

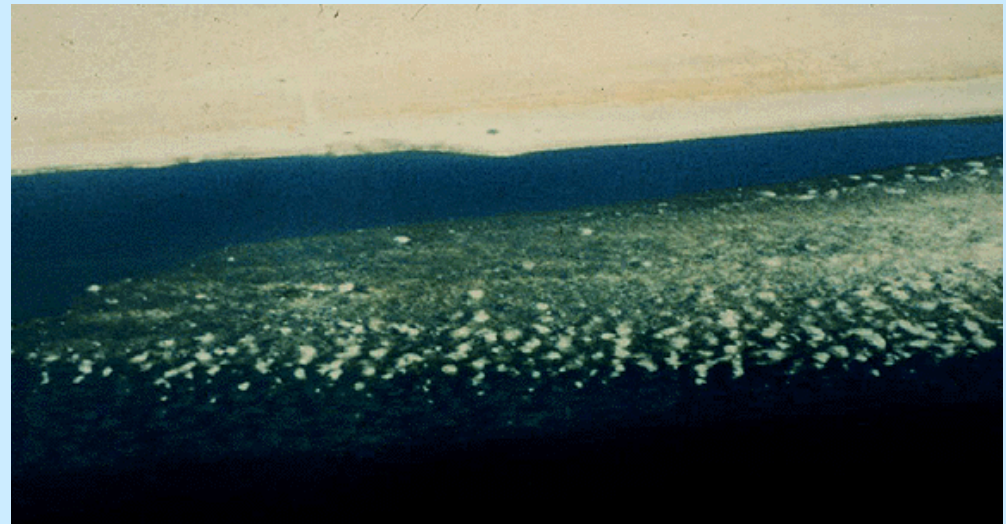
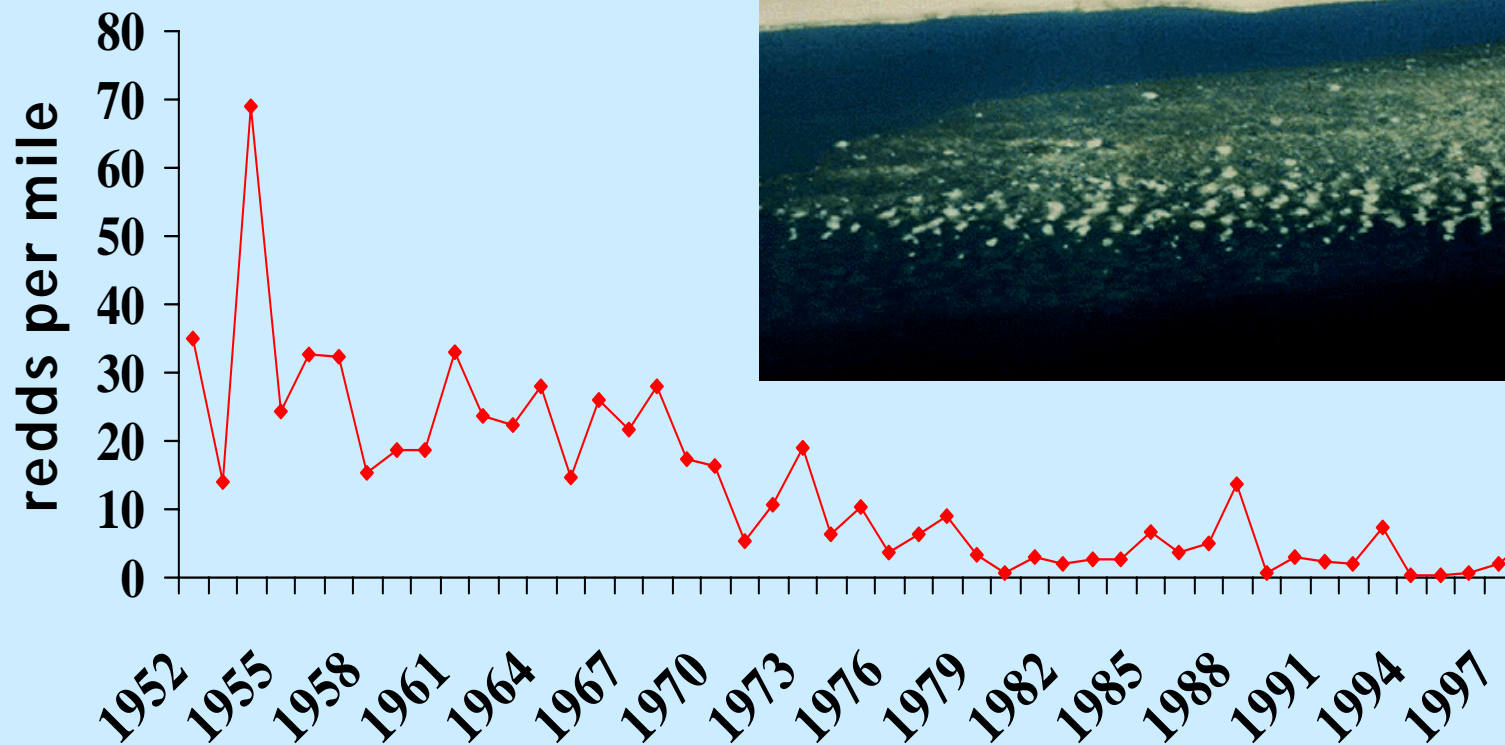
Parsimonious stochastic models for quasi-extinction dynamics for stochastic vertebrate population processes

Elizabeth E. Holmes

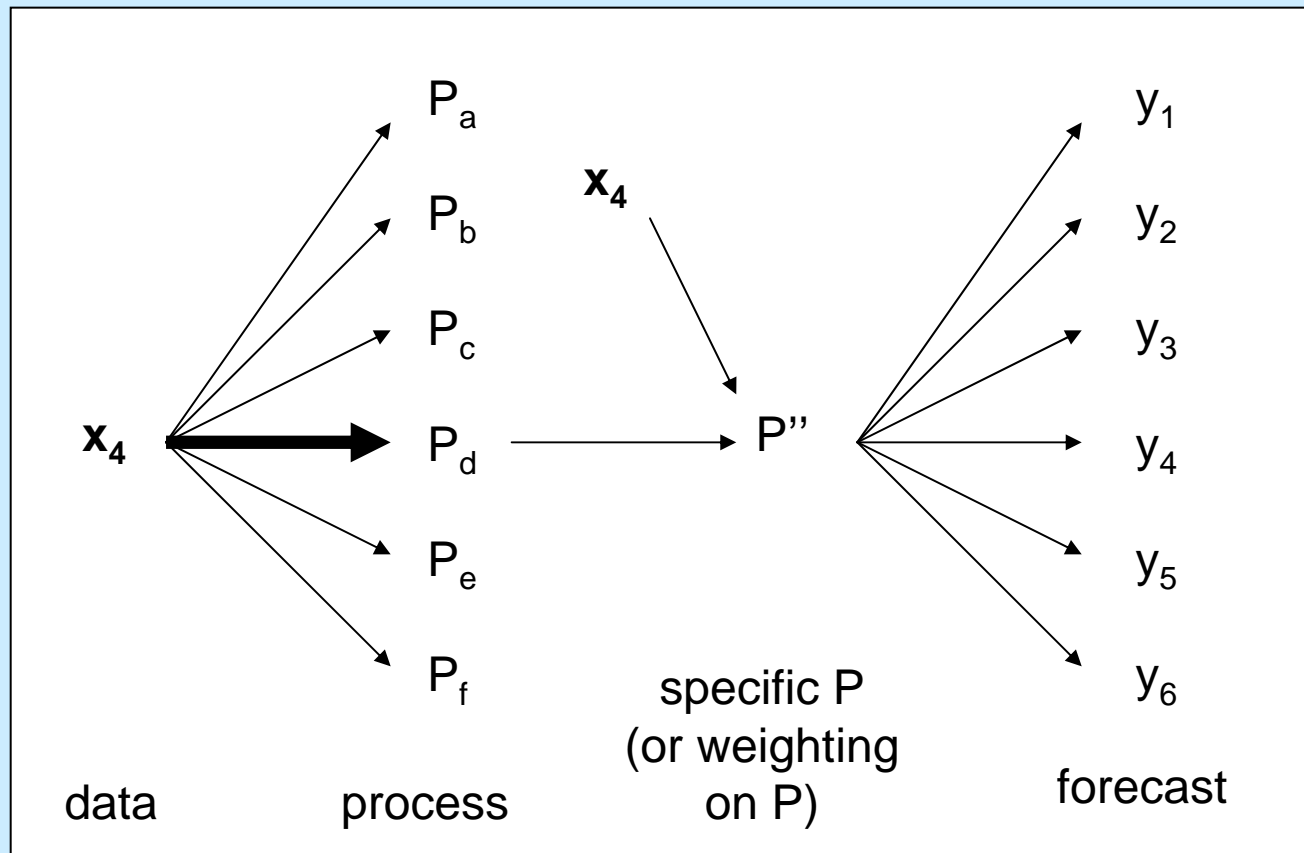
National Marine Fisheries Service



Goal: provide a well-behaved estimate of quasi-extinction probabilities given time series data from species of conservation concern



Dealing with process uncertainty: A common approach is model selection

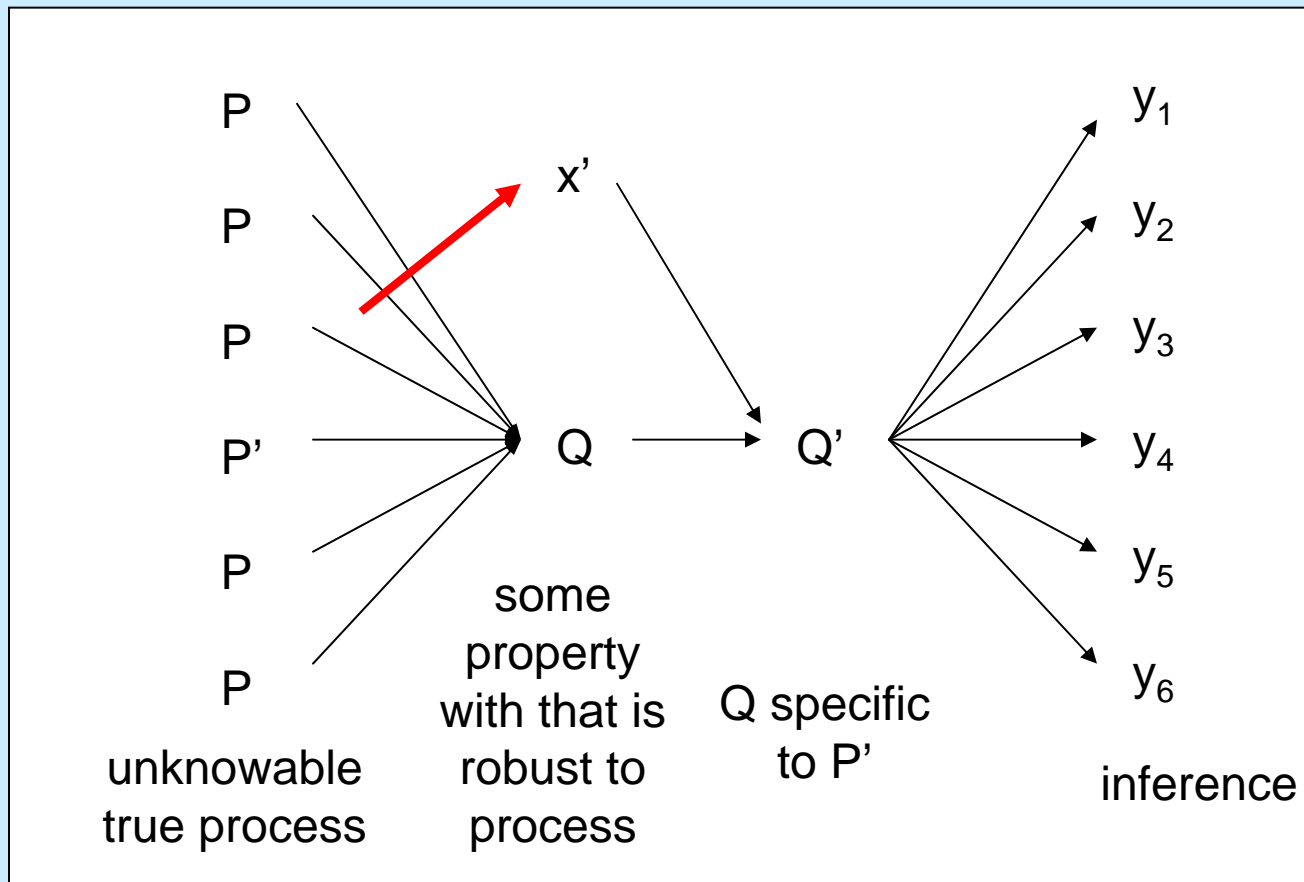


Model weighting

Parameter
estimation

Extrapolation

Dealing with model uncertainty: An approach from mathematical statistics

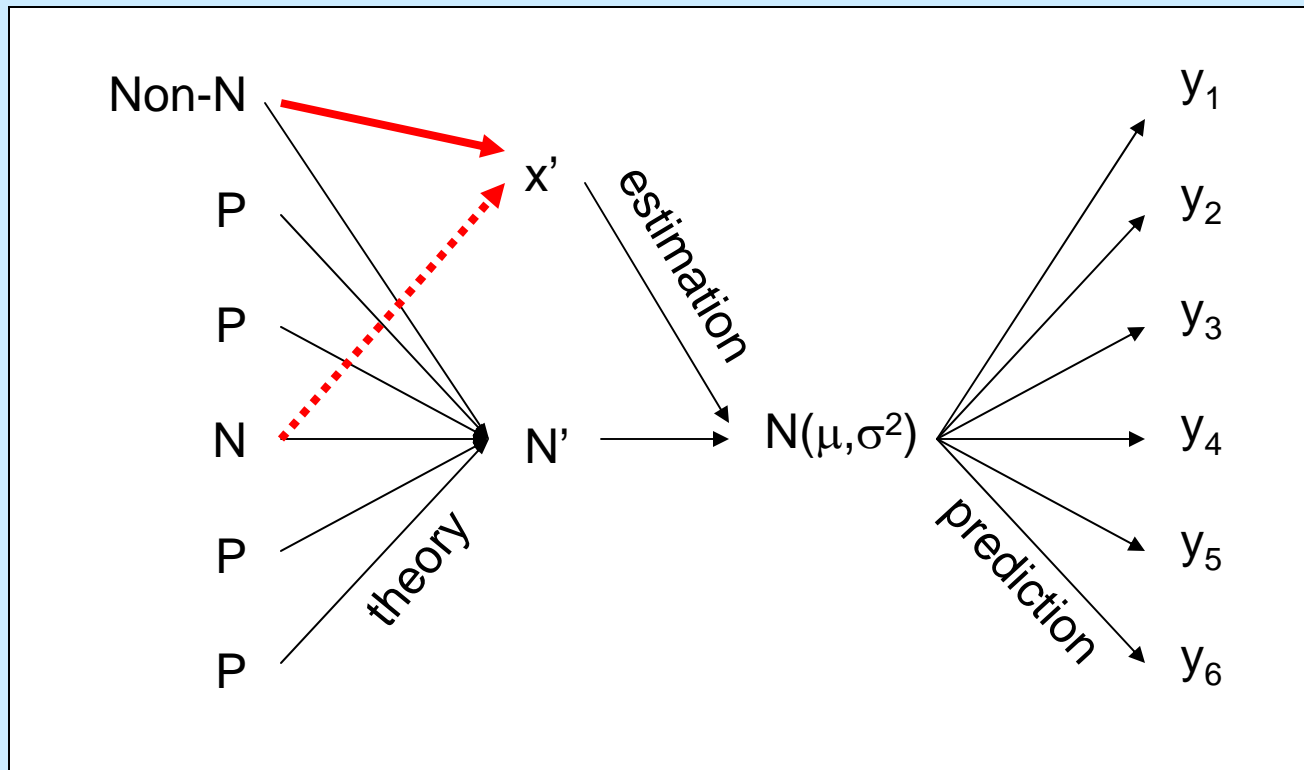


An analogy from statistics: what's the distribution of the mean of a large sample?

Data = measurements x_1, x_2, \dots, x_n from some unknown
distribution

Want to make inference about $\frac{1}{n} \sum_{i=1}^n x_i$

Central Limit Theorem says that under broad conditions
(whatever distribution x 's are from and not too non-i.i.d), mean
→ Gaussian distribution with some mean and variance.

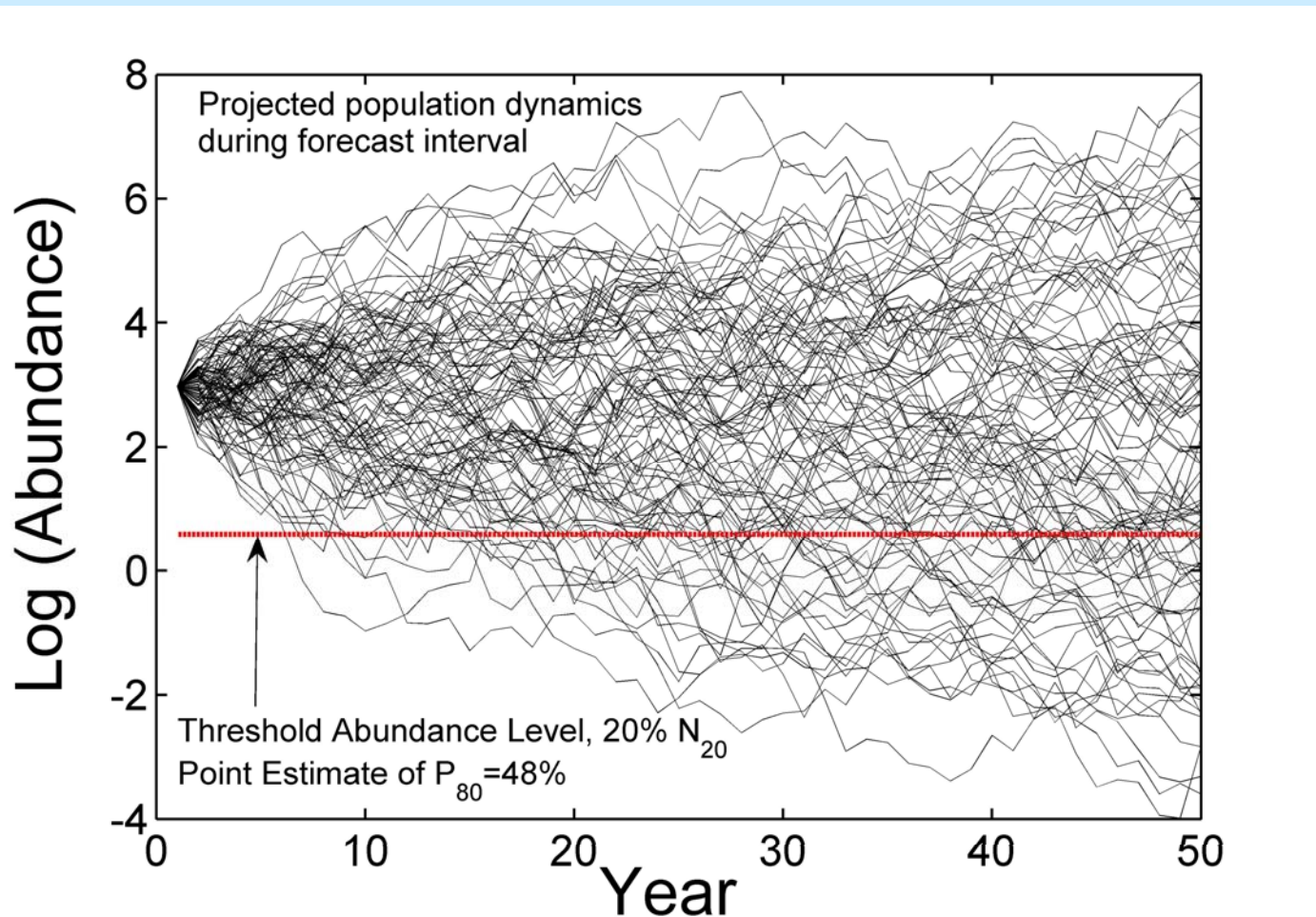


Unknown
true
process

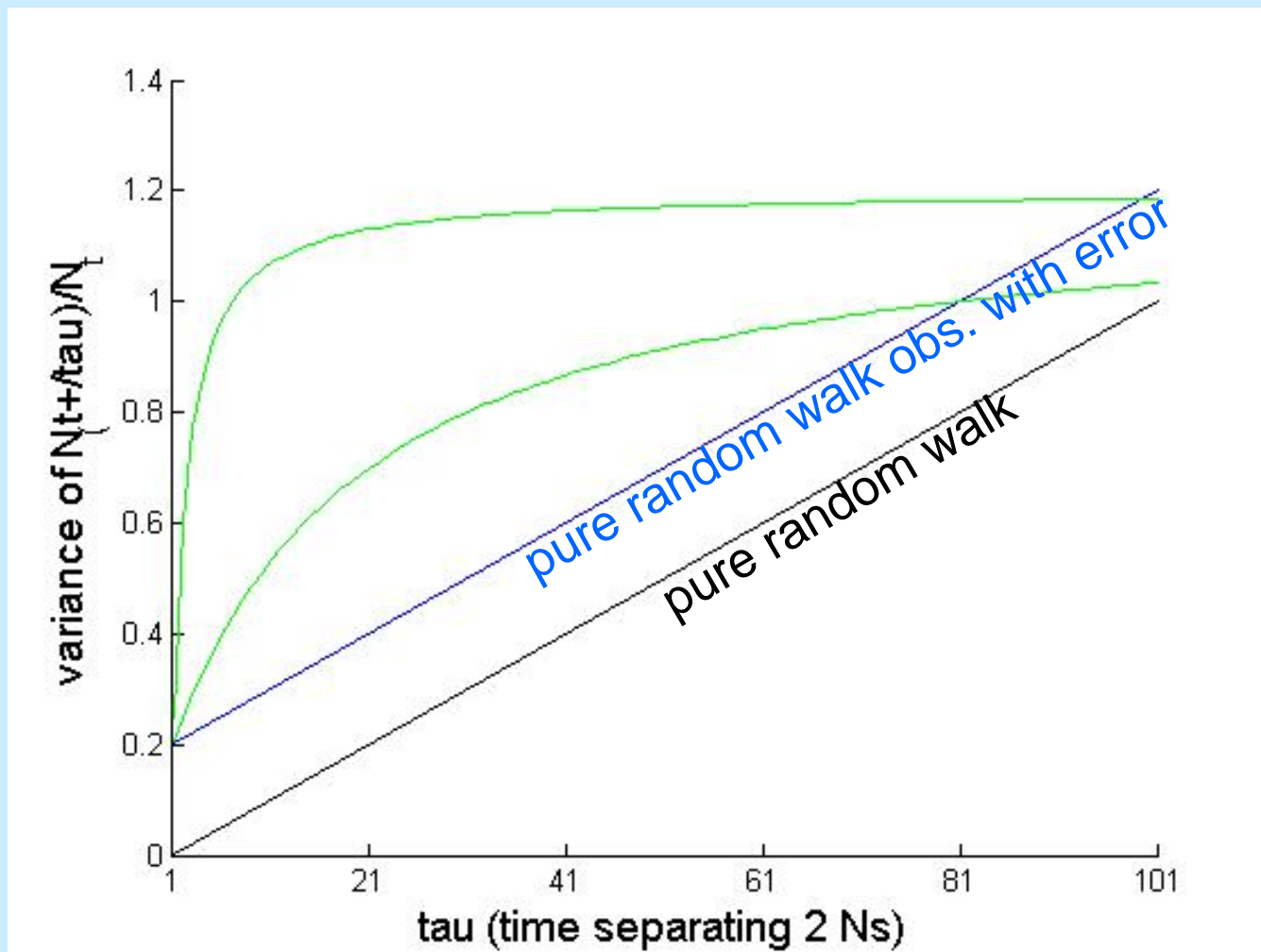
Large
sample
mean
(CLT)

Estimation of large
sample mean from
small sample

Why expect the existence of a simple stochastic process to approximate quasi-extinction probabilities?



Common patterns of relating how variance increases in stochastic population time series



Corrupted random walk

Pure discrete random walk (RW)

+ corruption (CRW)

$$\log(N_t) = \log(N_{t-1}) + \mu + \eta_{t-1}$$

Normal

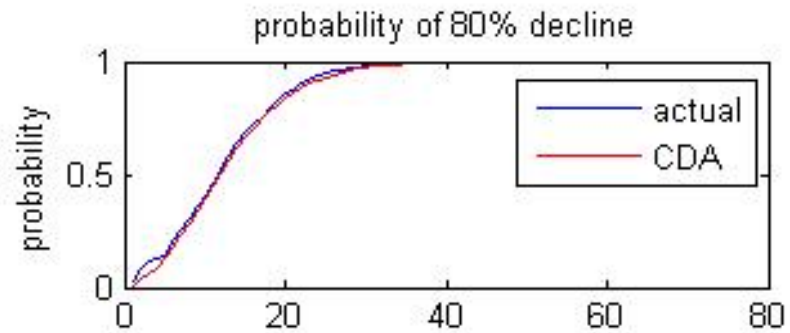
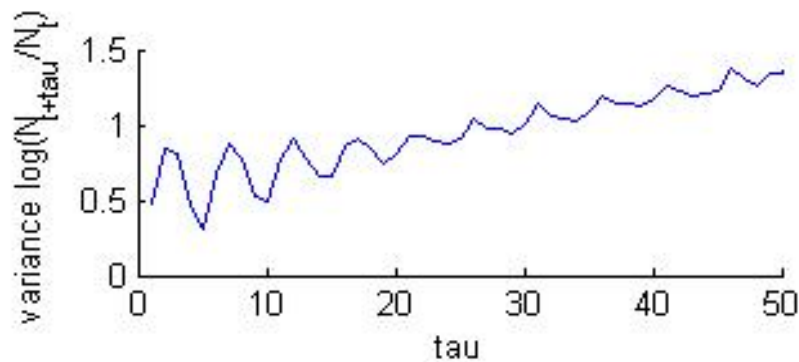
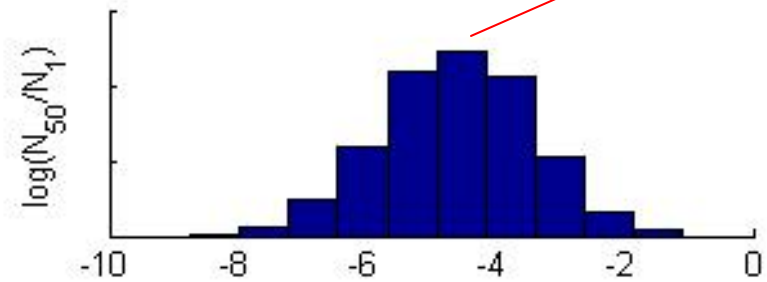
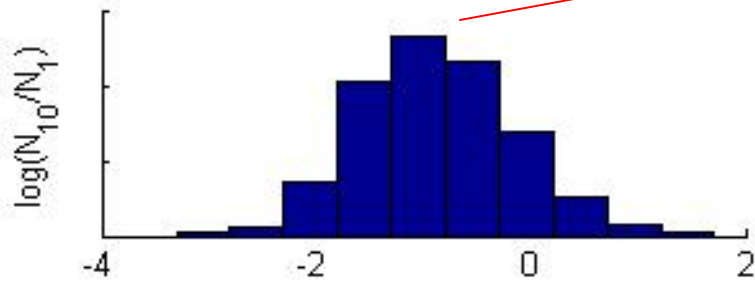
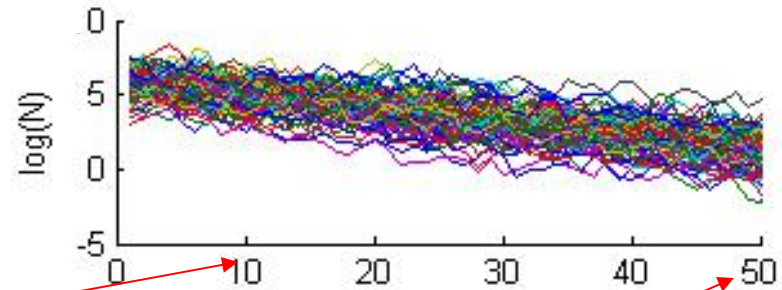
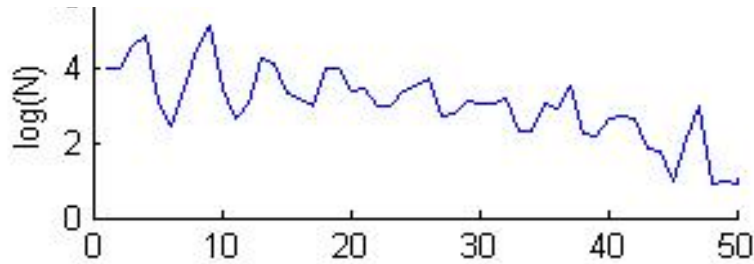
$$\mathbf{y}_t = \log(N_t) + \varepsilon_t$$

Exponential growth with viability in year to year growth rates

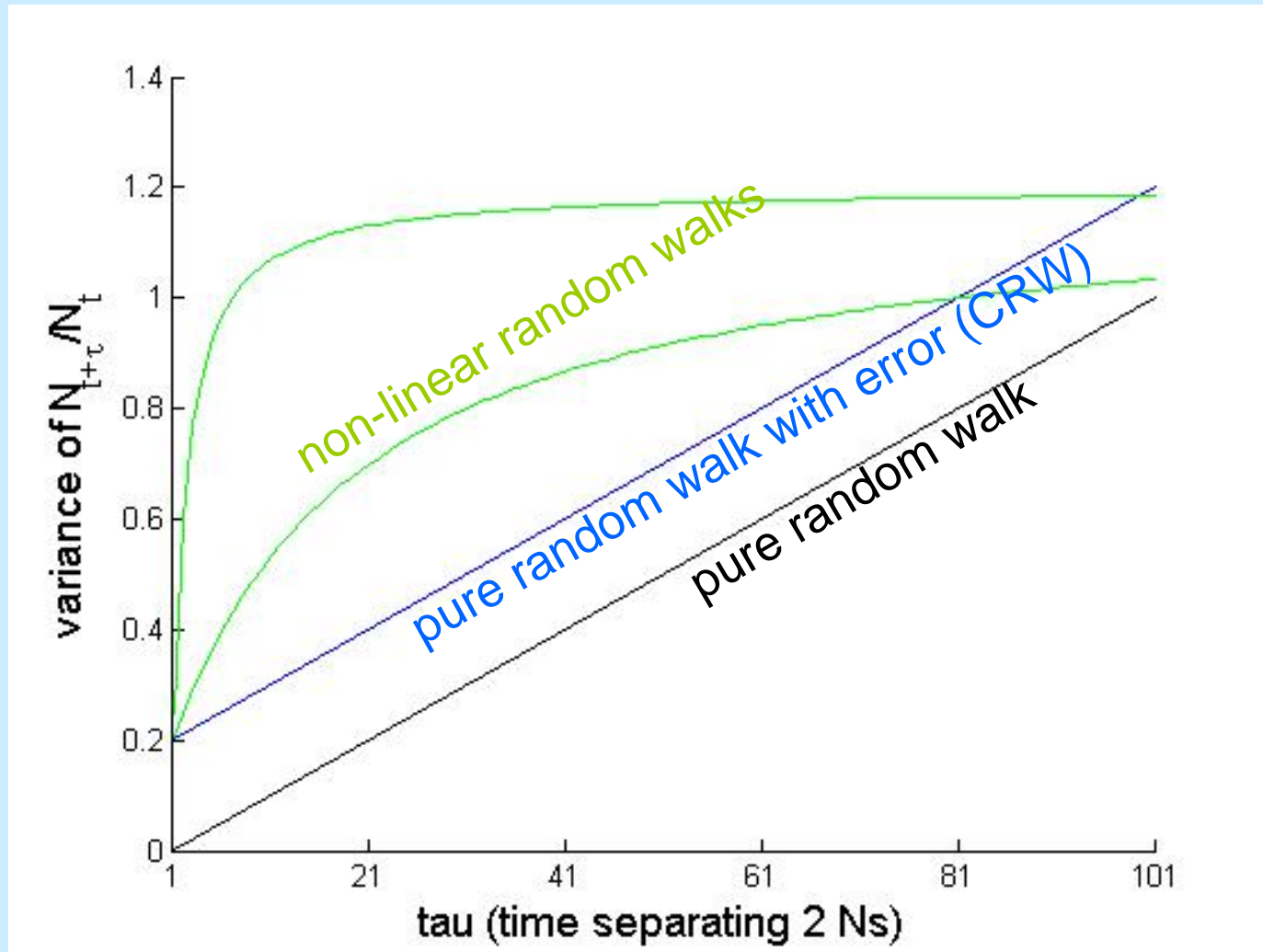
Variability that doesn't feed back into the process (e.g. measurement error, cycles)

Stochastic age-structured models are an example where a CRW approximation works

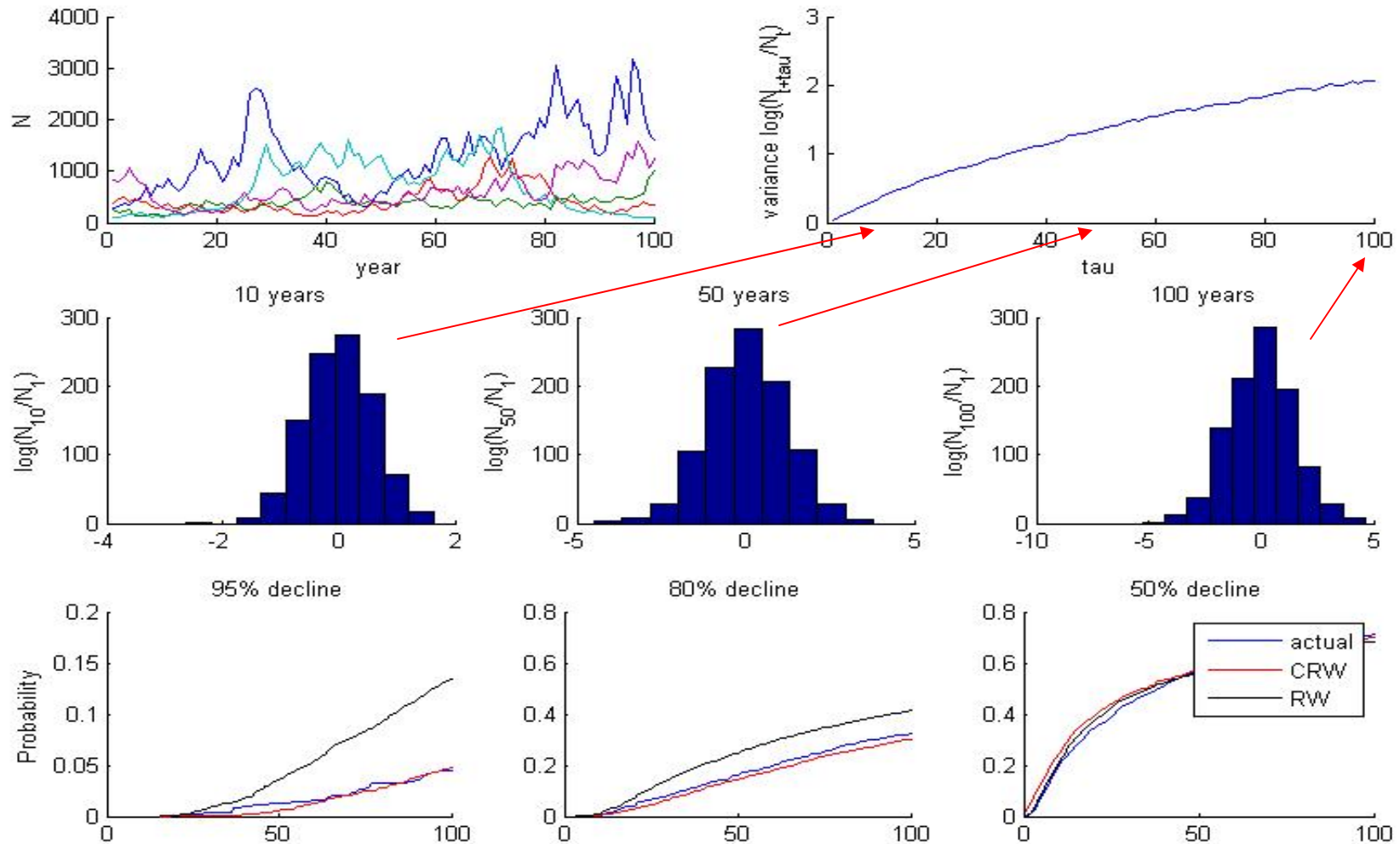
Age-structured stochastic Leslie matrix model for chinook salmon



What about density-dependent processes?



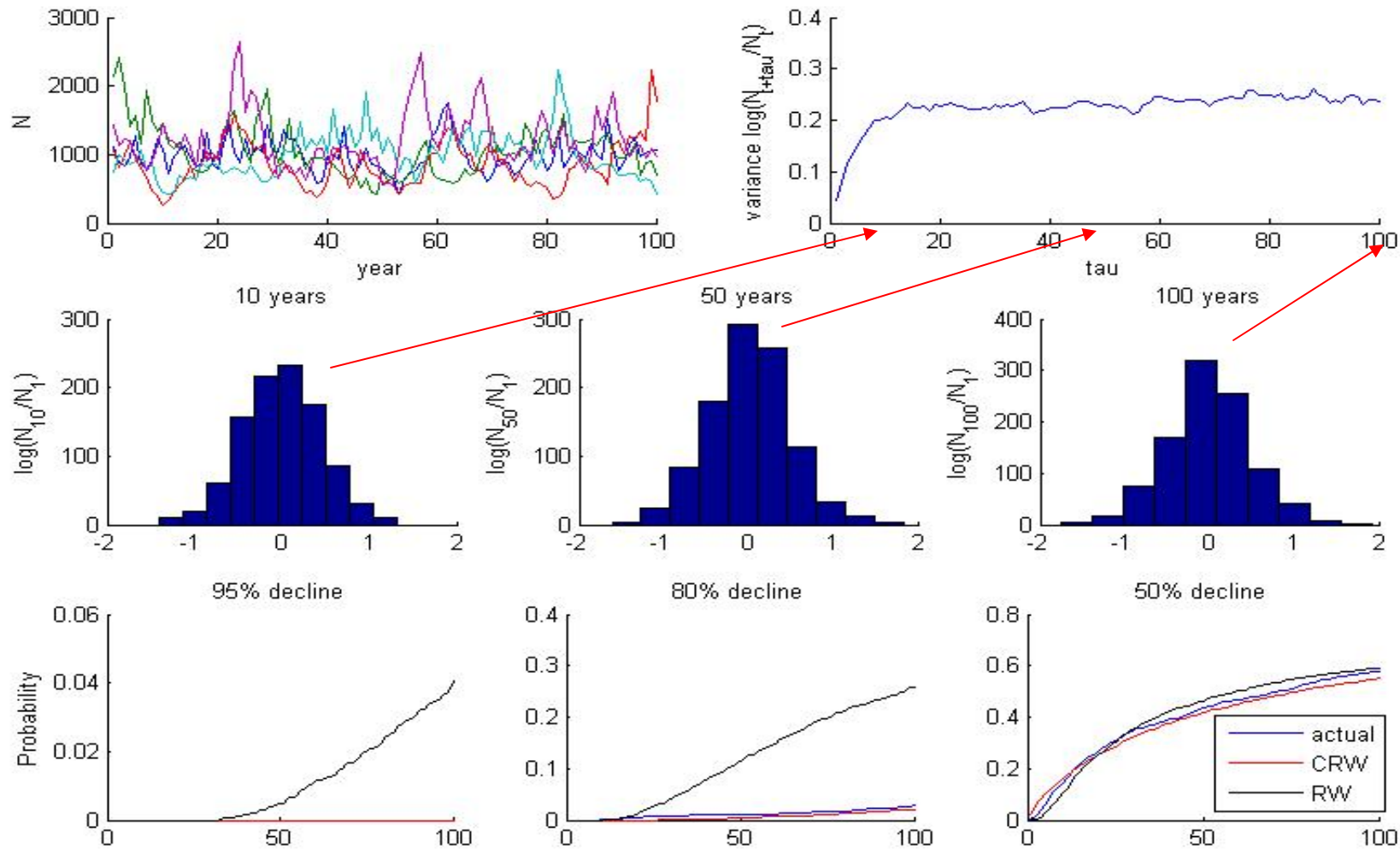
Low density-dependent population processes can still be approximated by a CRW



Stochastic ricker

time horizon

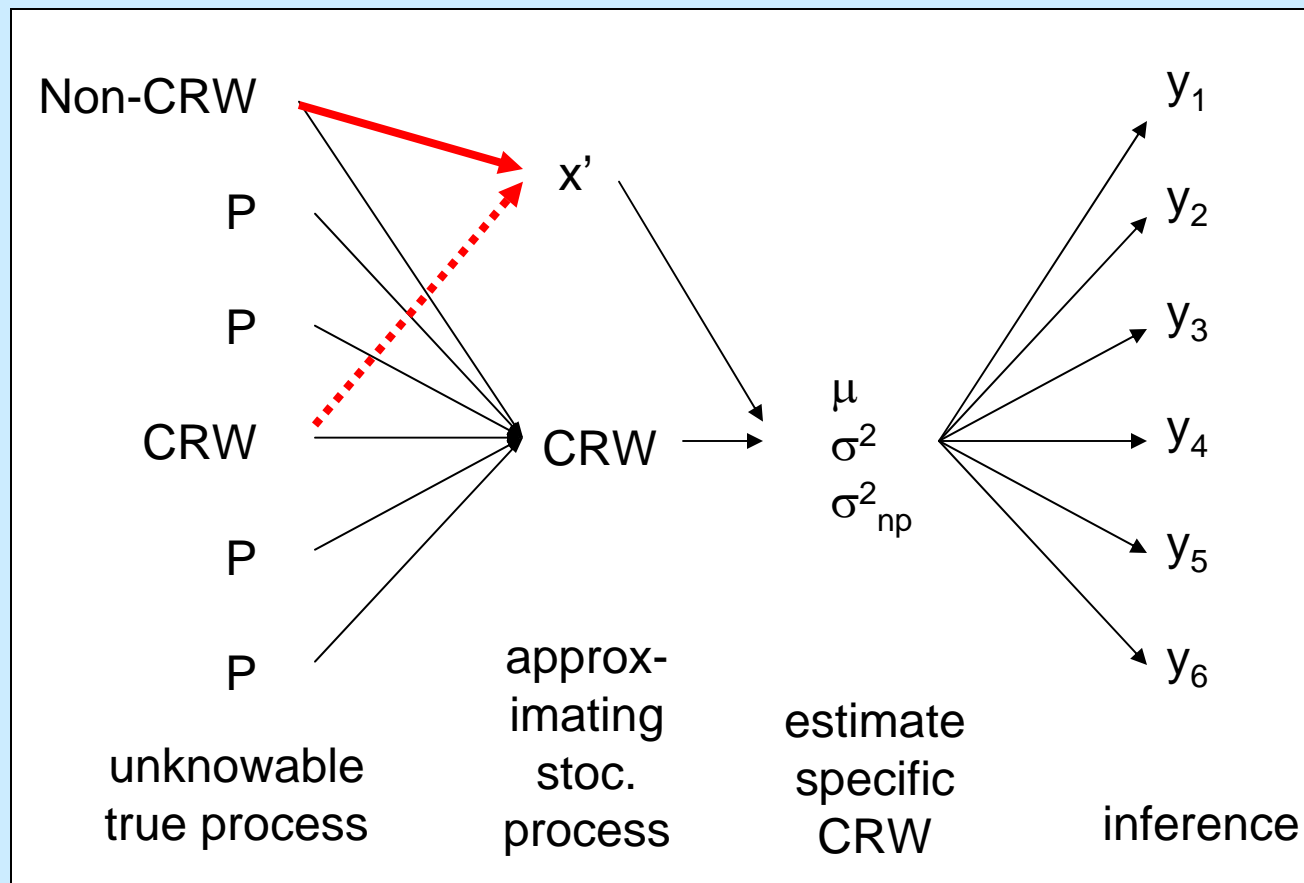
More obviously density-dependent processes may also be approximated



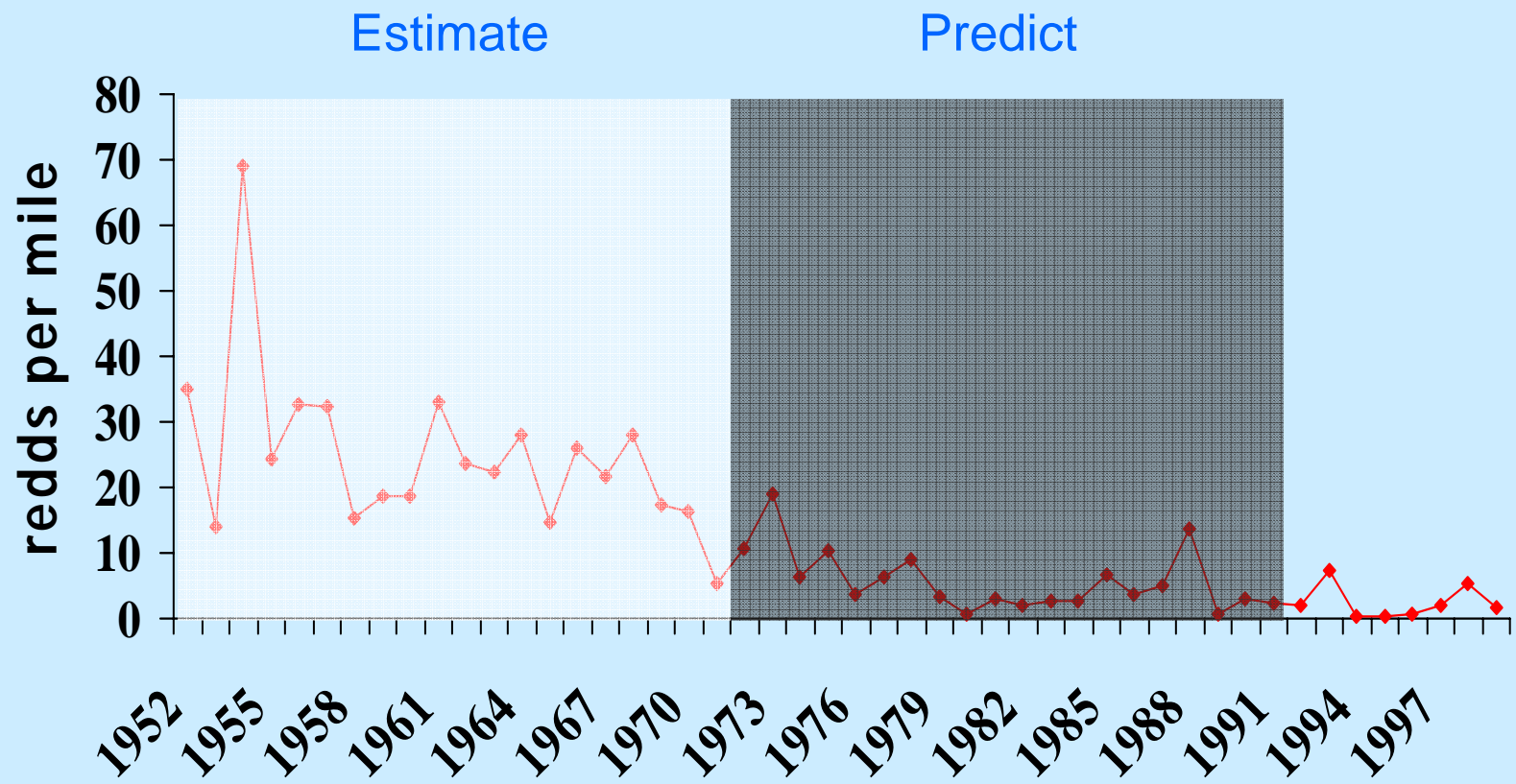
Stochastic ricker

time horizon

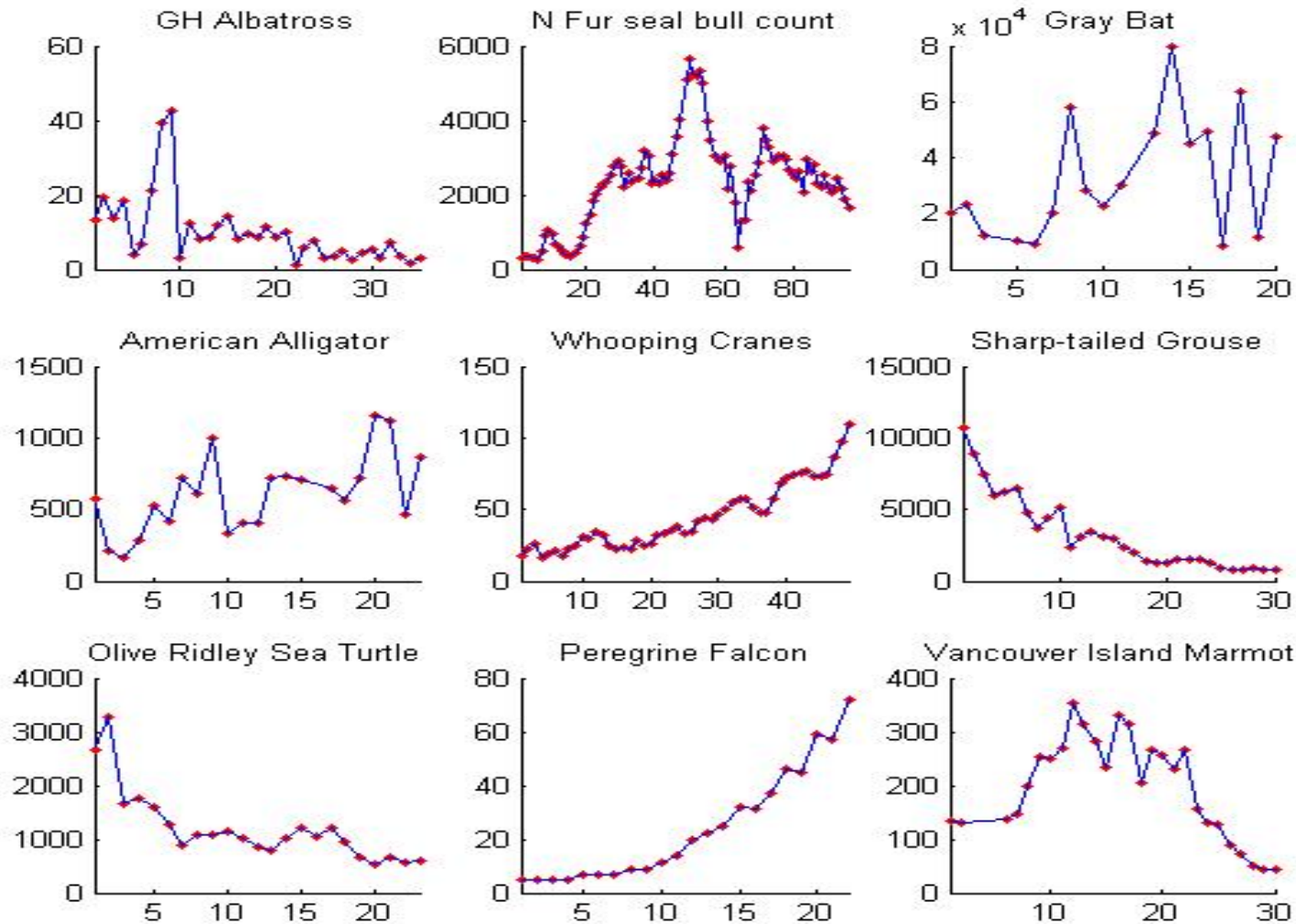
Existence of an approximating stochastic process is one thing, estimation it is another



Using cross-validations with real time series to study CRW approximations for quasi-extinction prediction

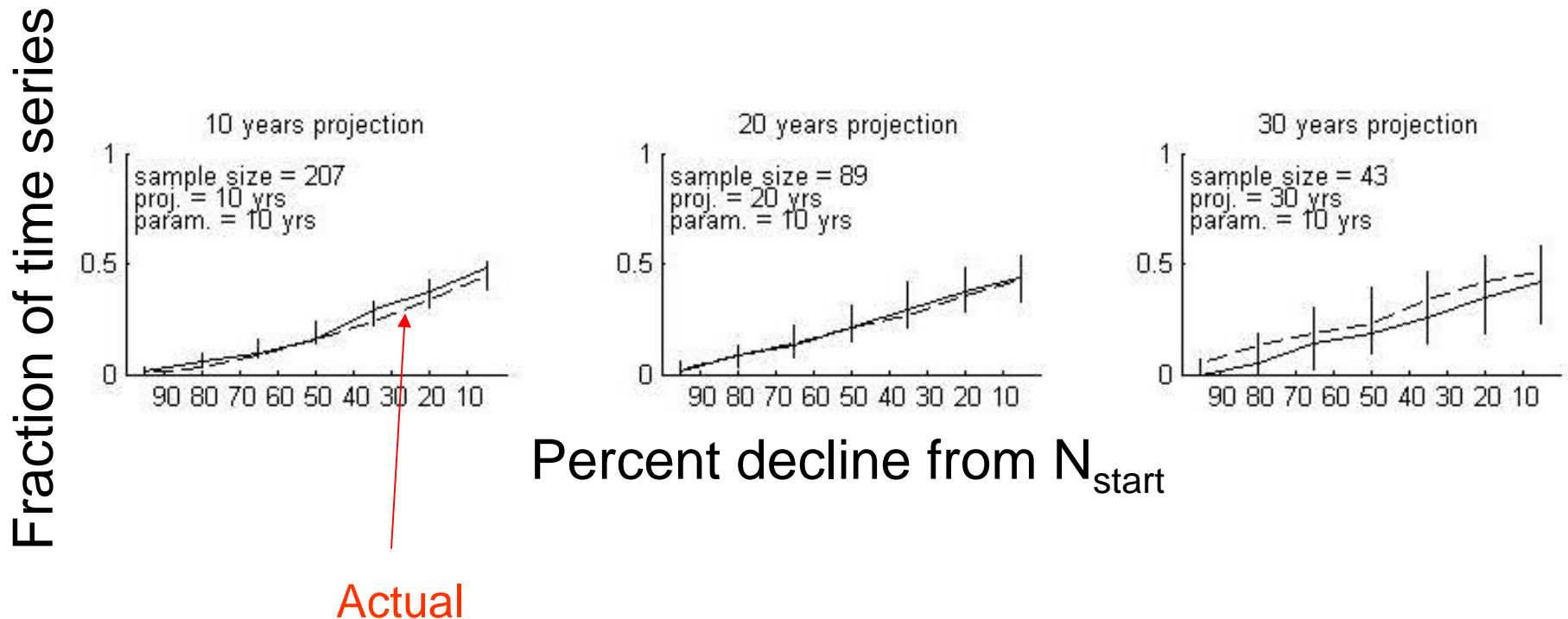


Database of species of conservation concern: 117 time series 20-50 yrs long mammal and bird dominated



Holmes, Fagan et al. (2006)

Low Bias: close correspondence between the expected and observed fraction of quasi-extinctions in the dataset as a whole

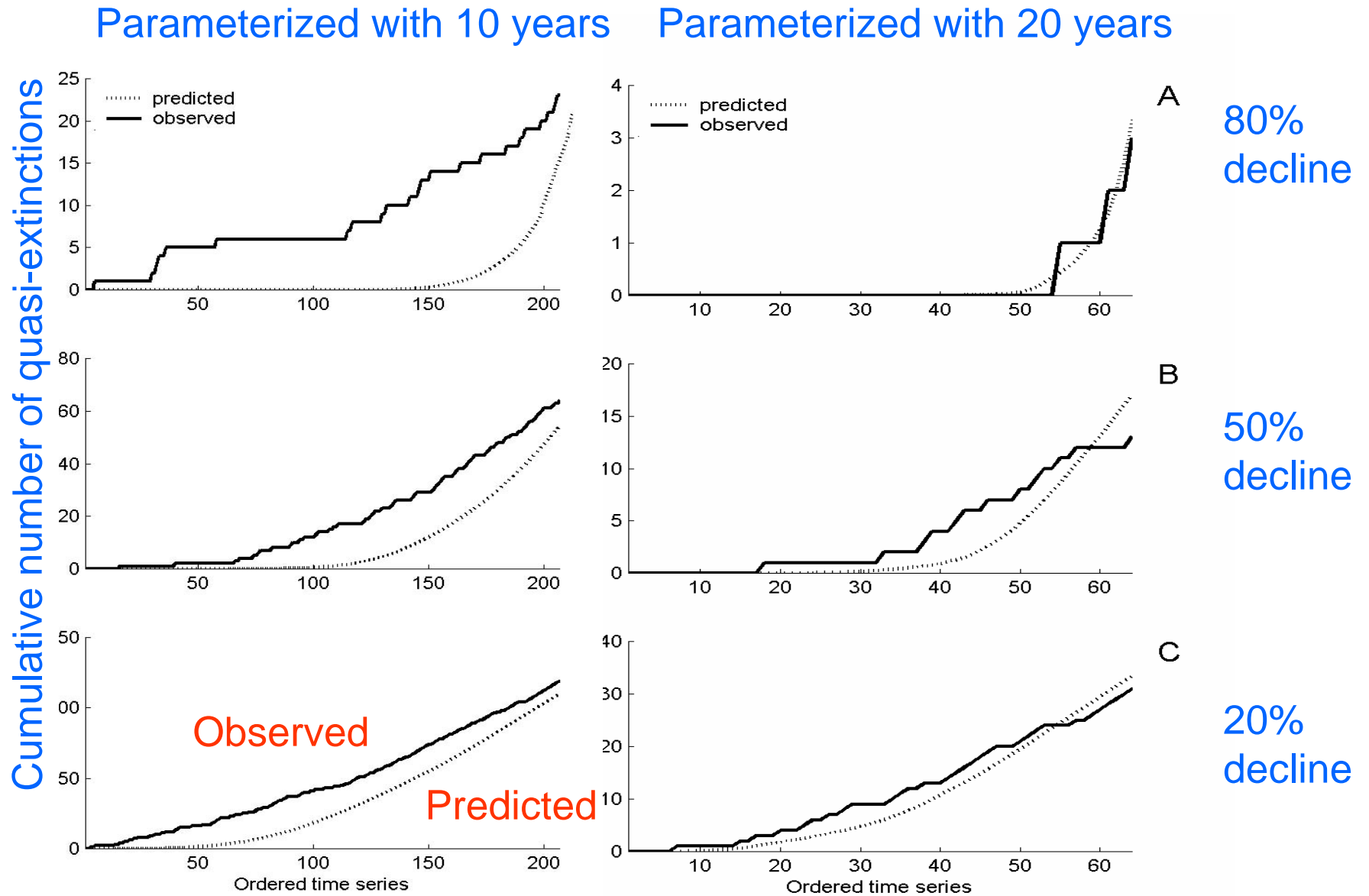


All examples use 10 years to parameterize and a kalman filter estimation

To look at correspondence, I examined cumulative quasi-extinctions

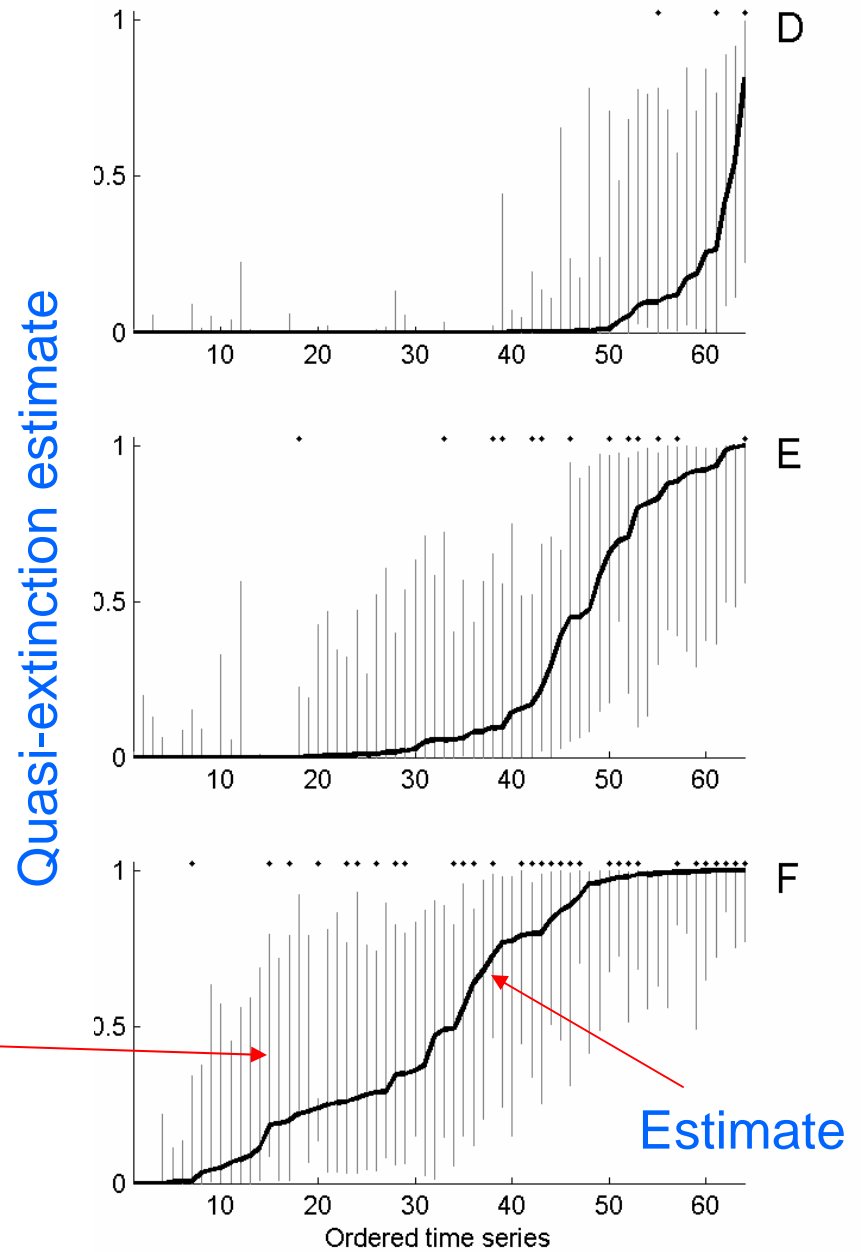
Estimate	Expected Cumulative	Quasi-extinctions	Actual Cumulative
0	0	0	0
.1	.1	0	0
.12	.22	1	1
.12	.34	0	1
.15	.49	1	2
.3	.79	0	2
.35	1.14	0	2
.7	1.84	1	3
1	2.84	1	4

Discrimination depends on parameterization



CRW projecting 10 years; kalman filter

Wide confidence intervals quasi-extinctions but not 0 to 1 when I use at least 20 years of data.



Kalman filter; 20 years parameterization

Conclusions

- Theoretical reasons to think that parsimonious approximations for first-passage probabilities exist
- Cross-validations with datasets (SOC, Salmon) suggest that a reasonable CRW can be estimated for 20-30 yr projections
- So far, properties of the estimates are well-characterized even when CIs are wide.

Some important results I didn't show

- Talk focused on CRW, but the analysis actually compares CRW and RW approximations.
- This dataset is not overly plagued by non-process error *and RW approx. also works well.*
- But CRW worked consistently better in our other cross-validations using large salmon data (Holmes and Fagan 2002), in predator-prey (Sabo & Gerber 2006) and density-dependent simulations (Holmes, Sabo & Viscido, in prep).
- We have separated out those time series representing extinction events (Fagan and Holmes 2006)

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