Spatial scales of dynamics in CalCOFI ichthyoplankton survey

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CalCOFI survey
Empirical dynamic modeling (EDM)

- [https://www.youtube.com/watch?v=8DikuwwPWsY&frags=pl%2Cwn](https://www.youtube.com/watch?v=8DikuwwPWsY&frags=pl%2Cwn)
- One time series
  - Reconstruct shape of attractor
Takens’ Theorem

- https://www.youtube.com/watch?v=ctOseiJoRul
- Evaluate reconstruction
- Can we predict?
  - Data quality
  - Representative
Re-assessment of the stock-recruit and temperature-recruit relationships for Pacific sardine (Sardinops sagax)

Sam McClatchie, Ralf Goericke, Guillermo Auad, and Kevin Hill

Shifts in system
CalCOFI and EDM

Distinguishing random environmental fluctuations from ecological catastrophes for the North Pacific Ocean
Chih-hao Hsieh¹, Sarah M. Glaser¹, Andrew J. Lucas¹ & George Sugihara¹
Nature, 2005

Why fishing magnifies fluctuations in fish abundance
Christian N. K. Anderson¹, Chih-hao Hsieh¹,²,³, Stuart A. Sandin¹, Roger Hewitt⁵, Anne Hollowed⁶, John Beddington⁷, Robert M. May⁸ & George Sugihara¹
Nature, 2005

Predicting climate effects on Pacific sardine
Ethan R. Deyle⁹,₁, Michael Fogartyb, Chih-hao Hsieh¹, Les Kaufmand,e, Alec D. MacCalff, Stephan B. Munchf, Charles T. Perrettii, Hao Ye⁹, and George Sugiharaa,₁
PNAS, 2013
Extensions into space and time

• Fish larvae
  • Annual averages, standardized
• Shared dynamics
  • Generated by same processes
  • Common response
• Where/when/which?
Shared dynamics (co-prediction)
1-D Simplex (Sugihara and May 1990)

From: https://github.com/opetchey/RREEBES
1-D Simplex (Sugihara and May 1990)

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From: https://github.com/opetchey/RREEBES
3-D Simplex (Sugihara and May 1990)

- Estimate dimension
- Nearest neighbors
- Compare predictions to observations
Synchrony results: sardine, one location

- Pairwise predictions
- Significance:
  - Spearman’s rho (p<.05)
  - Better than naïve prediction?
  - Less than 75% zeroes
- Here 2 significant sites
- 1951-2017
Synchrony results: sardine, two locations
Sentinel sites

Pacific sardine

Northern anchovy

Pacific hake

# copredicted sites

30
20
10
Synchrony to predict time series
Composite library

line 86.7 station 33
Prediction from composite library
Where do we predict well?
Scales of dynamics
Sentinel sites *through time*
Decadal regime shifts in southern California's ichthyoplankton assemblage

Clare E. Peabody¹, Andrew R. Thompson², Dov F. Sax¹, Ryan E. Morse³, Charles T. Peretti⁴
Extensions into space and time

- Shared spatial dynamics
  - Sentinel sites
  - Improve predictability
- Shared dynamics improve predictability
  - (Better defined attractor)
- Identification of causal relationships
Thanks

- CalCOFI ship crews and sorters