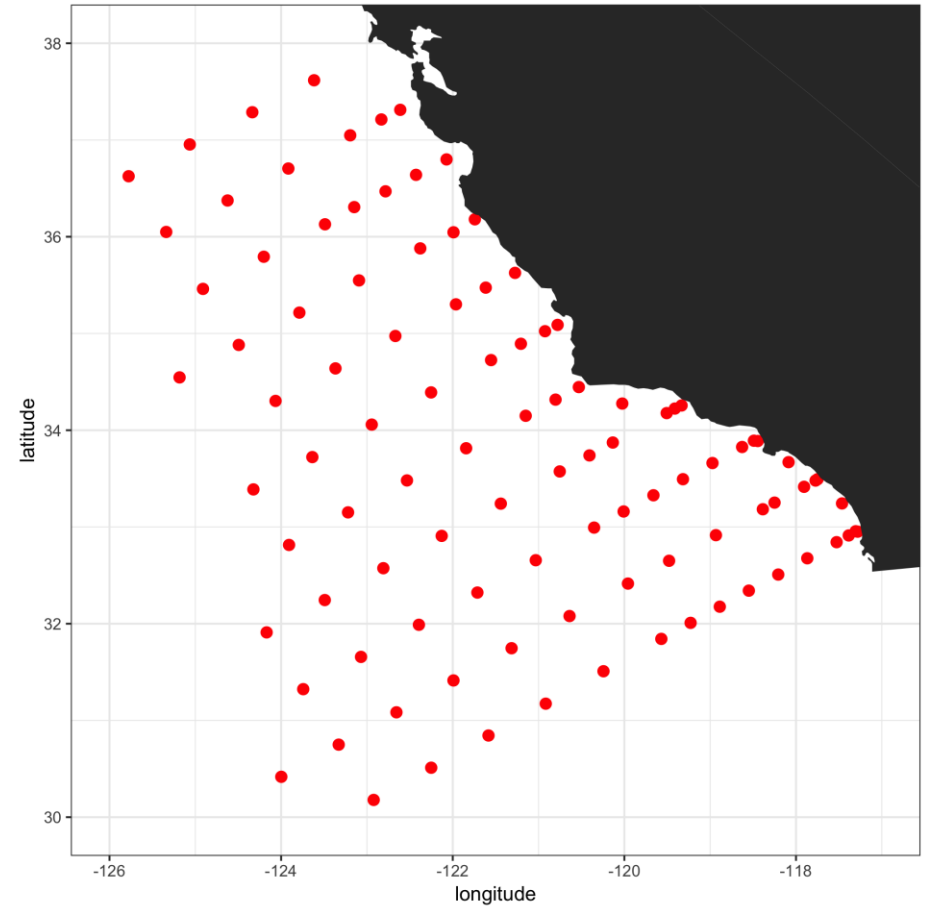


Spatial scales of dynamics in CalCOFI ichthyoplankton survey

Peter Kuriyama, Steve Munch, Brice Semmens

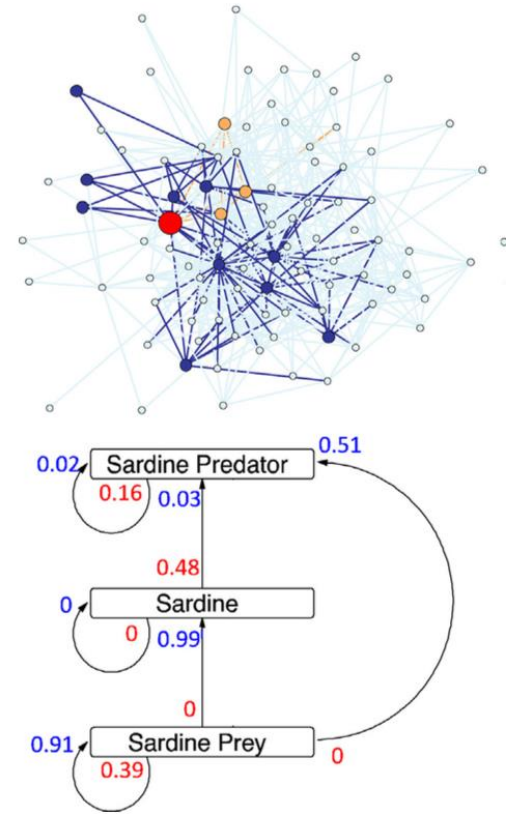
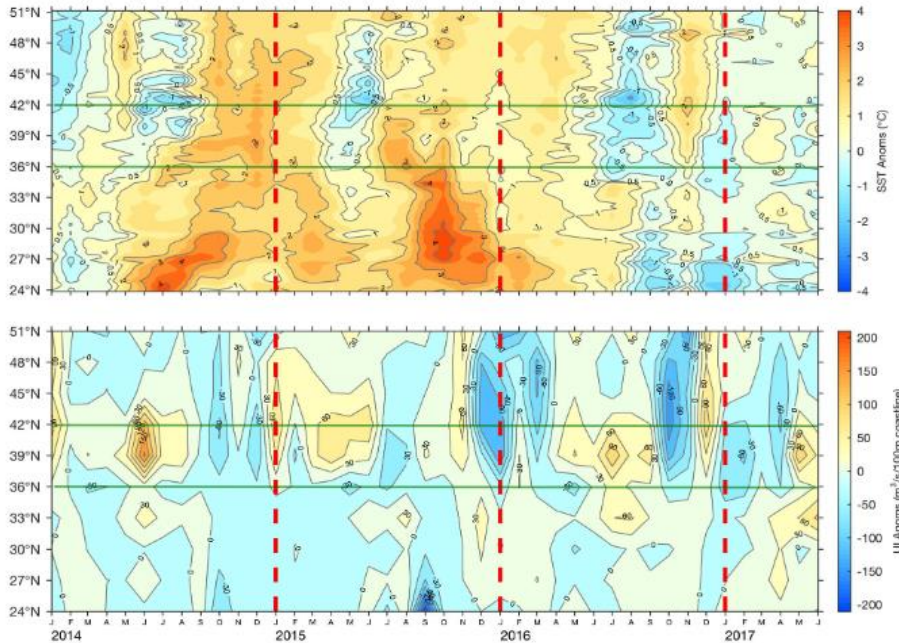
CalCOFI survey



Highly dimensional systems

STATE OF THE CALIFORNIA CURRENT 2016-2017: STILL ANYTHING BUT "NORMAL" IN THE NORTH
 CalCOFI Rep., Vol. 58, 2017

**STATE OF THE CALIFORNIA CURRENT 2016-17:
 STILL ANYTHING BUT "NORMAL" IN THE NORTH**



L.E. Koehn et al. / Ecological Modelling 335 (2016) 87-100

CalCOFI applications

Distinguishing random environmental fluctuations from ecological catastrophes for the North Pacific Ocean

Chih-hao Hsieh¹, Sarah M. Glaser¹, Andrew J. Lucas¹ & George Sugihara¹

Predicting climate effects on Pacific sardine

Ethan R. Deyle^{a,1}, Michael Fogarty^b, Chih-hao Hsieh^c, Les Kaufman^{d,e}, Alec D. MacCall^f, Stephan B. Munch^f, Charles T. Perretti^a, Hao Ye^a, and George Sugihara^{a,1}

Empirical dynamic modeling

[https://www.youtube.com/watch?v=8DikuwwPWsY
&frags=pl%2Cwn](https://www.youtube.com/watch?v=8DikuwwPWsY&frags=pl%2Cwn)

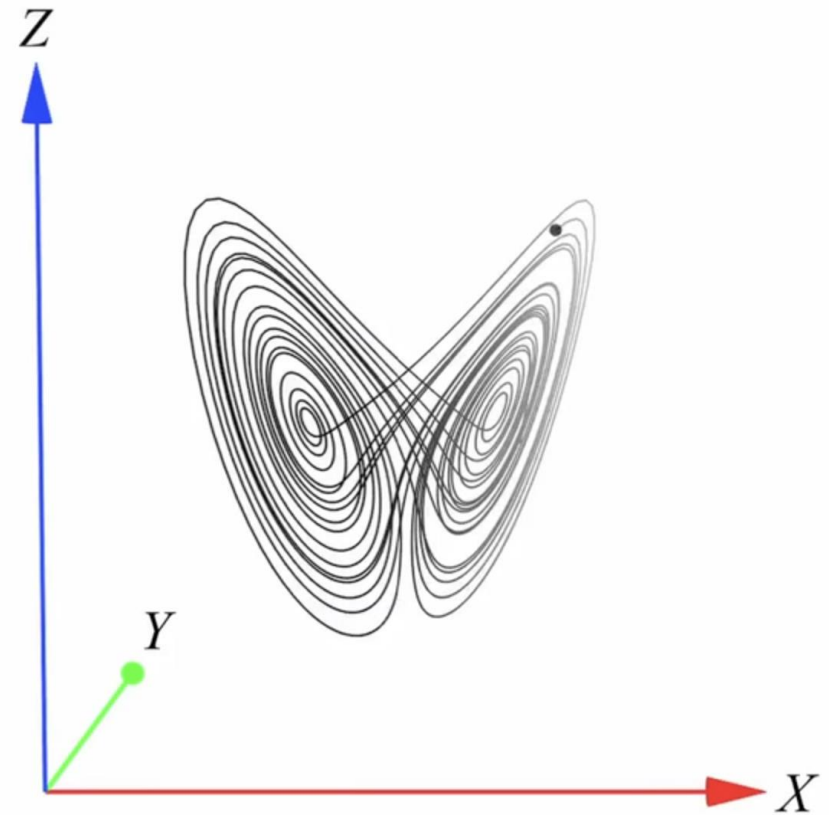
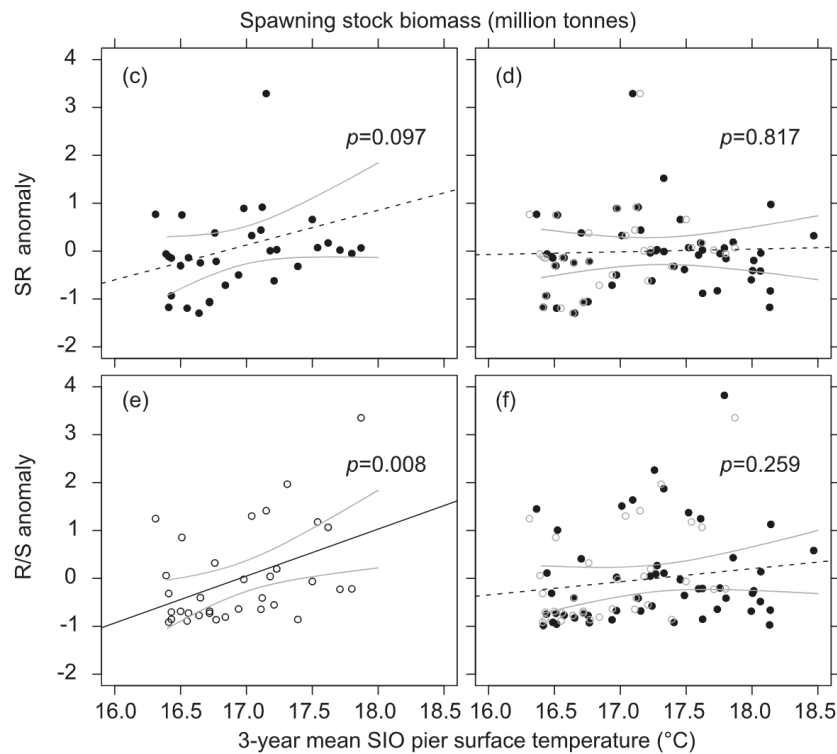
Takens' Theorem

- <https://www.youtube.com/watch?v=ctOseiJoRul>

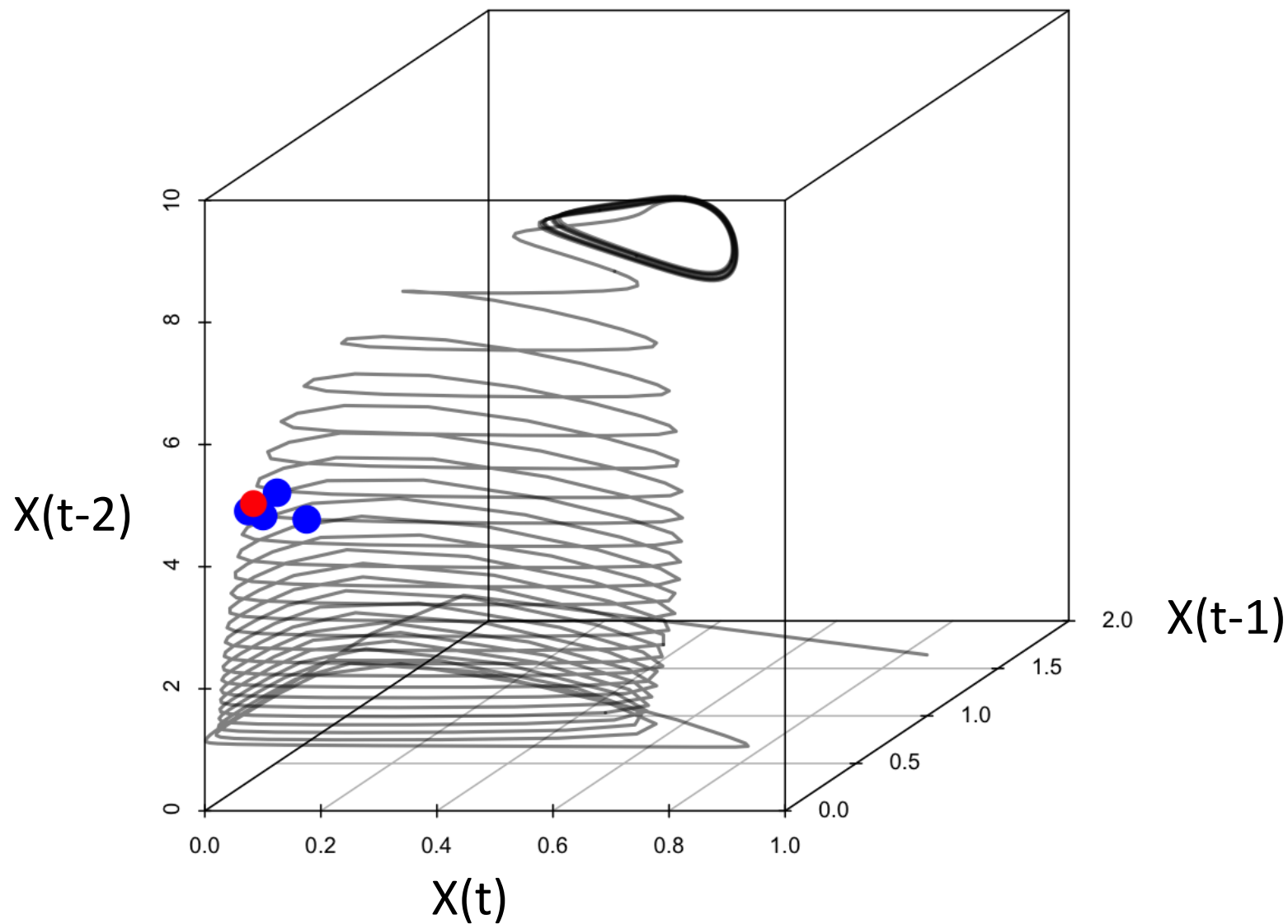
Shifts in system

Re-assessment of the stock–recruit and temperature–recruit relationships for Pacific sardine (*Sardinops sagax*)

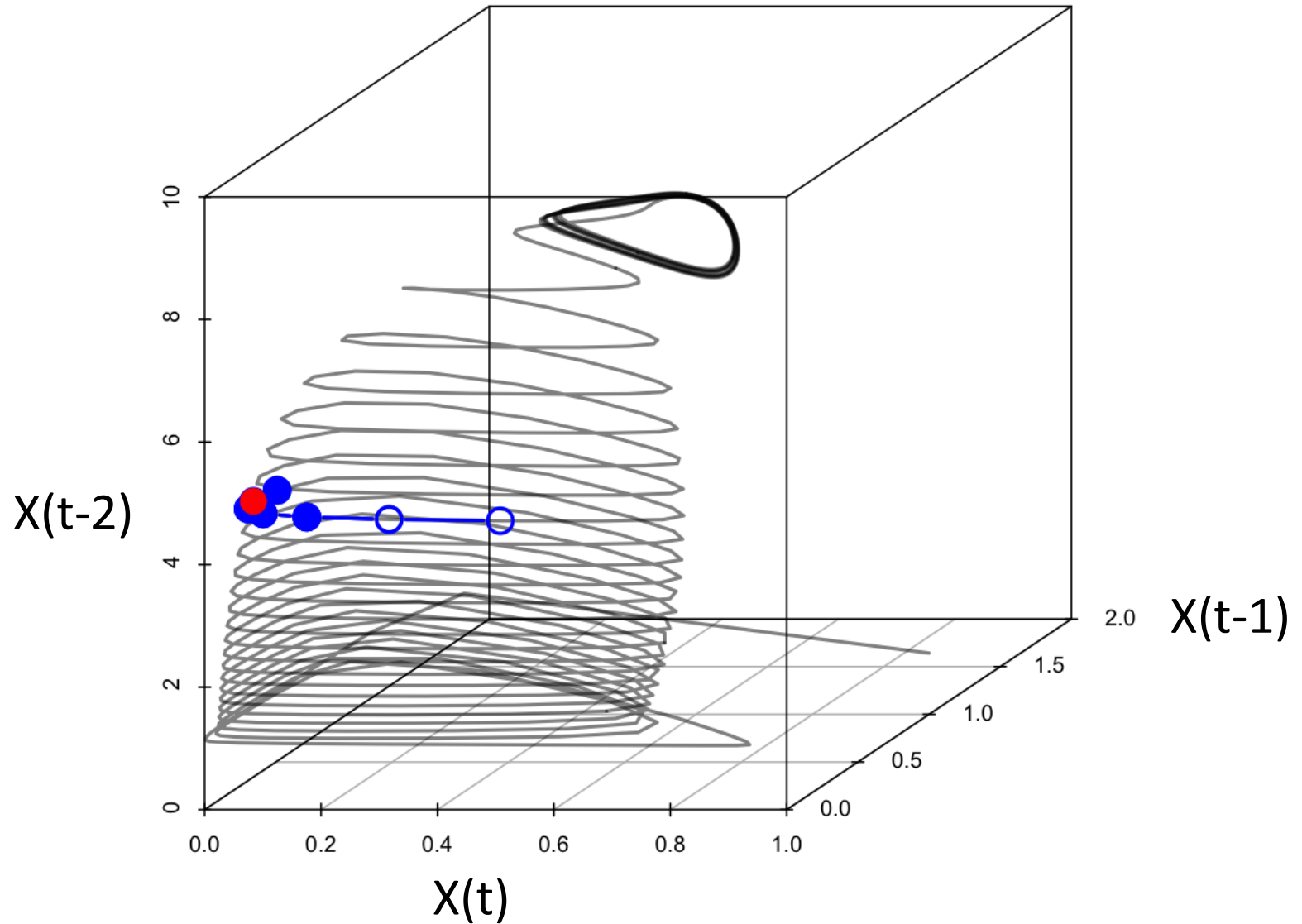
Sam McClatchie, Ralf Goericke, Guillermo Auad, and Kevin Hill



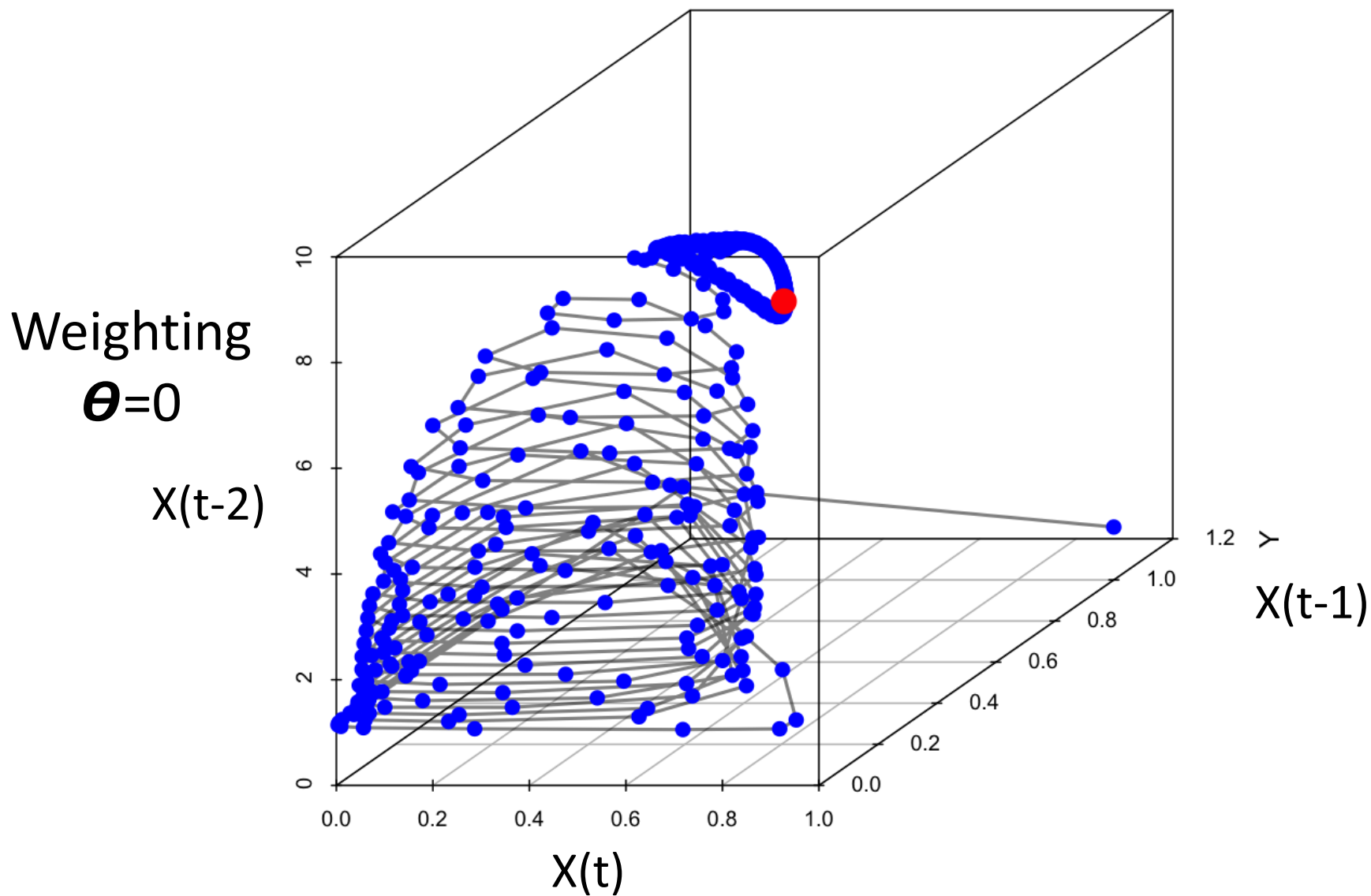
Simplex (Sugihara and May 1990)



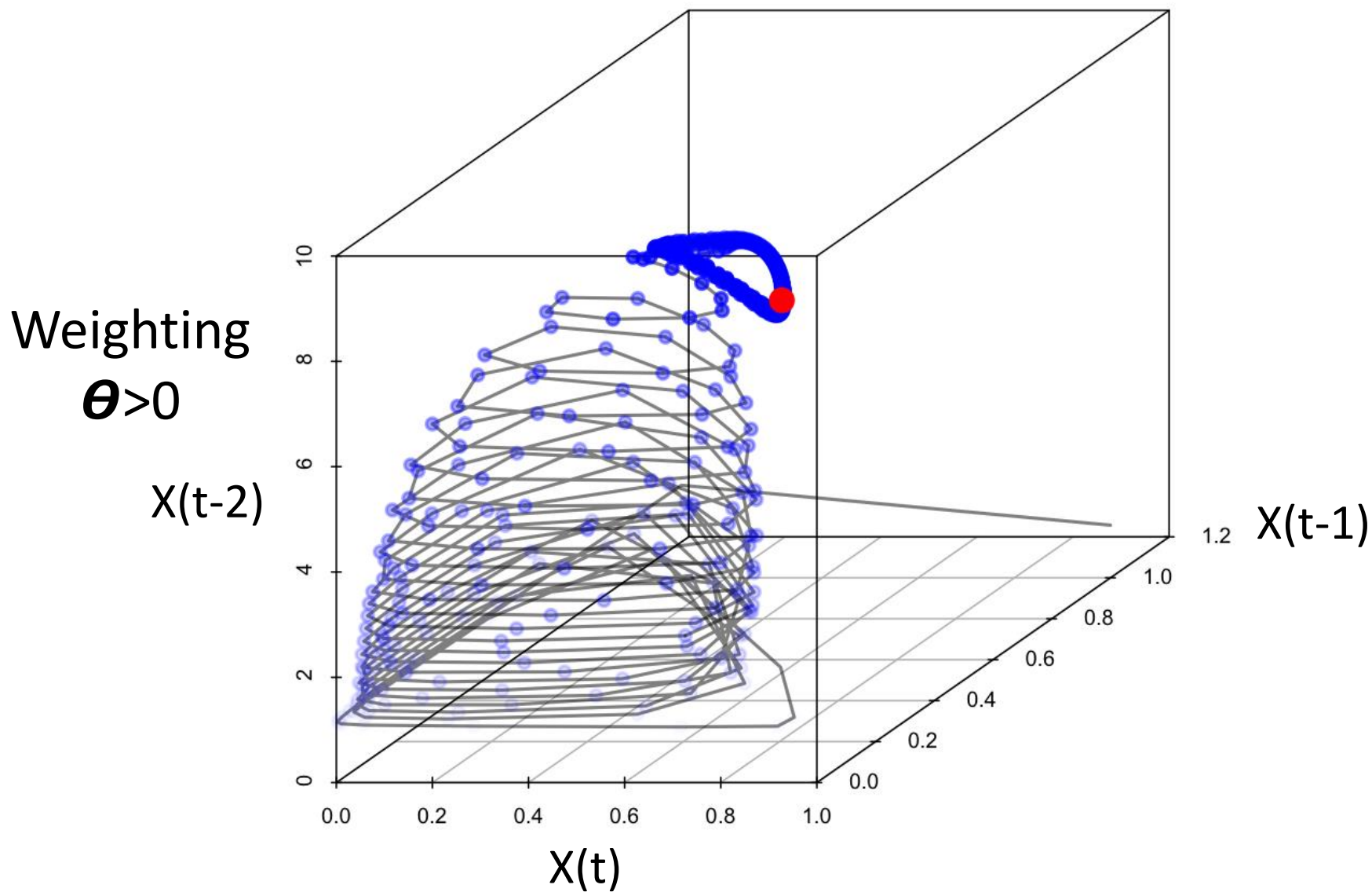
Simplex (Sugihara and May 1990)



S-maps (Sugihara 1994)

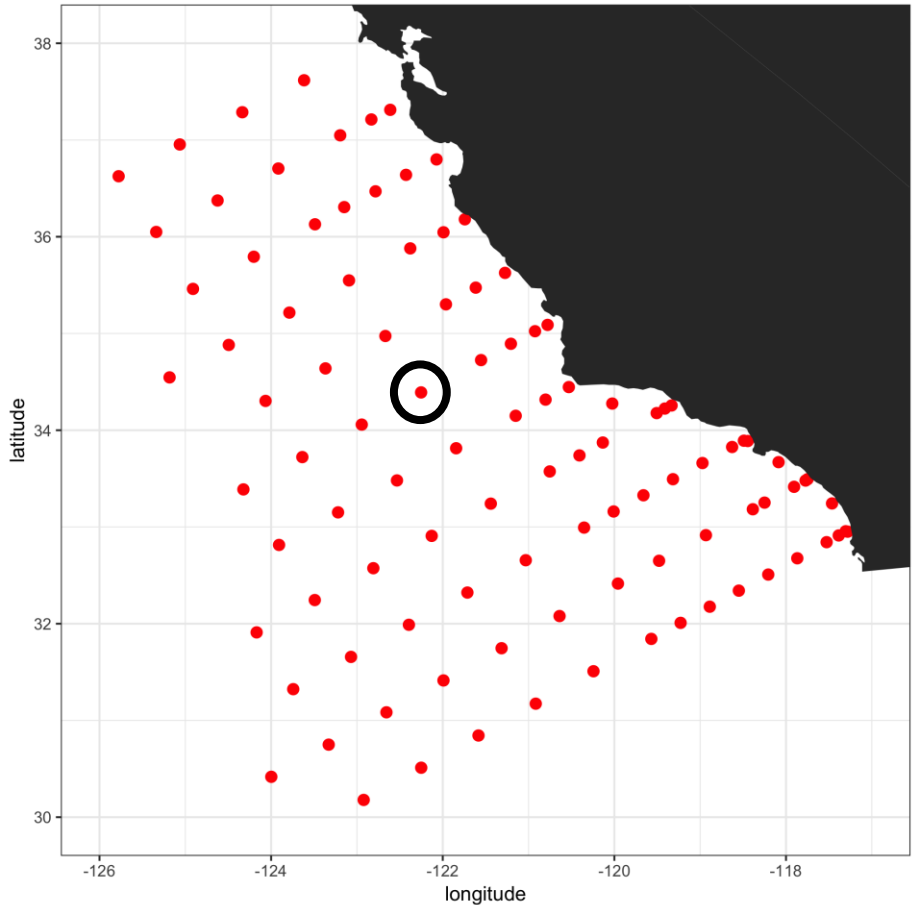


S-maps (Sugihara 1994)

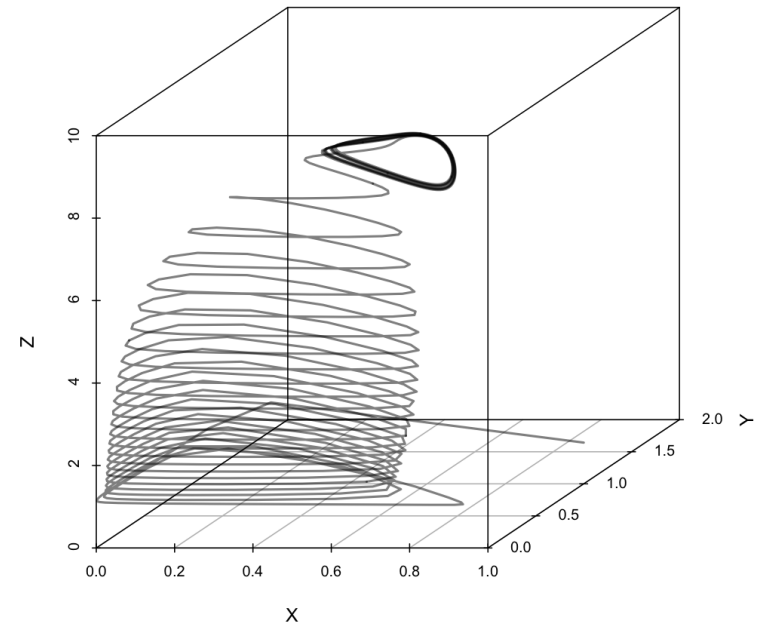
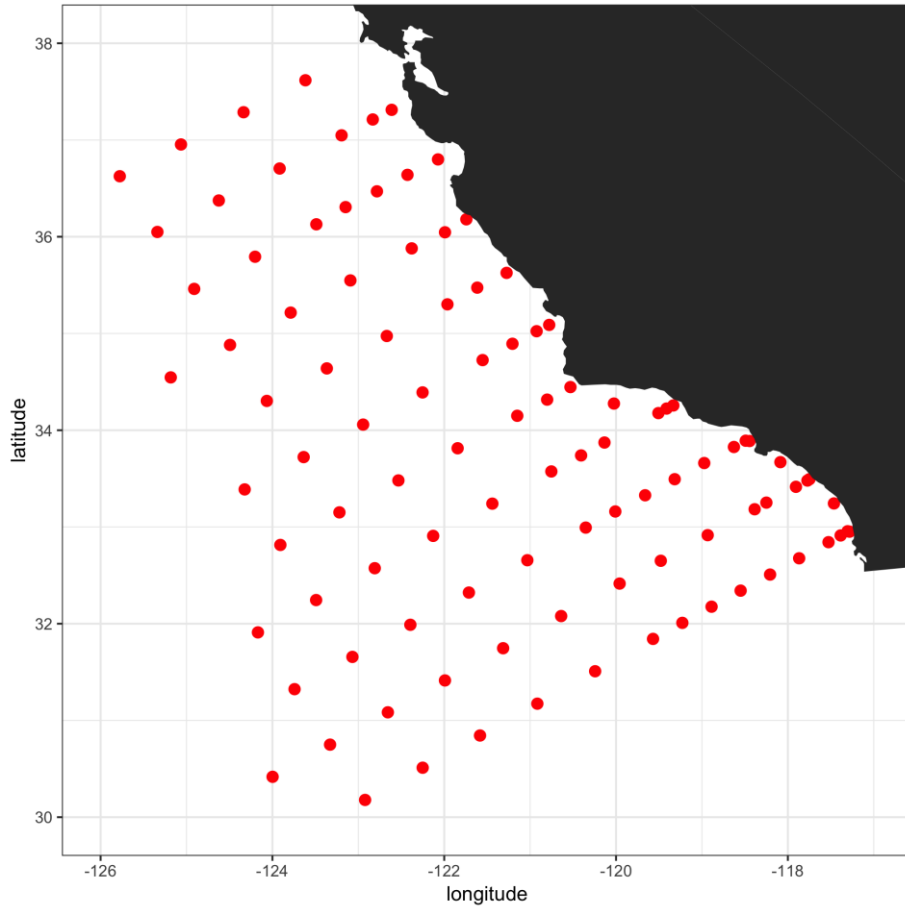


Composite libraries

- Single-species
 - Larval abundance
- Simplex and S-map
- Compare to Gaussian process?

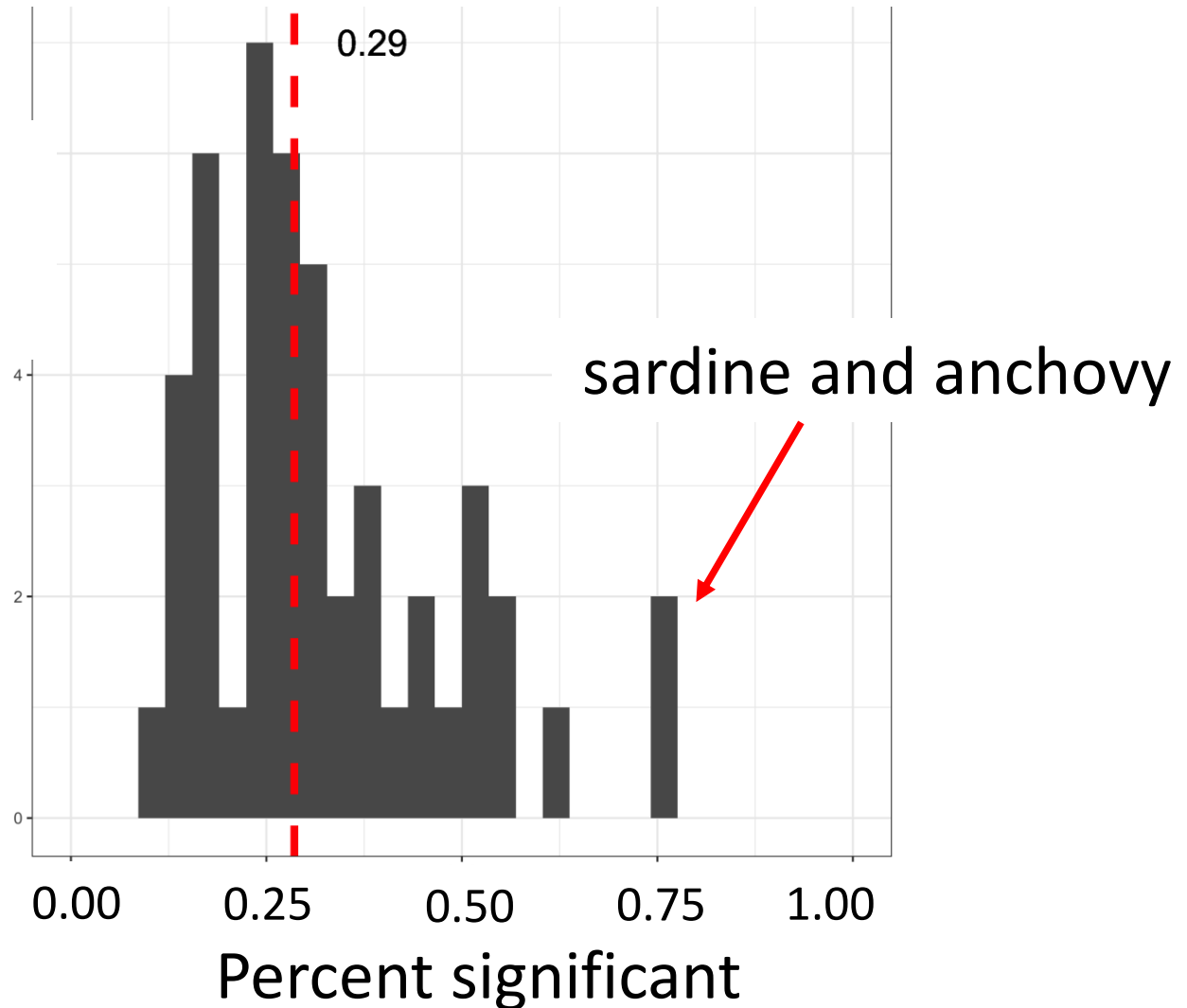


Gaussian process (Munch et al. 2016)

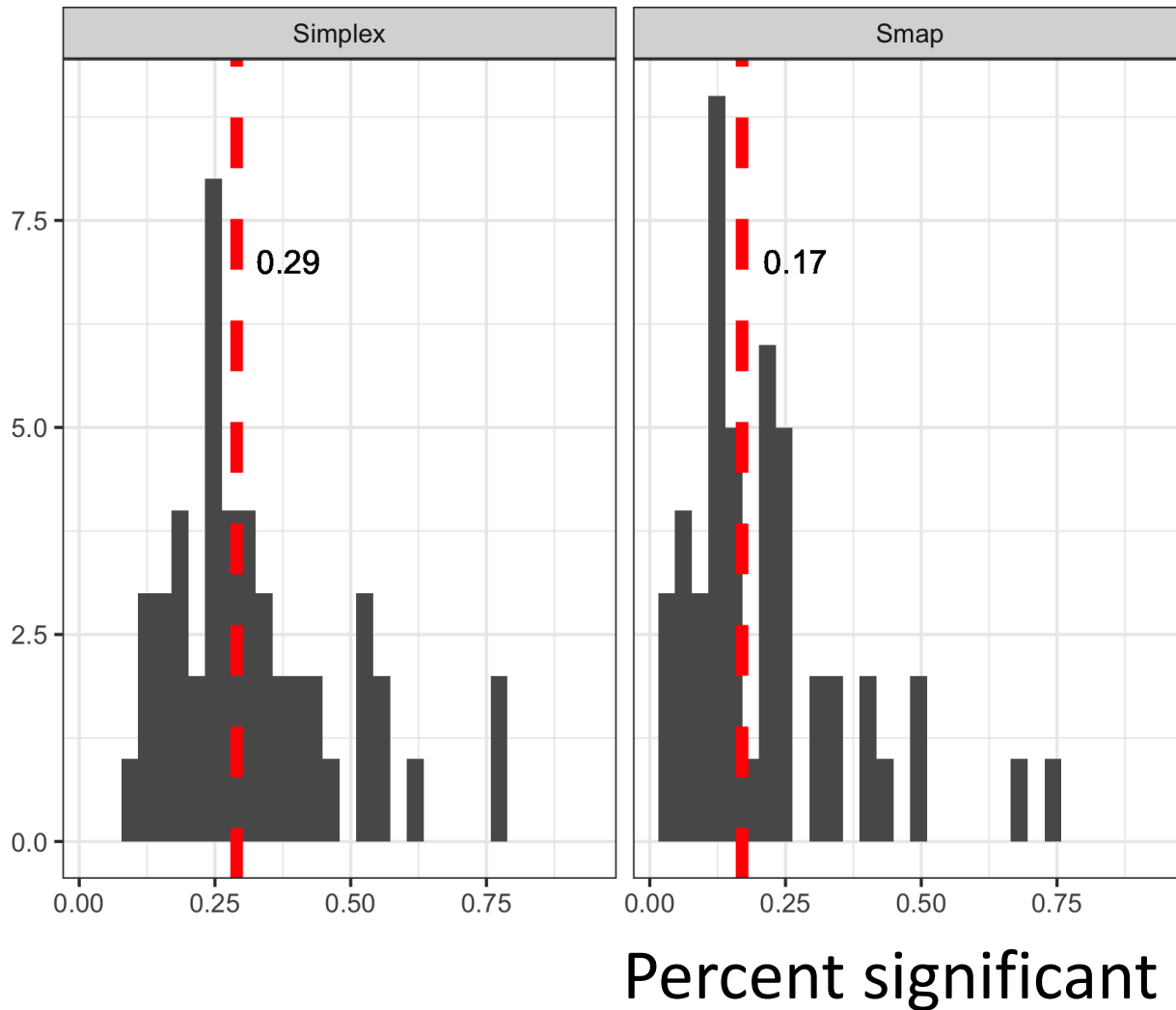


Significant correlations

- Per species
- Percent of ~100 stations

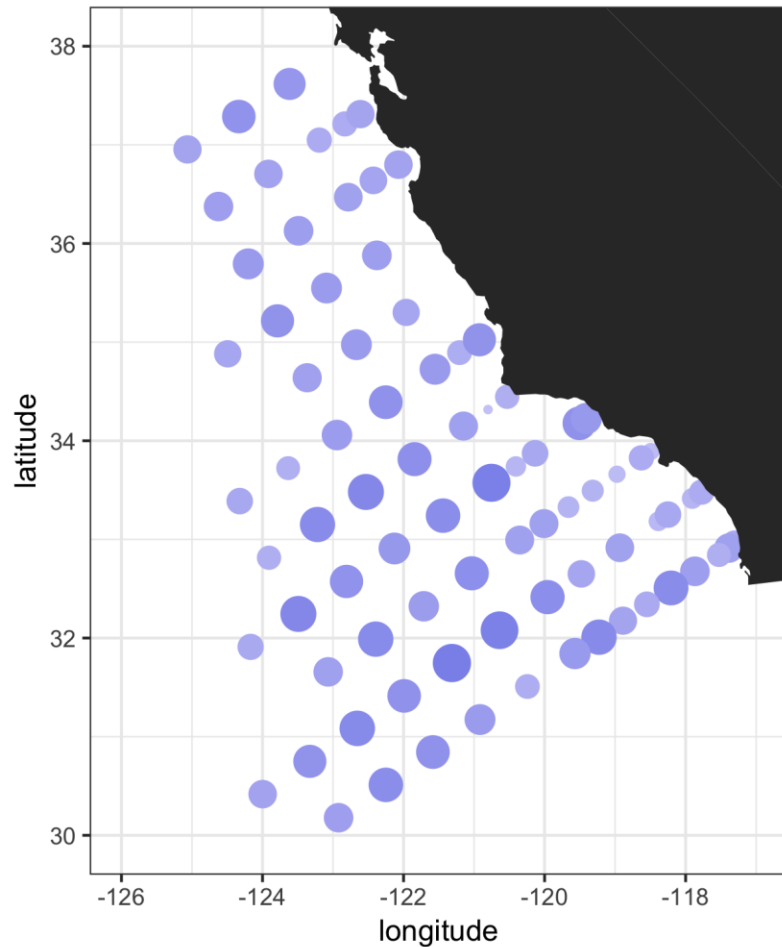


Gaussian process best

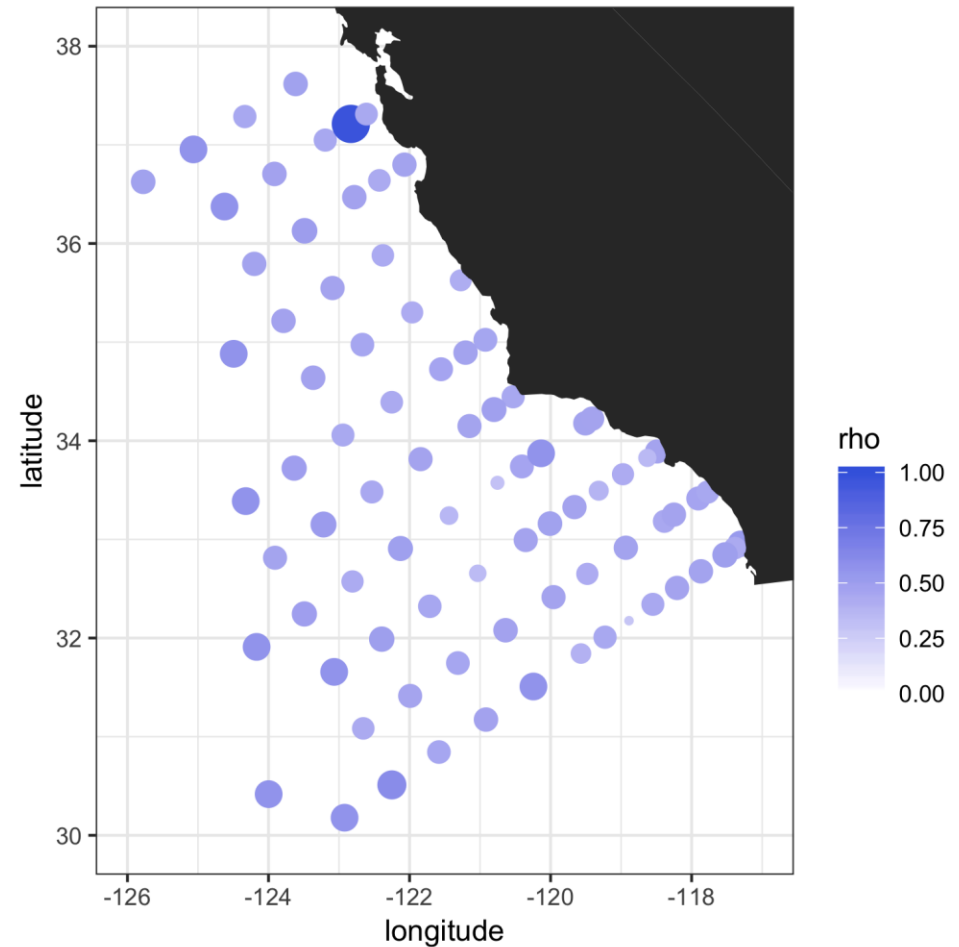


Station correlation (Gaussian)

sardine

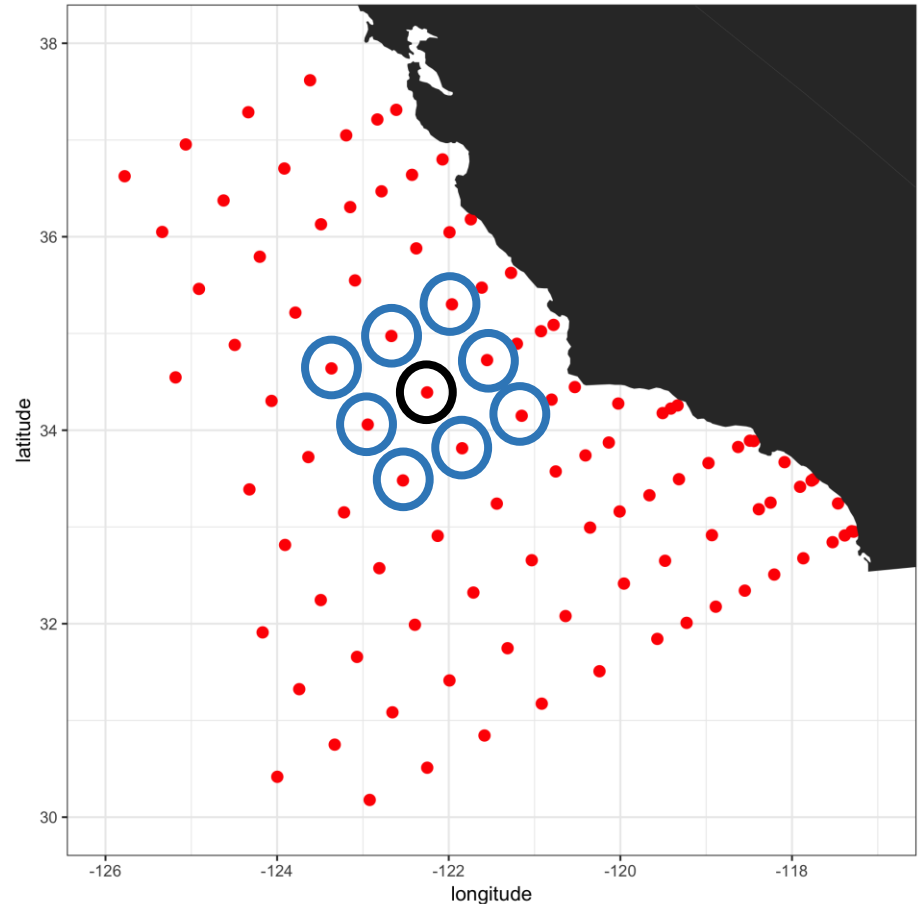


anchovy

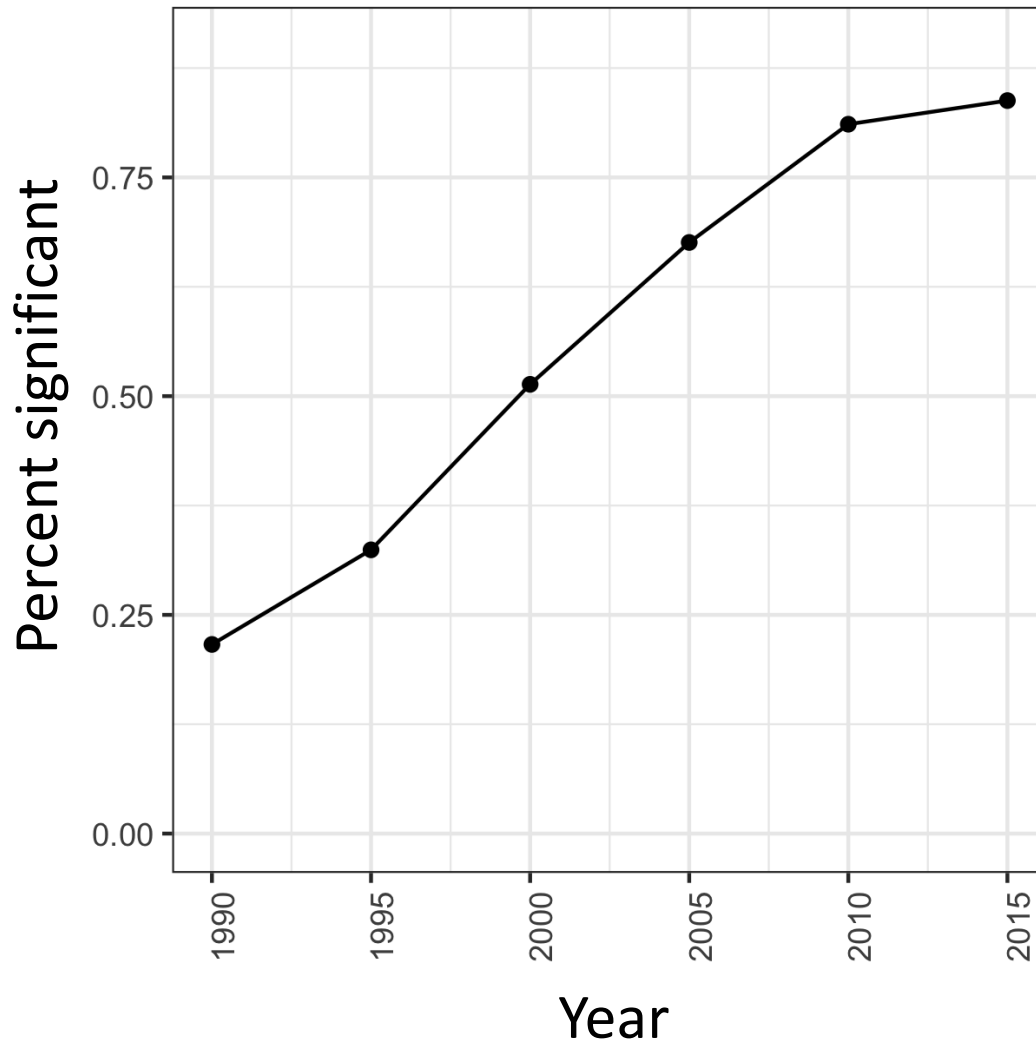


Smaller spatiotemporal scales

- Anchovy and sardine
 - Composite libraries
 - Simplex and S-maps
- 50, 100, 150, 200 km
- Time windows
 - 1951-1990
 - 1951-1995
 - 1951-2000
 - ...
 - 1951-2015

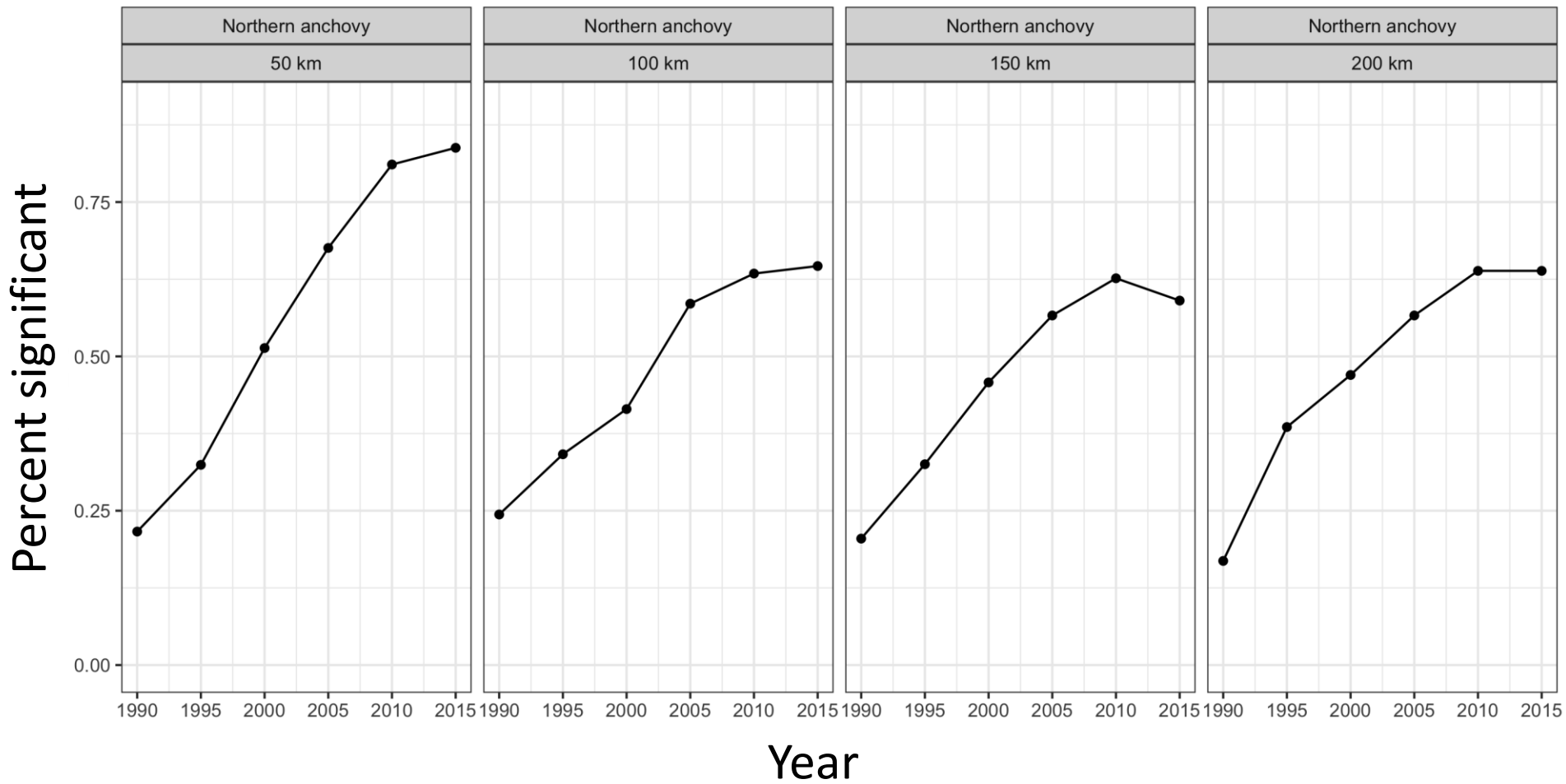


50 km results - anchovy

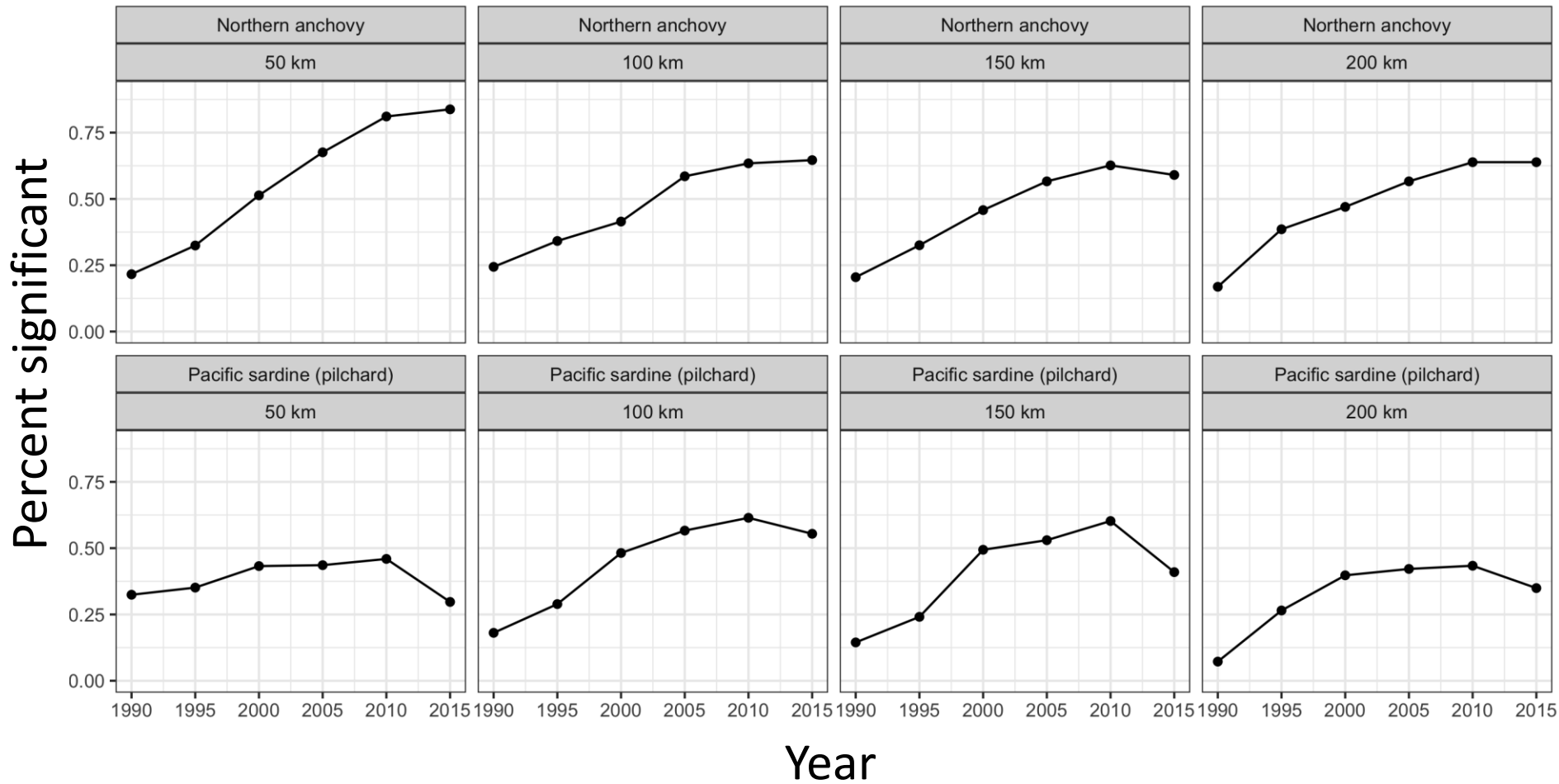


Simplex

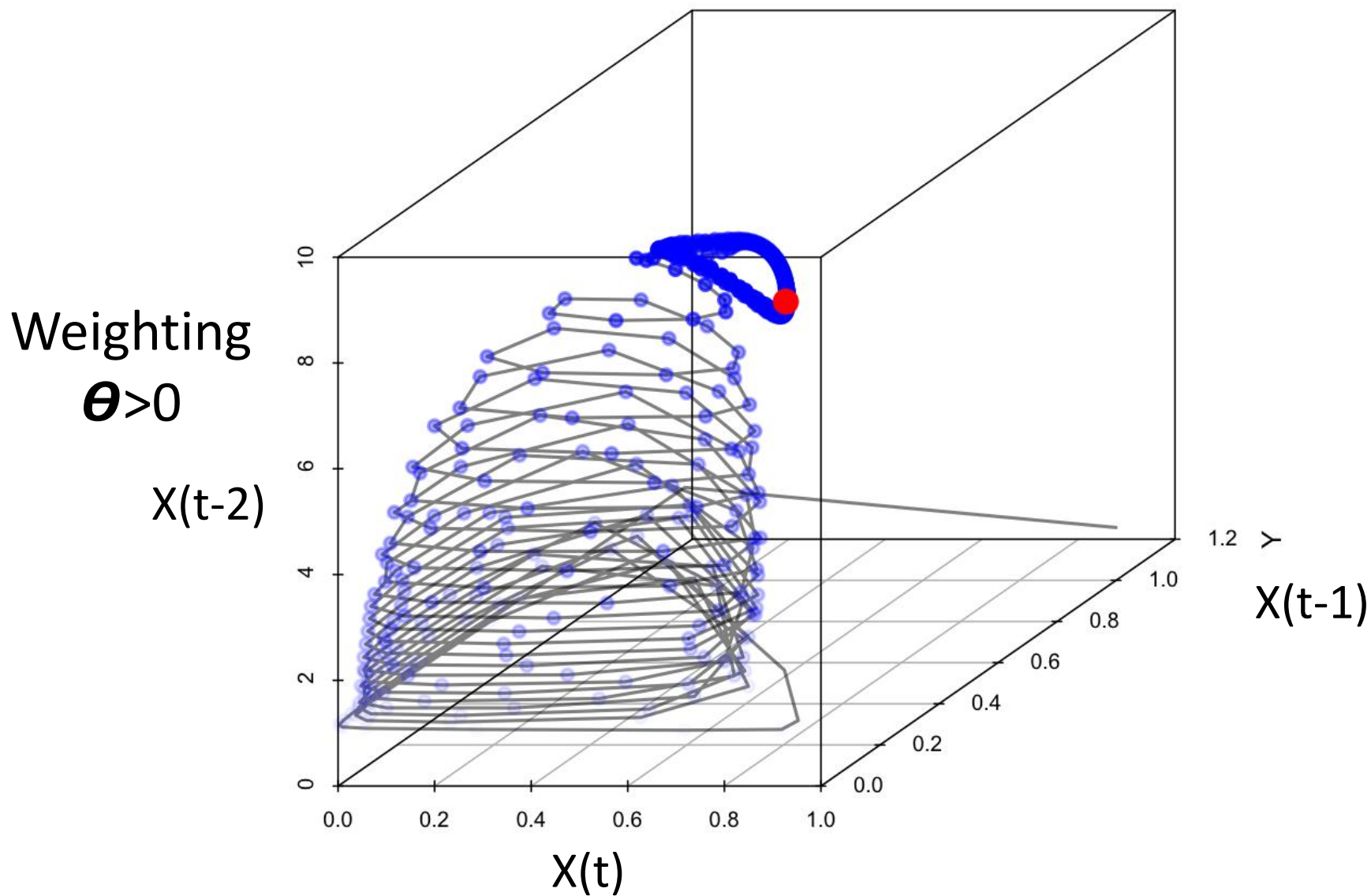
Anchovy results



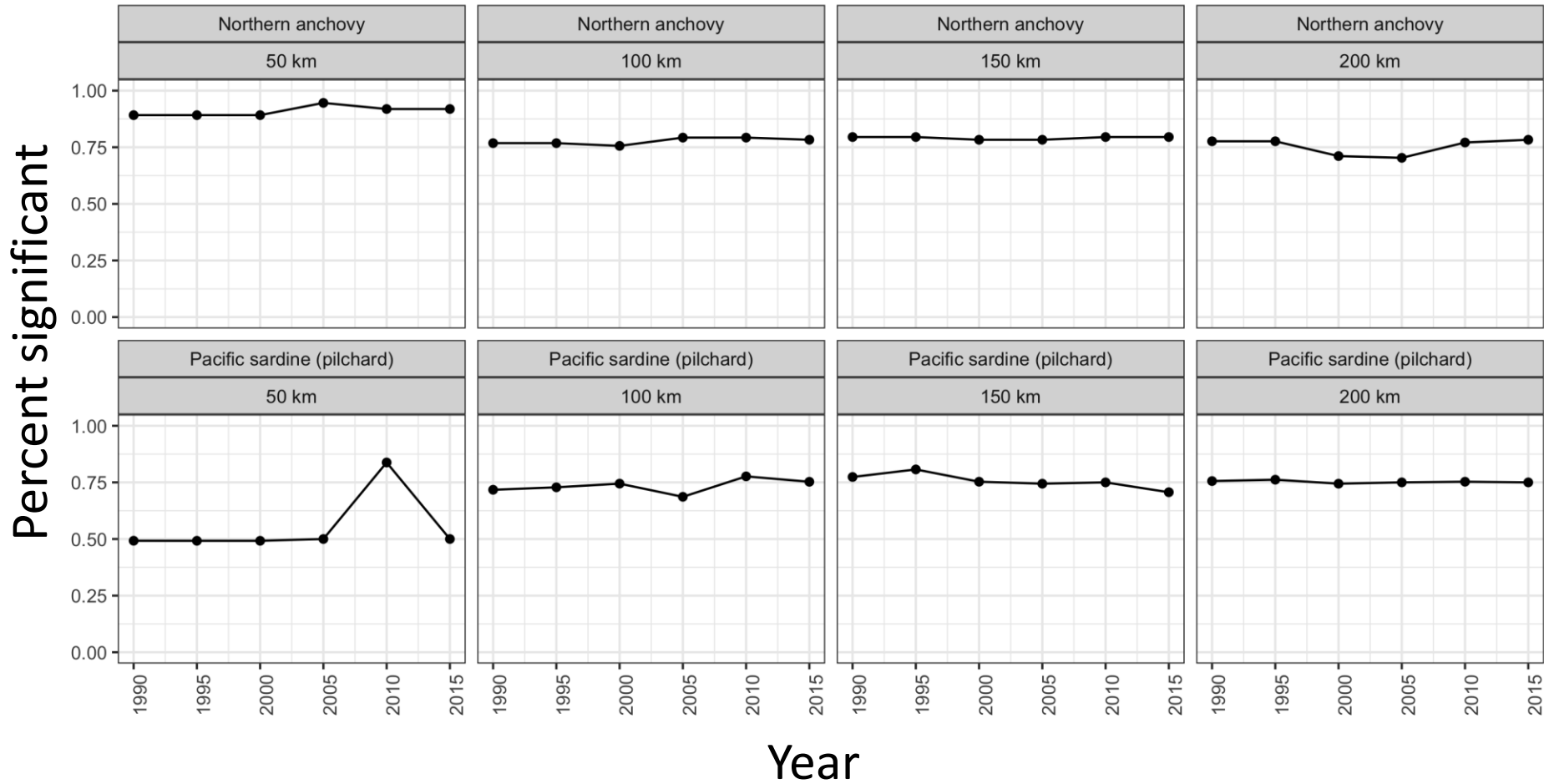
Anchovy and Sardine



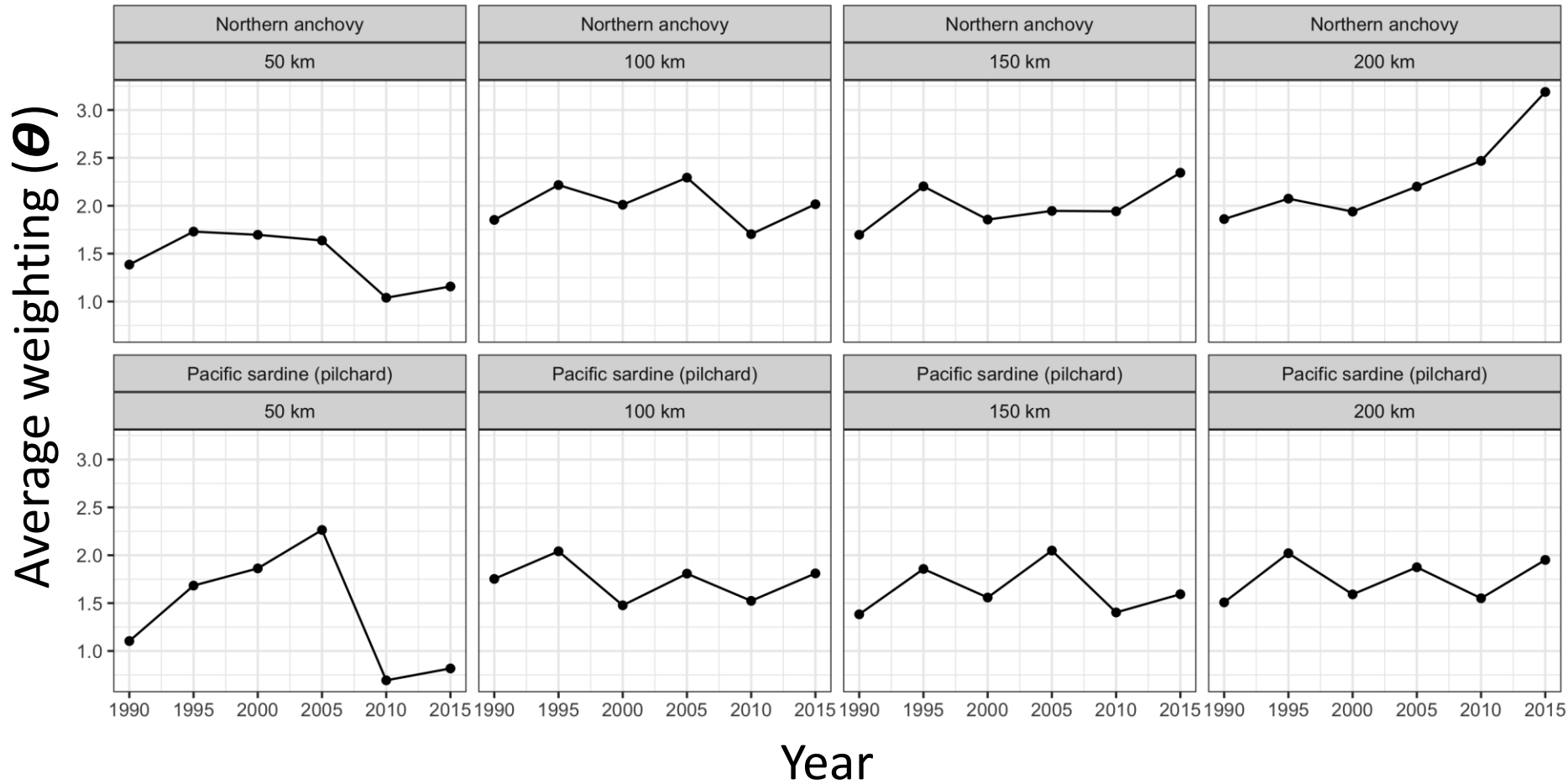
S-maps (Sugihara 1994)



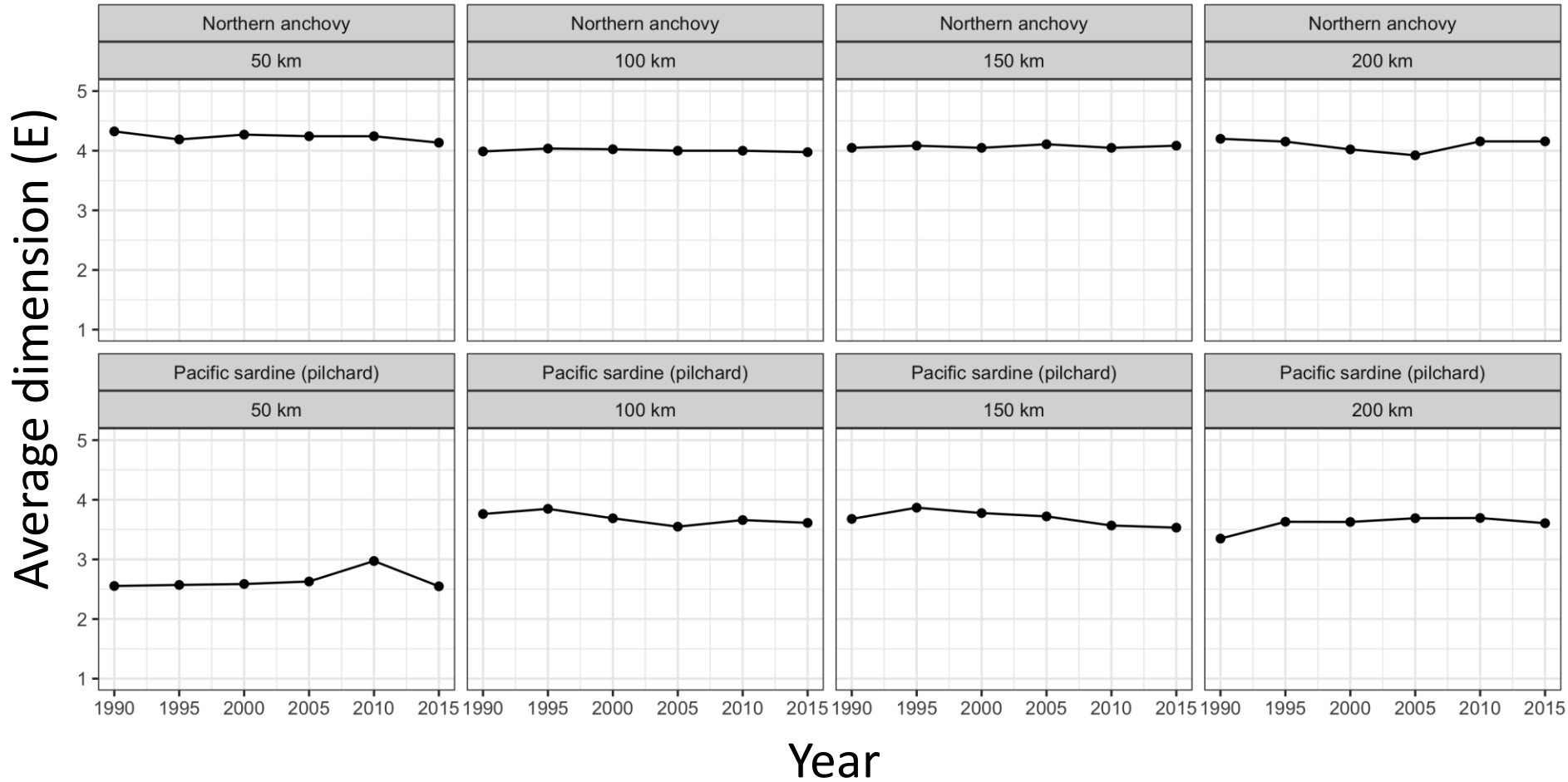
Change in significance?



Change in nonlinearity?



Change in dimensionality?

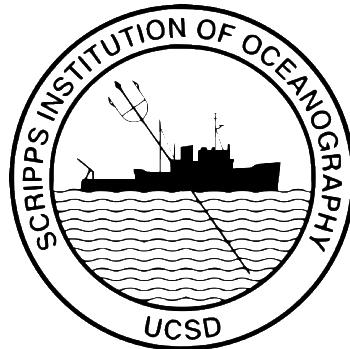


Next steps

- More species
- Population interactions
 - Zooplankton, eggs, larvae, oceanographic conditions
- Different spatial data sets

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**Southwest
Fisheries
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