Variation in Species Response to Environmental Variability

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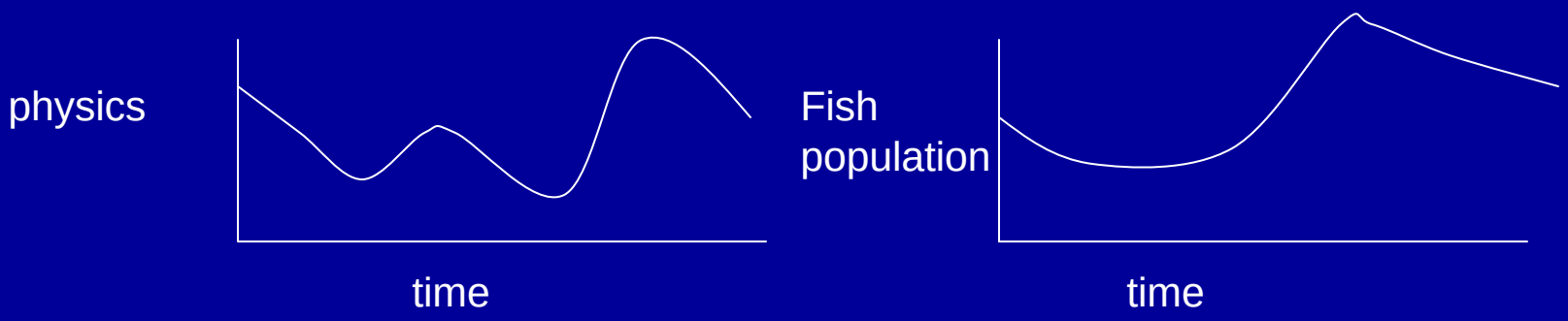
Identifying effects of environmental change on global ocean ecosystems

GLOBEC: A mechanistic approach

But typical scenario:



Correlated -> causal influence

Modeling: physics, NPZ….

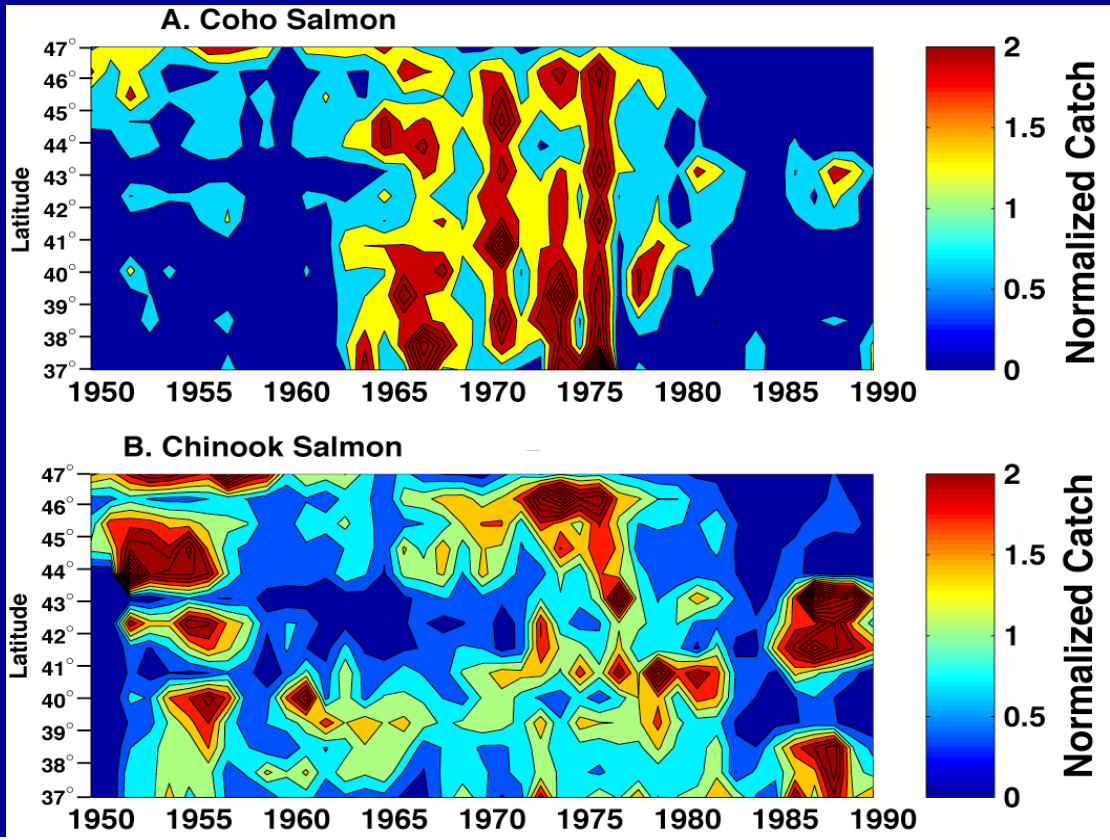
What's missing? Population dynamics of higher trophic levels

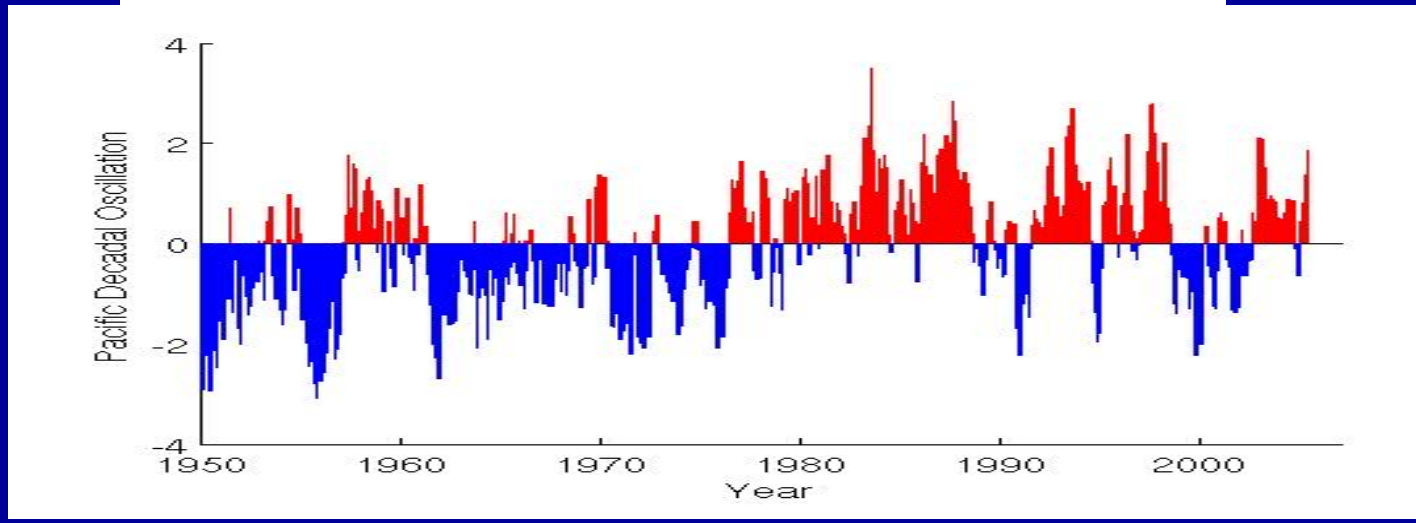
California Current salmon

Coho salmon collapsed coastwide mid-1970s

Chinook salmon did not

Same time as change in new index = PDO





California Current coho salmon

PDO → Change in zooplankton composition → Coho abundance

Peterson &Schwing (2003)

But how (point of action)?

1. Coho growth rate
2. Coho survival year 1
3. Coho survival year 2

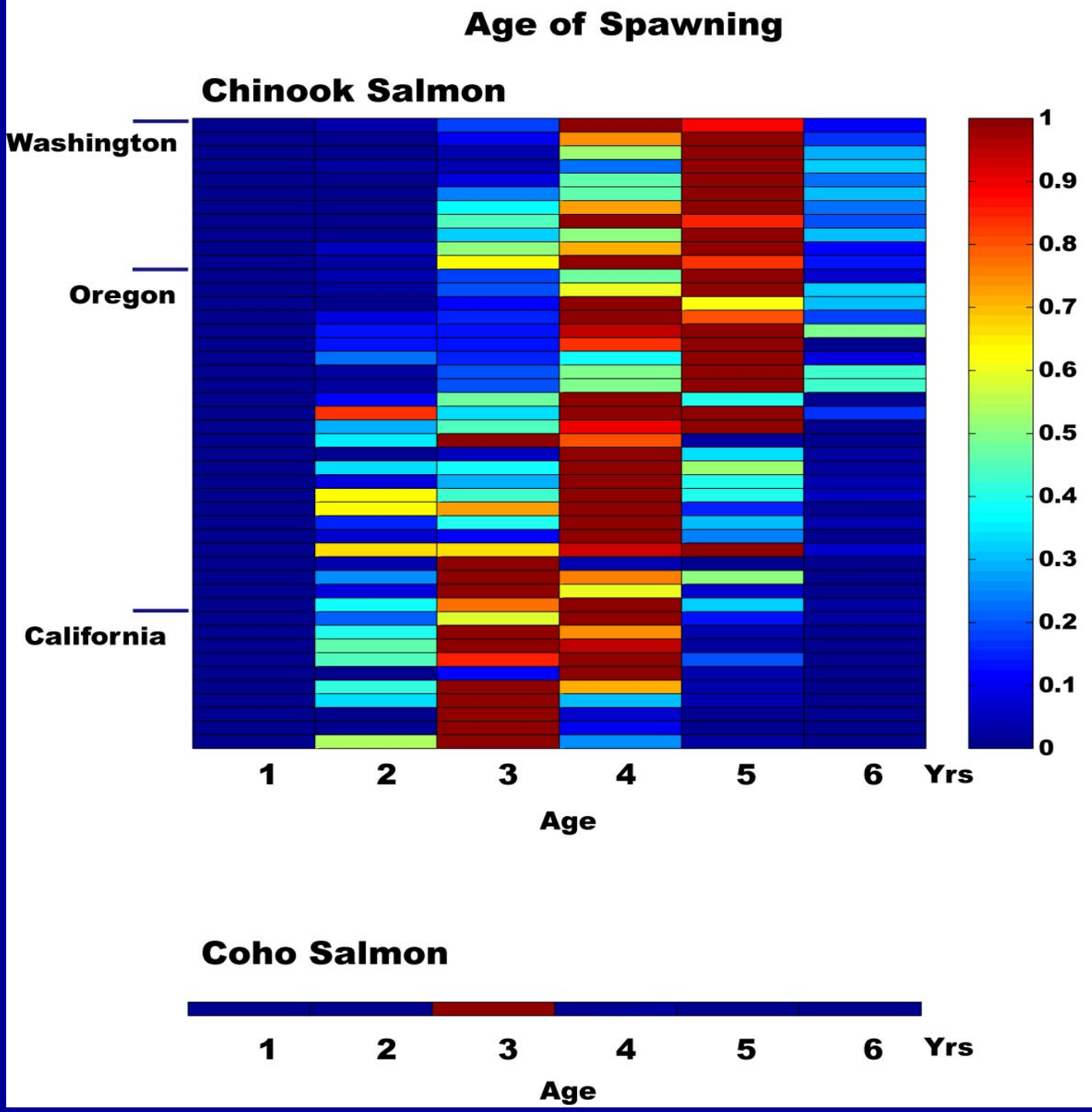
Related to why chinook salmon respond differently?

Different physics?

Different population dynamics?

Differences in spawning ages

Both semelparous (die after spawning)



Question:

Populations of same species (or congeners) respond differently at different locations.

Different Physics?

Different Population Dynamics

Global Study: Salmon, Cod

Recent findings in population dynamics

Re: response to environmental variability

1. Point of action (e.g., survival at age 3, juvenile growth rate) makes a difference in response
2. Age composition of observation also determines response (e.g., recruits, catch).
3. Fishing, long-term survival changes that response
4. Spawning age structure makes a difference.

Worden, et al. 2009 - coho and chinook salmon

Myers, et al. (1998) - sockeye salmon

Bjornstadt, et al. (2004) - Atlantic cod

Worden, et al. (2009)

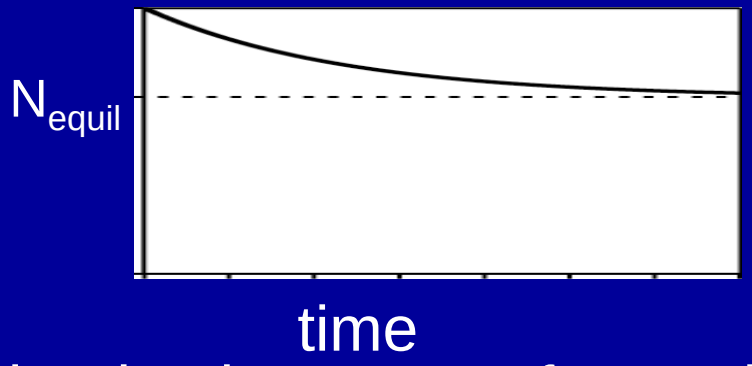
Analysis: Behavior of age structured model with Beverton-Holt stock recruitment, linearized about equilibium

Results: Presented as
(std. dev. of response)/(std. dev. of envirnment)
plotted vs. frequency

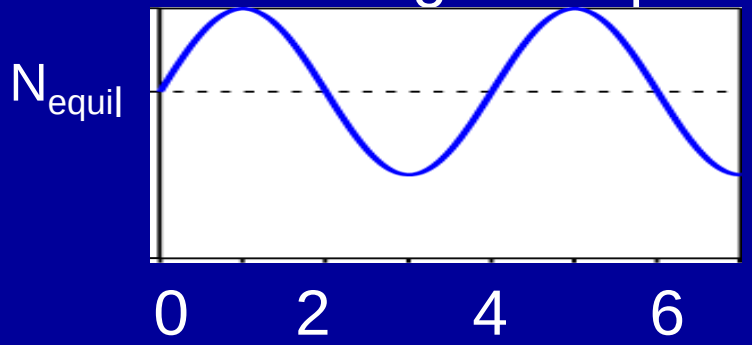
From Worden, et al.

Several dominant modes of response:

1. Geometric decay



2. A cycle with period = dominant age of reproduction



Effects of environment?

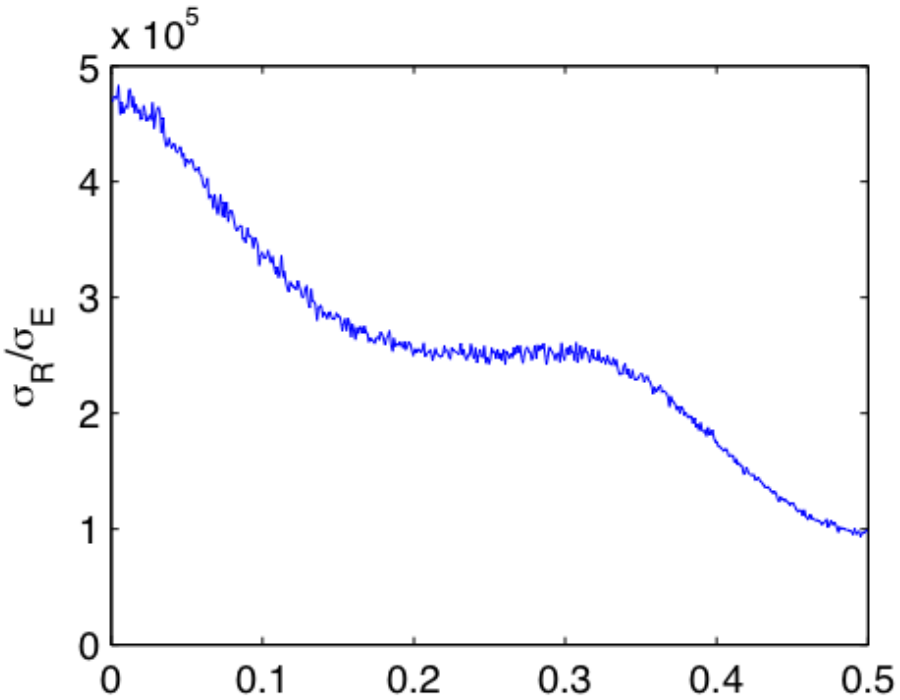
Varying survival rate → geometric decay mode

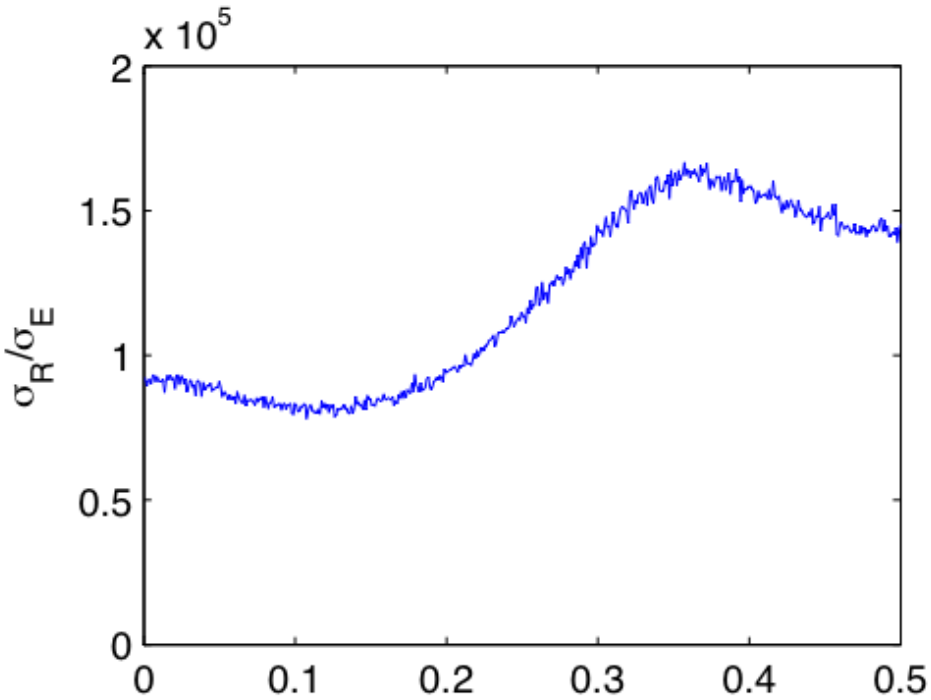
Varying maturation/age schedule → cyclic mode.

Example: CCS coho salmon

Varying ocean survival

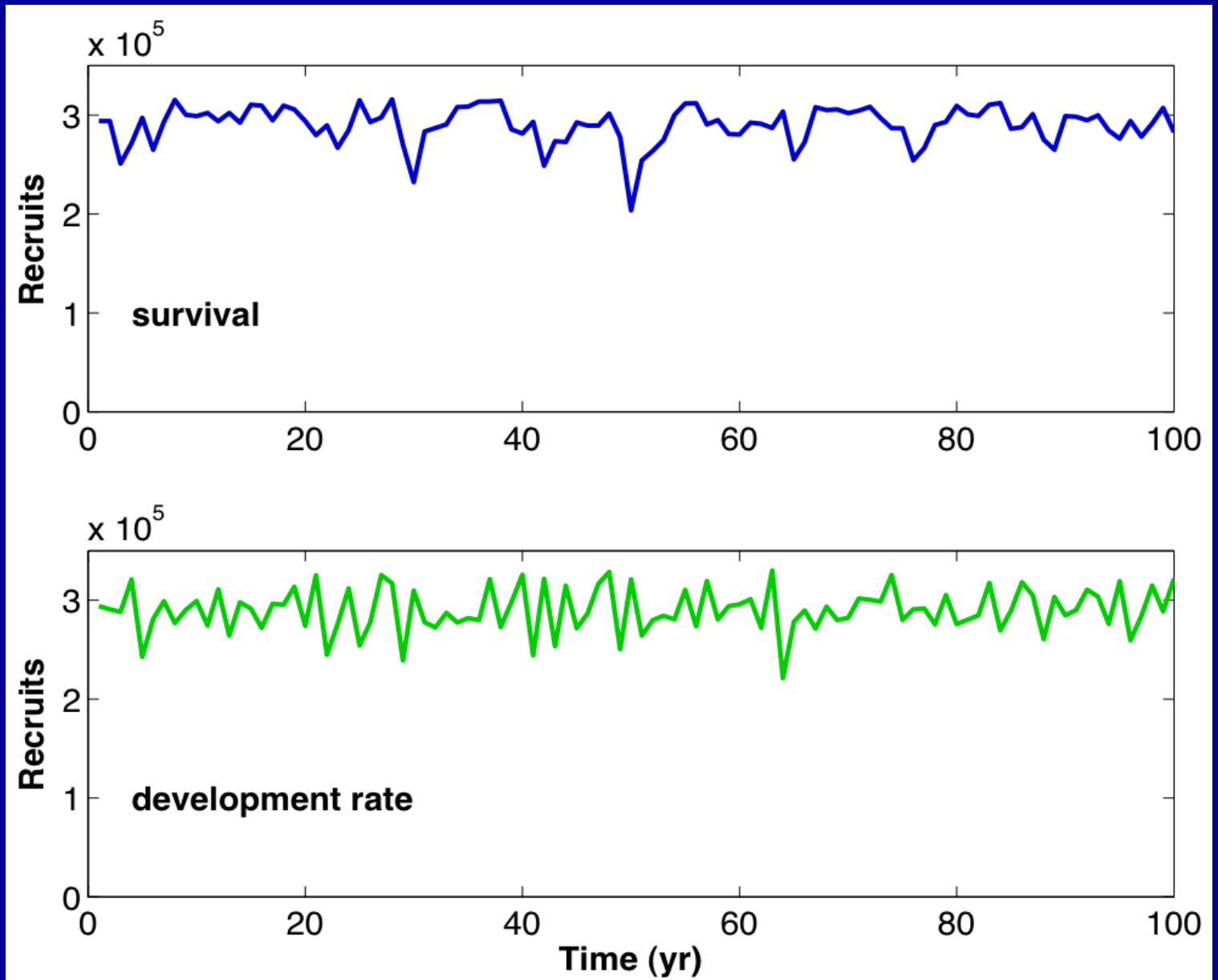
Varying growth rate





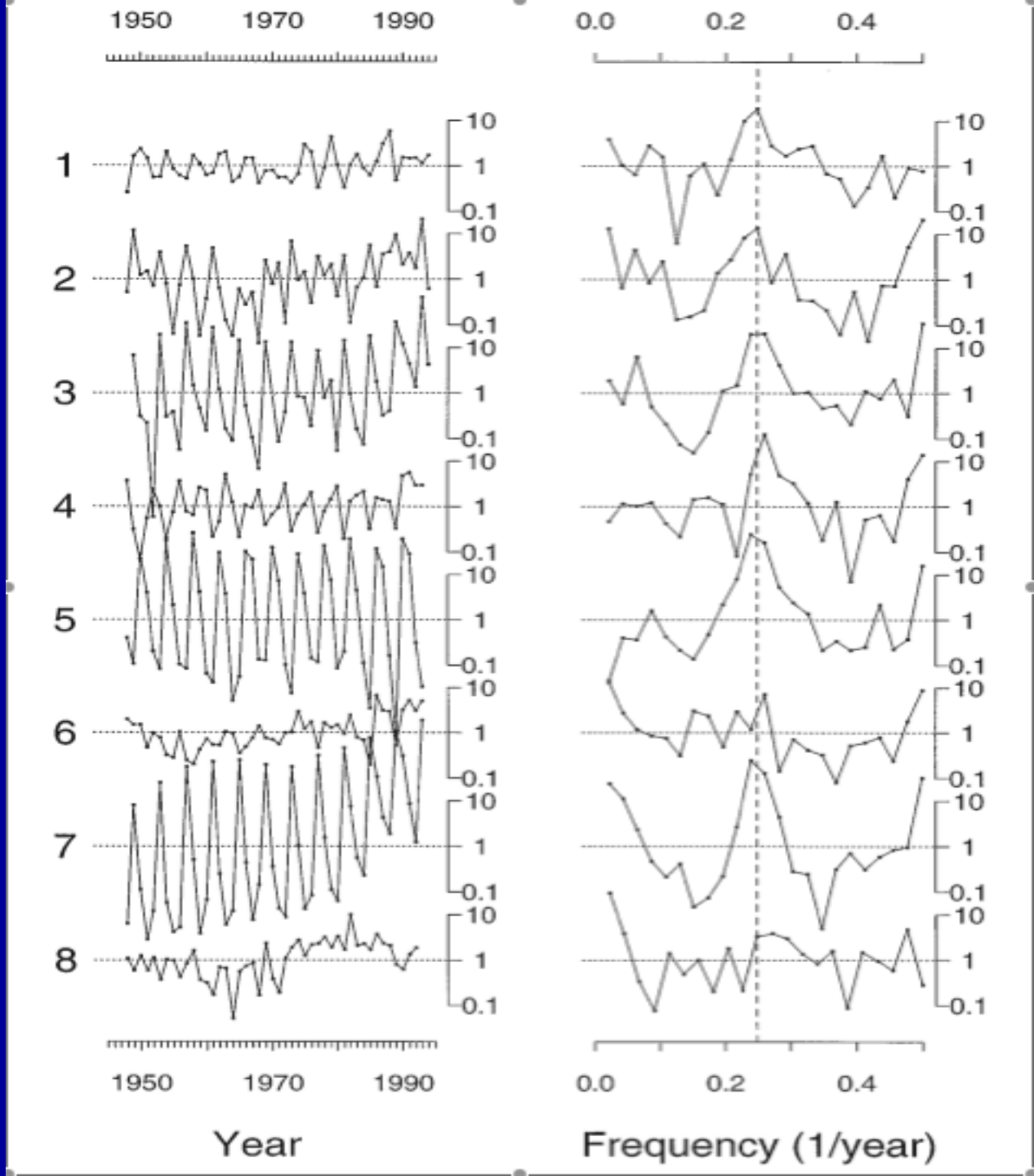
frequency (y^{-1})

Time series: varying survival vs. growth rate (white noise)



Example: cyclic salmon populations

Fraser River sockeye salmon spawning runs, major streams (Myers, et al. 1998)



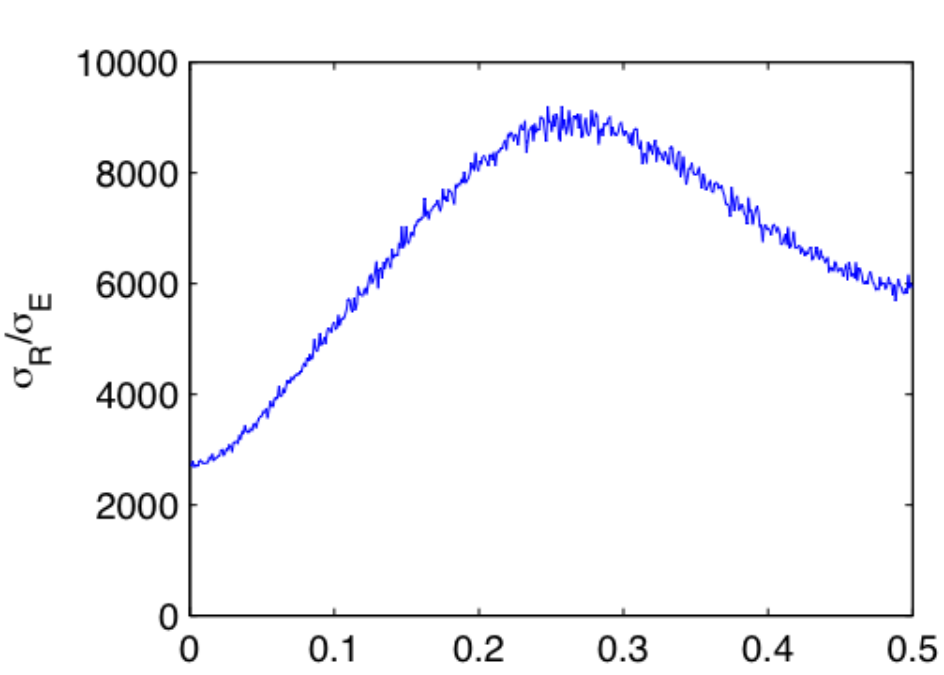
View of response depends on method of observation:

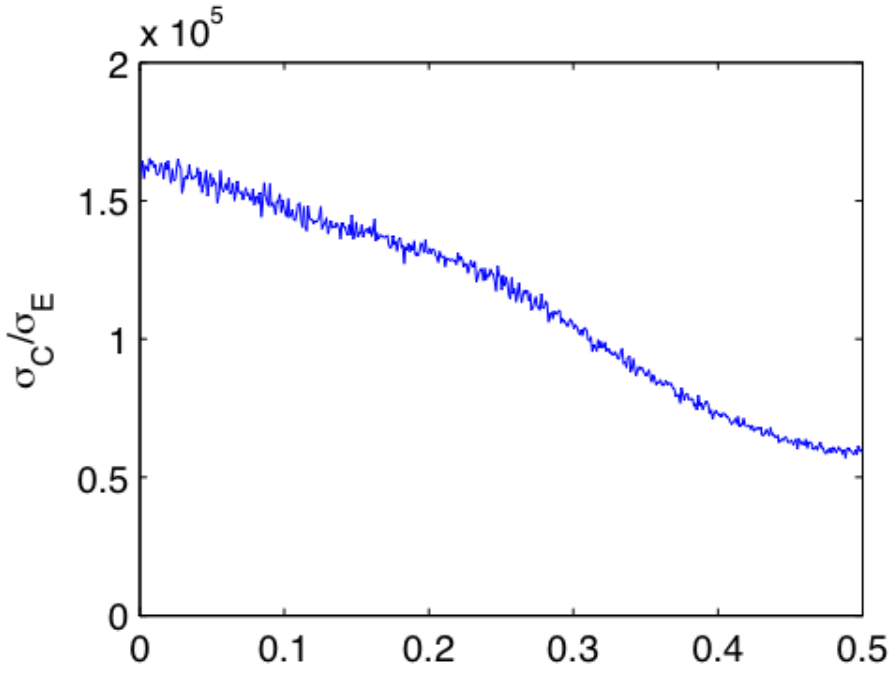
1. Recruitment
2. Spawners
3. Catch (constant fishing)

Example: CCS chinook salmon, variable growth rate

Recruitment

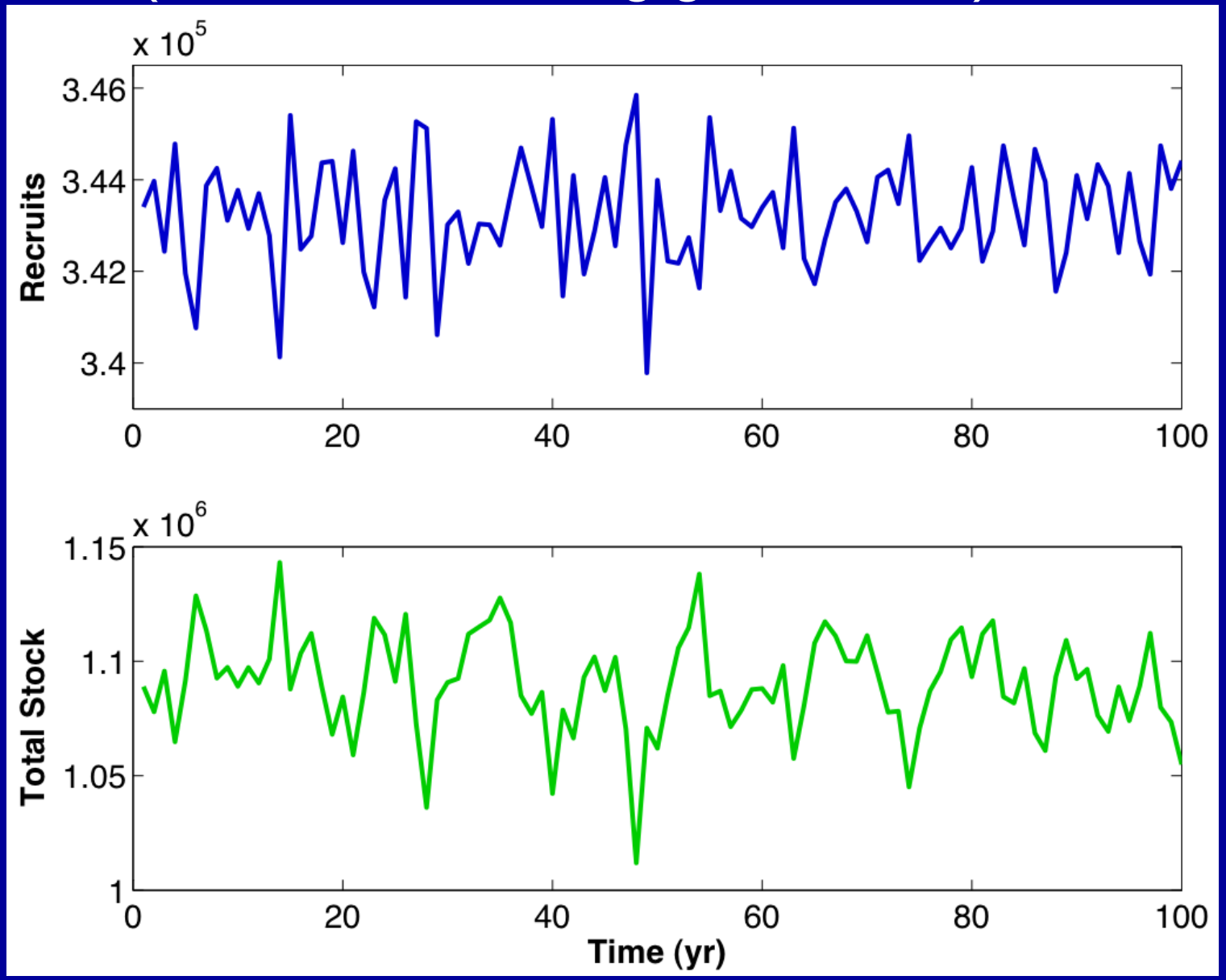
Abundance





frequency (y^{-1})

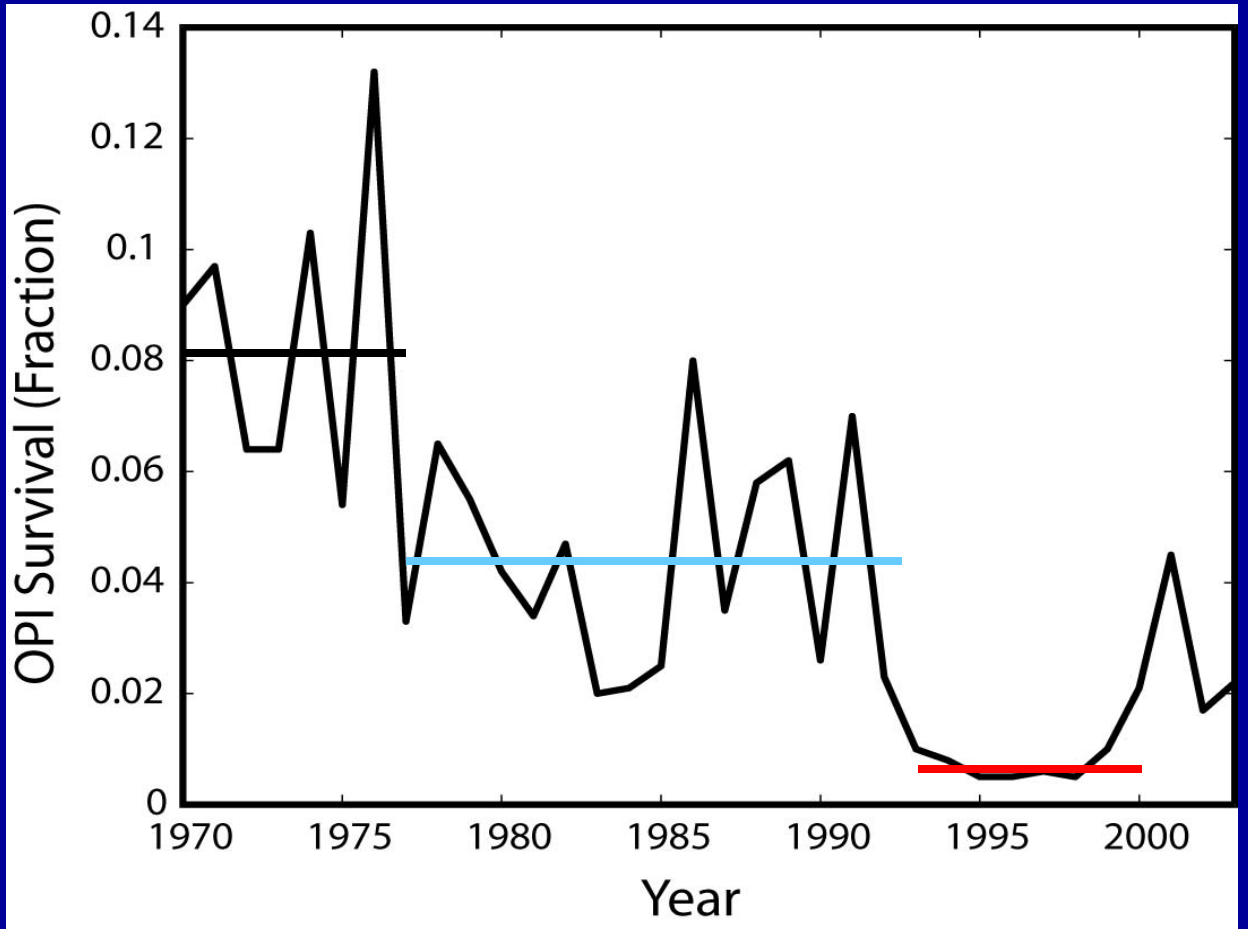
Time series: Observation of recruitment vs. abundance. (white noise driving growth rate)



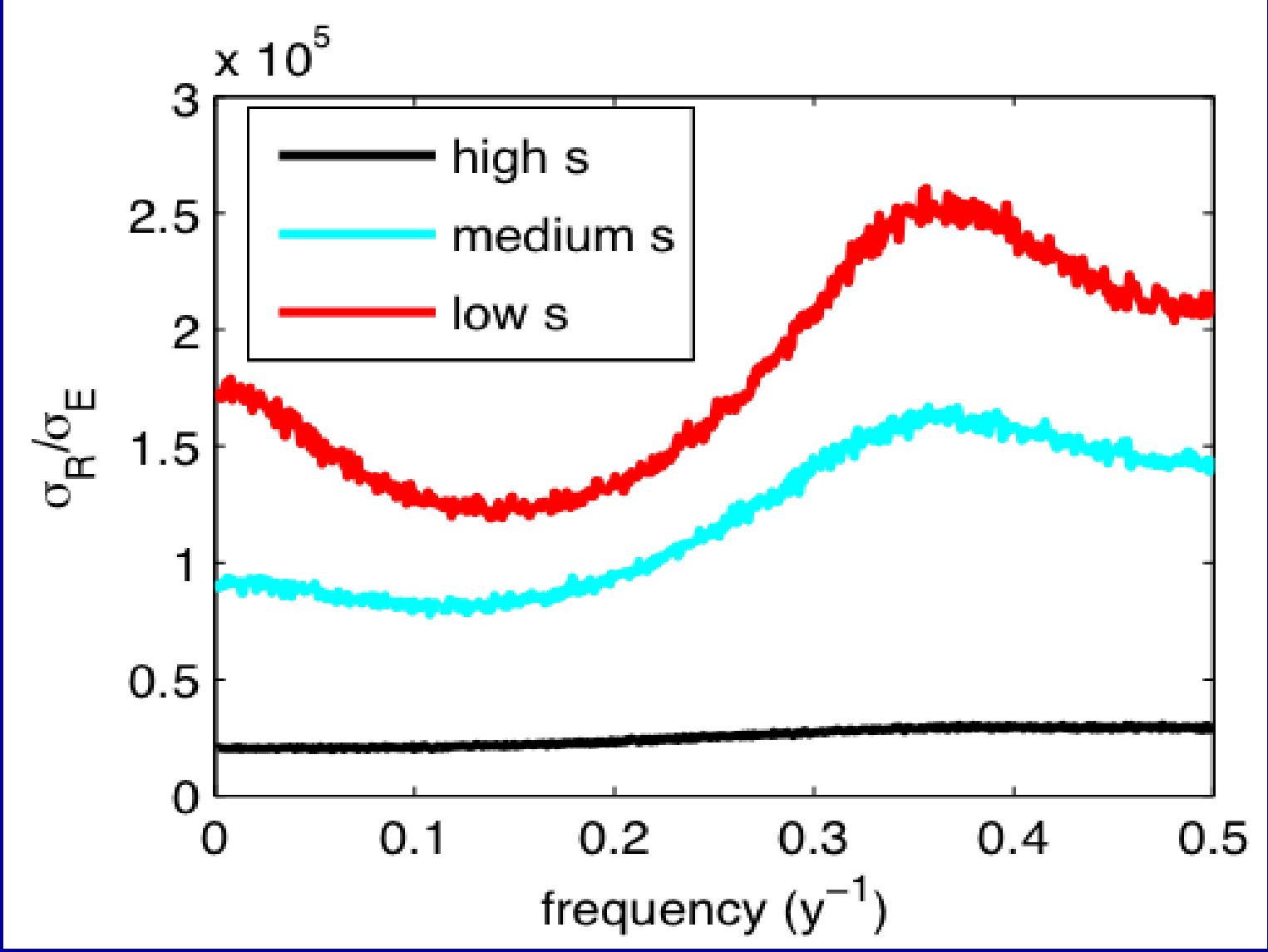
Results of fishing or long-term decline in survival:

1. Increase in resonance
2. Decline, then collapse

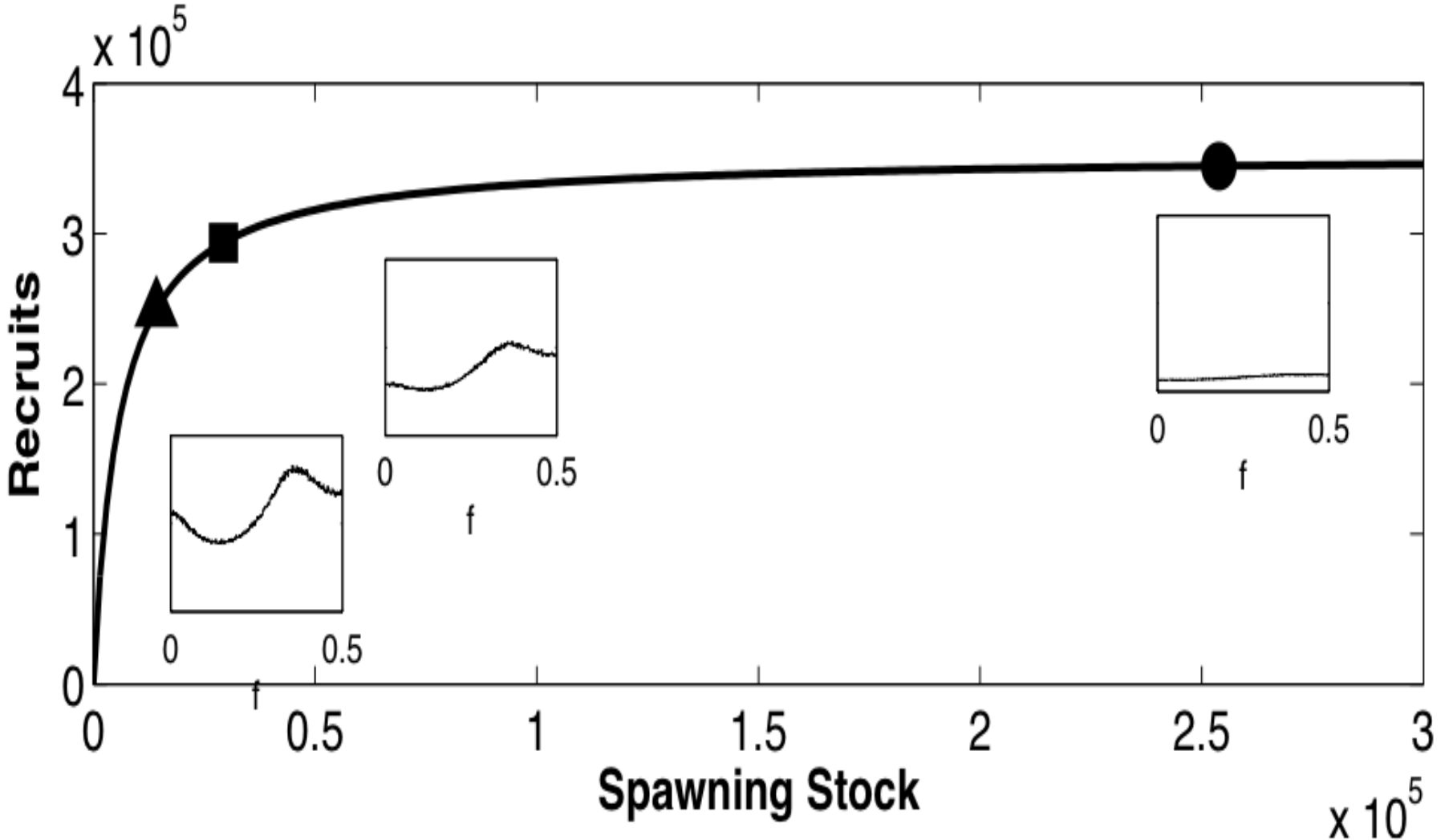
Example: CCS coho salmon



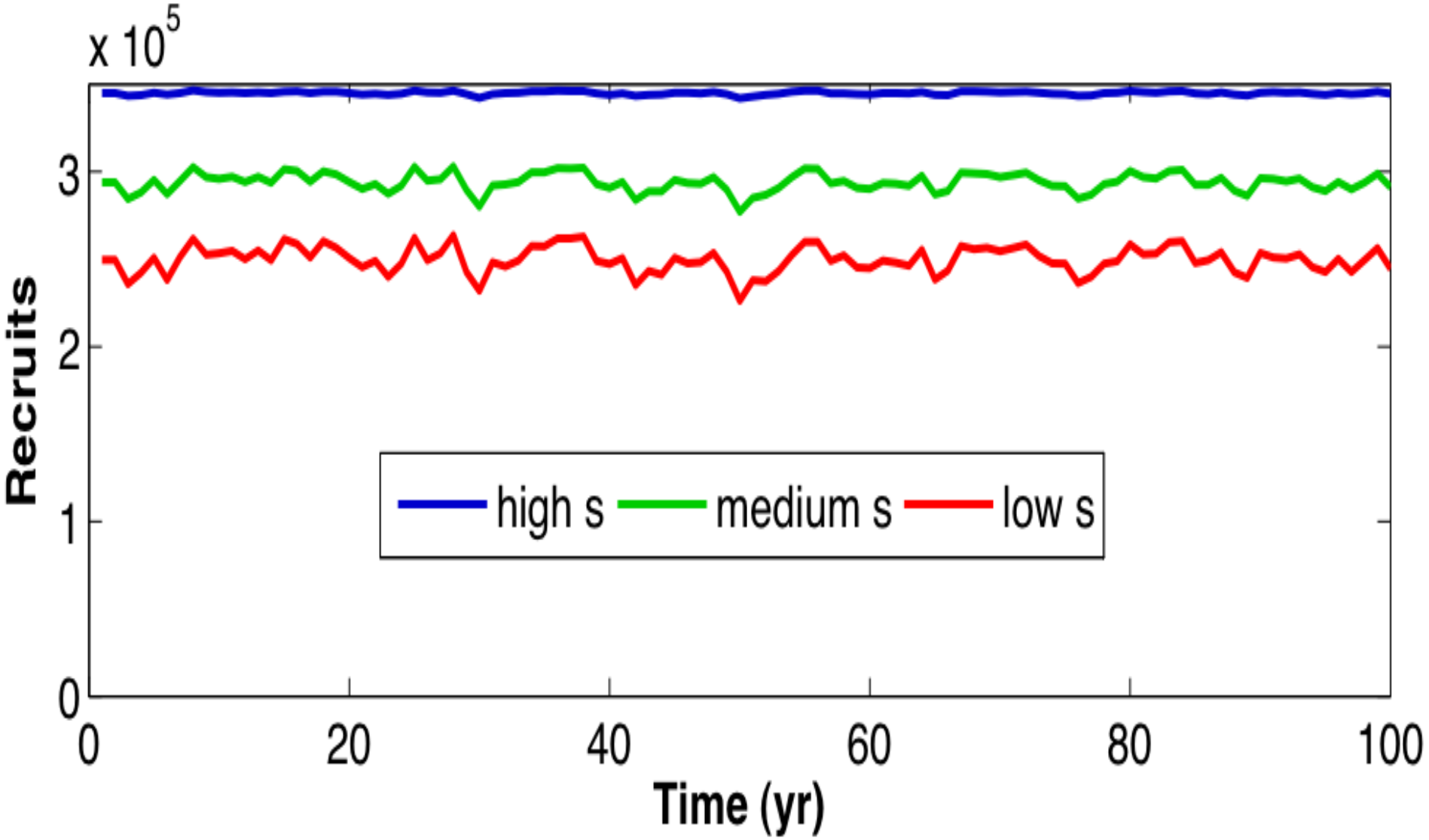
CCS Coho salmon with different ocean survivals, and time varying growth rate (white noise)



Changes in equilibrium and frequency response, as long-term survival changes

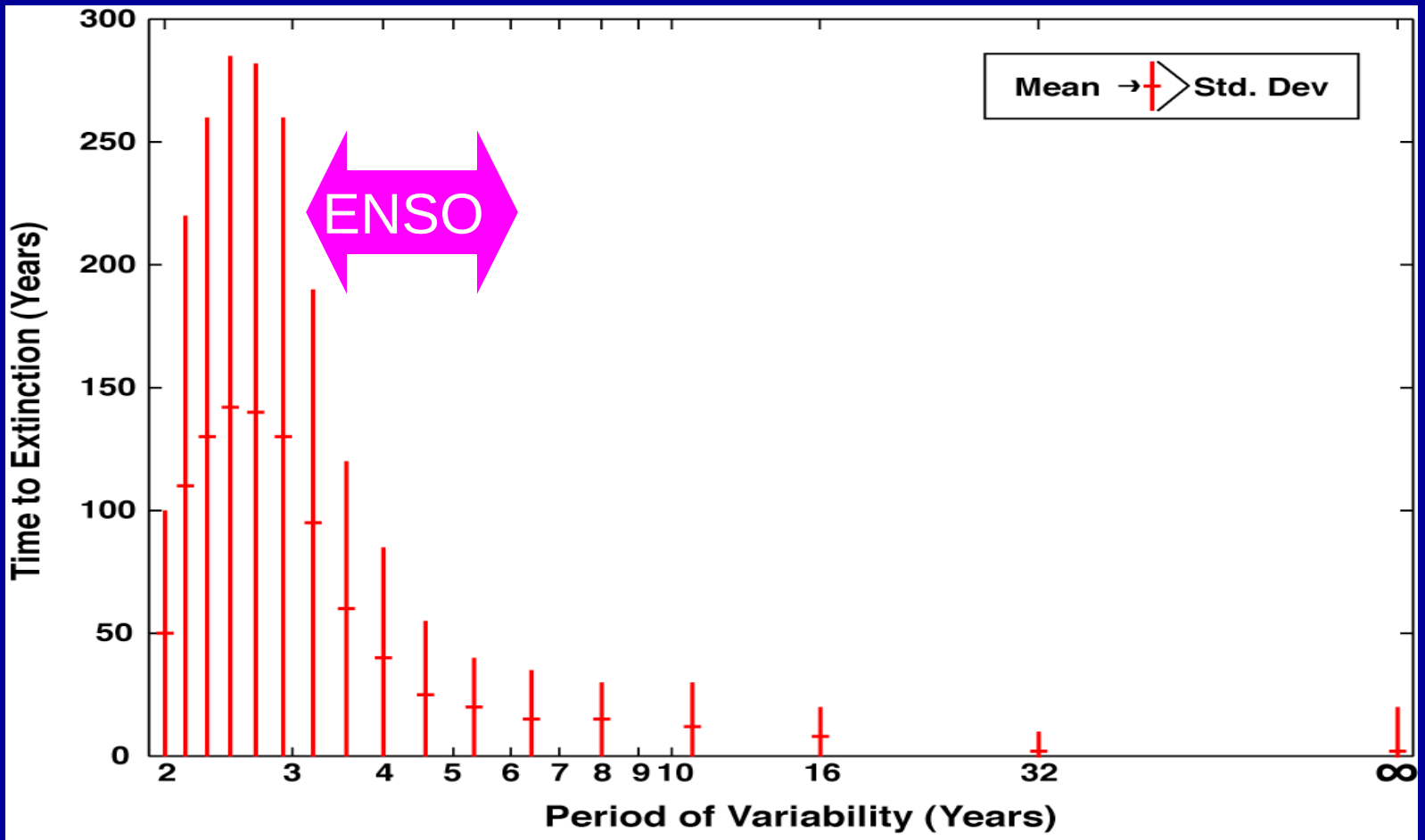


Time series of coho salmon at different constant ocean survivals, and time varying growth rate (white noise).



Relevance to climate change

1. Sensitivities to slow change
2. Sensitivity to change in time scales of variability, e.g., ENSO.



Our plans:

PAST

Synthesis of what is known re: Pacific and Atlantic salmon, Pacific and Atlantic cod response to environmental variability

How much of the differences in response are due to differences in life histories vs. differences in physical forcing?

FUTURE

Interact with physicists regarding current and likely future time scales of environmental variability

Determine population response to variability on these different time scales from data and modeling results.