Linear or non-linear? Understanding the effect of Climate Change on Atlantic Cod recruitment

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Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

MARmaED

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Why is Recruitment important?

"Number of juveniles entering in the adult stock"

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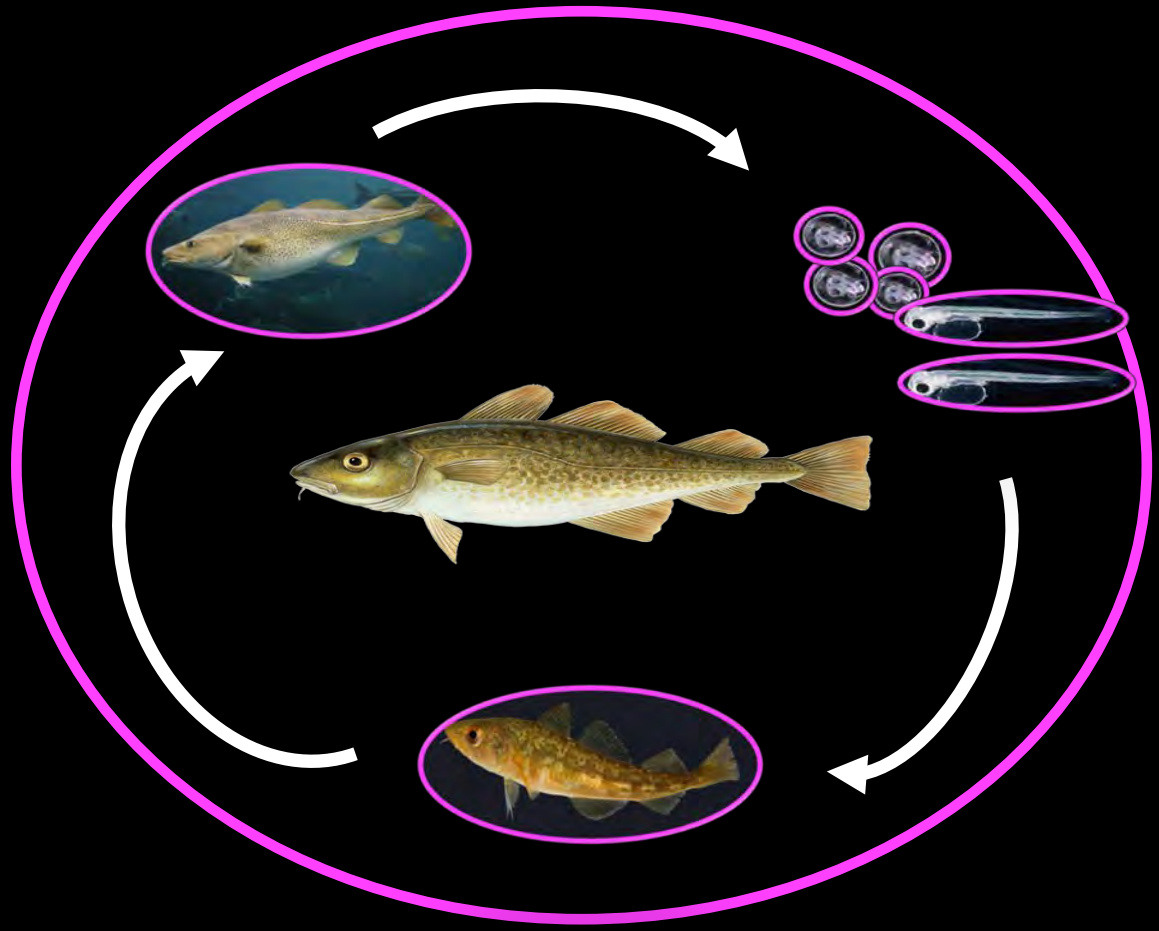
Recruitment is complex and influenced by multiple factors



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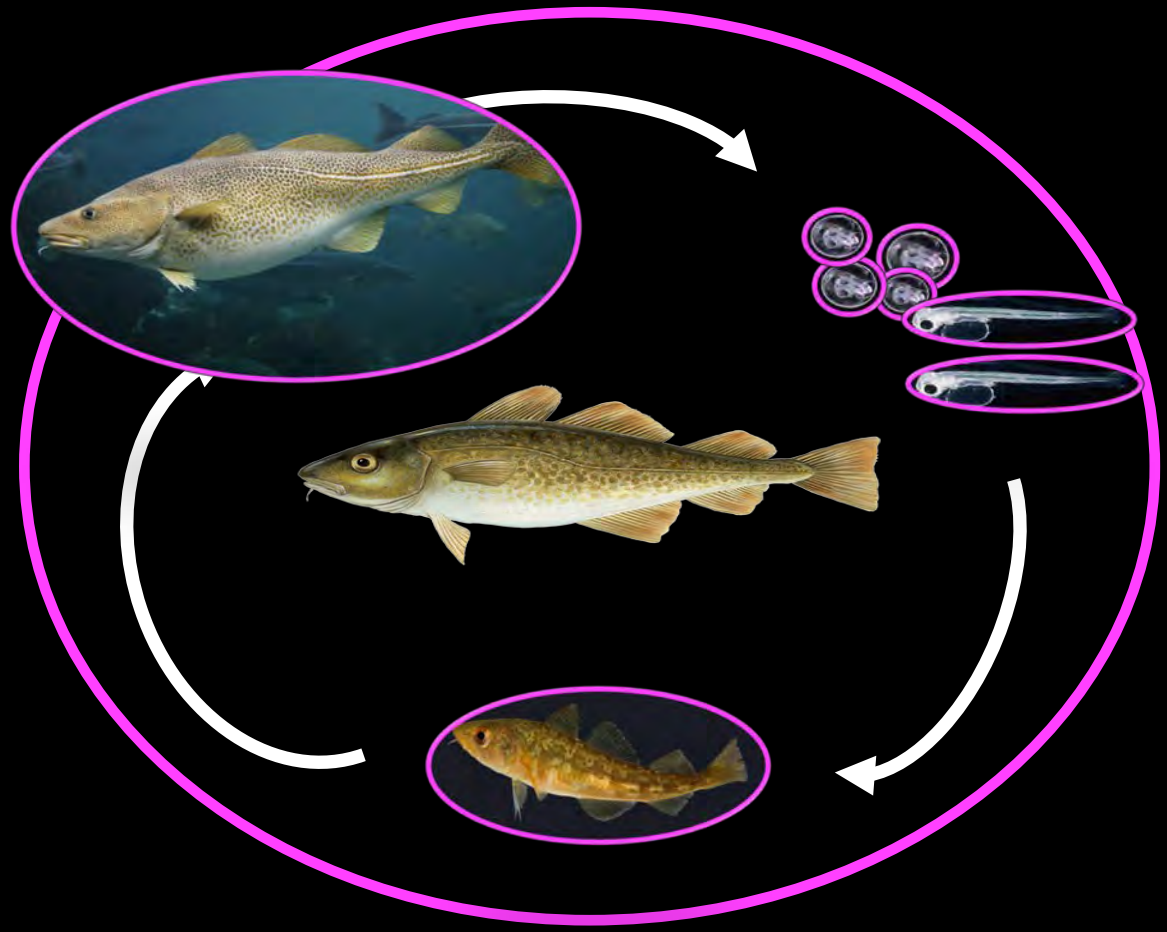
- Weight



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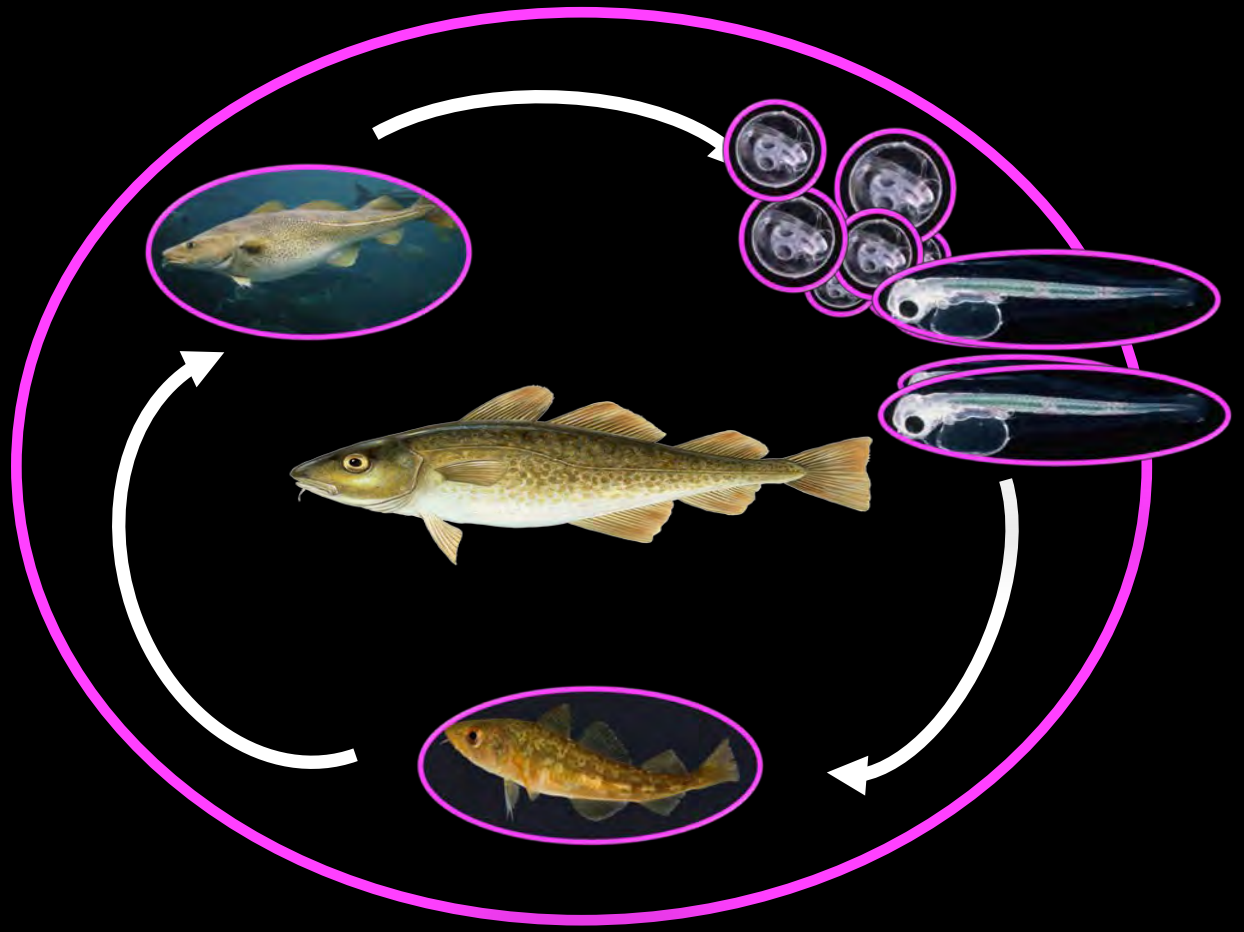

- Environmental factors
- Currents
- Predation

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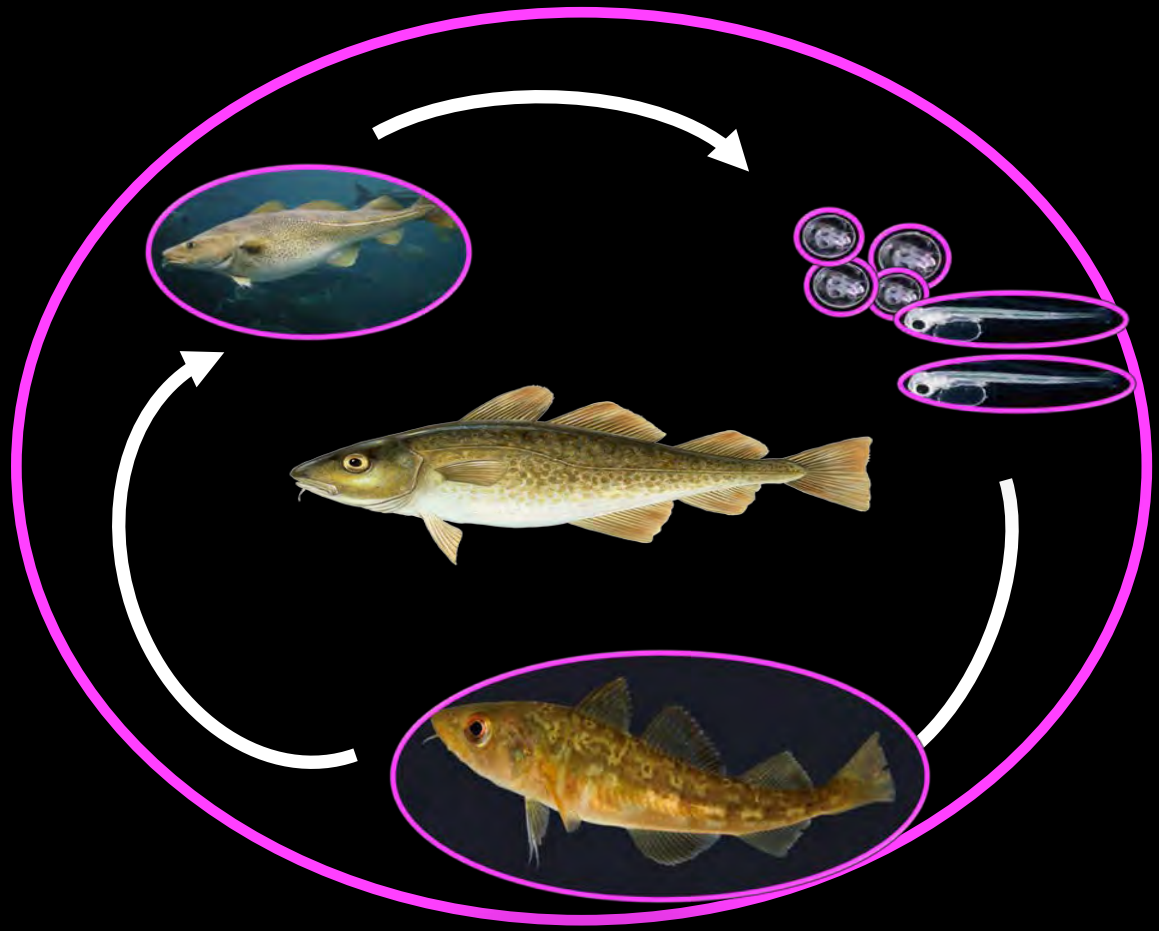

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- Competition
- Cannibalism

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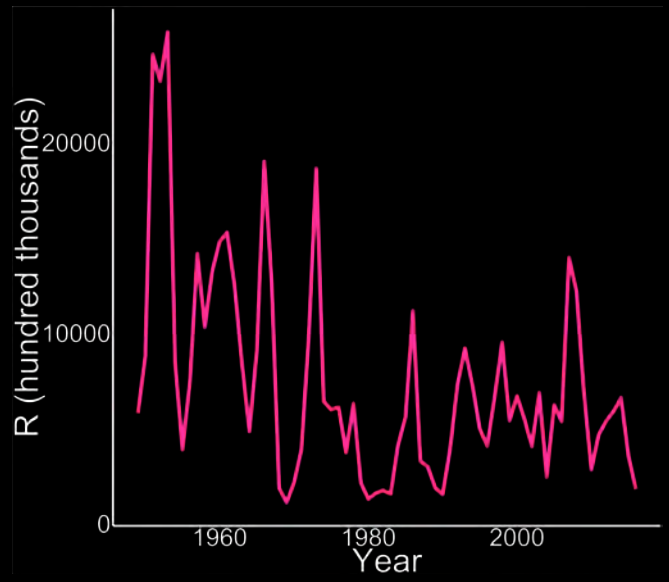
Recruitment Paradox

R dynamics often chaotic



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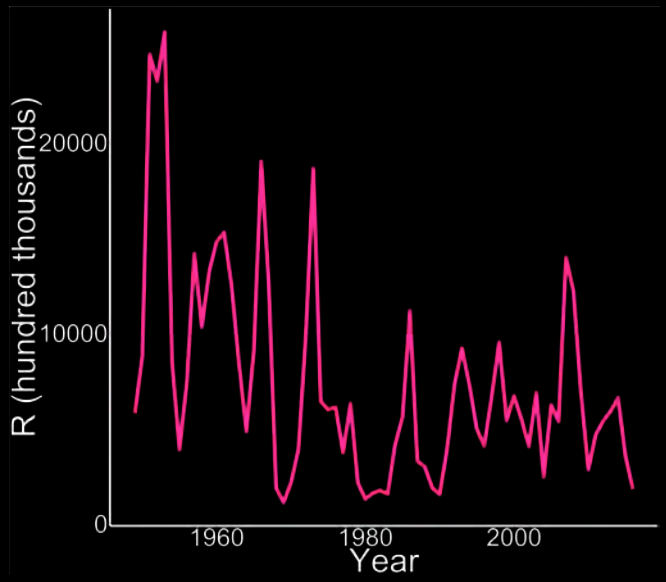

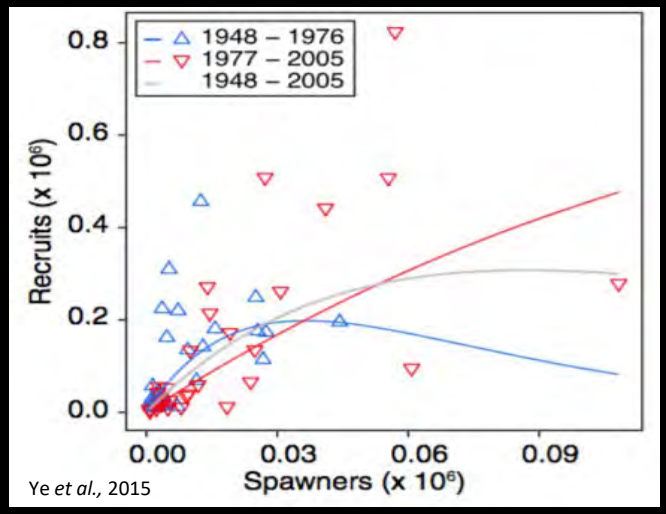

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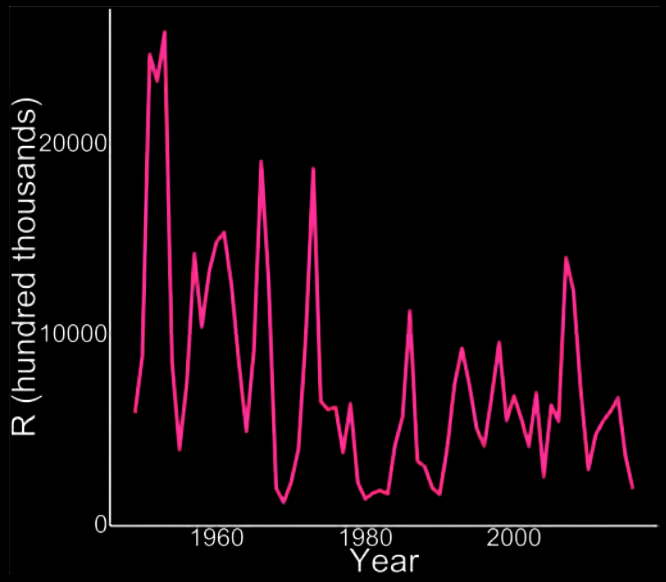

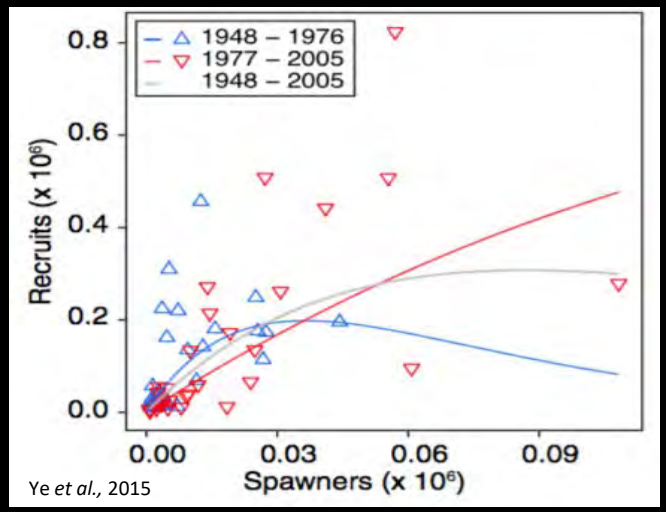

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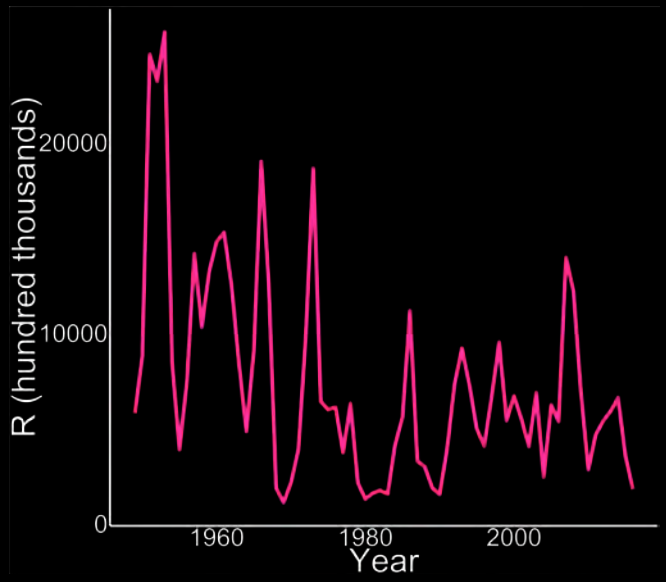

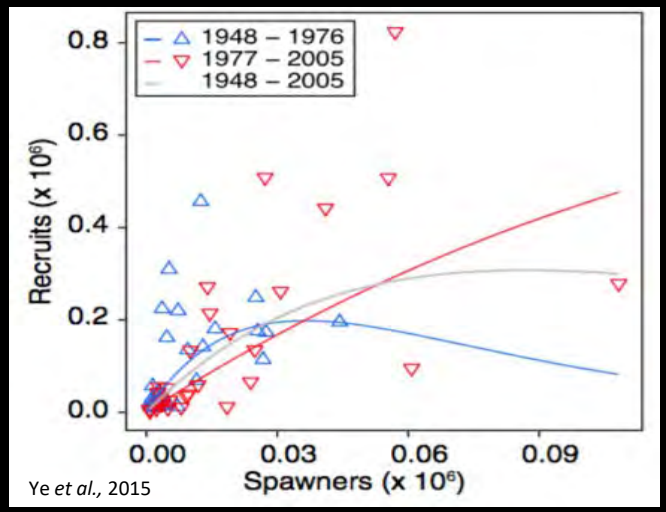

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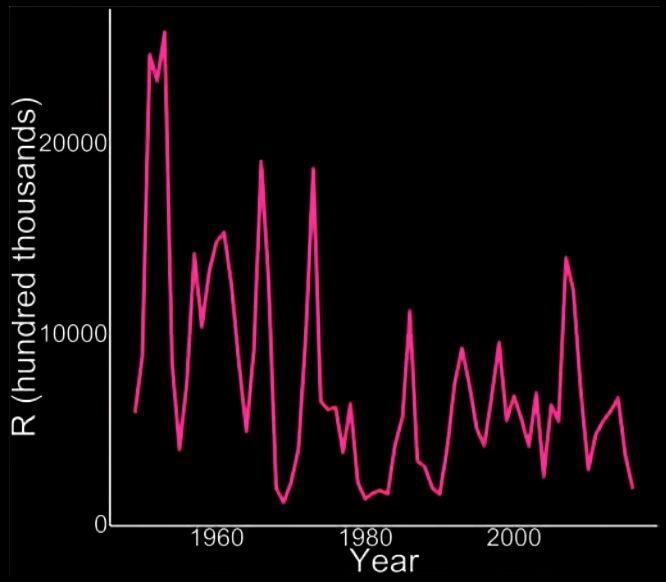
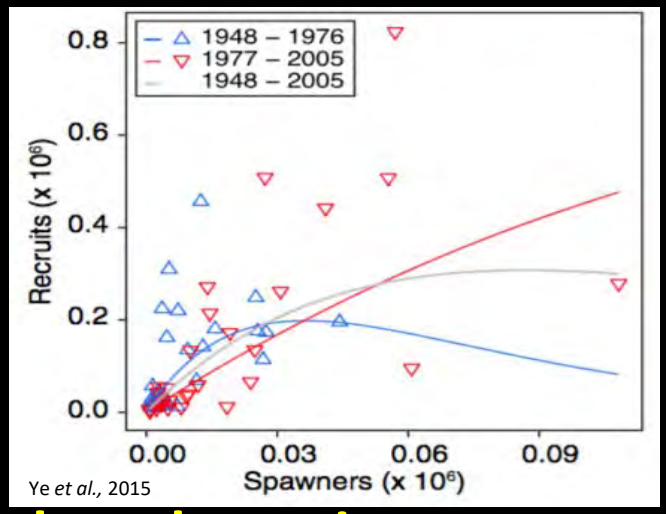




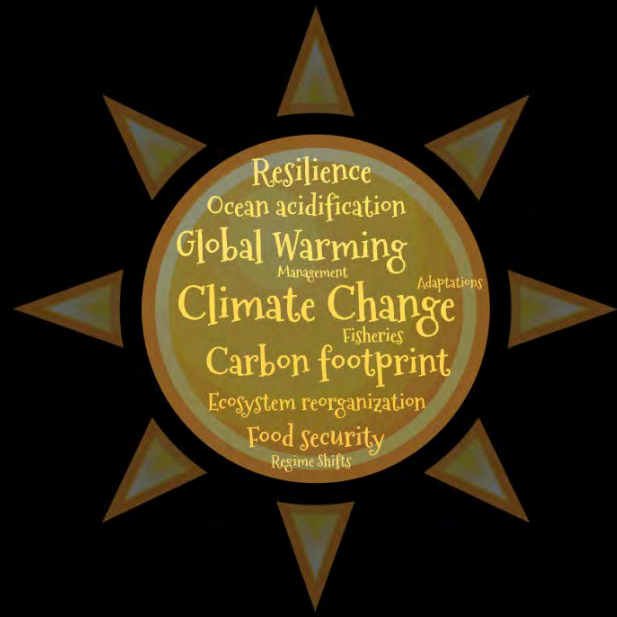
Ye *et al.*, 2015

We ignore possible discontinuous, state-dependent dynamics

Myers 1998; Duffy – Anderson *et al.*, 2005, Olsen *et al.*, 2011, Ye *et al.*, 2015

Research Questions

Is Atlantic cod recruitment non-linear?



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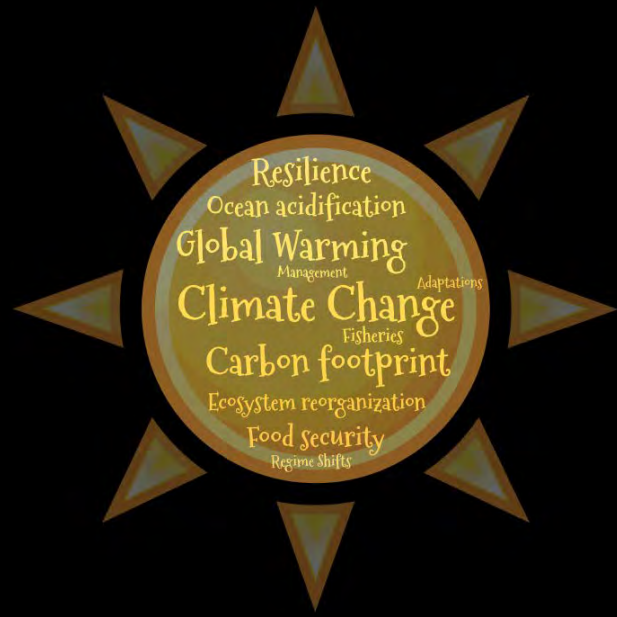

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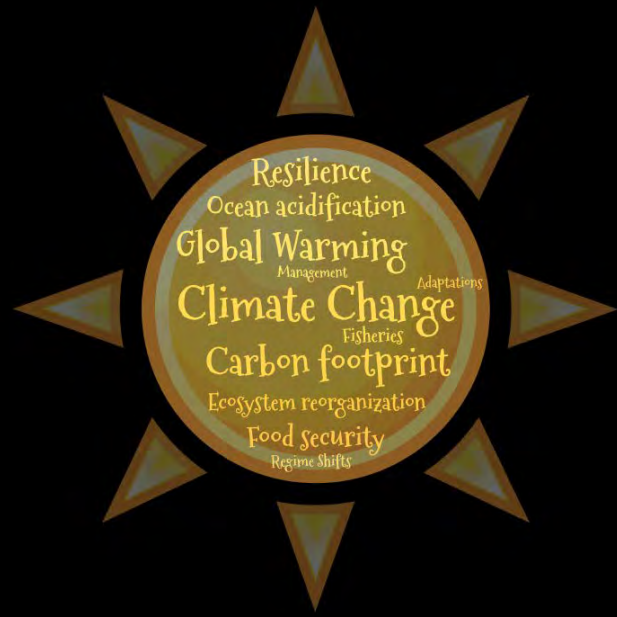
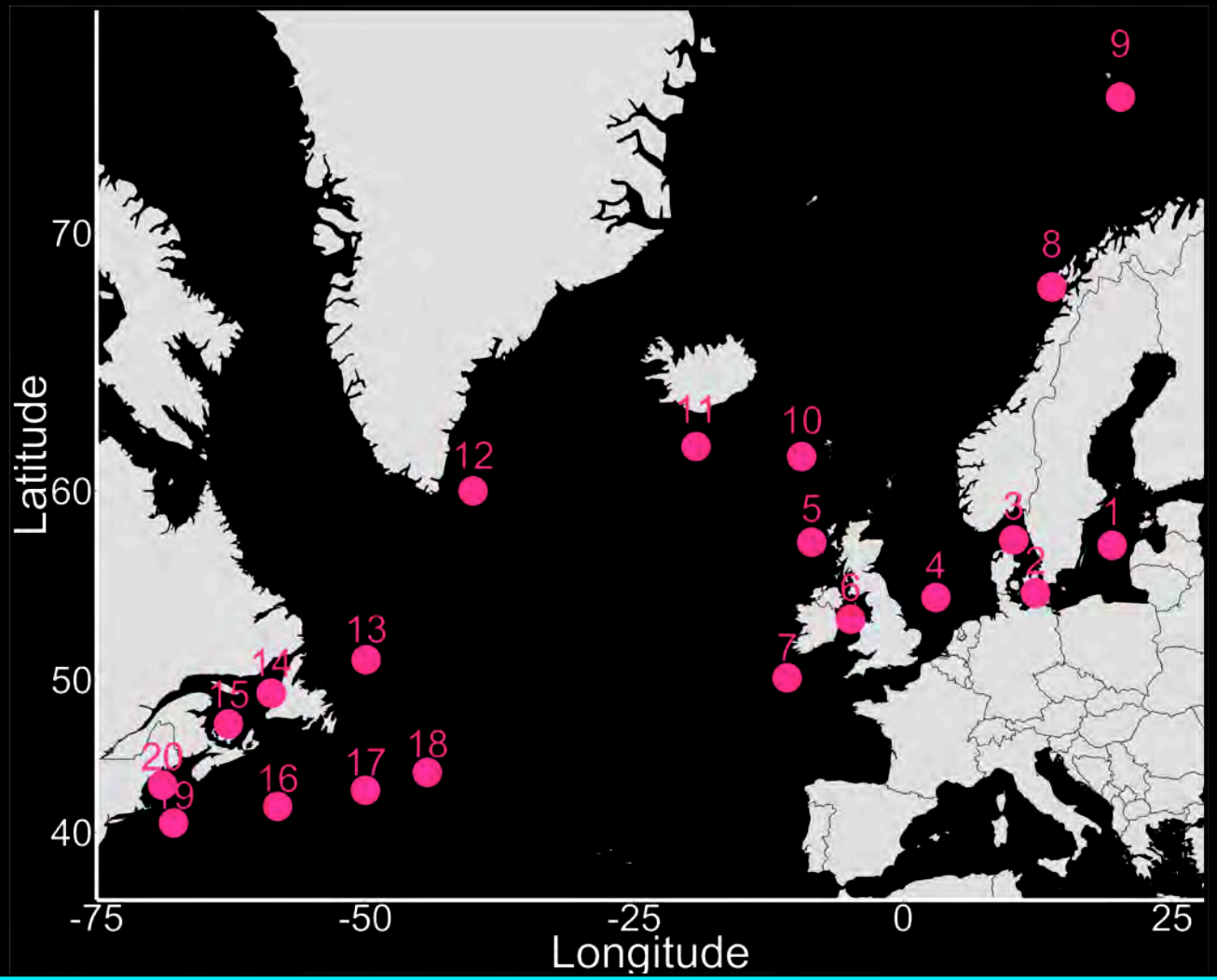
Are environmental factors important?



Stock Assessment Data of 20 Atlantic cod stocks



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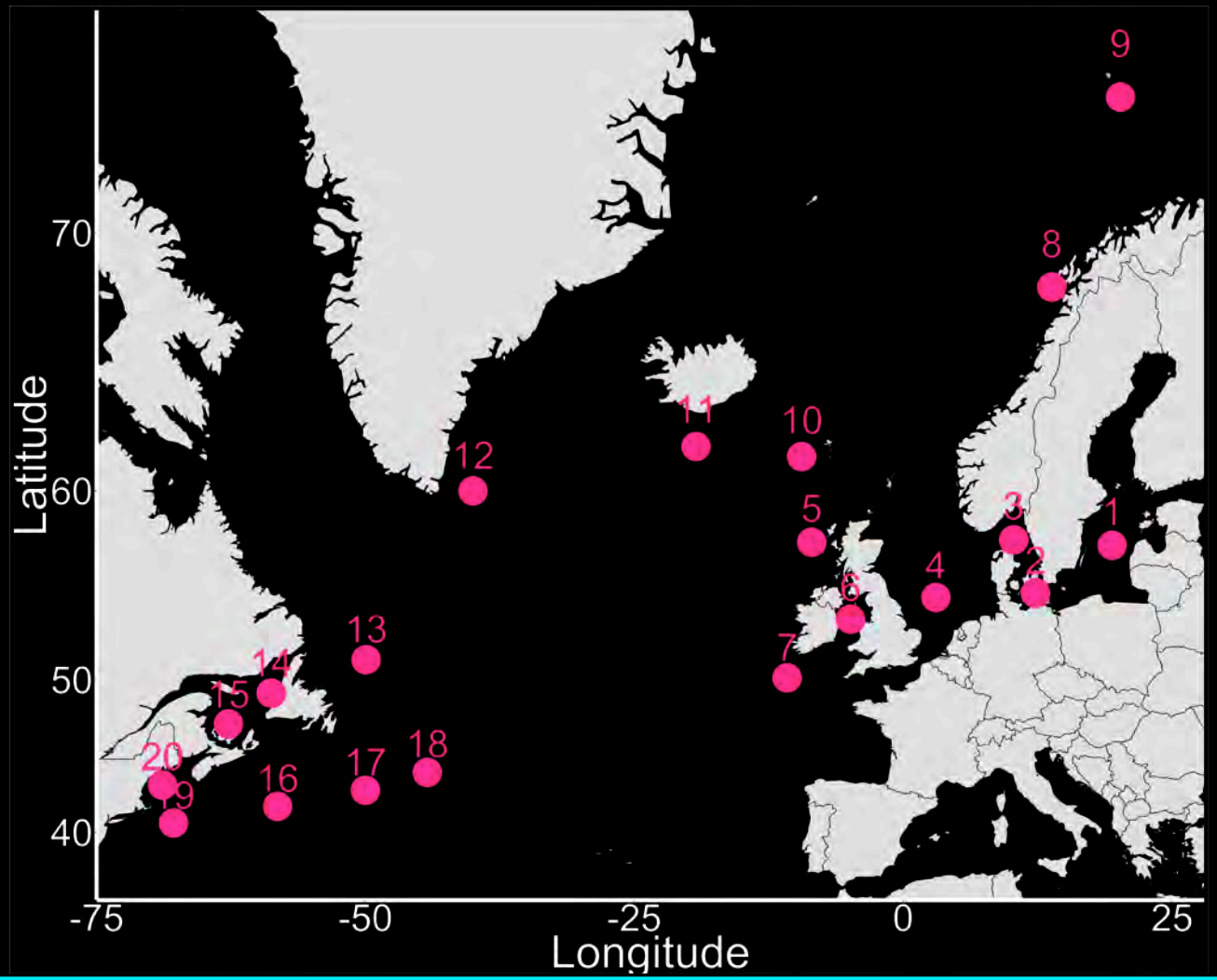

Data used

- **Recruitment**

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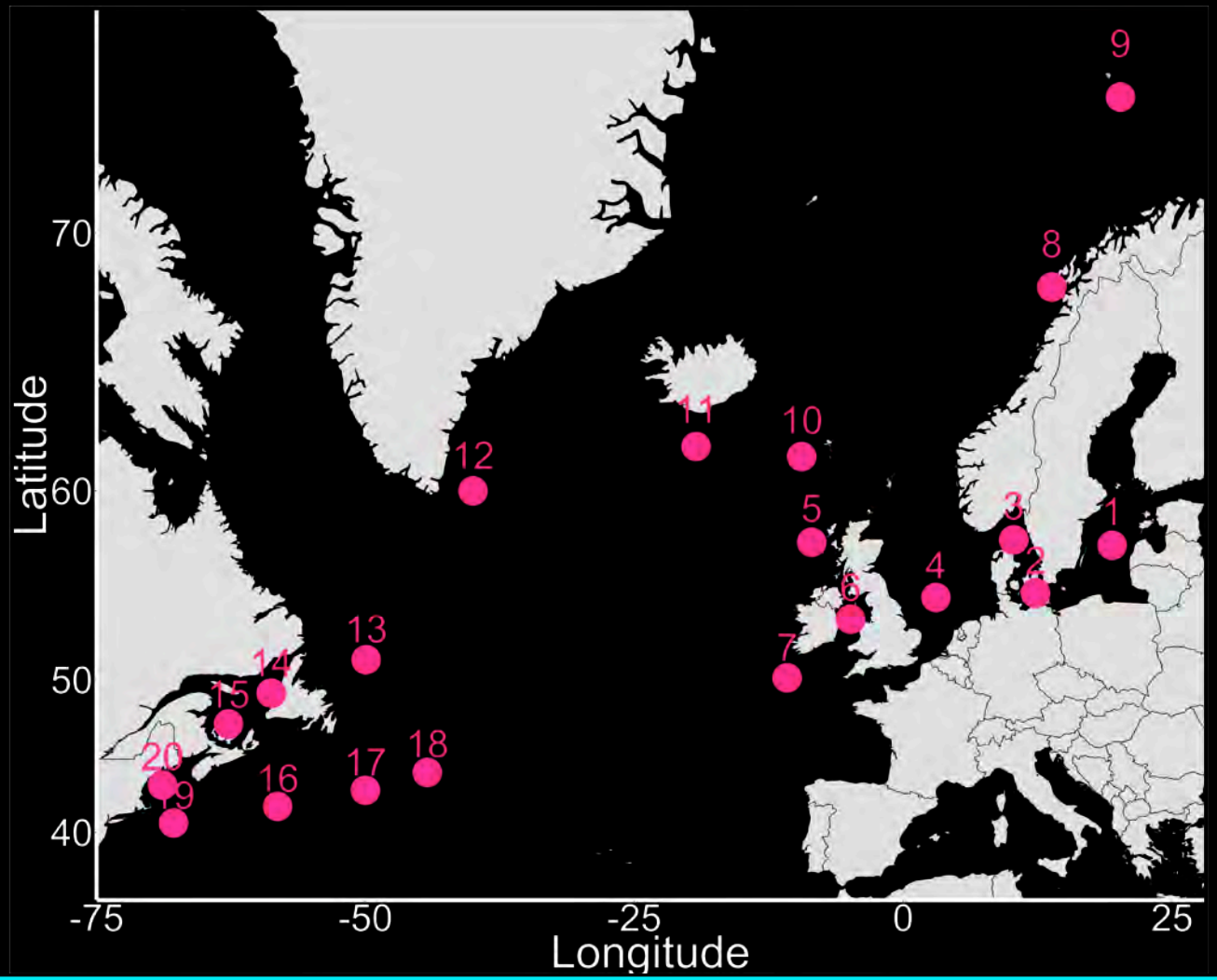

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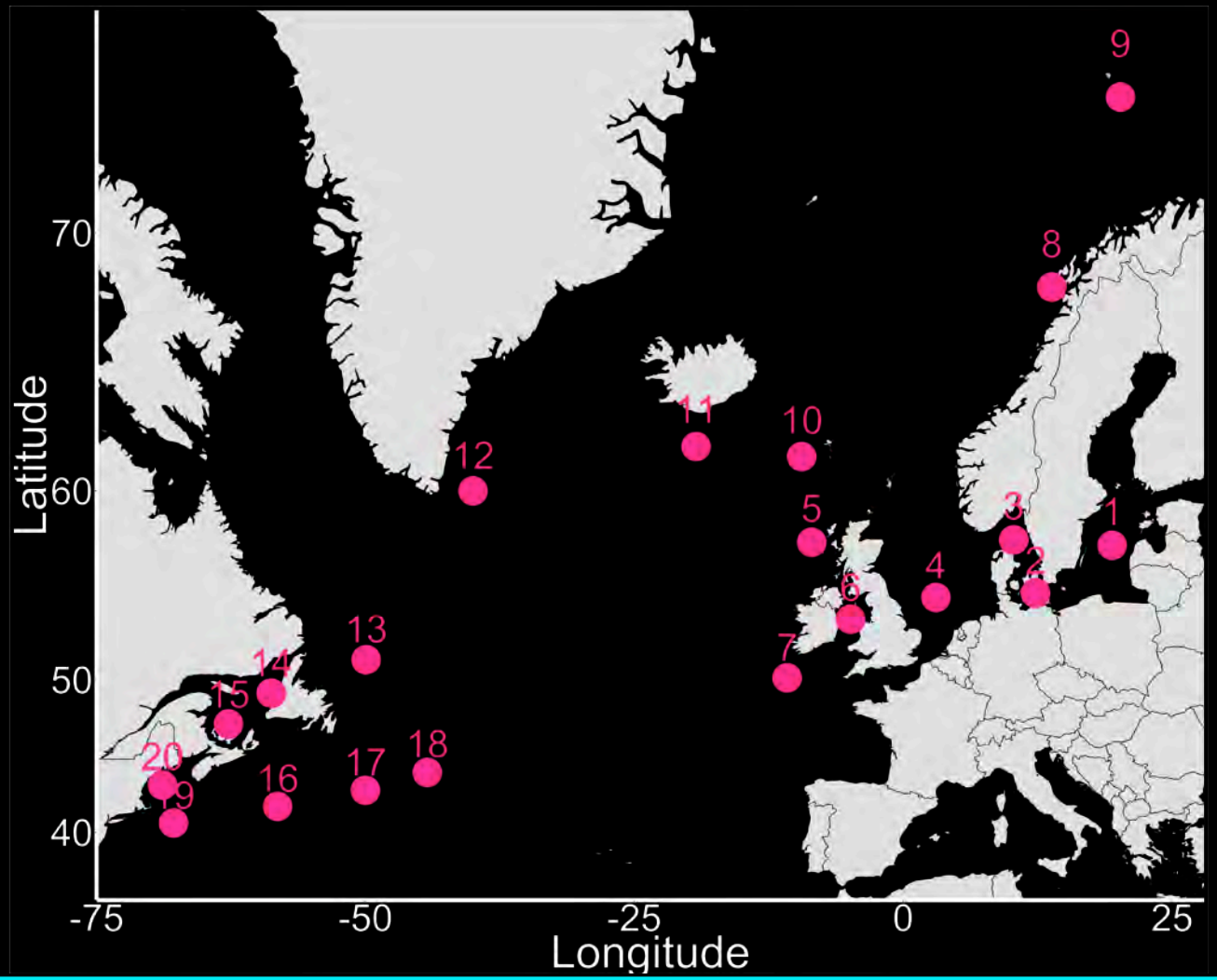

Data used

- **Recruitment**

- **SSB**
- **Environment:**
  - SST
  - AMO
  - NAO

Tests for non-linearity in recruitment dynamics

- Simplex Projection
- S-Map

Ye et al., 2015; Harford et al., 2017,Perlala *et al*., 2017, Sguotti et al., in prep

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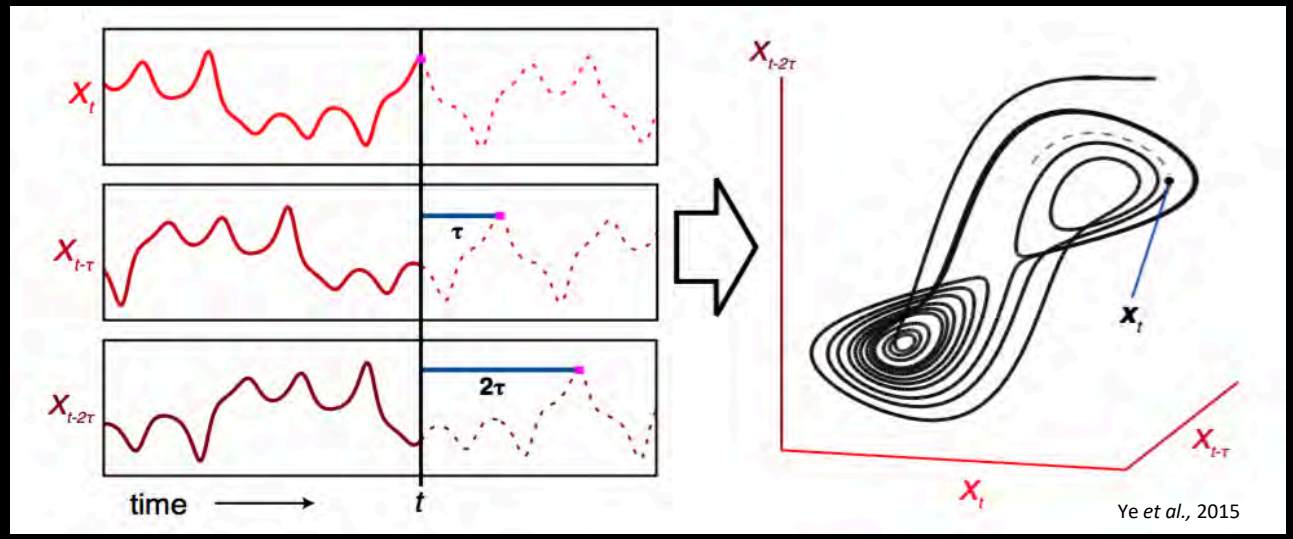

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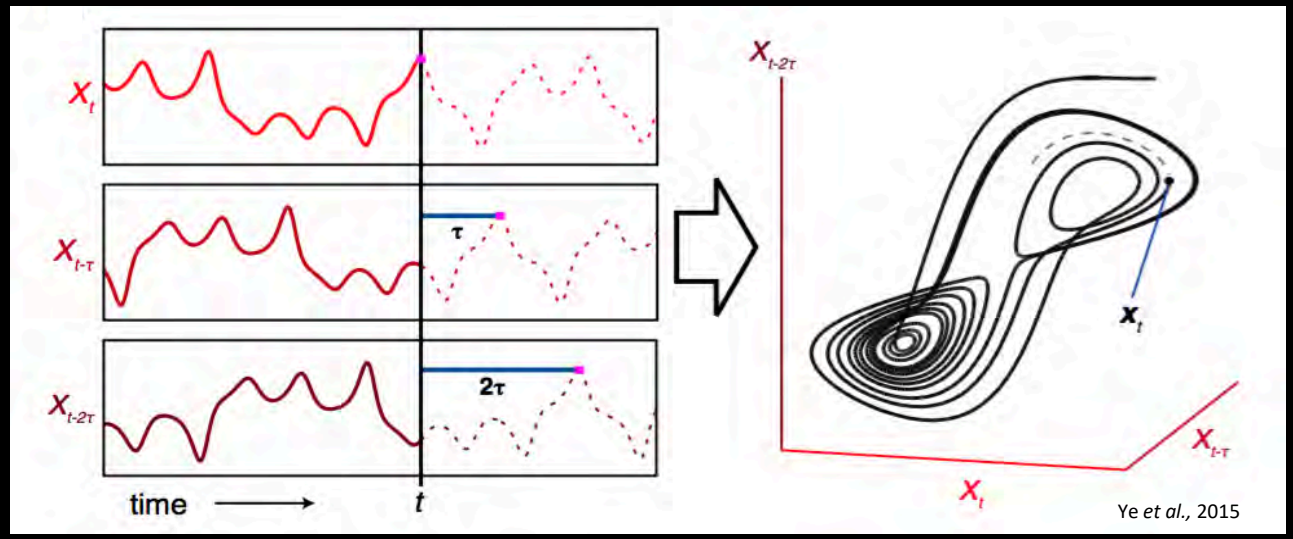

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Attractor manifold or state space reconstruction of n-dimensional system

Ye et al., 2015; Harford et al., 2017,Perlala *et al.*, 2017, Sguotti et al., in prep

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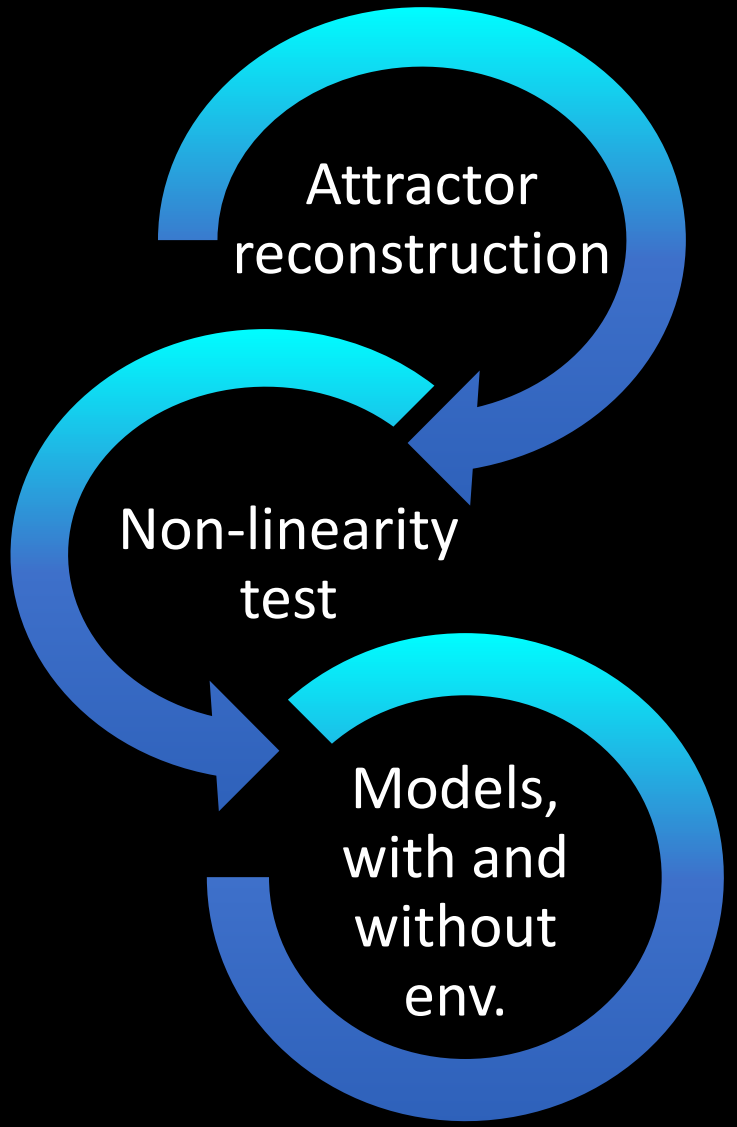

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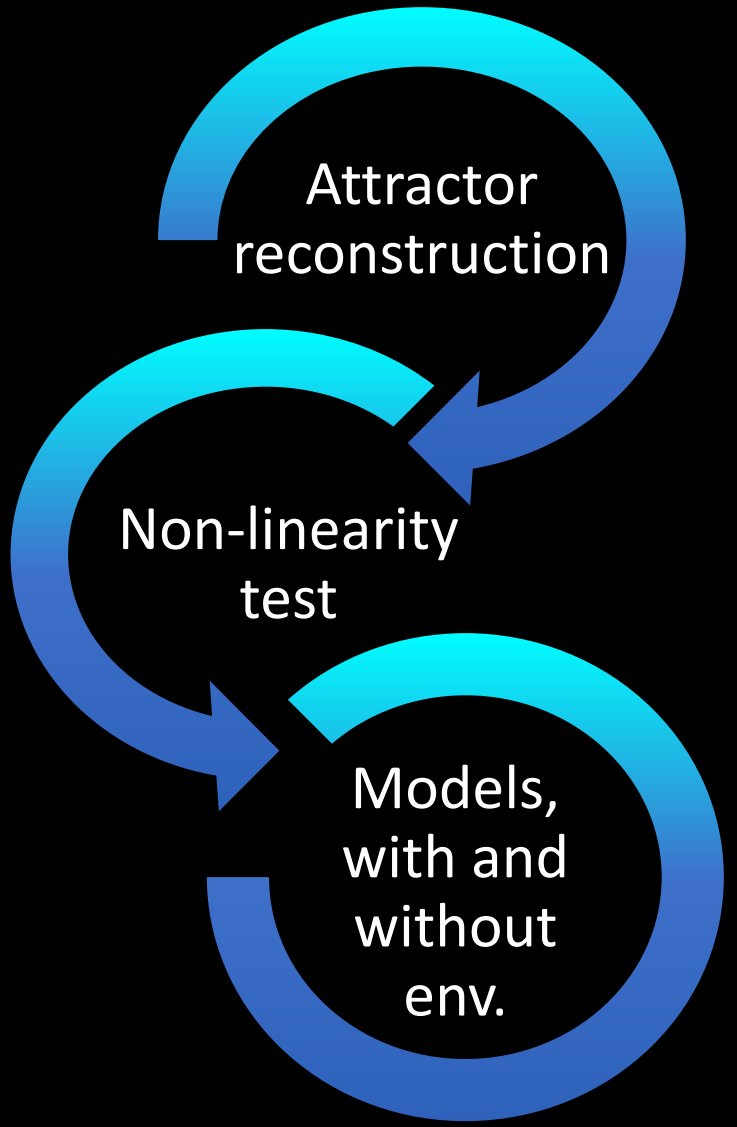
3 different types of model applied

- Standard parametric model
- Model based on catastrophe theory
- State-dependent model



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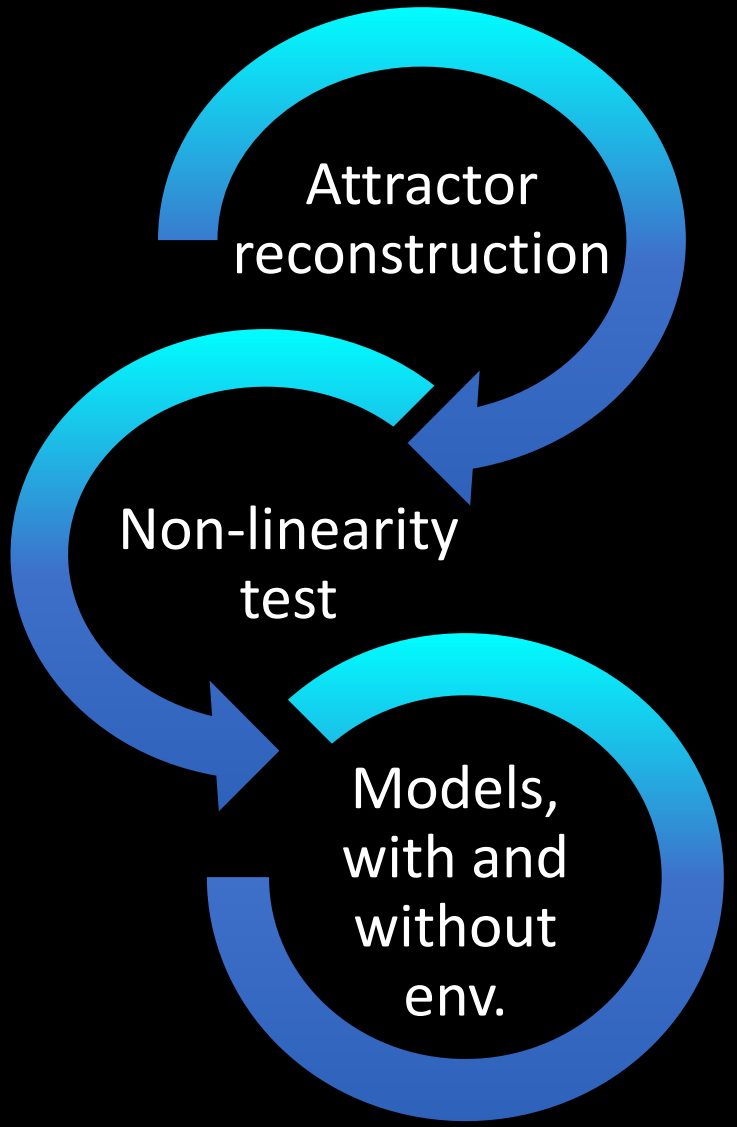
Model Comparison

- 5 fold Cross Validation



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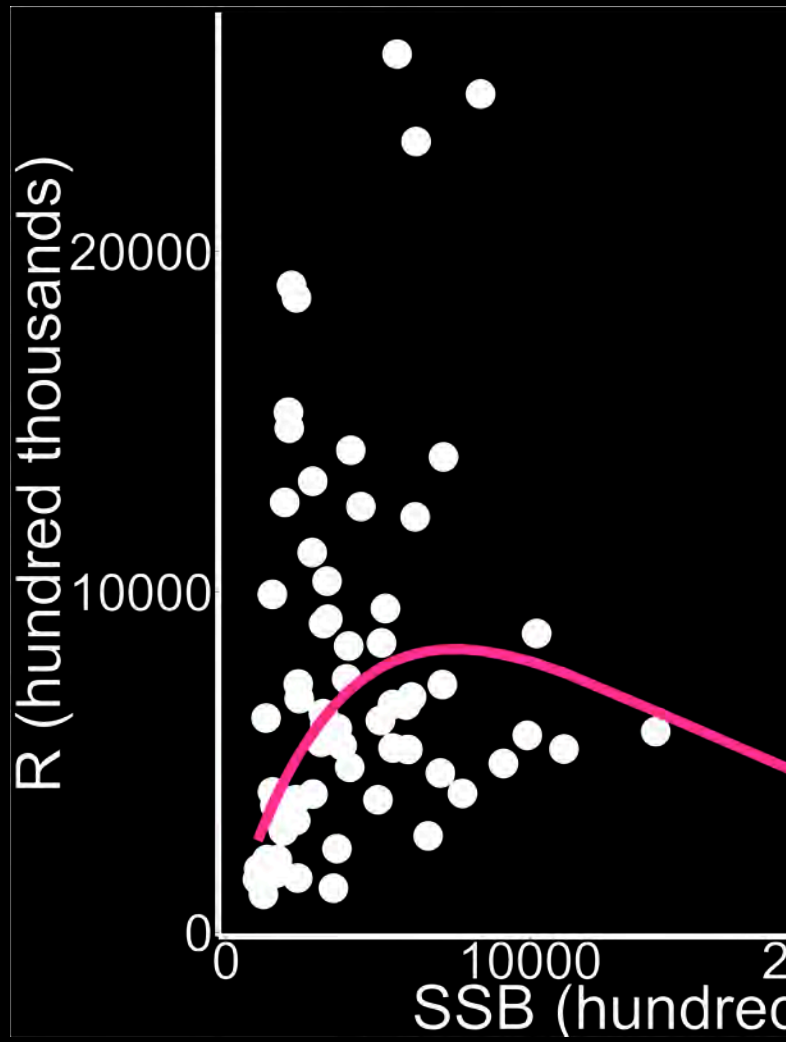
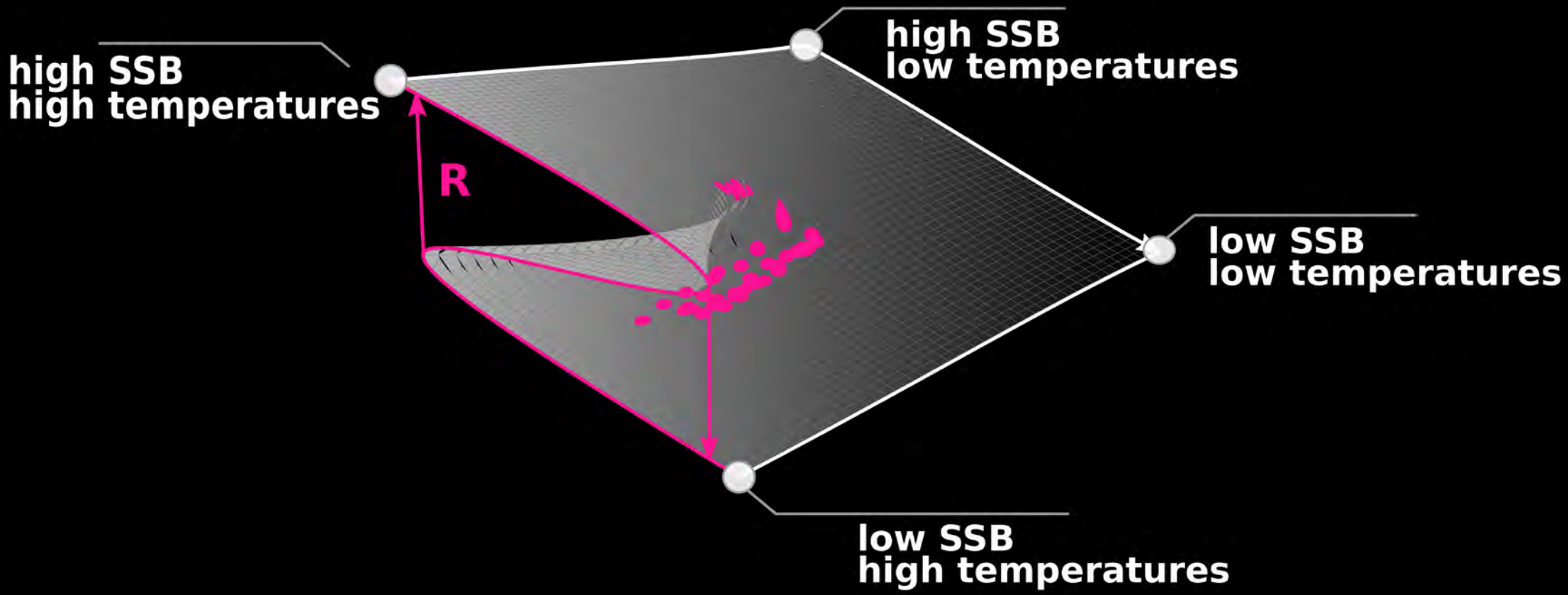
Parametric model: Ricker S-R model



Ricker 1954, Olsen *et al*,2011

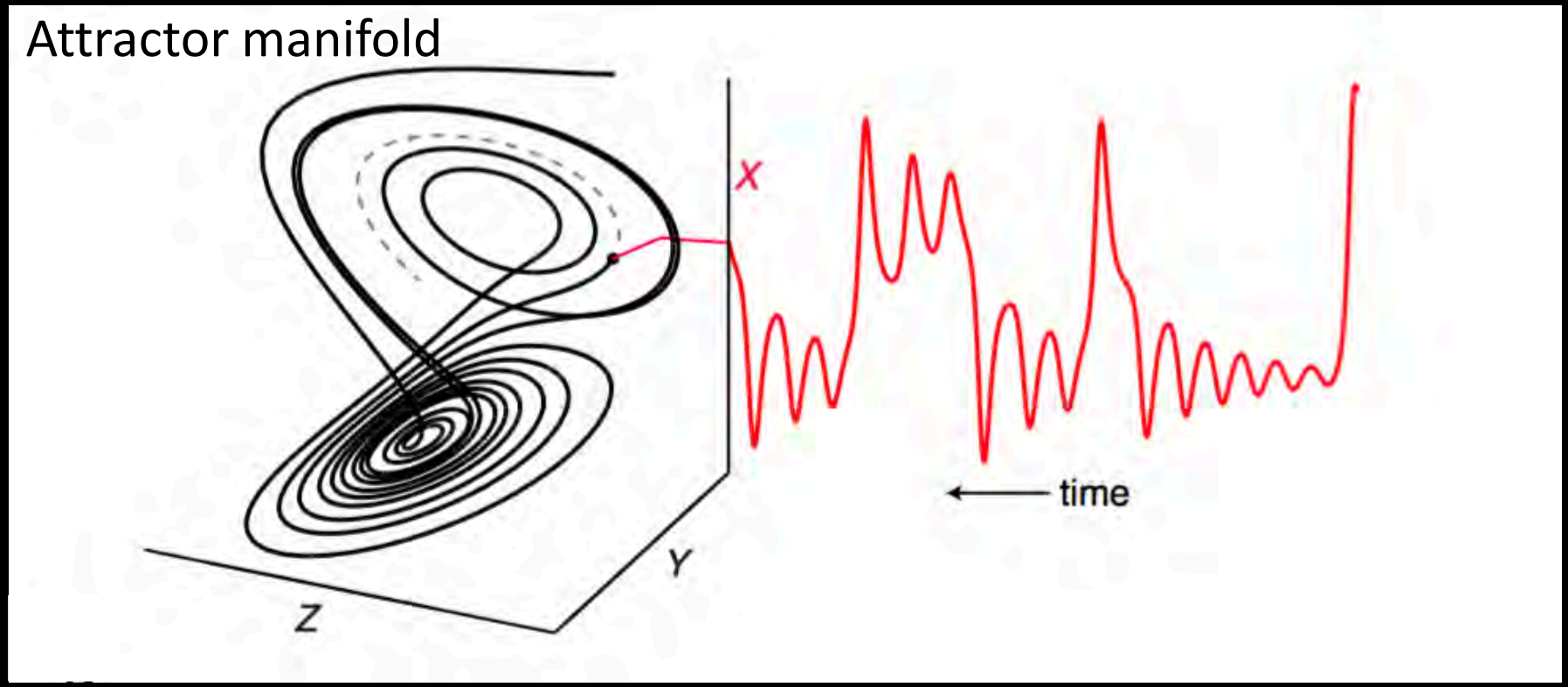
Catastrophic model: Stochastic Cusp Model



Diks *et al.*, 2016, Petraitis *et al.*, 2016,Sguotti *et al.*, in prep,

State dependent Model: Empirical Dynamic Modelling

Multivariate Simplex Projection to forecast n-dimensional system



Sugihara et al., 2012, Ye et al., 2015; Munch et al., 2016, Harford et al., 2017

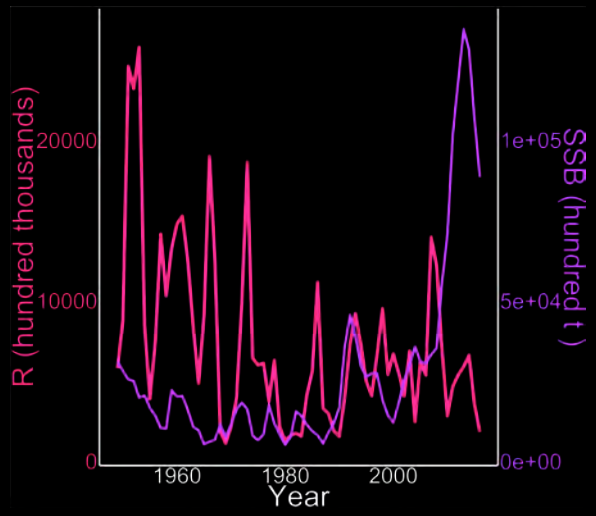
Linear & non-linear Recruitment dynamics

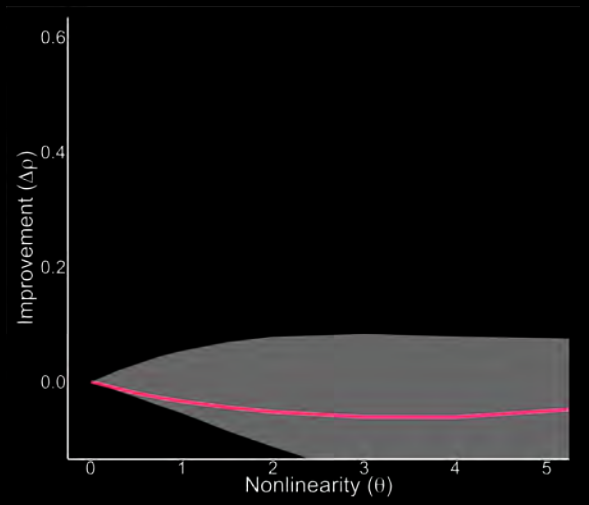
13 out of 20 stocks shows non-linear recruitment dynamics

Linear & non-linear Recruitment dynamics

North-East Arctic:

Linear





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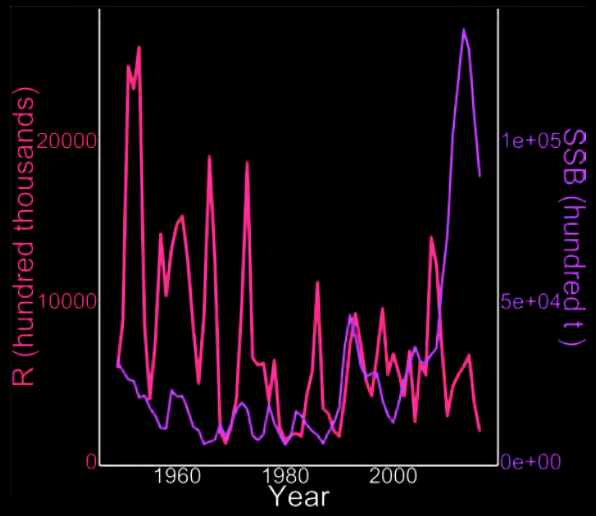
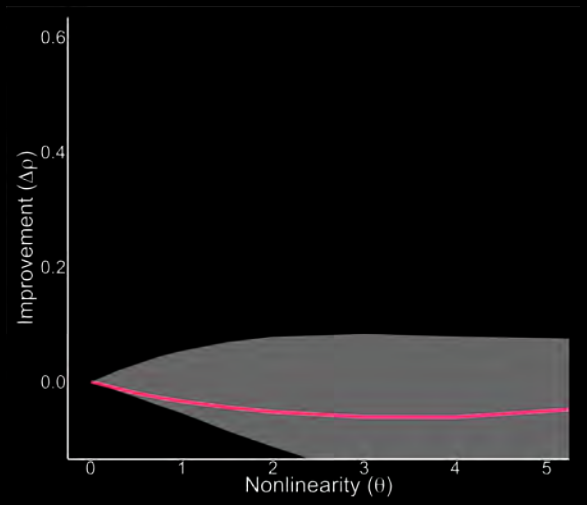
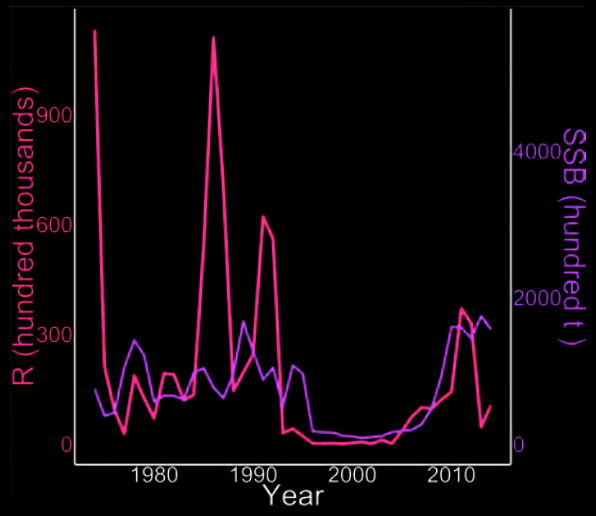
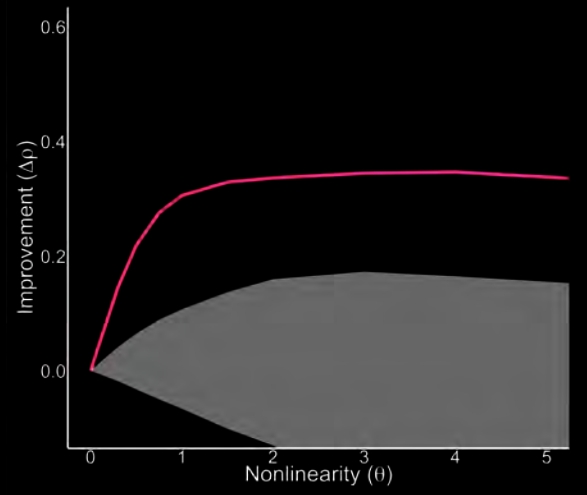




Flemish Cap:
Non-linear





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Linear dynamics or
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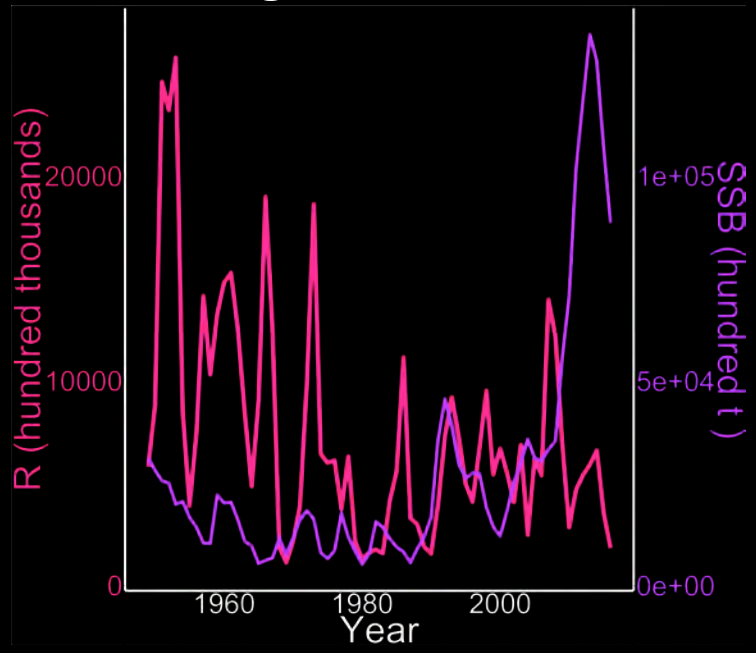

Ricker model

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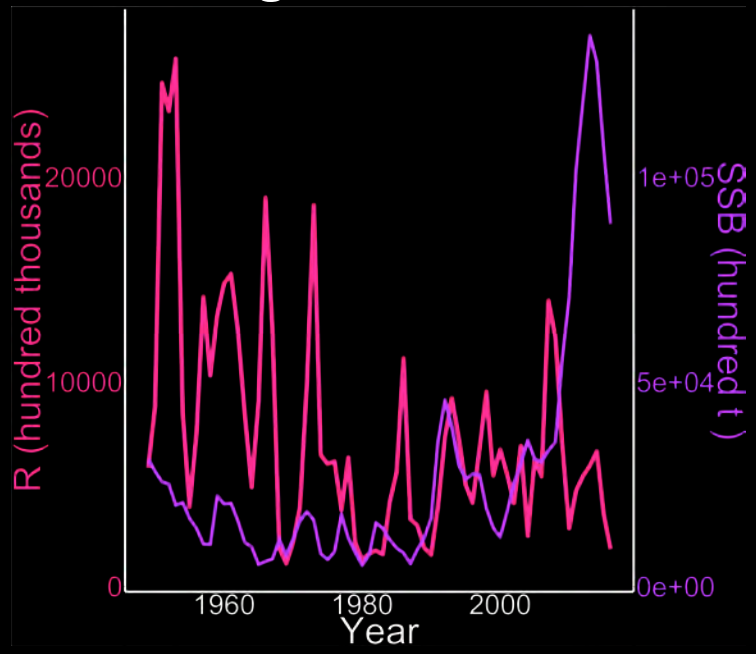

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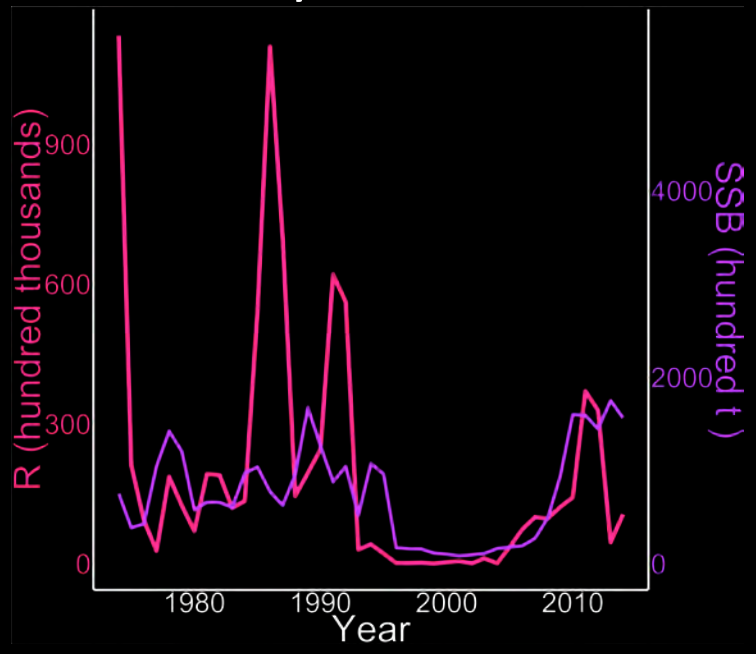
Catastrophic dynamics



Stochastic Cusp Model

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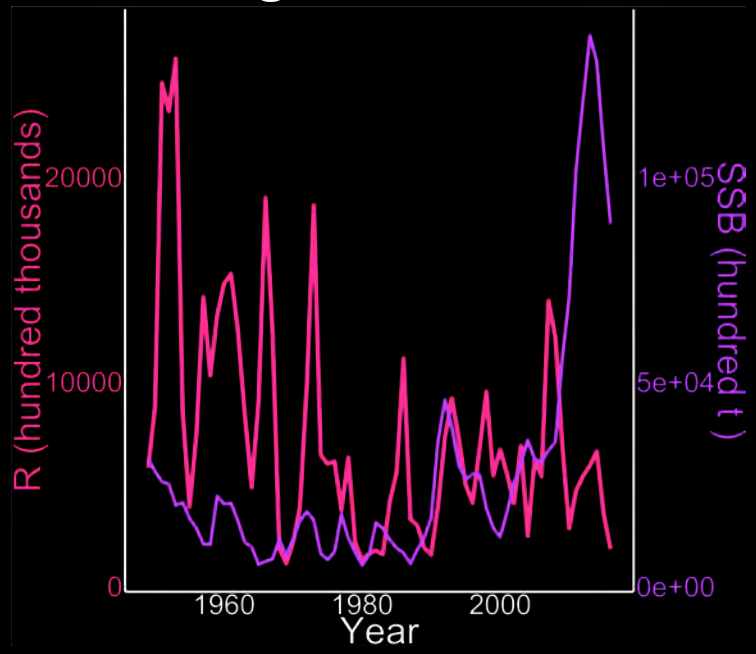

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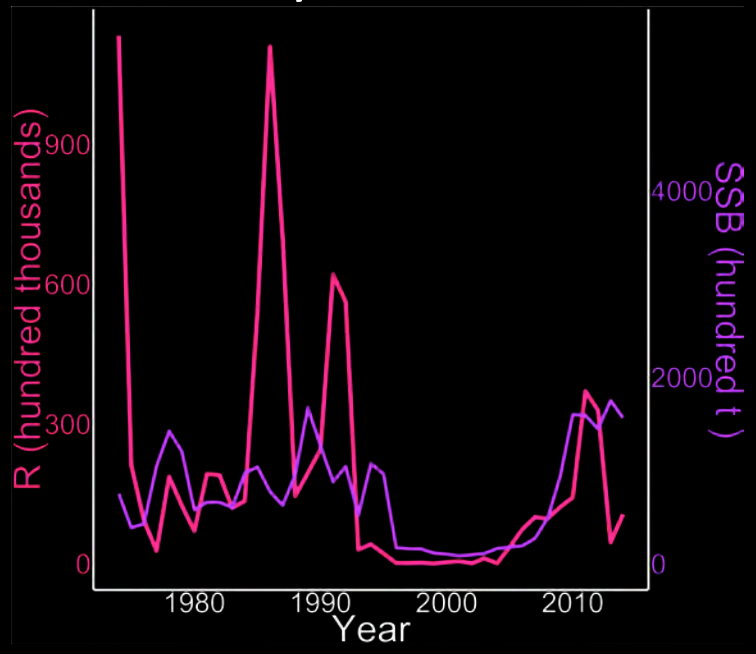

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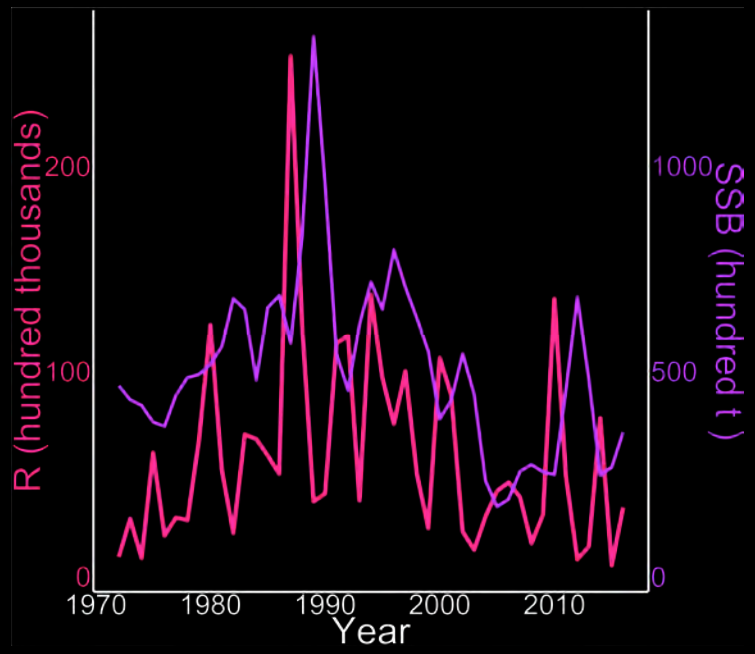
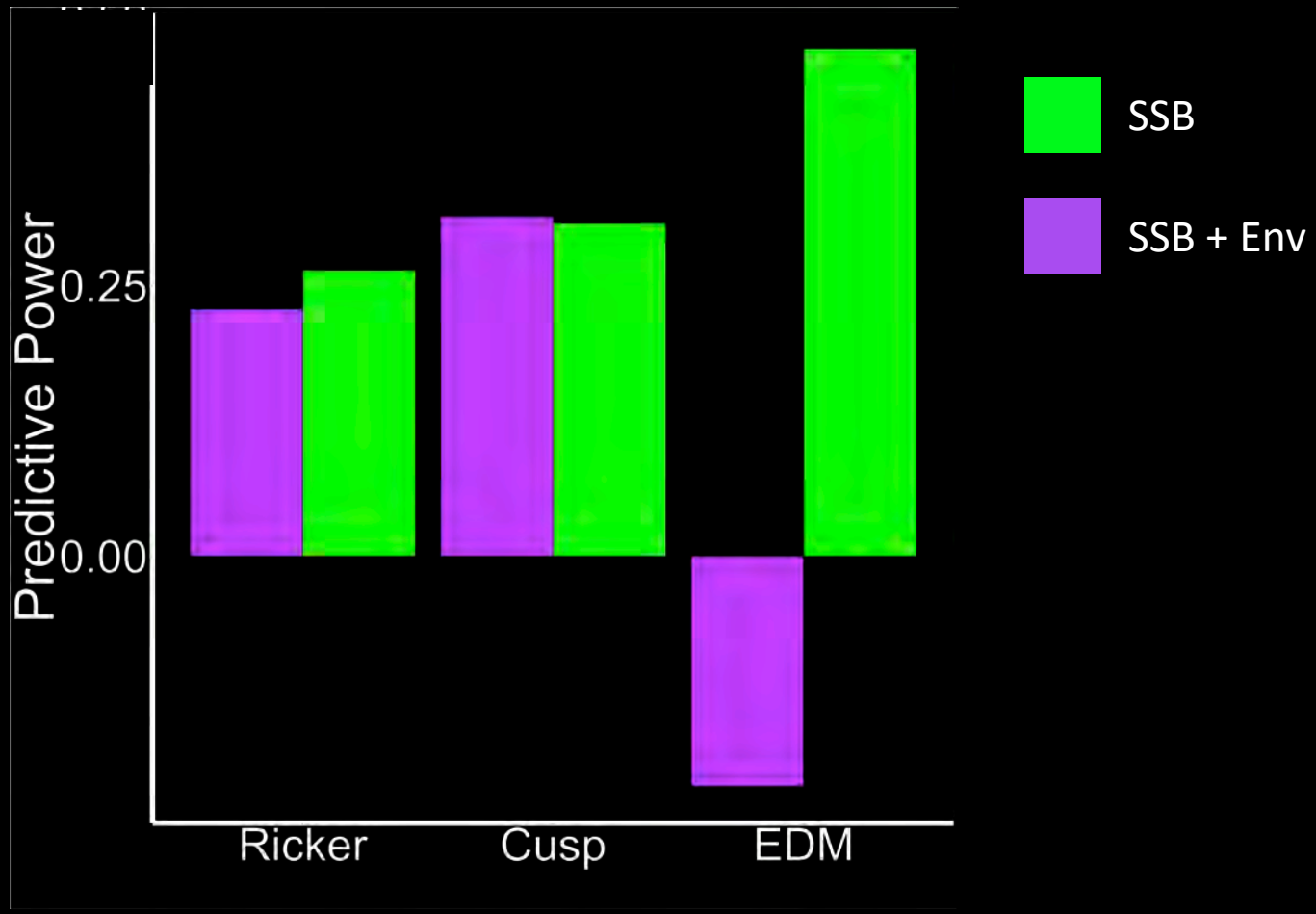


Empirical Dynamic Modelling

Importance of environmental factors



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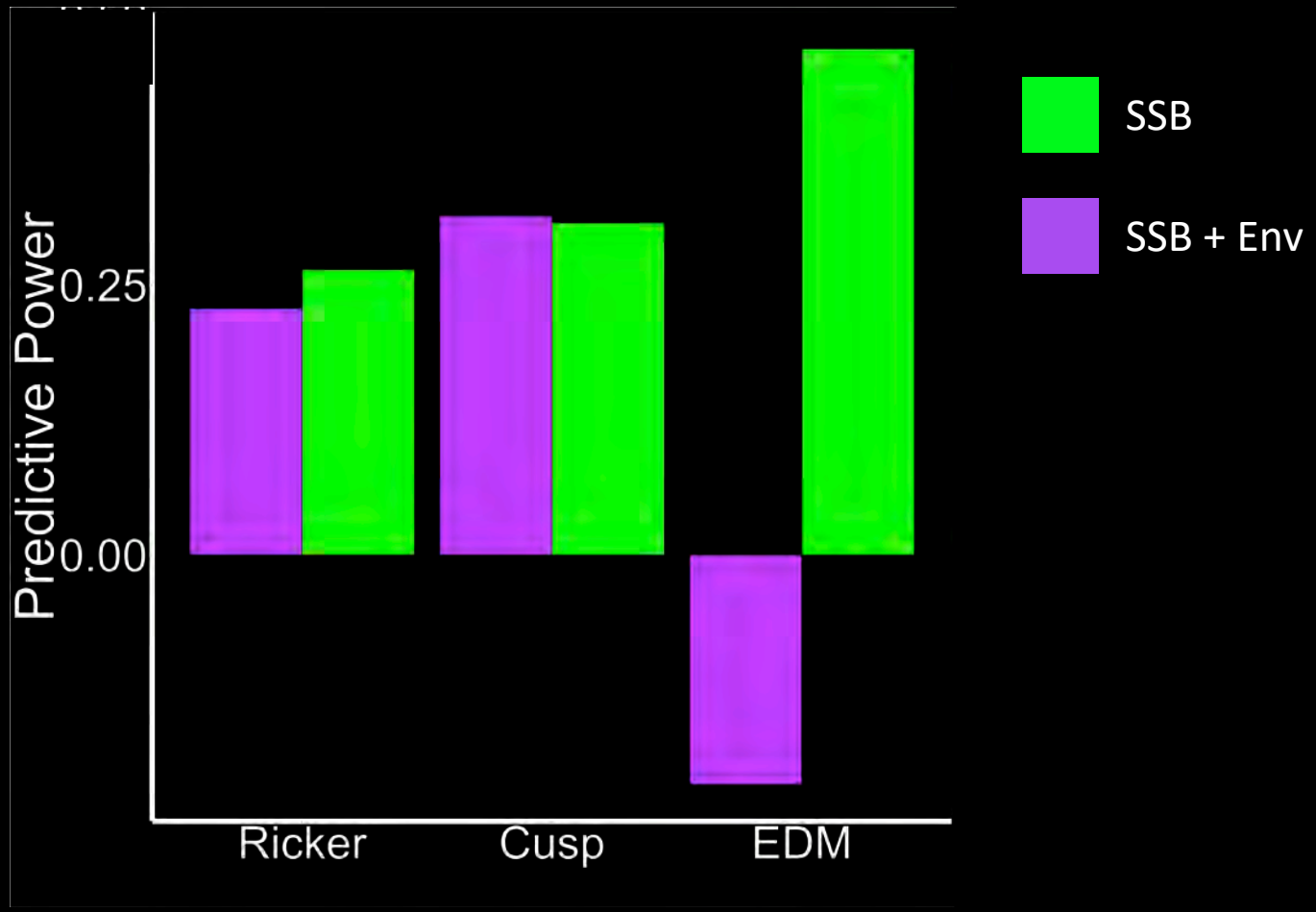

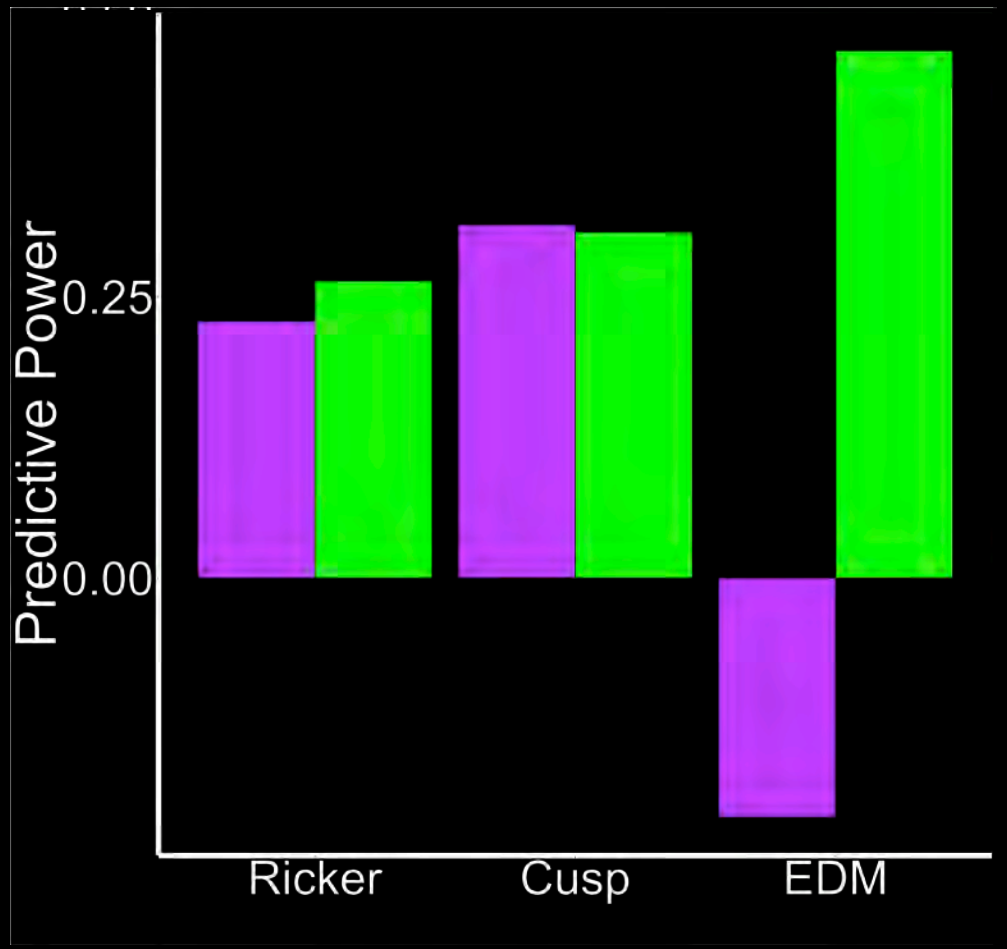

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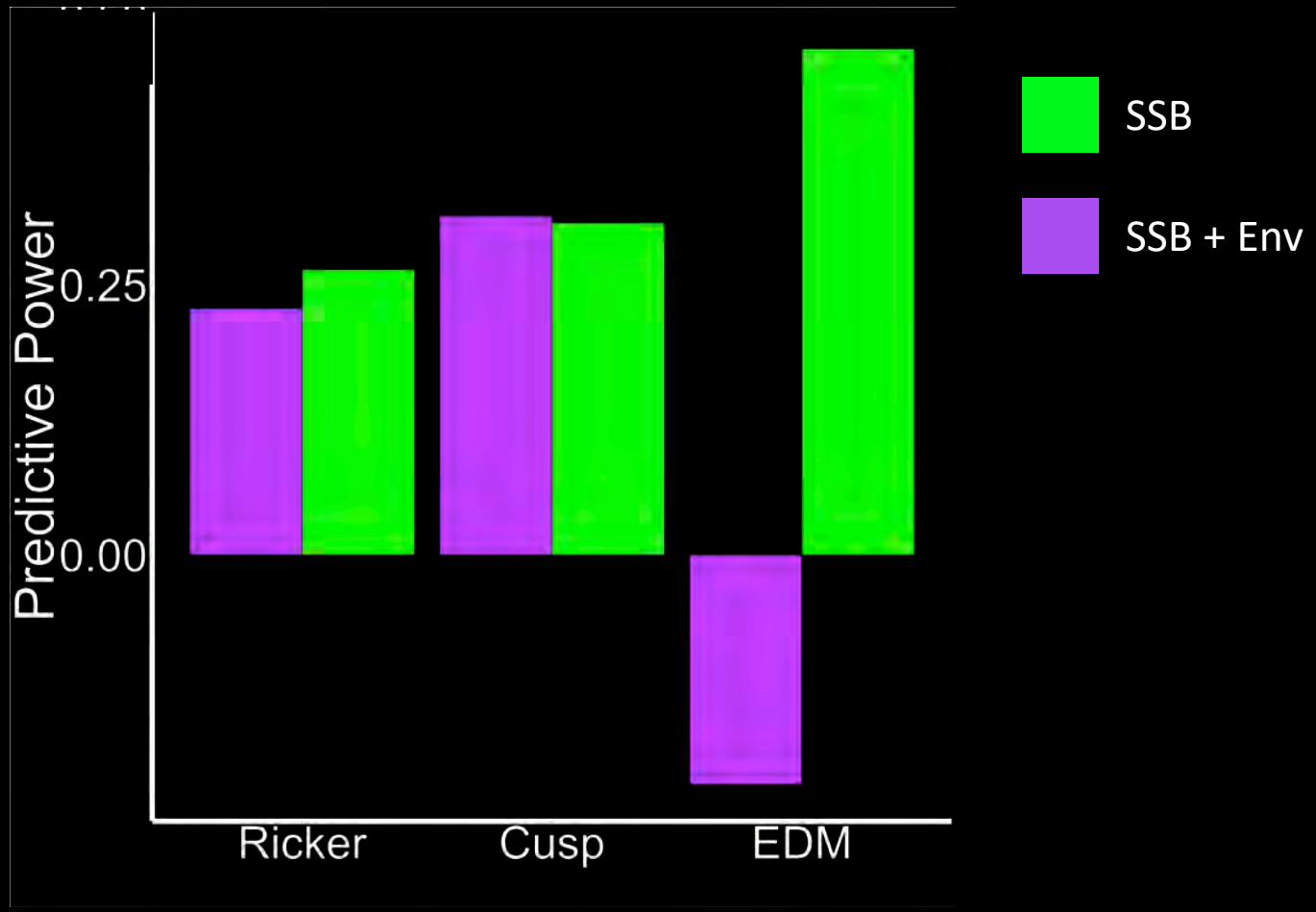

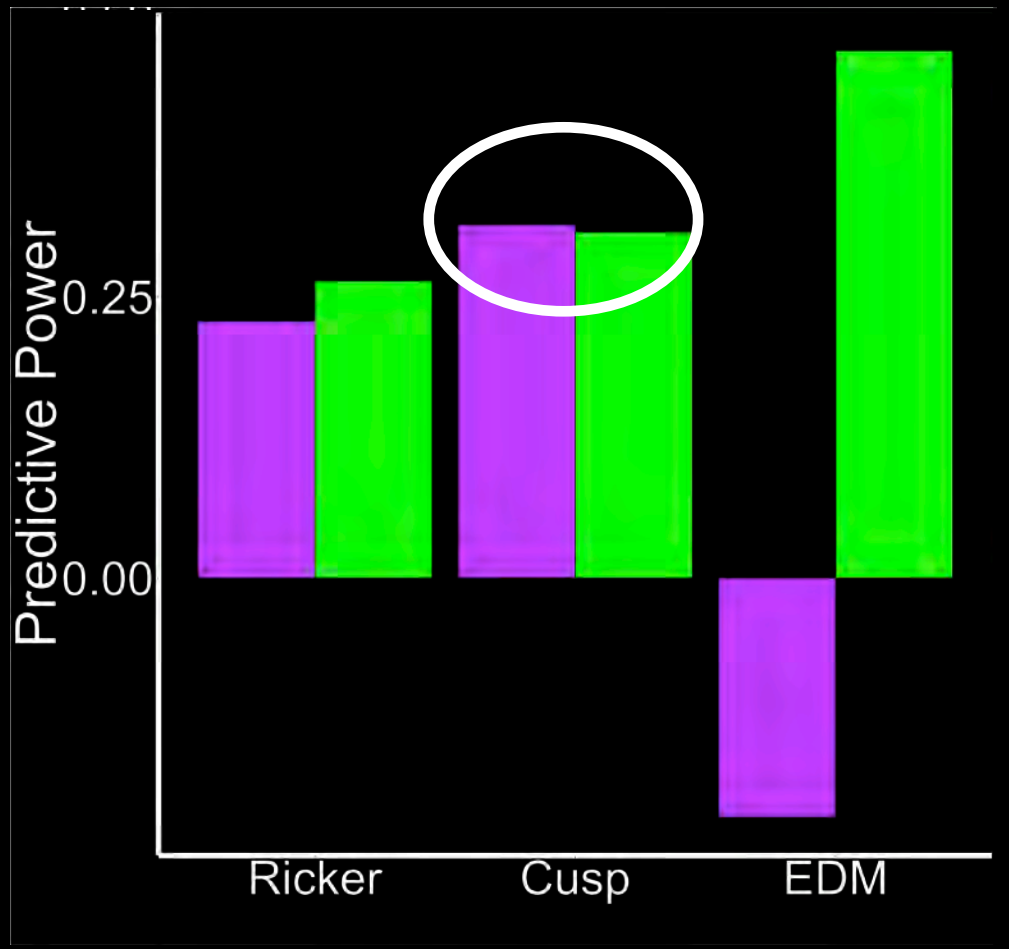

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- Depending on stock dynamics there might be better models to apply

- Environmental factors can increase predictive power

- Multiple stressors can be included in these models

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A flexible model choice is fundamental to move towards Ecosystem Based Management

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Future perspectives

- Investigate discontinuous dynamics in fish stocks
- Understand R-SSB dynamics in Atlantic cod better
- Ways to incorporate alternative models in management

Acknowledgments

- My co-authors
- Prof George Sugihara and Dr Ethan Deyle
- The MARmaED project & network

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THANK YOU FOR THE ATTENTION!

Questions?

camilla.sguotti@uni-hamburg.de