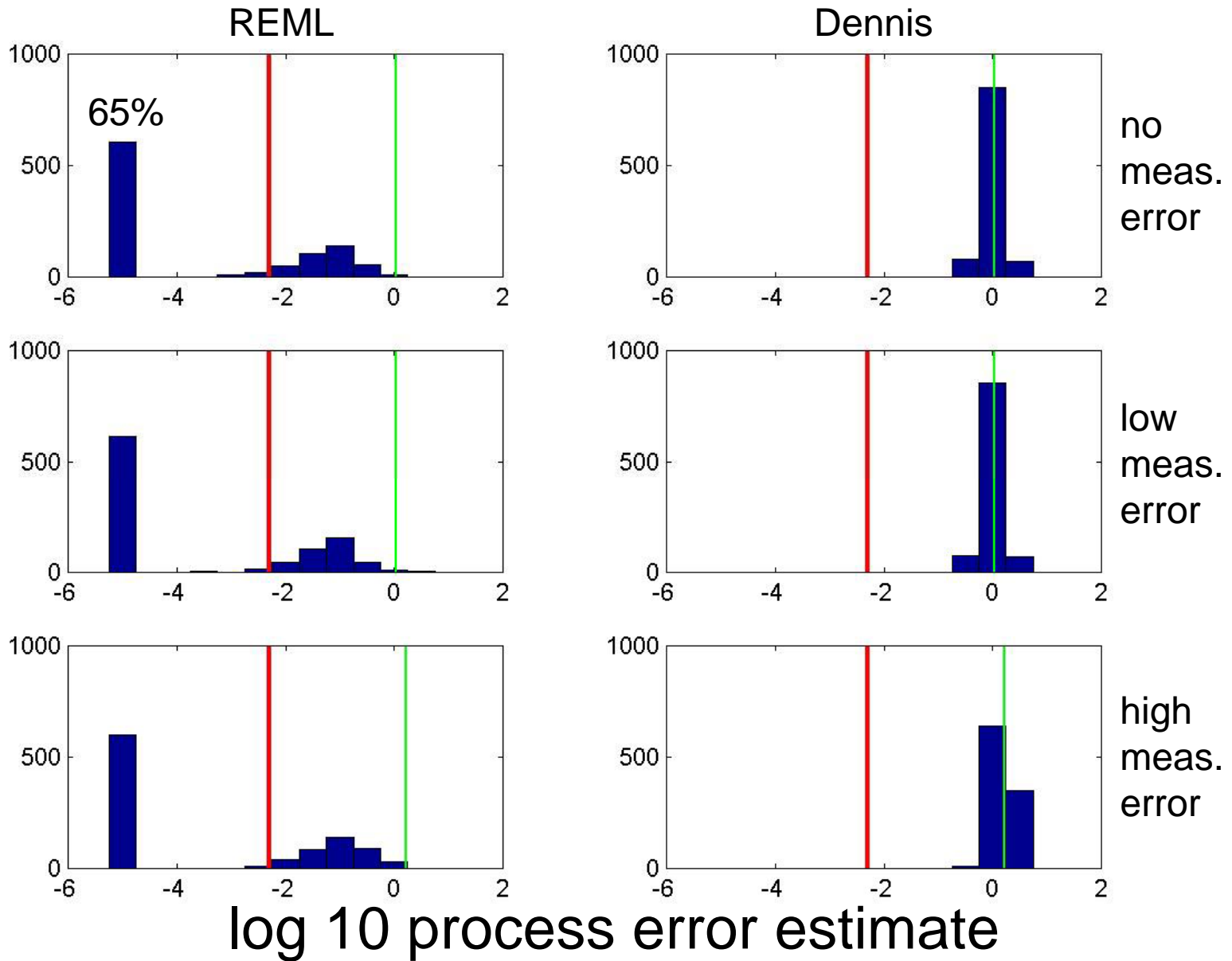
Petrel: pretty good...



Salmon: struggling...



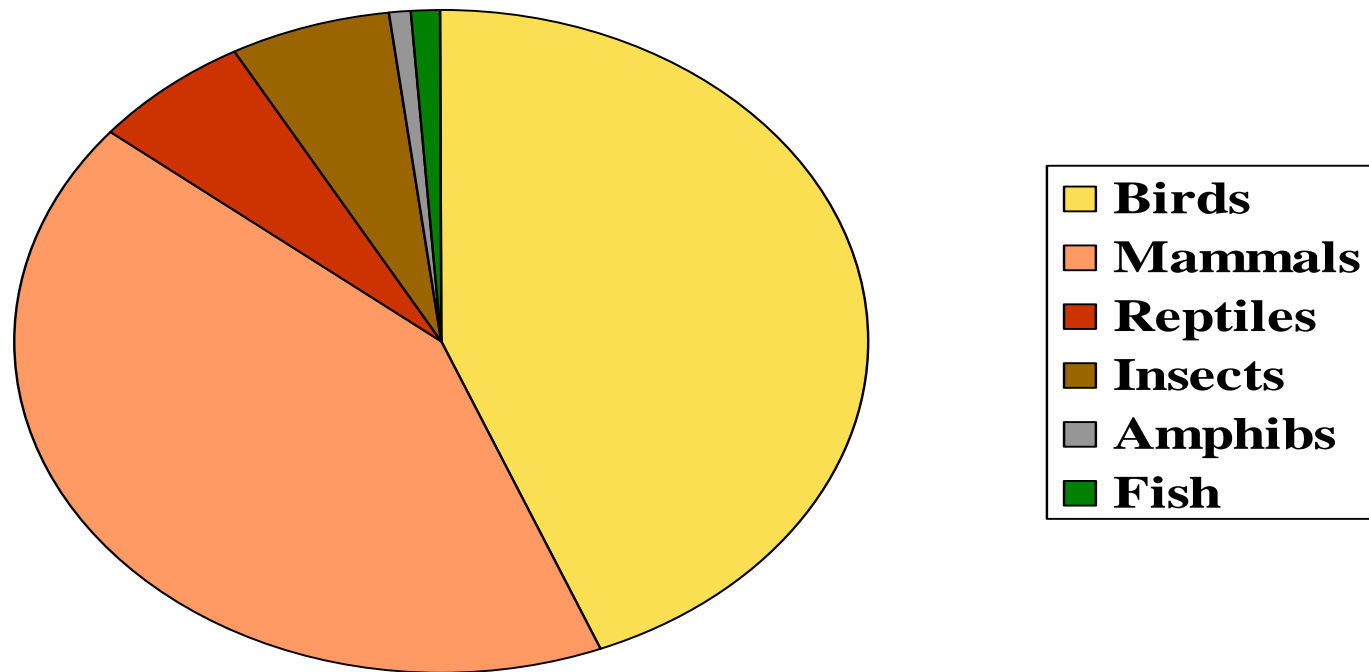
Turtle: more struggling...



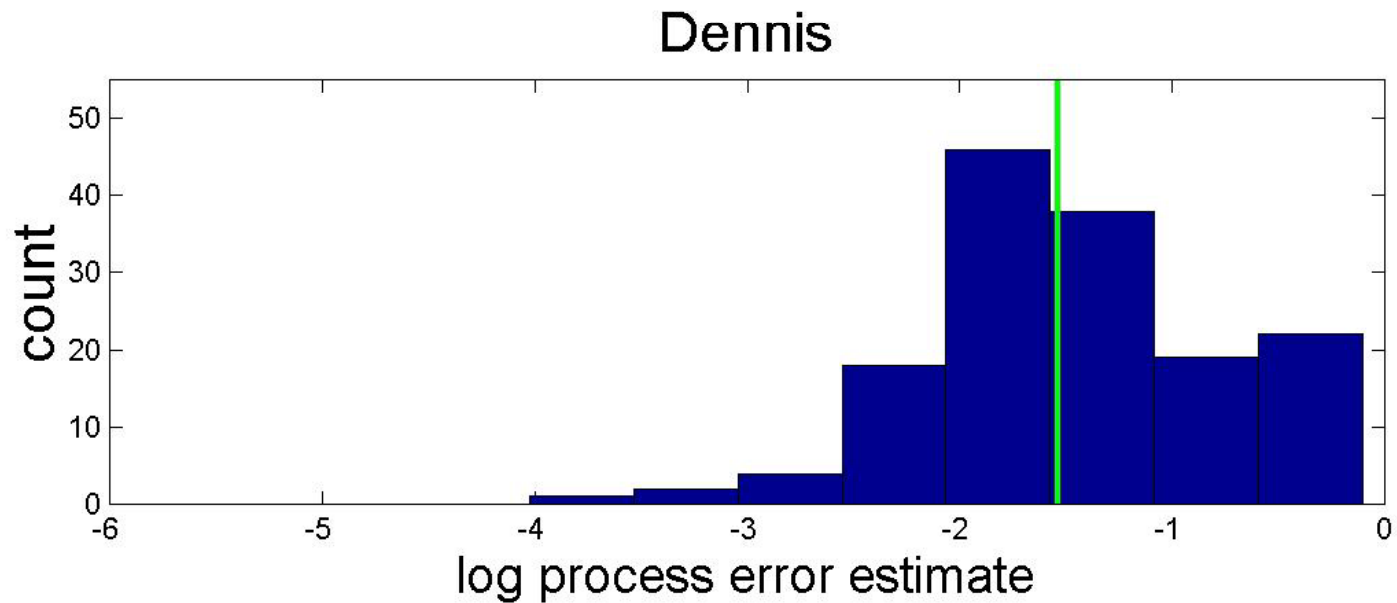
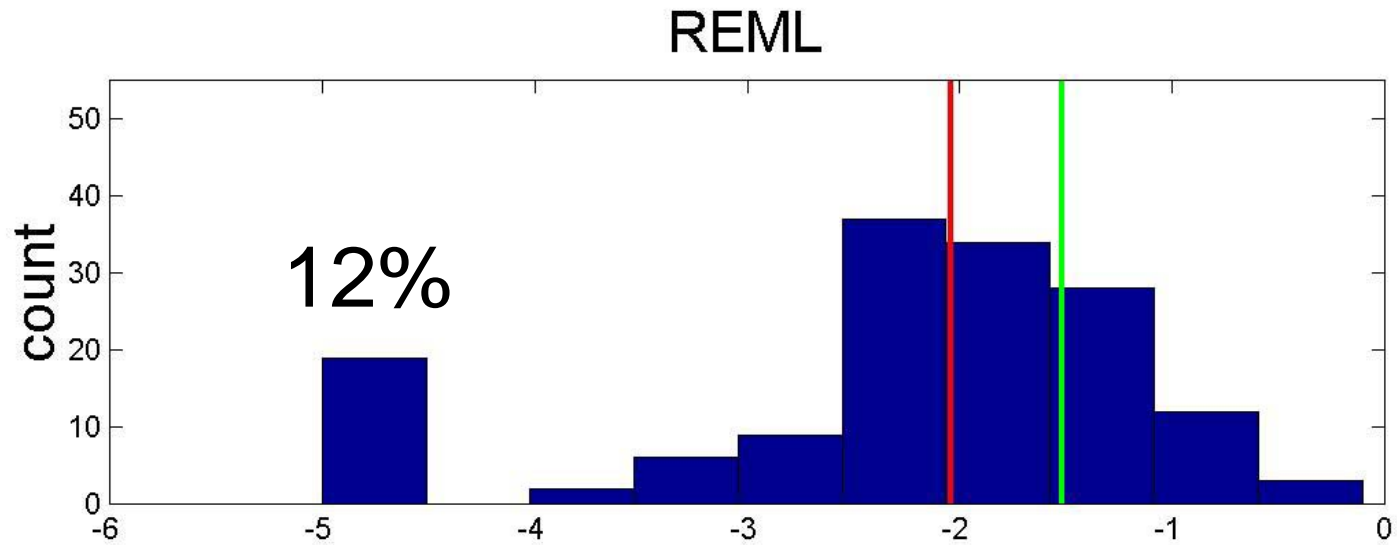
Estimating parameters might be challenging for some species

- What does real data tell us about the performance of these methods? Are most data “petrel-like” or “sea turtle-like”?

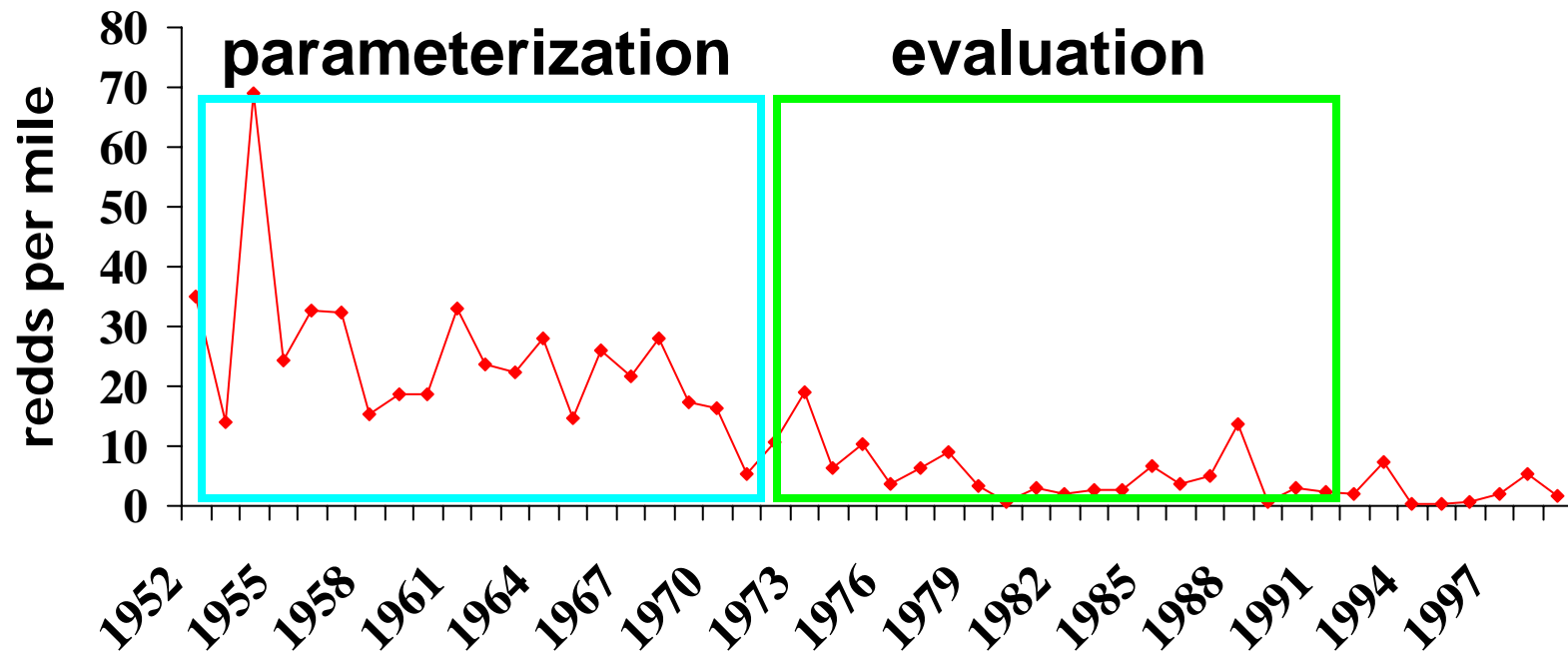
117 Time series 20-50 yrs long
72 are listed species



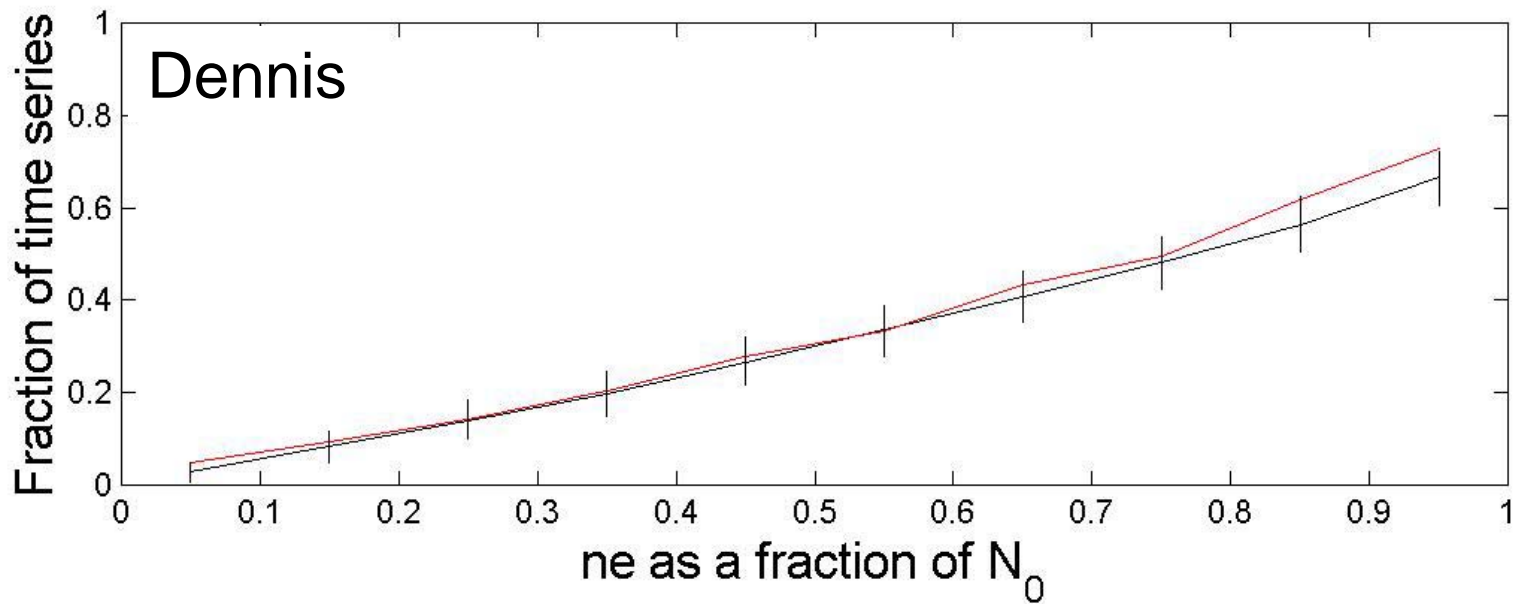
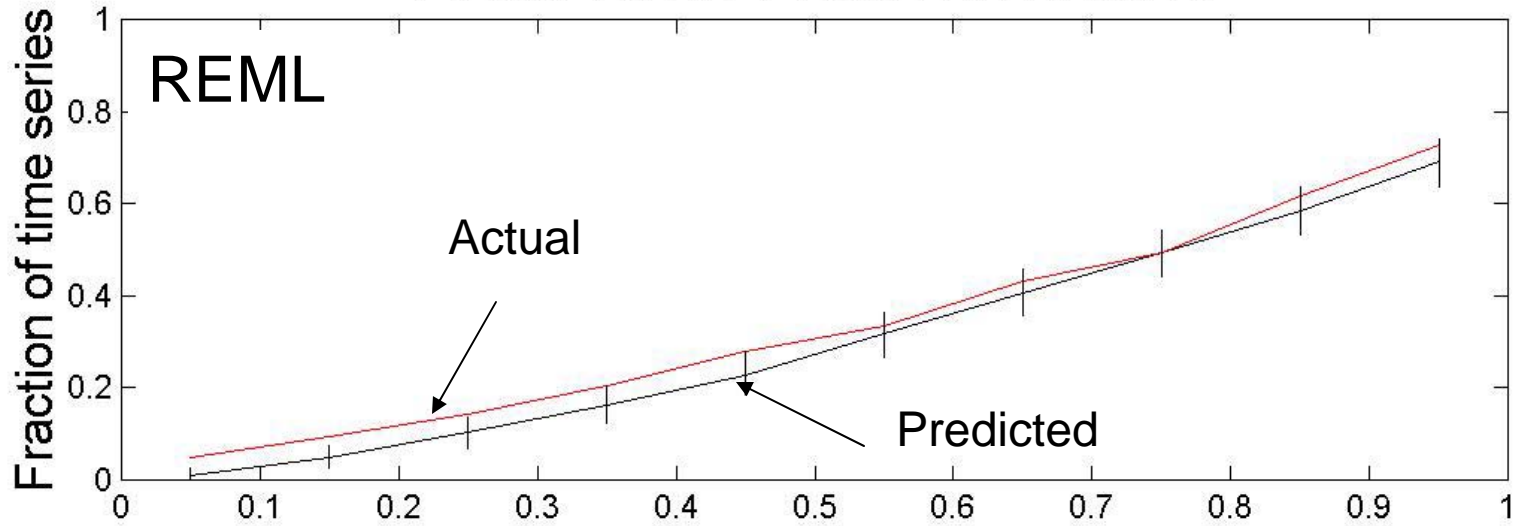
Distribution of process error estimates



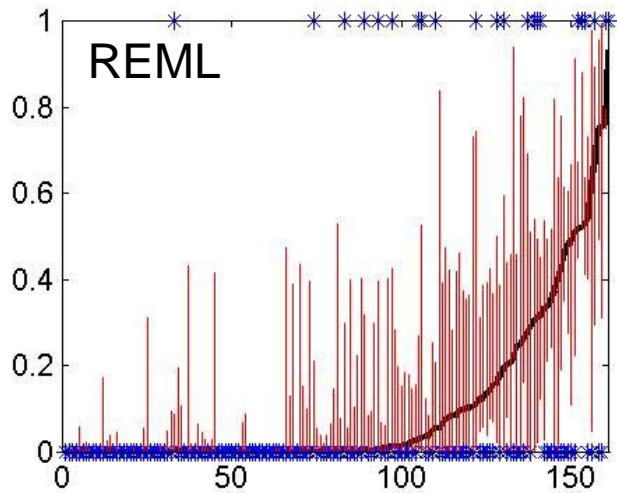
Cross-validation



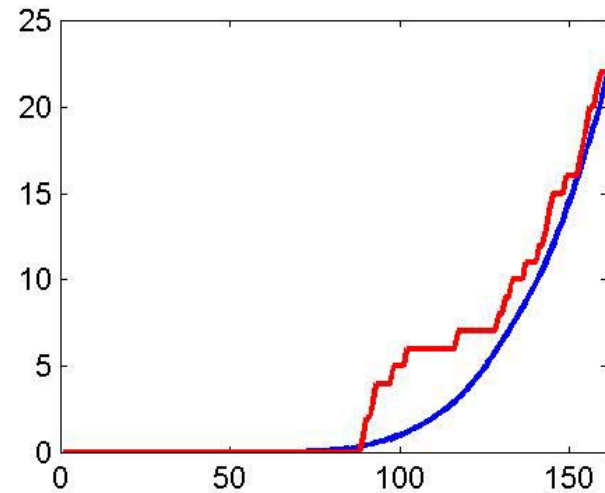
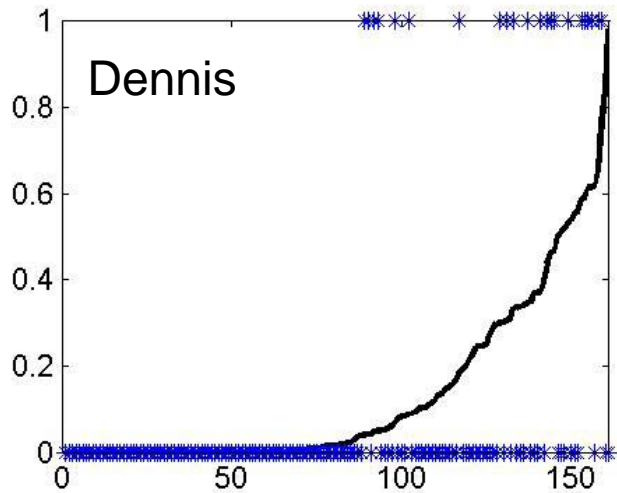
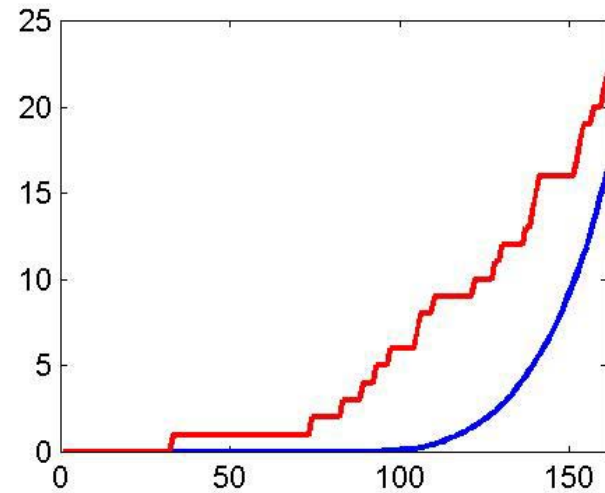
Actual versus Predicted Declines



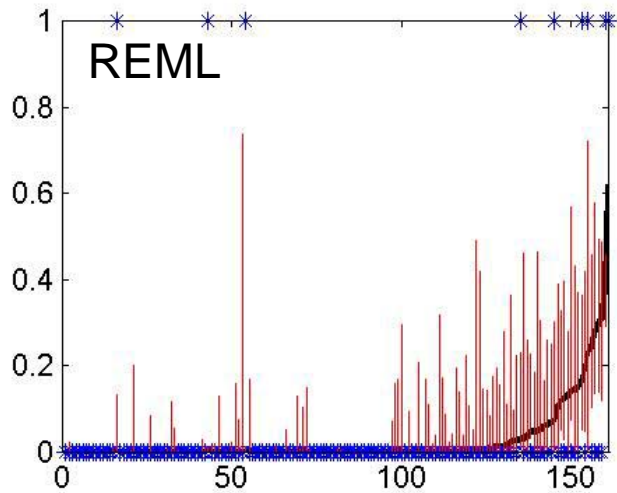
Estimated 75% decline risk vs actual 75% decline



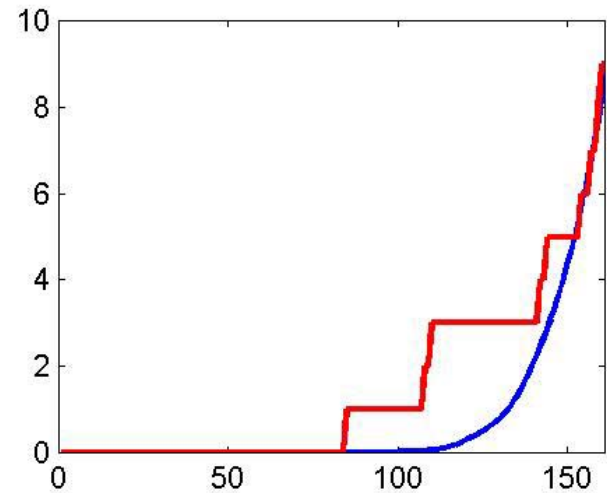
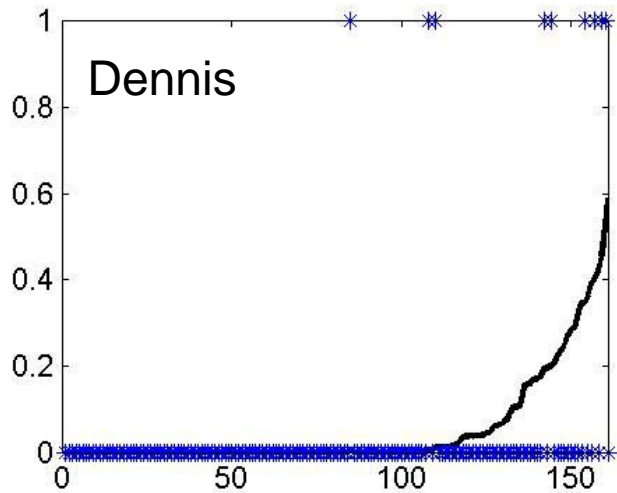
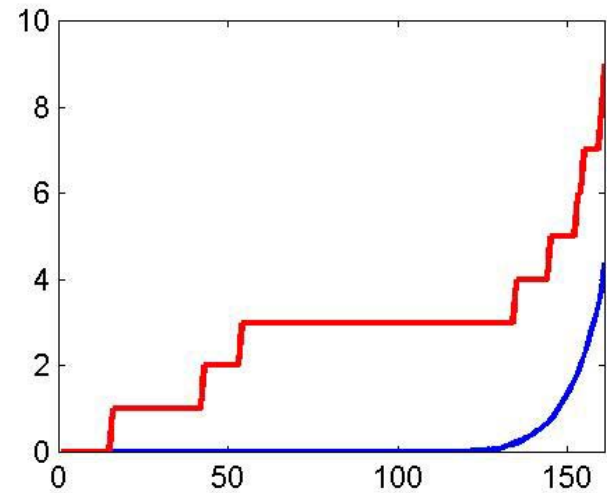
Predicted accumulated 75% declines versus actual



Estimated 90% decline risk vs actual 90% decline



Predicted accumulated 90% declines versus actual



In conclusion....

- Separation of process error and non-process error appears challenging for some types of monitoring data
 - Still a lot of improvement to be done
- This problem does not appear pervasive in data on species of conservation concern
- There appears to be a trade-off between precision of estimates versus bias