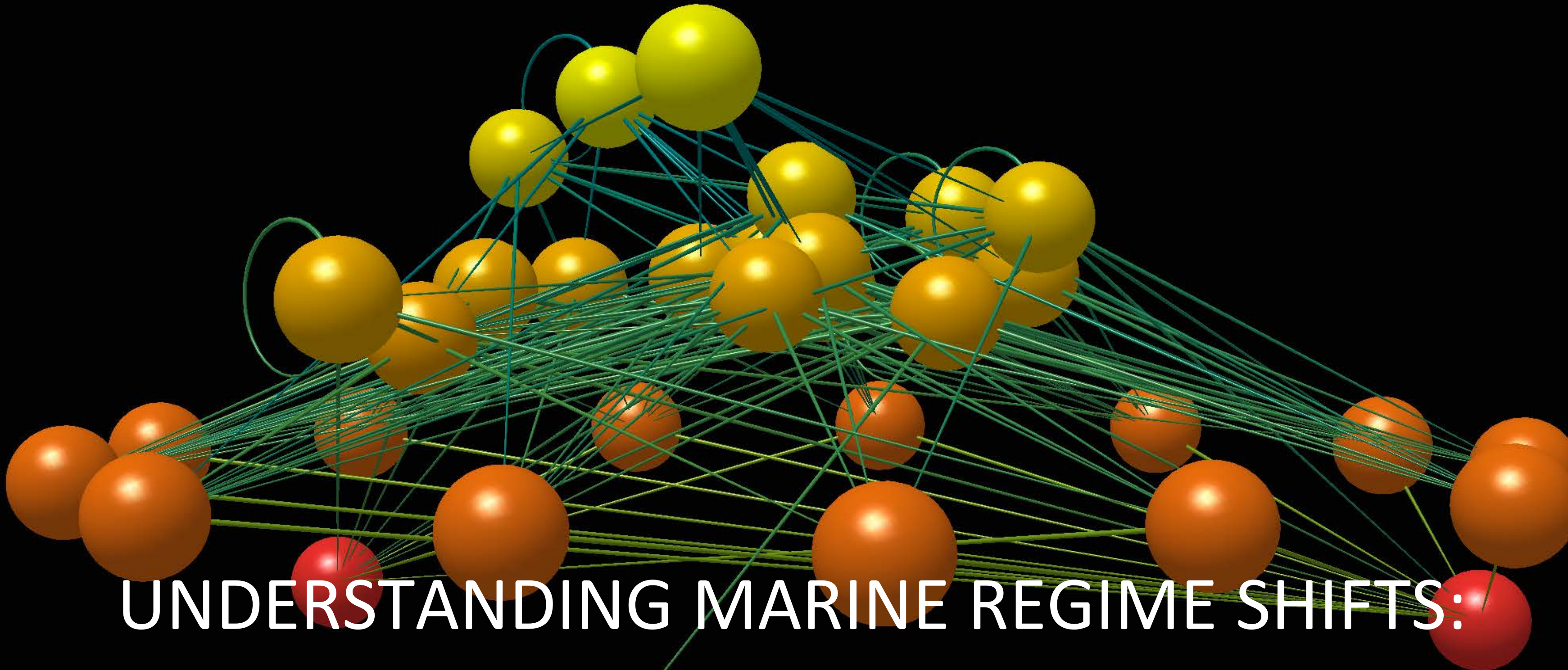

UNDERSTANDING MARINE REGIME SHIFTS: DETECTING CHANGES IN STRUCTURES AND FUNCTIONS IN FOOD WEBS

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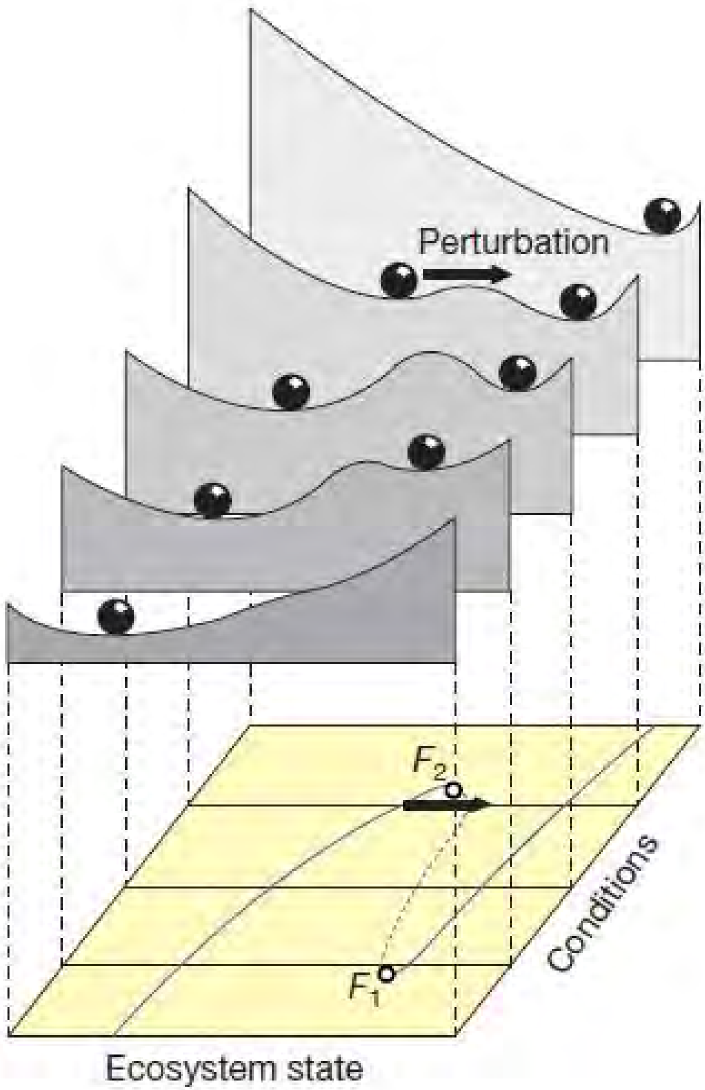
Key Questions

Do substantial changes in ecological processes, as captured by changes in motif prevalence in whole species communities, co-occur with marine regime shifts?

Exponential Random Graph Models (ERGM) for ecological networks.

Regime shifts change the structure and functioning of marine ecosystems



Scheffer & al. 2001

Sudden, persistent, substantial reorganisations that are hard to reverse.

Multiple drivers

Challenging for management

Often less productive, less predictable states from which fisheries recovery is difficult

Documented in several marine regions

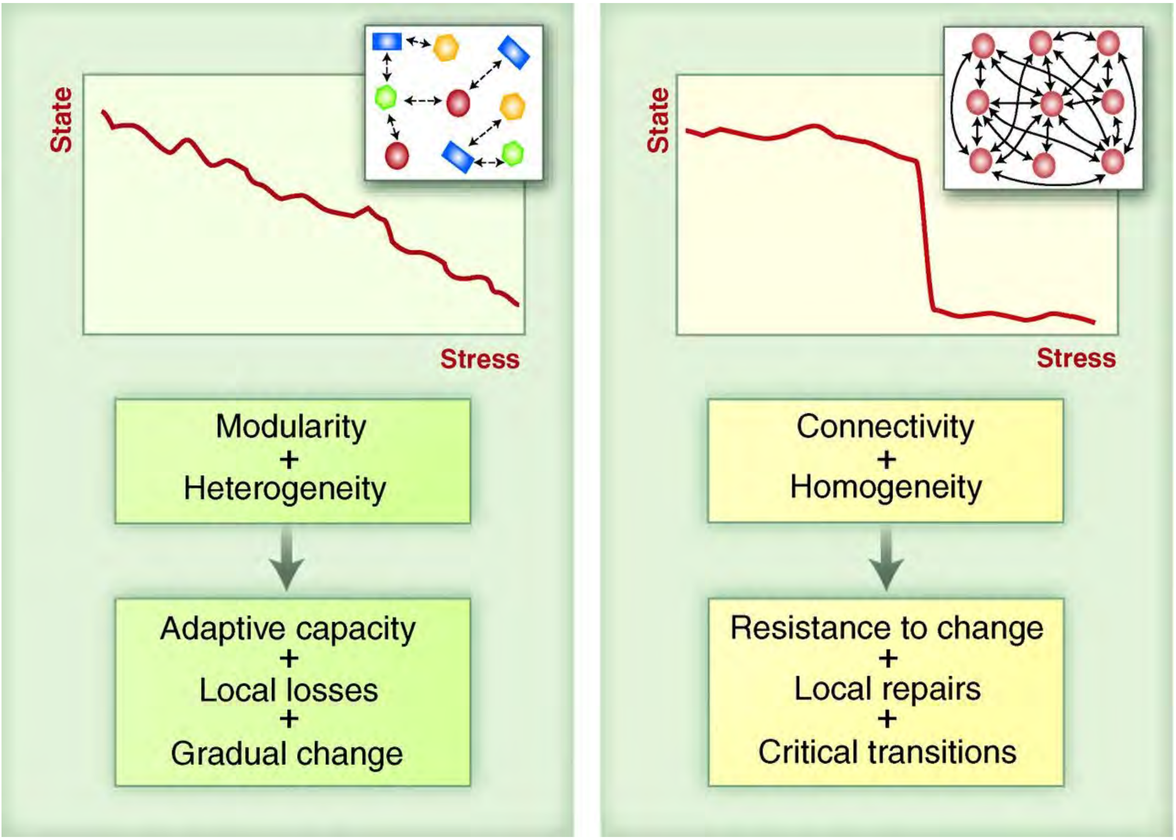
Network structure can affect system resistance to change

- Node similarity: similar responses
- Connectivity/modularity: subsidiary inputs

Local resilience may give false impression of resilience!

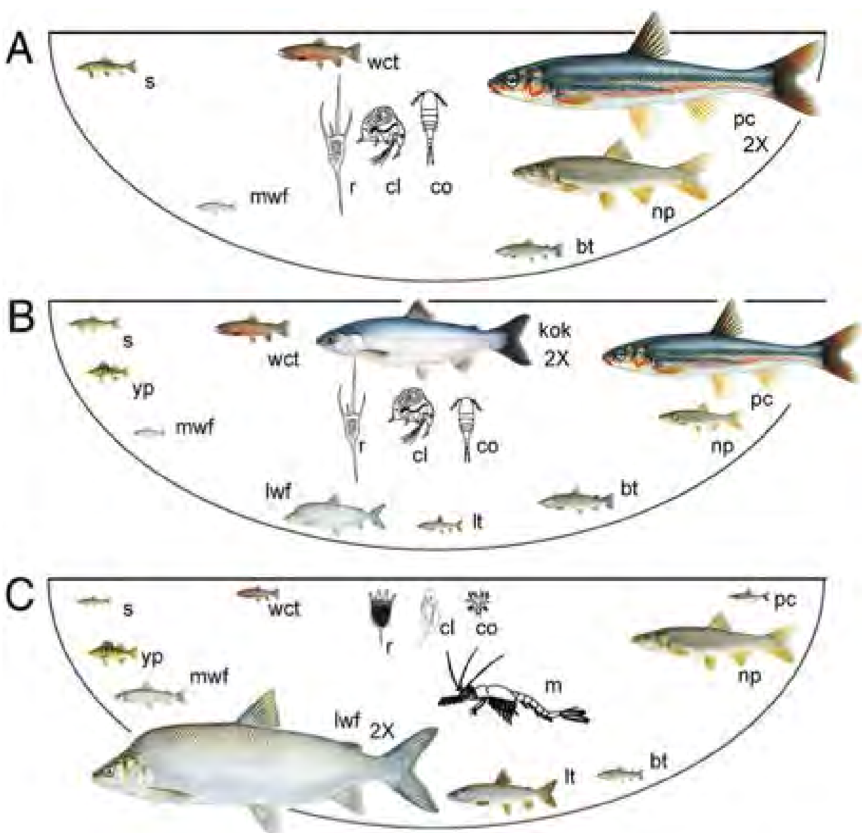
Gradual change:

Abrupt change:

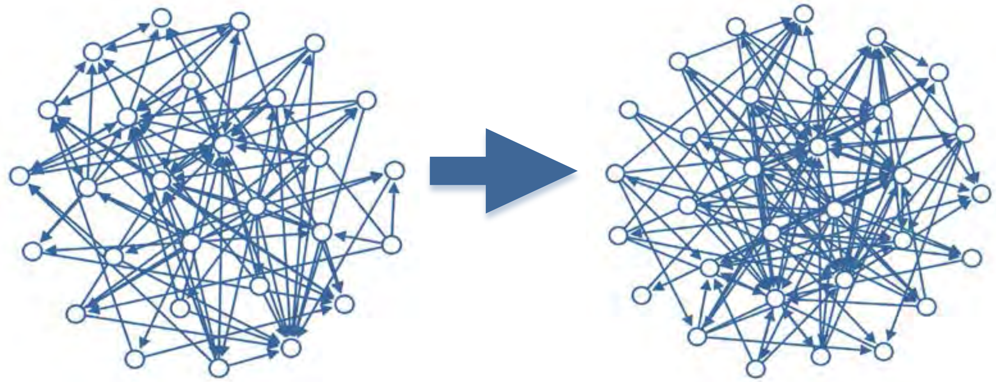


Scheffer & al. 2012

Food web reorganisations

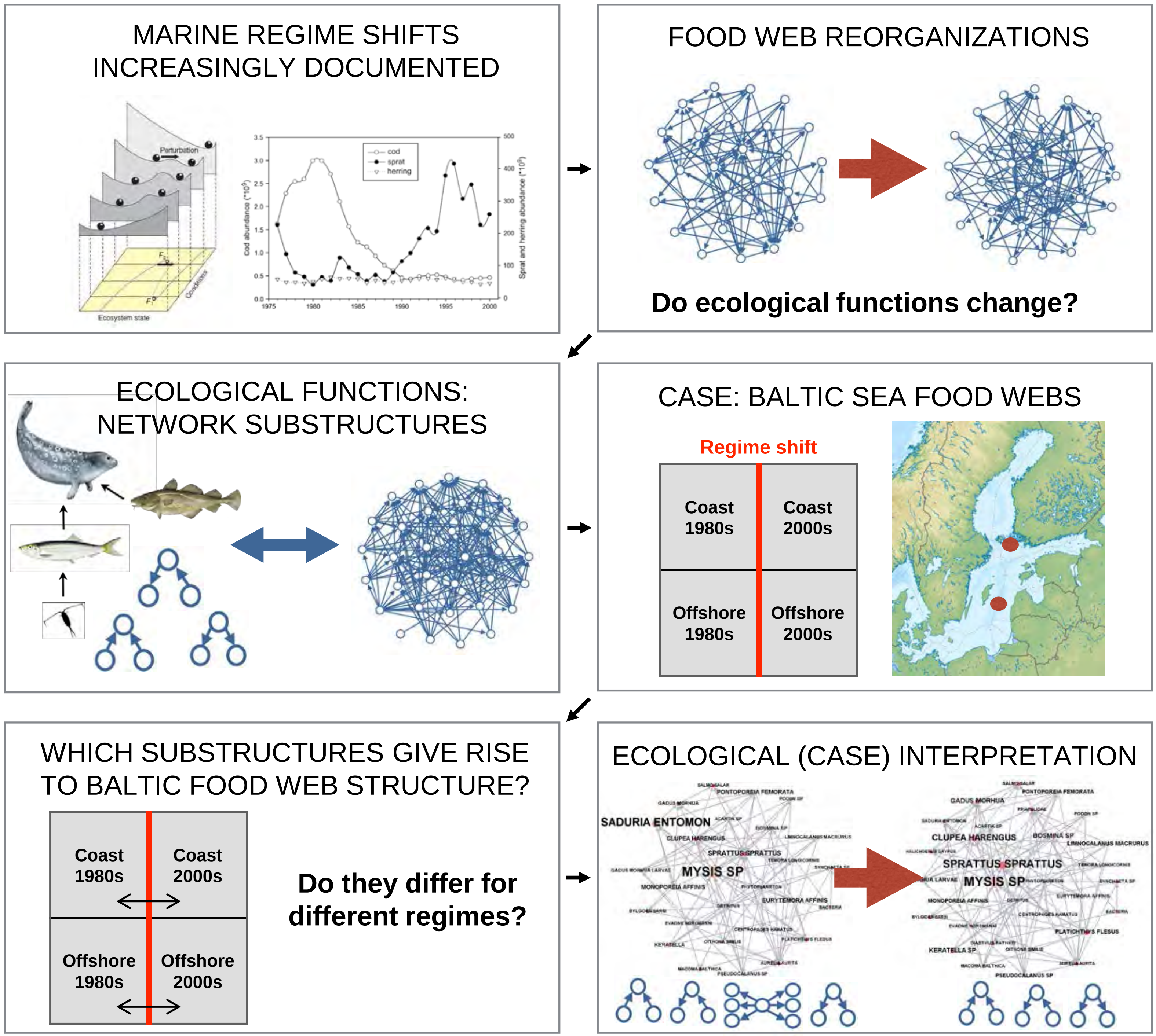


Ellis et al. 2011



"Fisheries science and management must develop a sharper focus on species interactions and how disrupting these interactions can push ecosystems …past their tipping points." Travis & al. 2014

Food webs: nonlinear dynamics and feedback loops


MARINE REGIME SHIFTS INCREASINGLY DOCUMENTED
Perturbation
Ecosystem state
Conditions
cod
sprat
herring
FOOD WEB REORGANIZATIONS
Do ecological functions change?
ECOLOGICAL FUNCTIONS: NETWORK SUBSTRUCTURES
CASE: BALTIC SEA FOOD WEBS
Regime shift
Coast 1980s
Coast 2000s
Offshore 1980s
Offshore 2000s
WHICH SUBSTRUCTURES GIVE RISE TO BALTIC FOOD WEB STRUCTURE?
Coast 1980s
Coast 2000s
Offshore 1980s
Offshore 2000s
Do they differ for different regimes?
ECOLOGICAL (CASE) INTERPRETATION
SADURIA ENTOMON
CLUPEA HARENGUS
SPRATTUS SPRATTUS
MYSIS SP
GADUS MORHUA
BOSMINA SP
KERATELLA SP
PLATICHTHYS FLESUS
PSEUDOCALANUS SP
MONOPOREIA AFFINIS
EURYTEMORA AFFINIS
PONTOPOREIA FEMORATA

Case study: Baltic Sea

The heavily exploited Baltic Sea

Semi-enclosed brackish water basin

Large environmental gradients

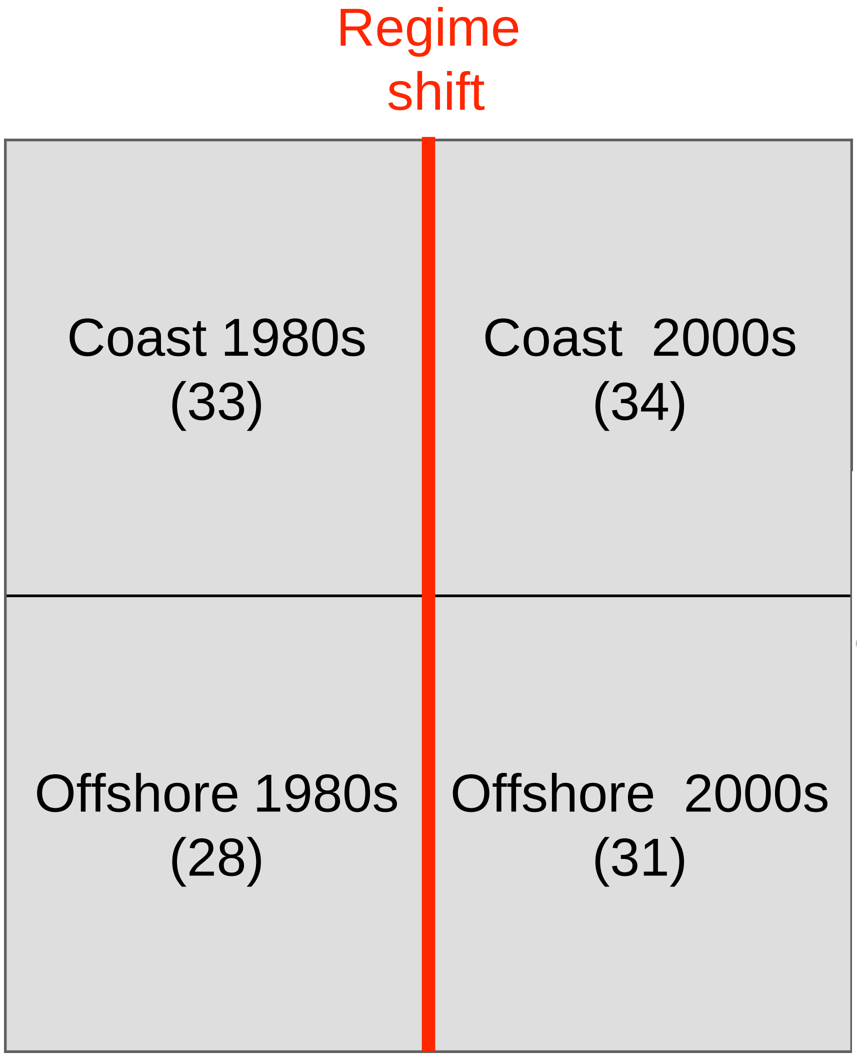
Large catchment area with 85 million inhabitants

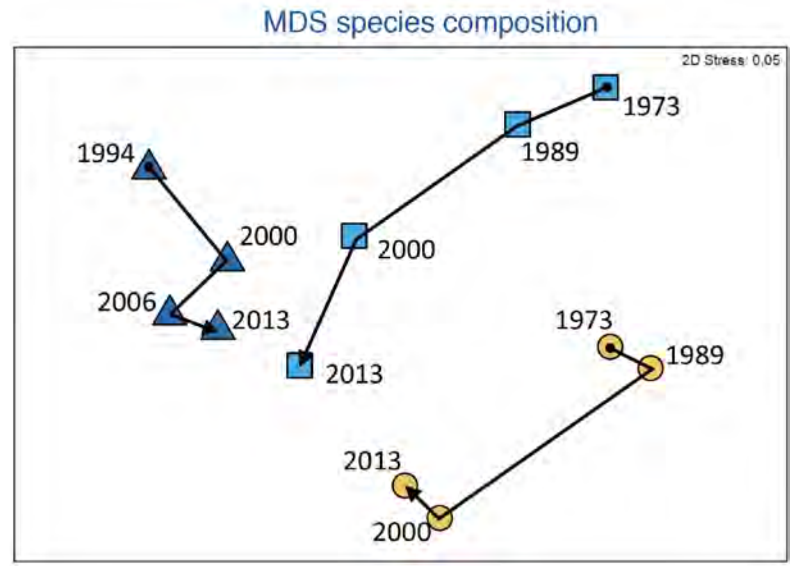
Strong anthropogenic stressors

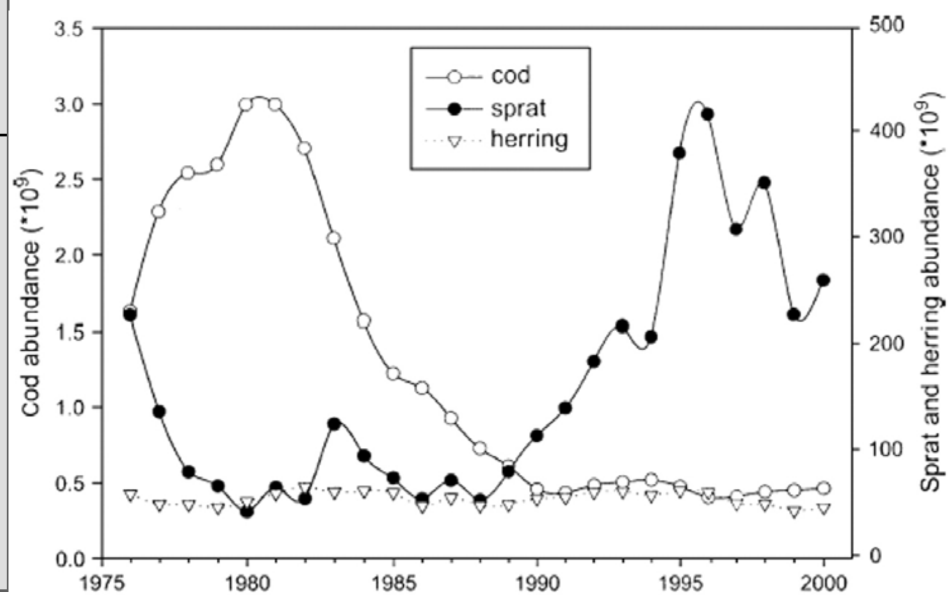
Young sea

Fast rate of climate warming

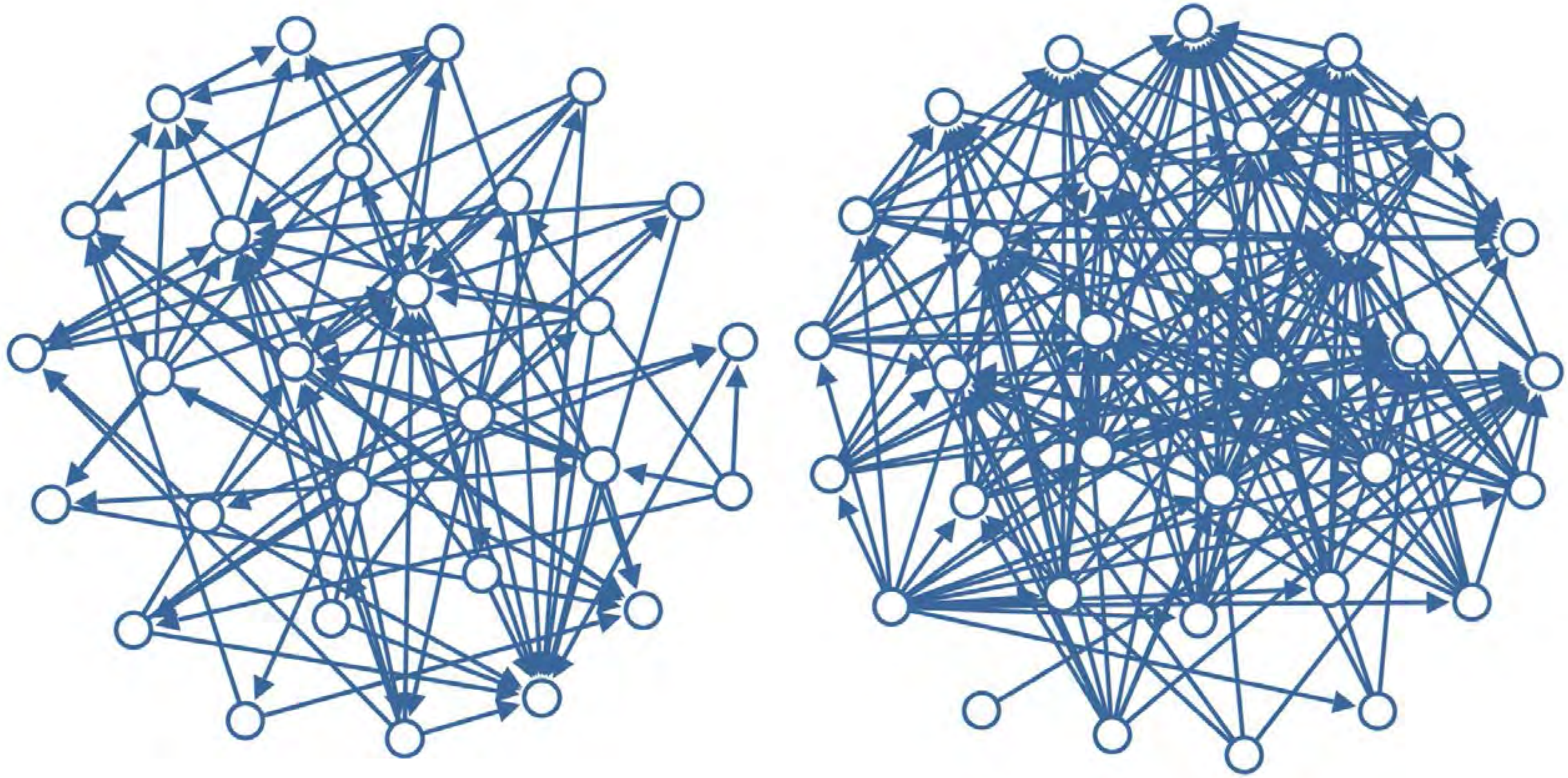
Baltic Sea food webs







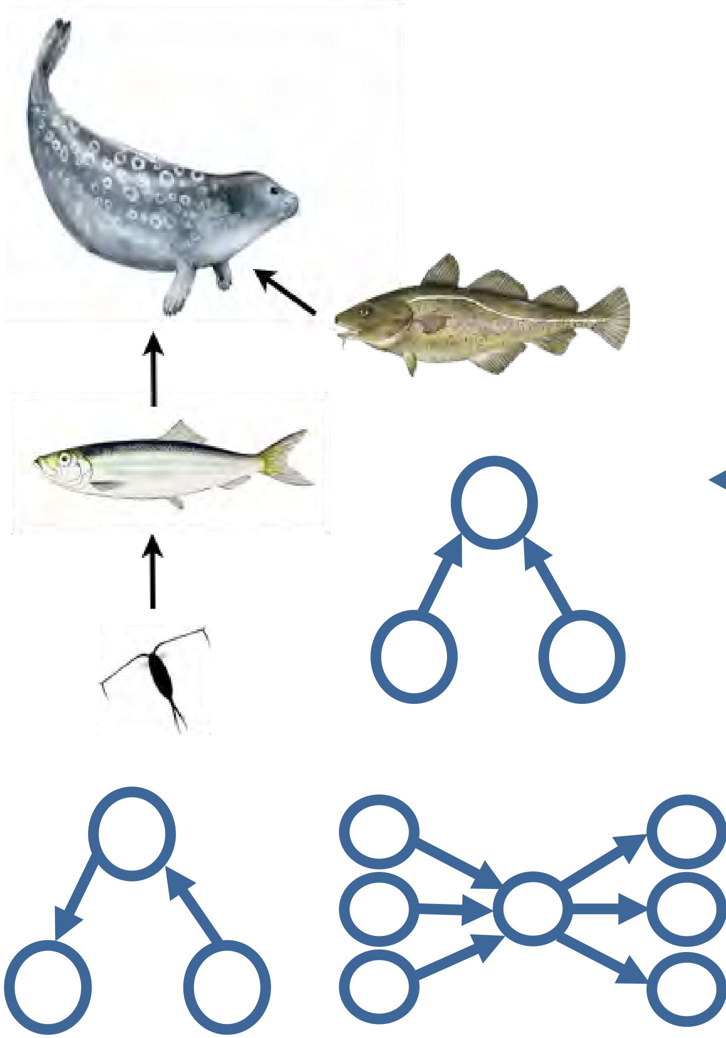
Weigel & al. (in press); Alheit & al. 2005 (Köster & al. 2003)



Phytoplankton	1	Zooplankton	>10
Bacteria	1	Benthic fauna	>5
Detritus	1	Fish	>5/10
Microalgae	1	Mammals	1

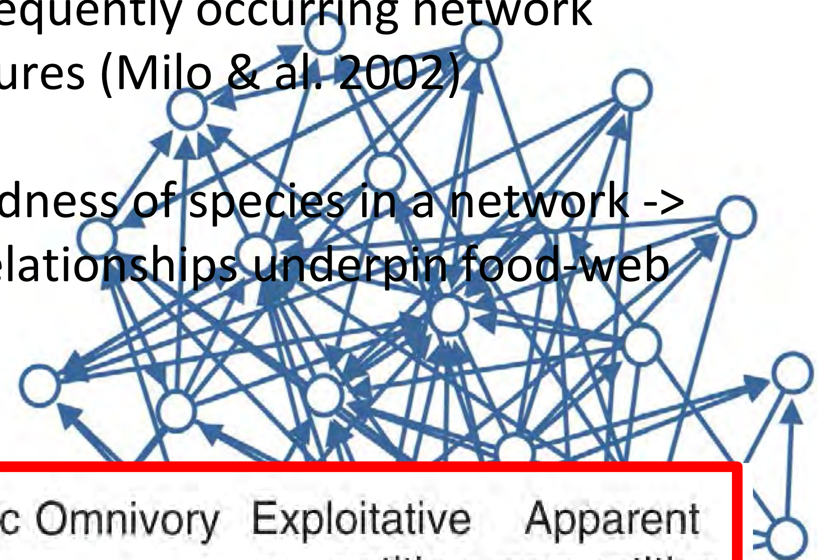
Structural network analysis

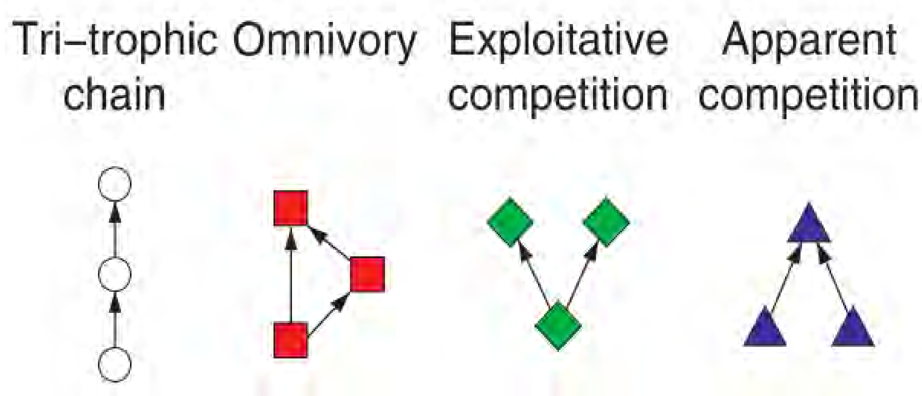
Any network can be disentangled to a set of motifs



Motifs: frequently occurring network substructures (Milo & al. 2002)

Embeddedness of species in a network -> species relationships underpin food-web function





Camacho & al, 2007; Stouffer & Bascompte 2010.

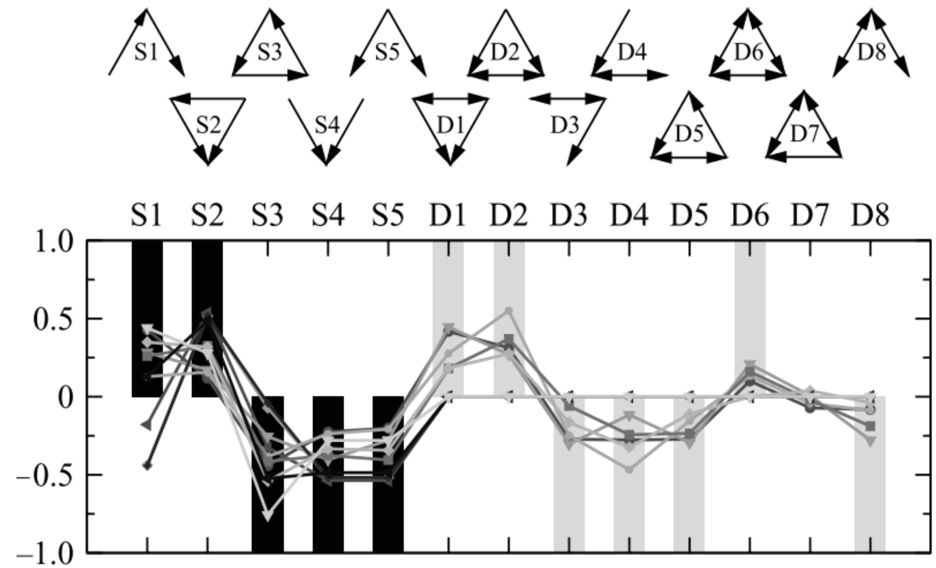
From local scale to the whole community

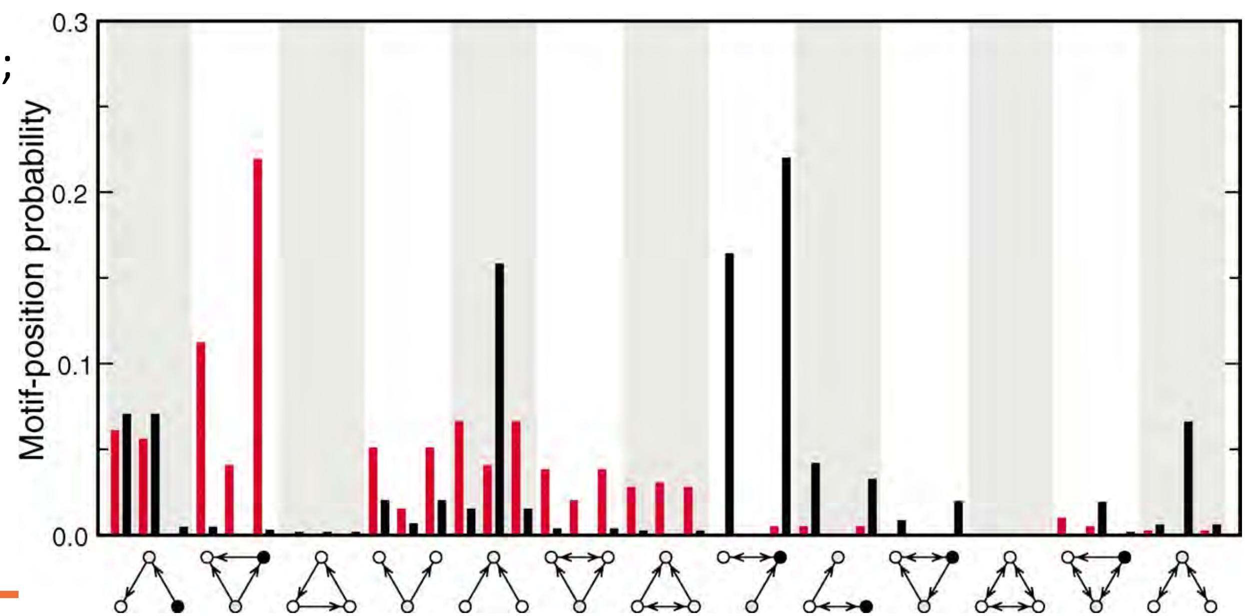
Motif frequency generalities in food webs (Bascompte & Melian 2005; Camacho & al 2007; Dunne & al. 2013; Stouffer & al. 2007)

Motif contribution to food web persistence (Kondoh 2008; Stouffer & Bascompte, 2010)

Species roles (Baker & al, 2015; Stouffer & al, 2012)

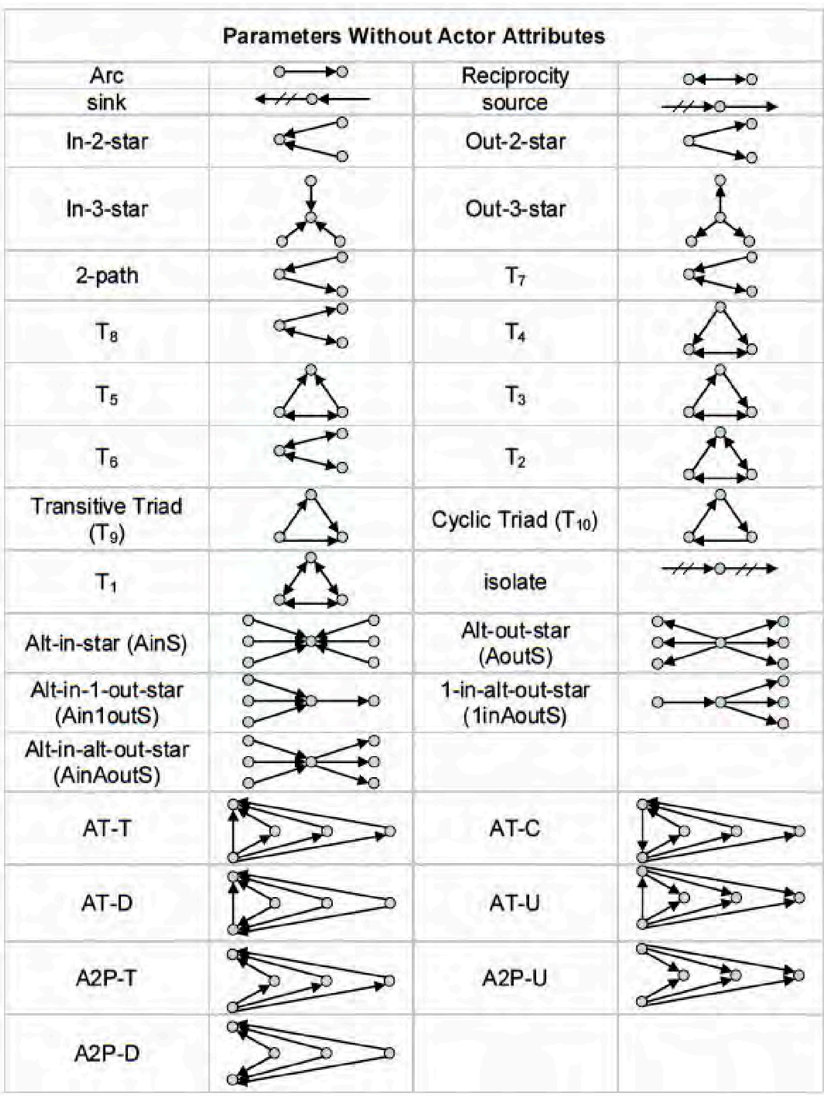
E.g. overfishing of marine food webs (Bascompte & al, 2005)





Stouffer & al. 2007; Stouffer & al. 2012

Exponential Random Graph Models (ERGM): process-based network modelling



Data input + model specification

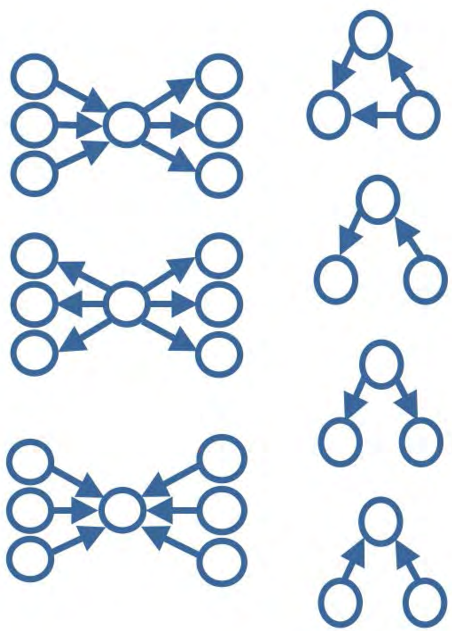
Estimation: search for parameter values

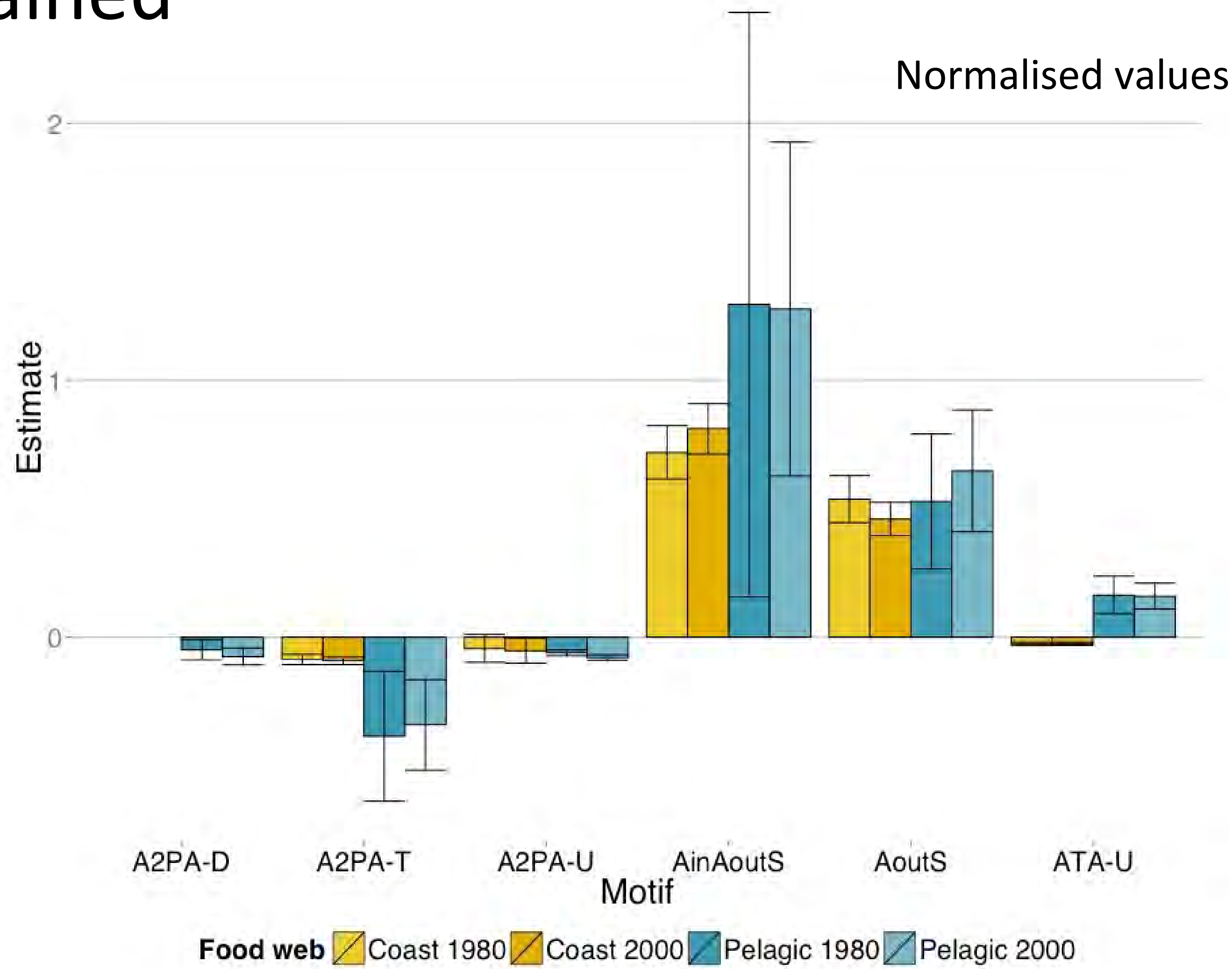
Model convergence + GoF

EFFECT	PARAMETER	SE	T-RATIO	
ArcA	-5.7522	2.643	-0.022	*
AinSA	2.1638	0.87	-0.028	*
AoutSA	0.7339	0.703	-0.028	
AinAoutSA	2.2518	0.987	0.037	*
ATA-U	0.2741	0.189	0	
A2PA-T	-0.617	0.108	0	*
A2PA-U	-0.1099	0.068	-0.023	

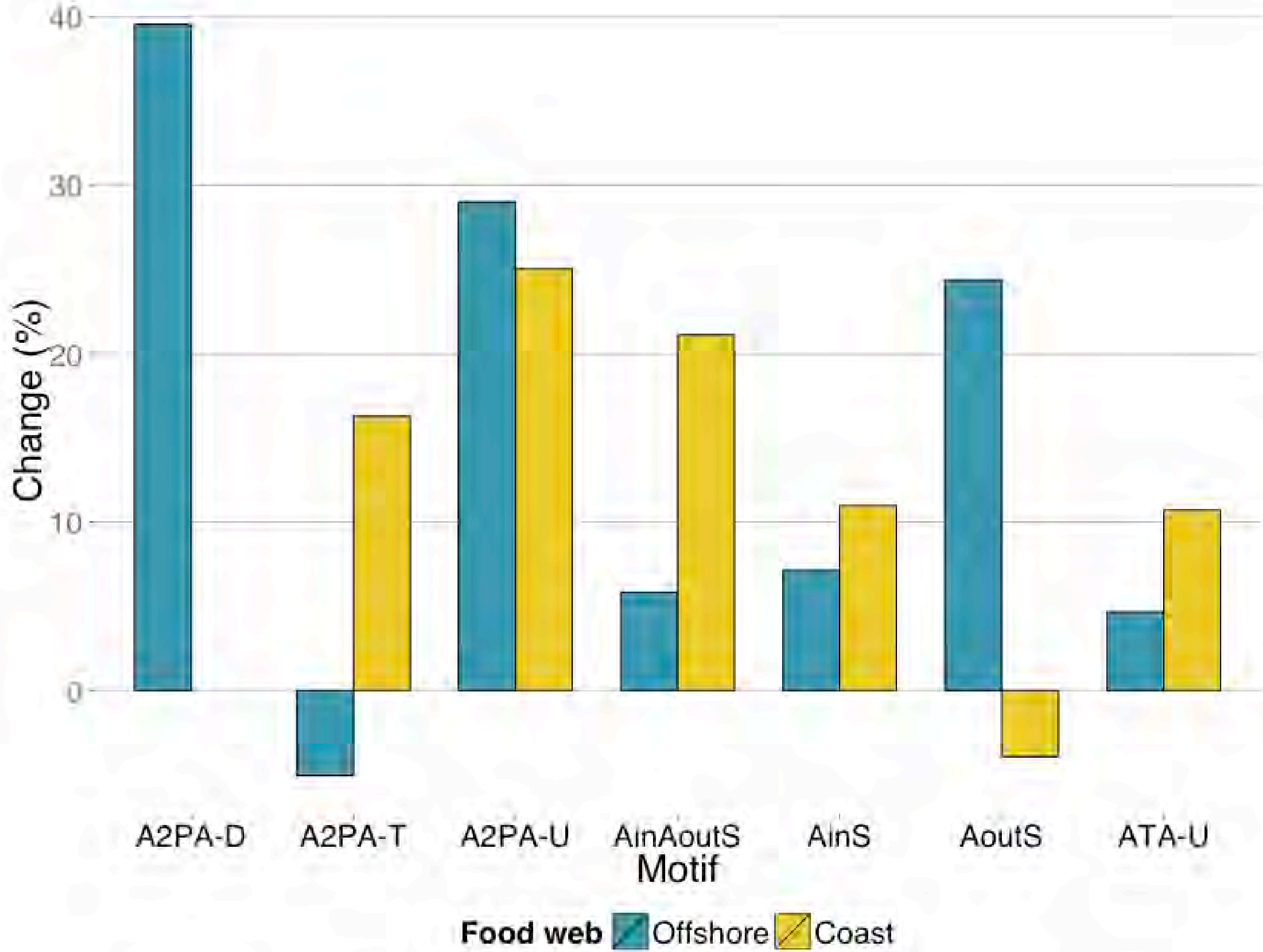
Results: statistical models disentangling the structure of the Baltic Sea food webs

6-7 motifs basis for all Baltic Sea food webs; the same dominant ecological processes have remained



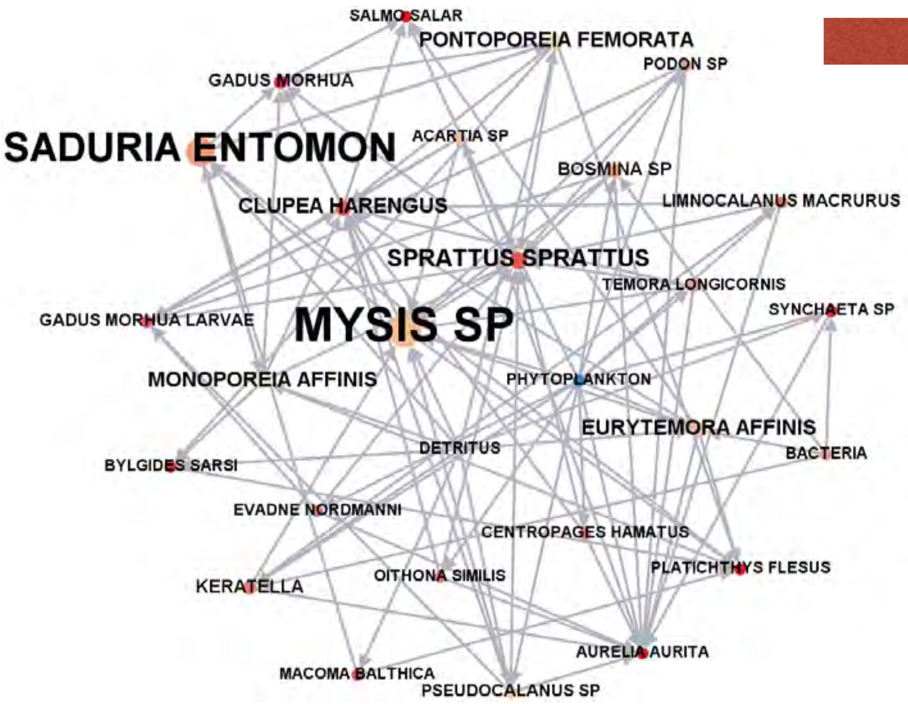


Motif effect has changed from 1980s to 2000s (before/after the regime shift)

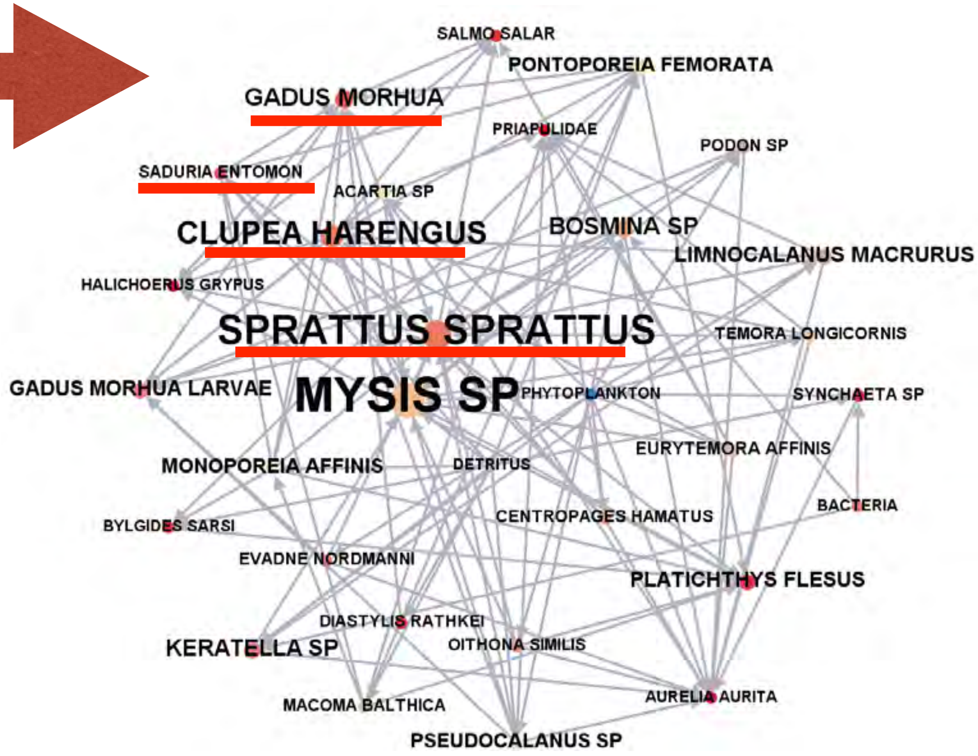


Linking back to species

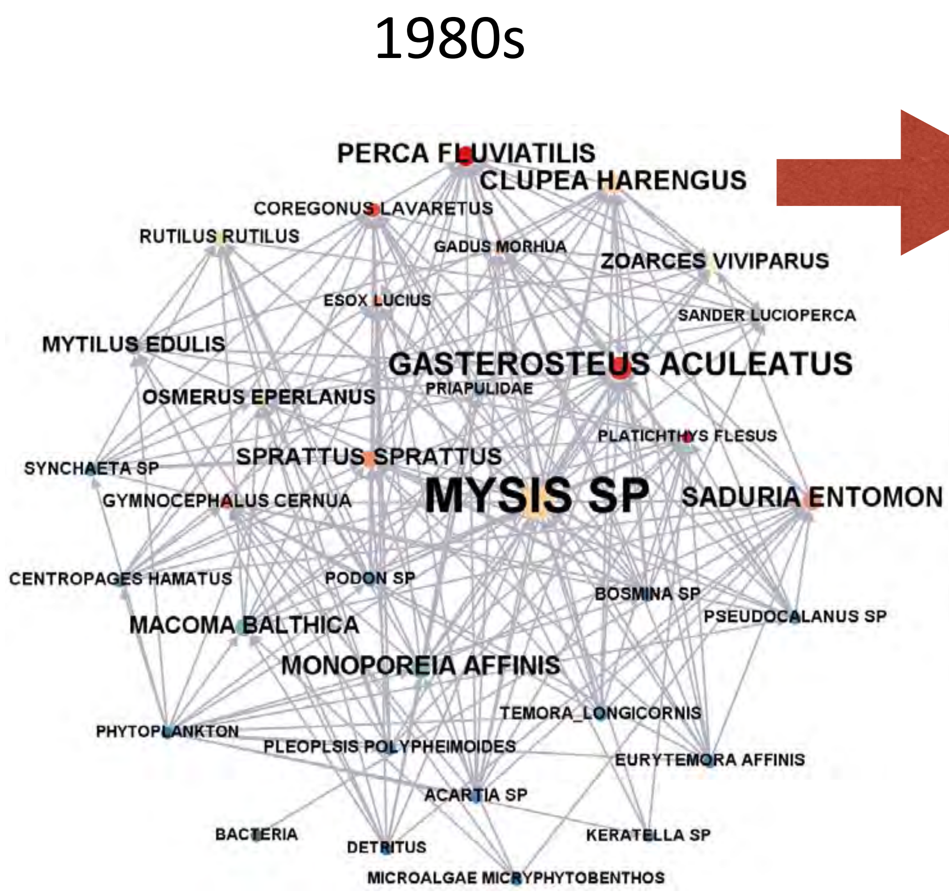
1980s

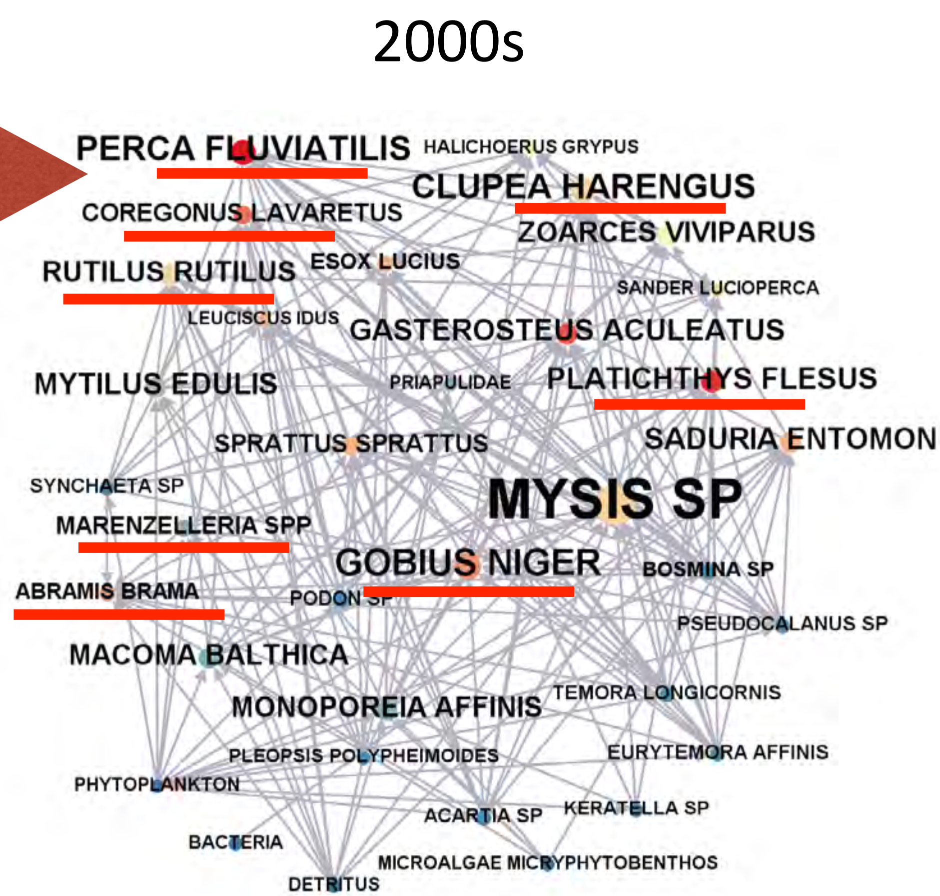


2000s



Linking back to species





Regime shifts may occur without change in ecological functions (prevalance of motifs)

- The Baltic Sea has been able to maintain the dominant ecological functions despite the changes in species community and environment.

- The magnitude of these functions has changed.

- Pelagic Baltic food web appears to be more resilient to changes in motif frequency.

ERGM: detailed models of food web state

- Enables testing what gives rise to food webs

- Statistical models which allow secondary effects

- Hypothesis testing

- Only a few substructures interpreted to traditional community ecology
- Key species?

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Stockholm University

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ÖRJAN BODIN

Åbo Akademi

ERIK BONSDORFF
BENJAMIN WEIGEL
MARIE NORDSTRÖM

Thank You!

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