A BAYESIAN DECISION NETWORK MODEL FOR ECOSYSTEM-BASED MANAGEMENT OF THE GEORGES BANK SOCIAL-ECOLOGICAL SYSTEM

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NOAA FISHERIES

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  - Gavin Fay
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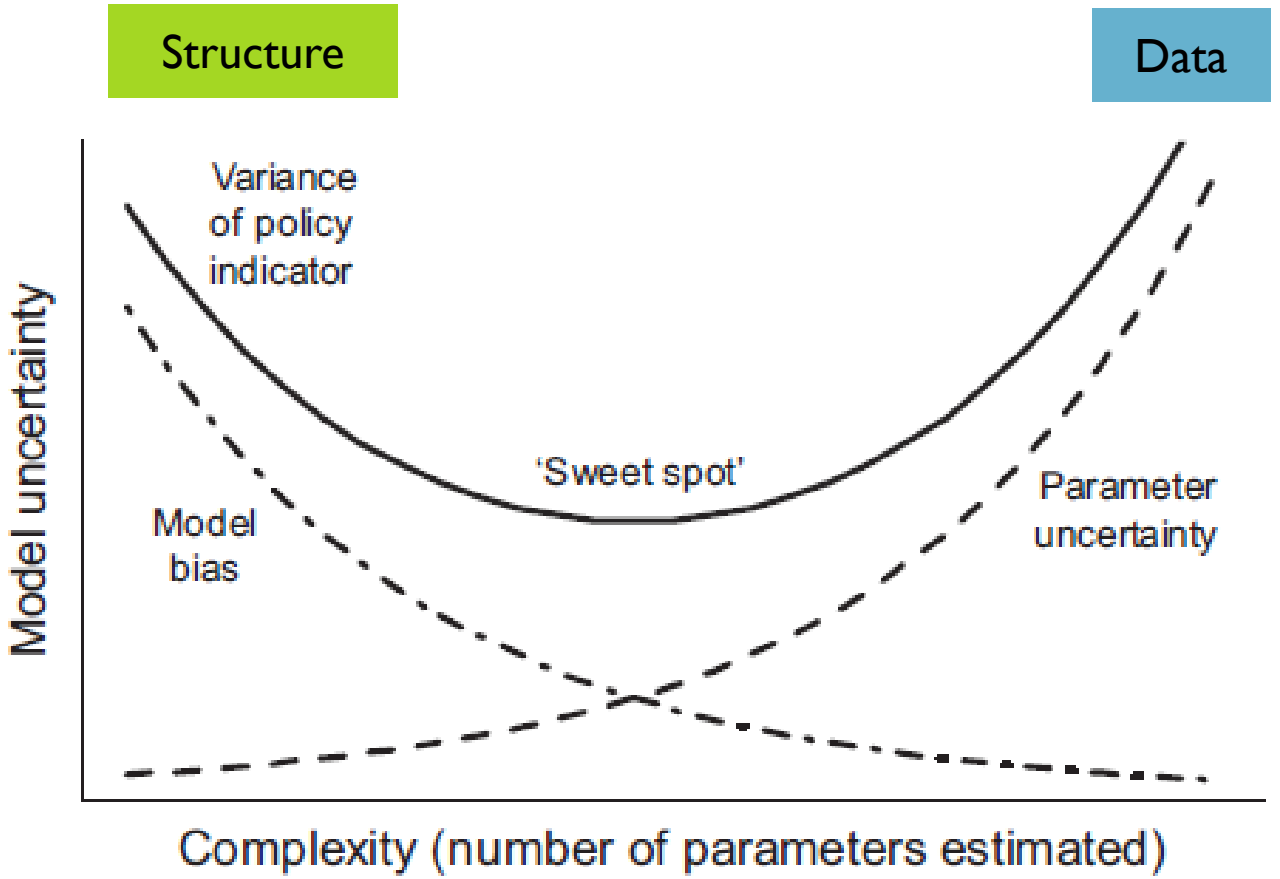
Social-ecological models

- Assess multiple management objectives
- Account for multiple interactions and components
- Integrate various sources of knowledge and information

integratedecosystemassessment.noaa.gov

Social-ecological models

- Assess multiple management objectives
- Account for multiple interactions and components
- Integrate various sources of knowledge and information
- Rely on:
  - Data availability
  - Understanding of relationships



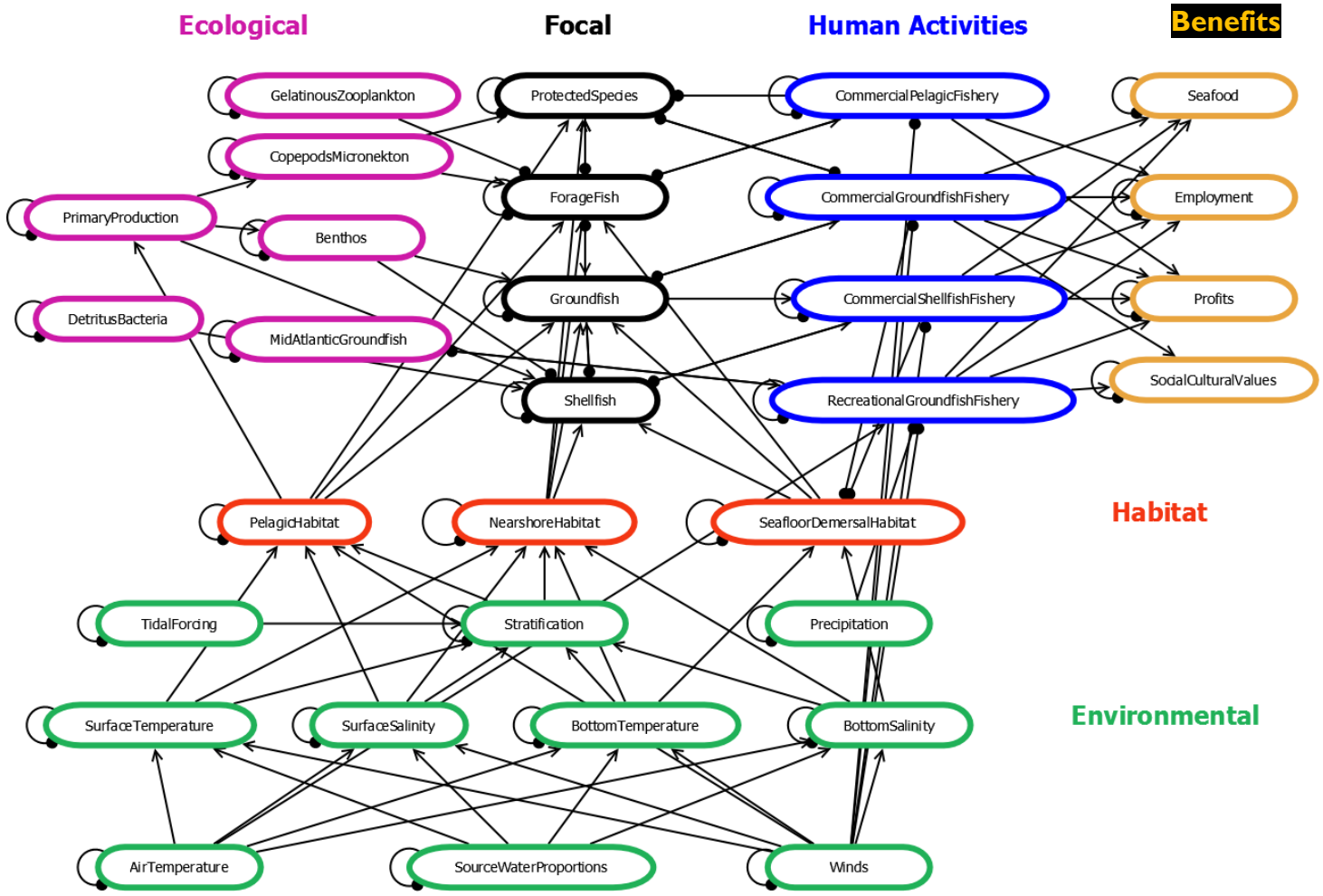
Collie et al. 2016 Fish Fish

CONCEPTUAL MODELS PROVIDE A FRAMEWORK

Structure

Caveats

- No statistics
- No dynamics
- Limited evaluation of uncertainty in interactions & structure



Georges Bank conceptual model

BAYESIAN NETWORKS BUILD ON THE FRAMEWORK

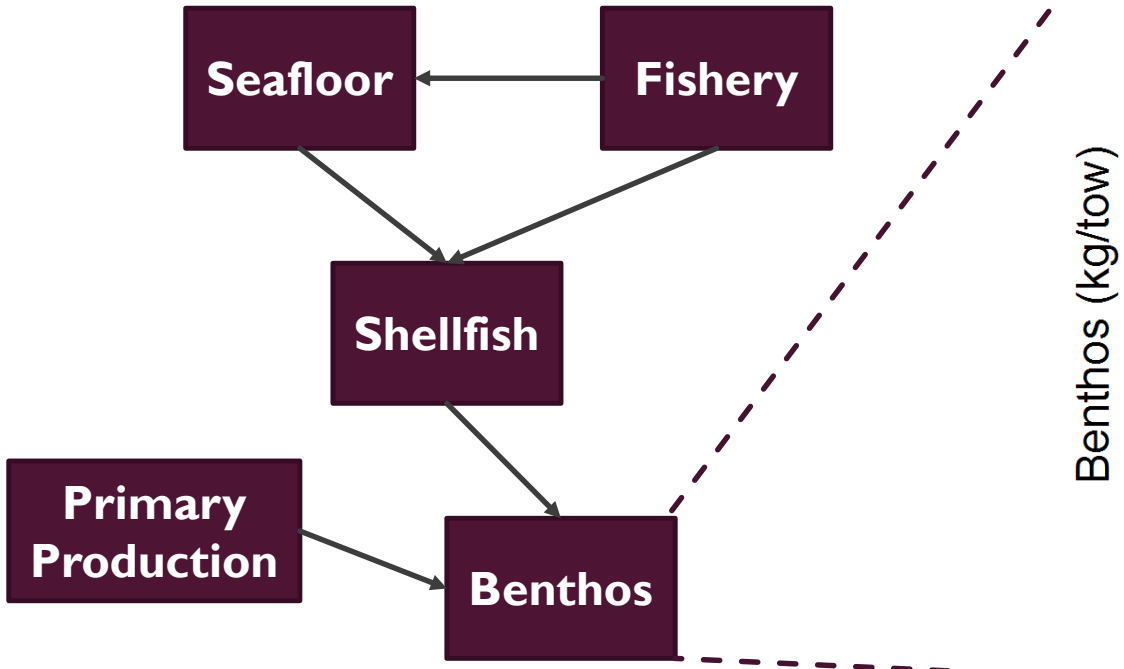
Bayesian networks provide:

- A systems approach
- Measures of statistical error around variables of importance to management
- Cross-disciplinary inclusion of
  - Expert knowledge
  - Monitoring data
- Visualization of influences

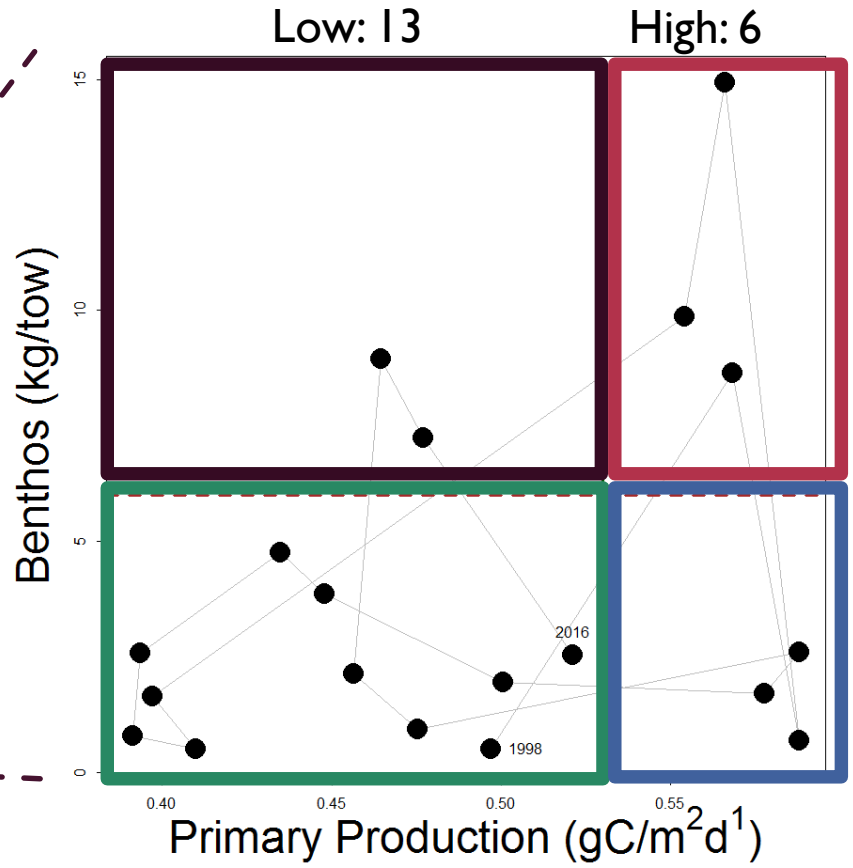
Bayesian networks reflect **uncertainty in interaction strengths** and **functional form**

Structure

Influence Diagram



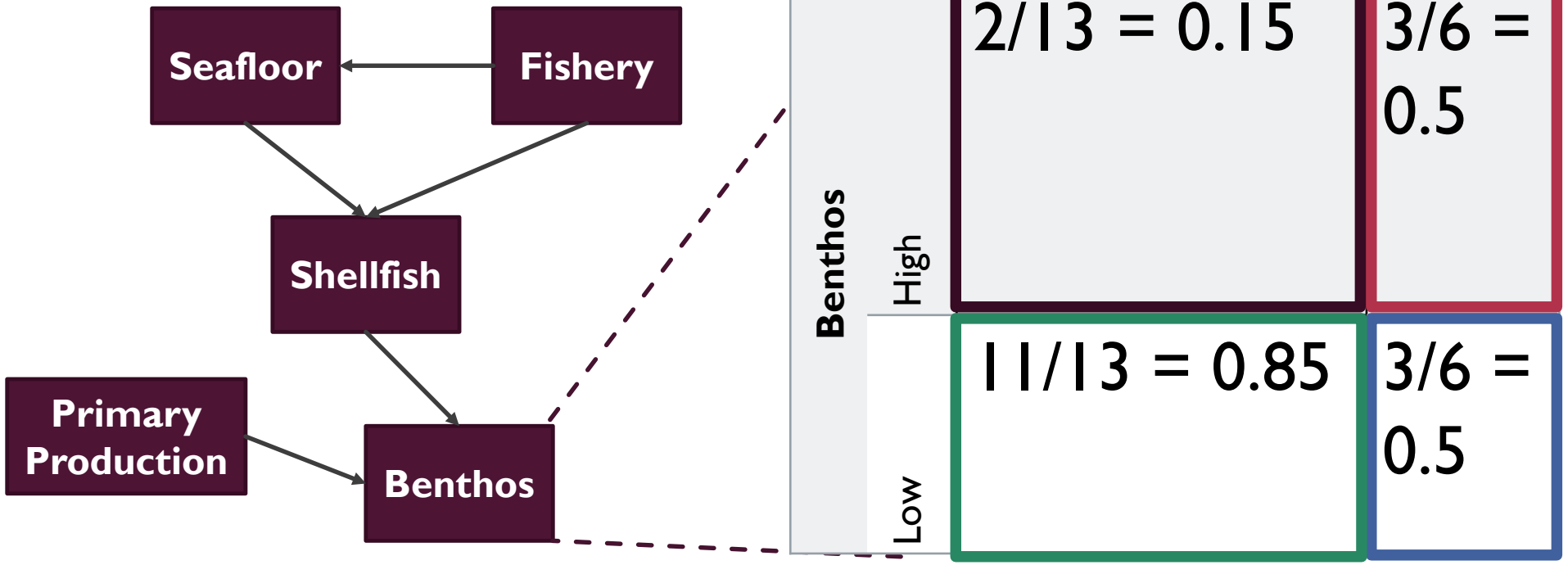
Data



Bayesian networks reflect **uncertainty in interaction strengths** and **functional form**

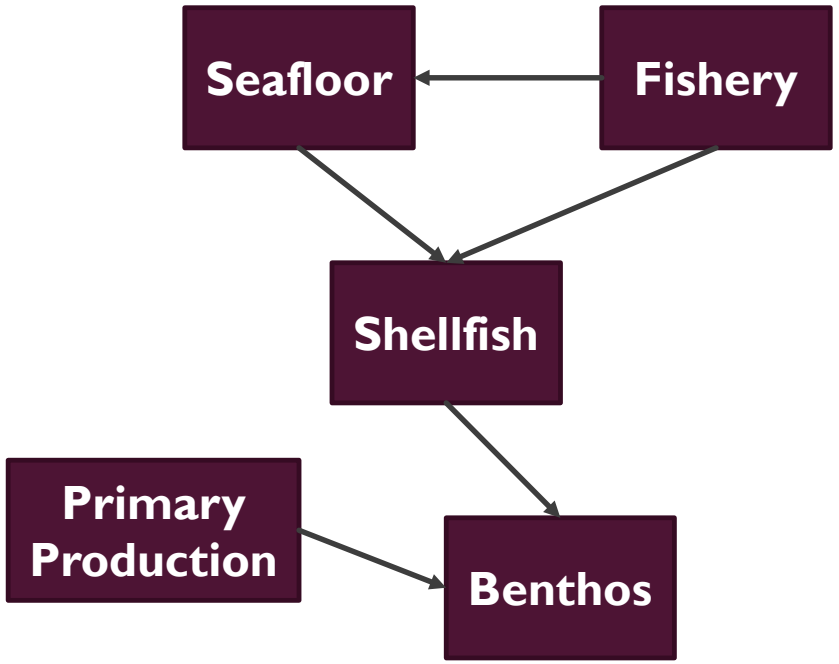
Structure — Influence Diagram

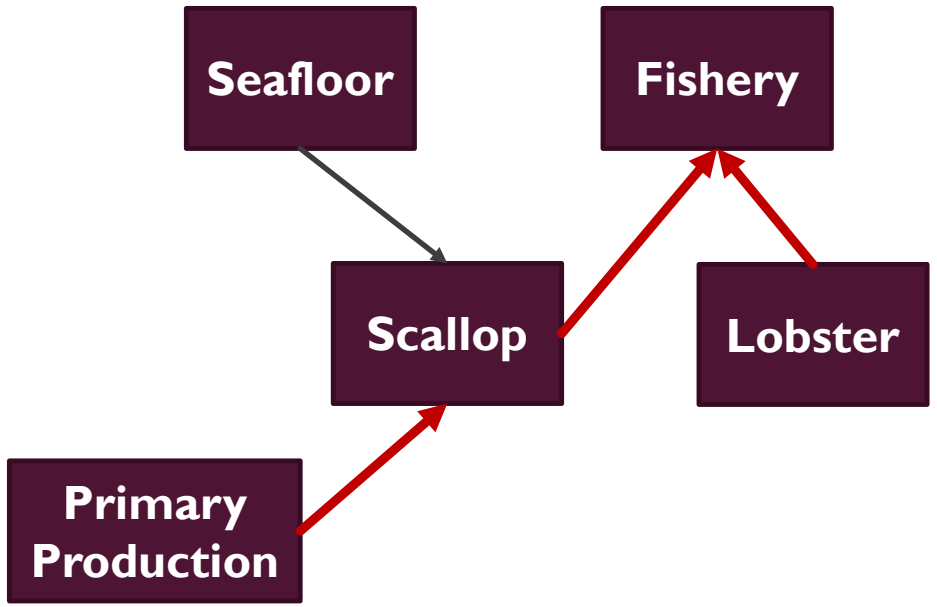
Data — Conditional Probability Table (CPT)



Bayesian networks reflect uncertainty in **structure**

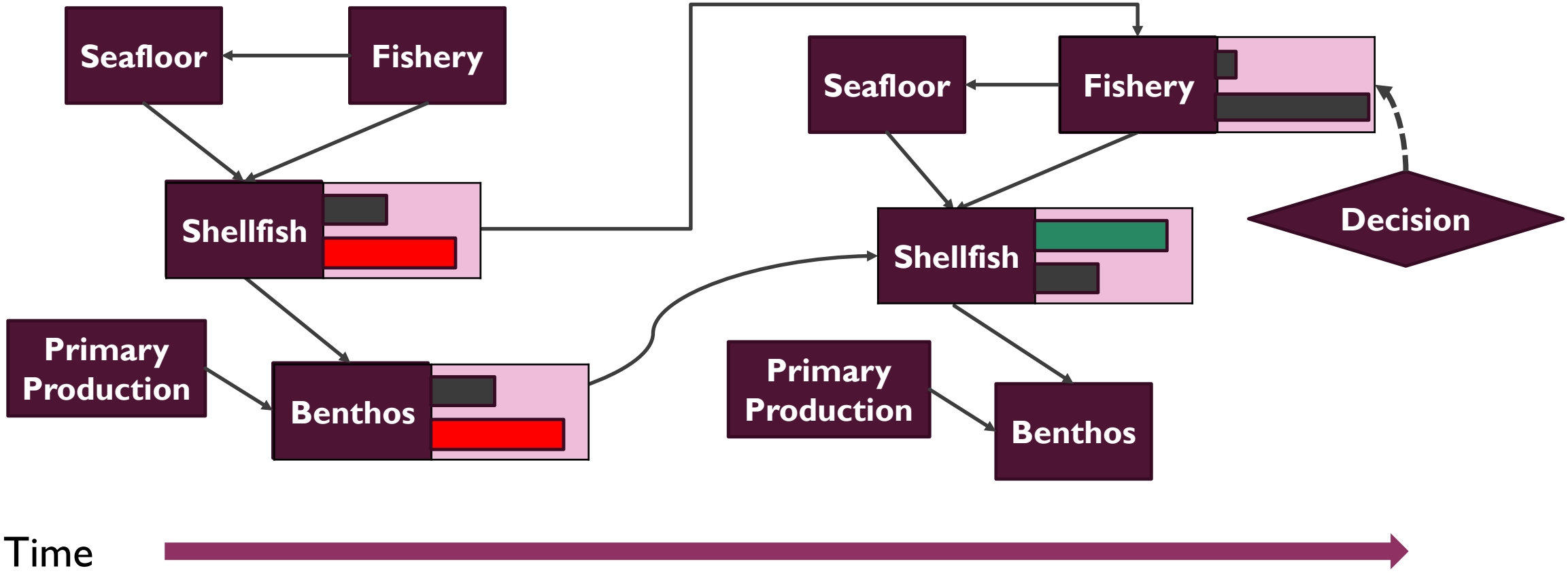
Structure





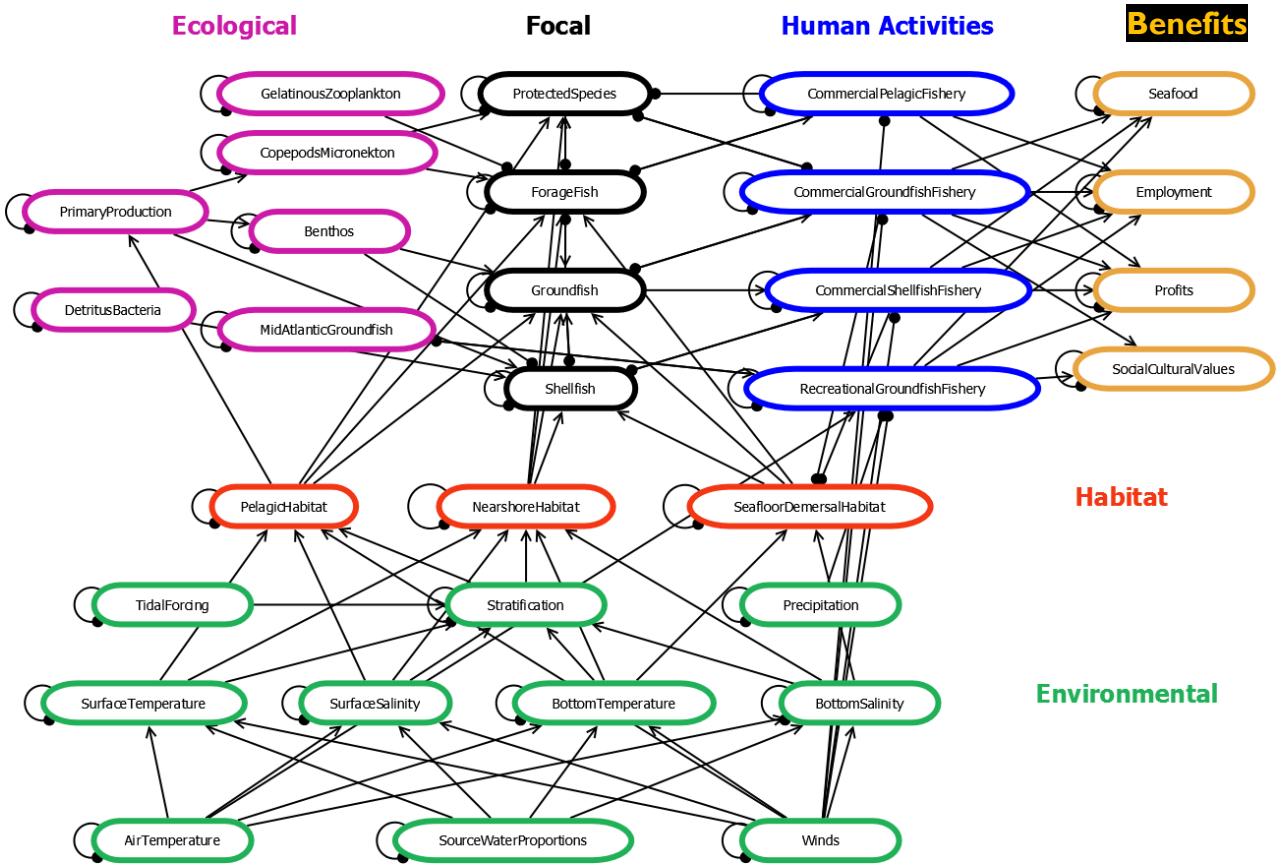
Dynamic Bayesian networks allow **prediction** of effects of management actions

Structure



Georges Bank case study

Data



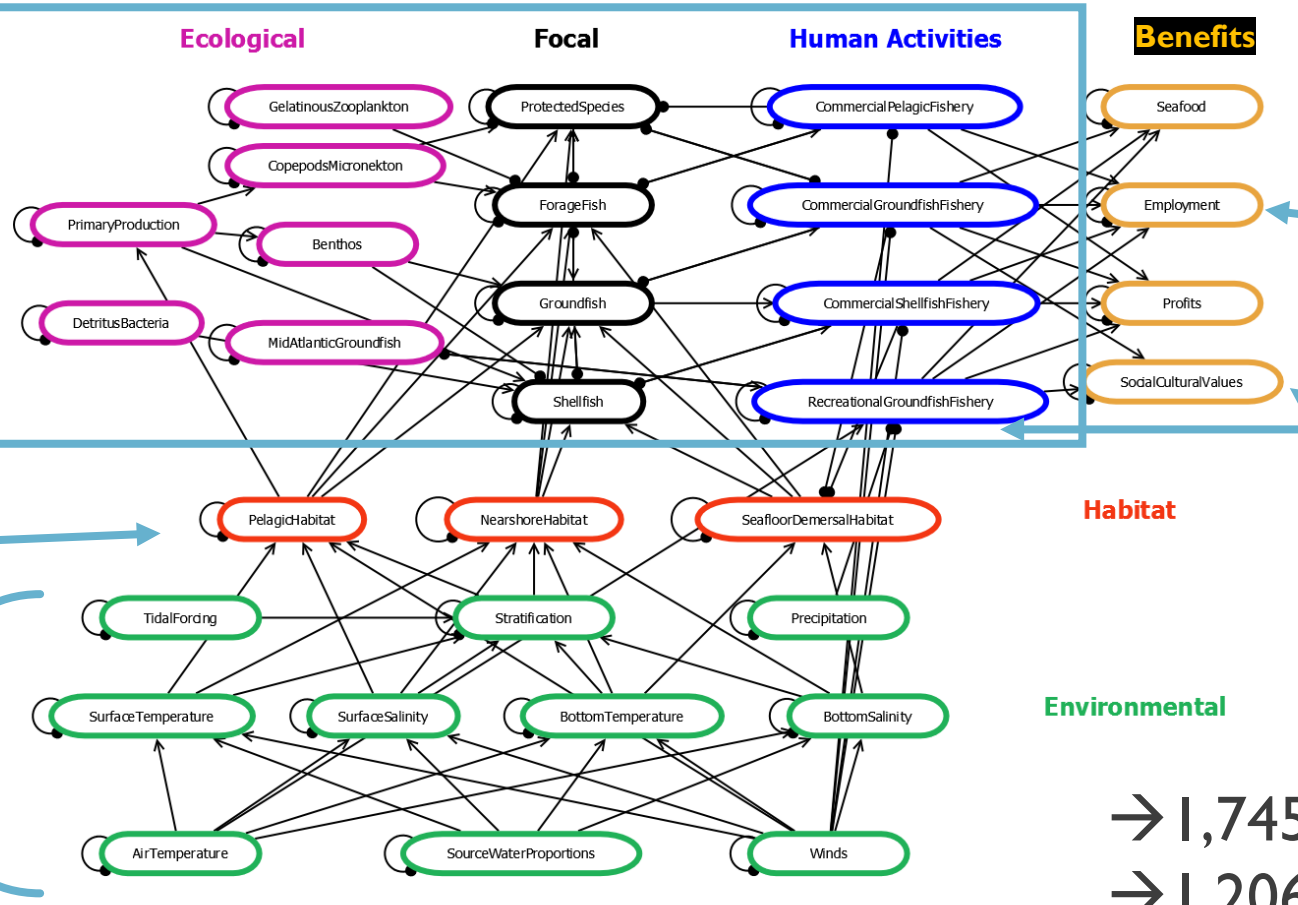
Georges Bank case study – 58 yrs

Data

Northeast Fisheries Science Center & State of Ecosystem report

Published literature & State mapping products

NOAA modeled products



NMFS Social Science Branch

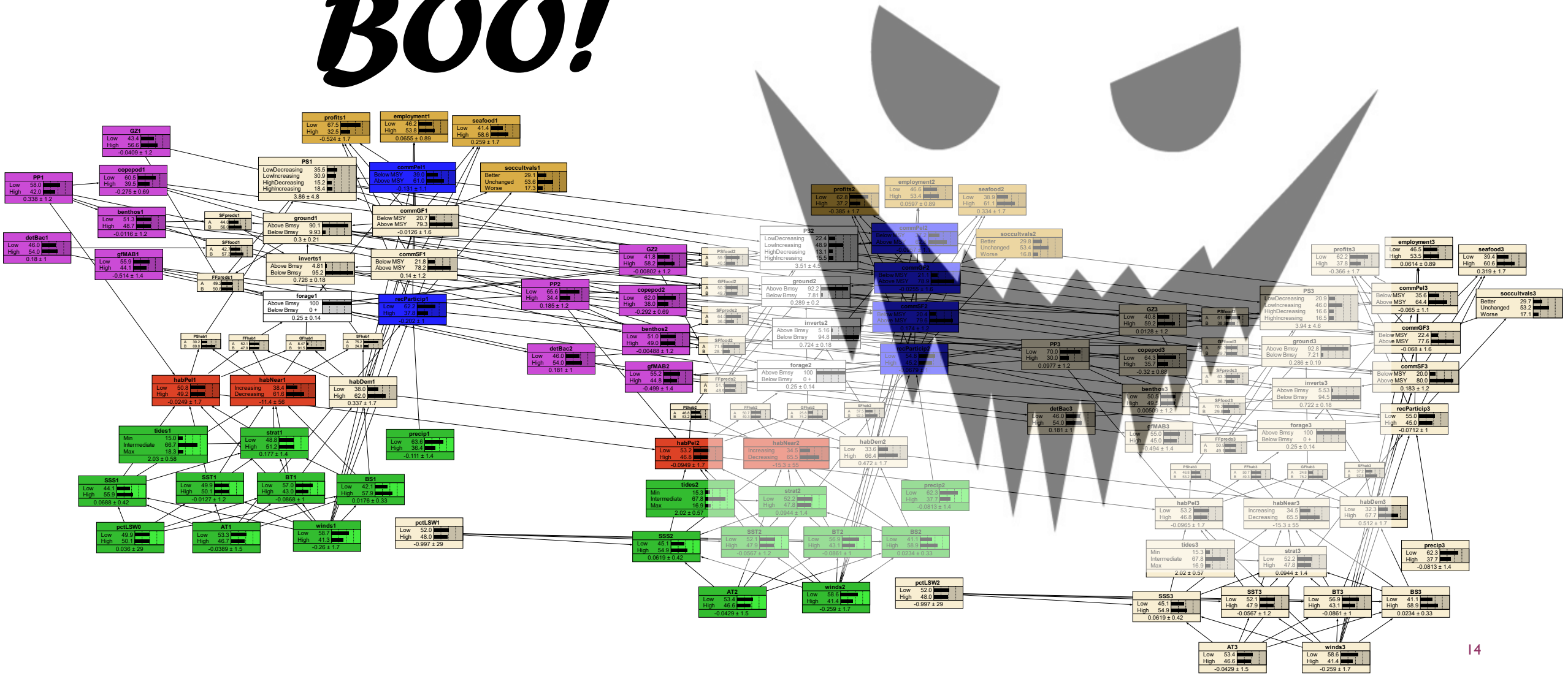
Survey of social science experts

→1,745 parameters

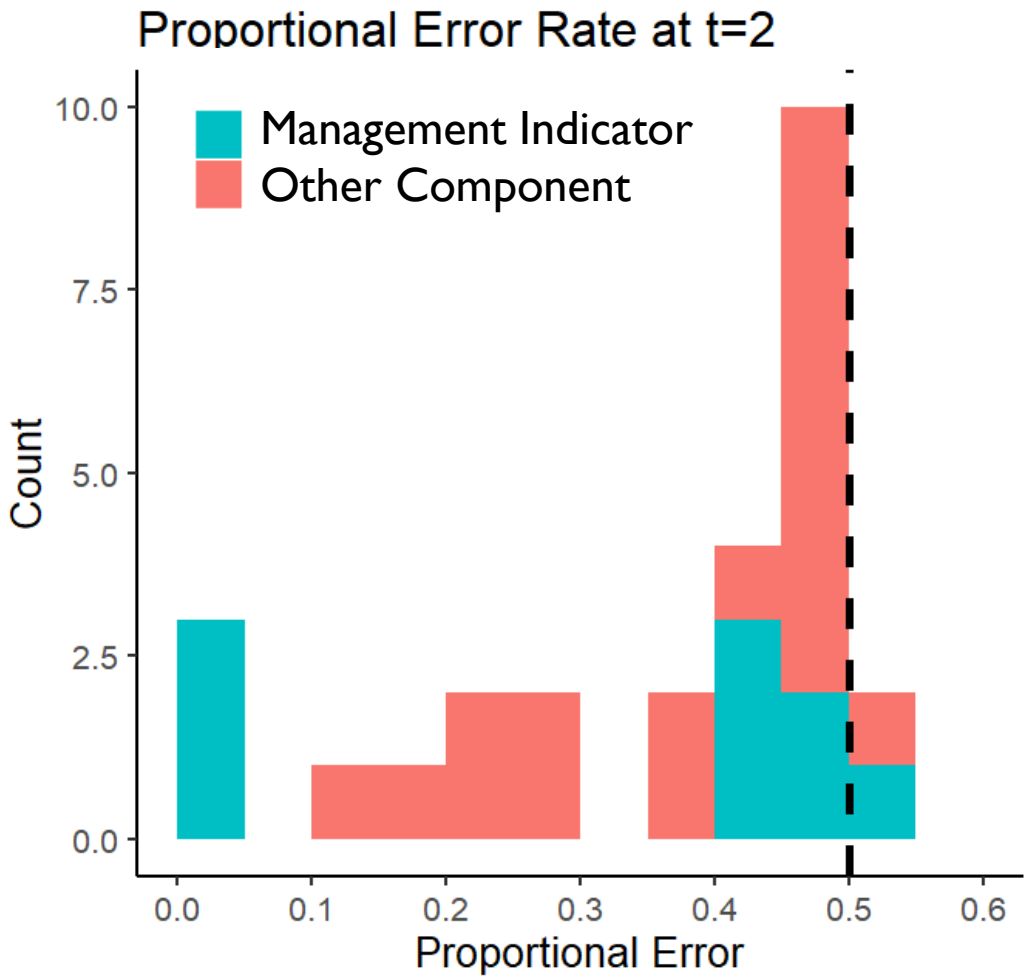
→1,206 data points

WELLAMO RESULTS

BOO!



Wellamo dynamics and model fit



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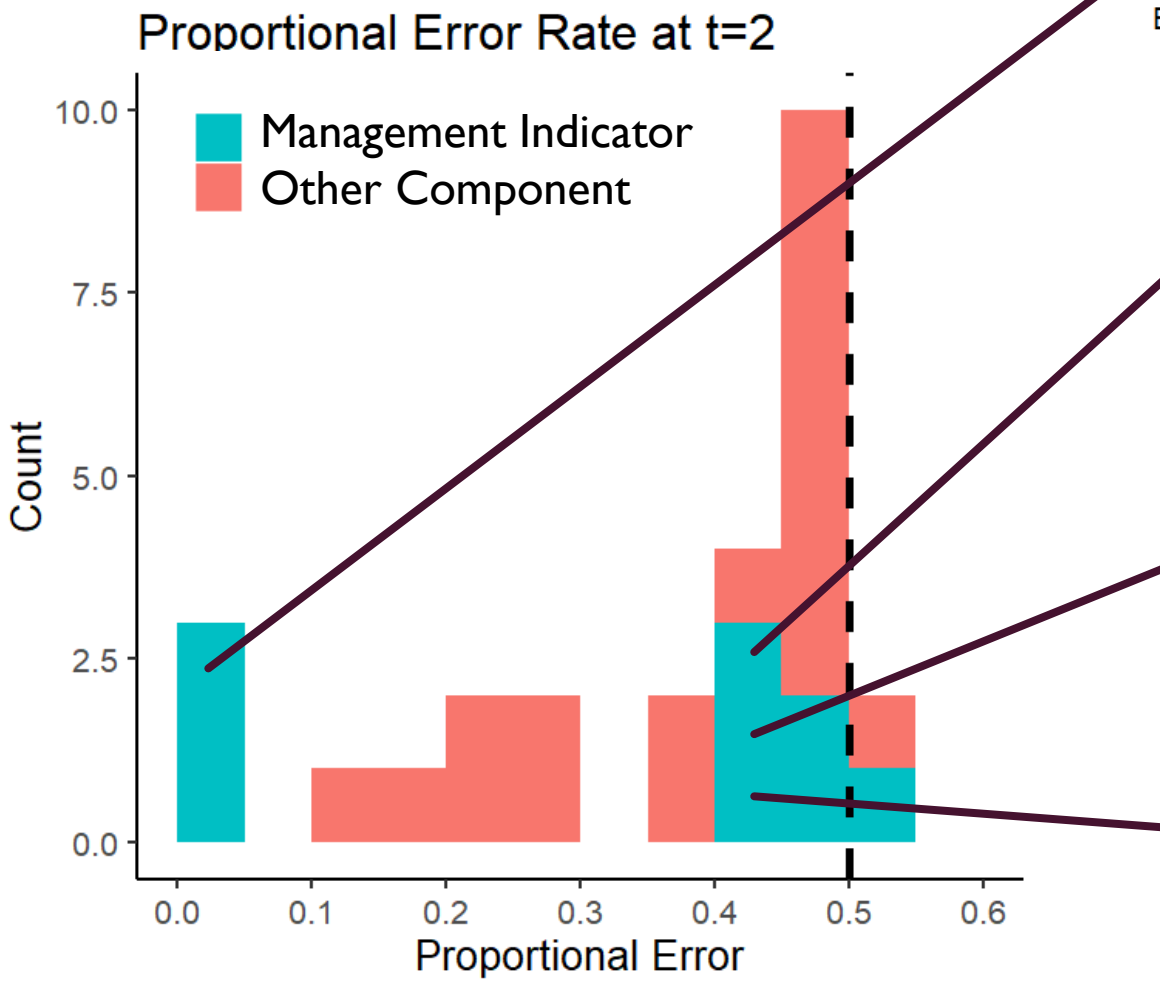
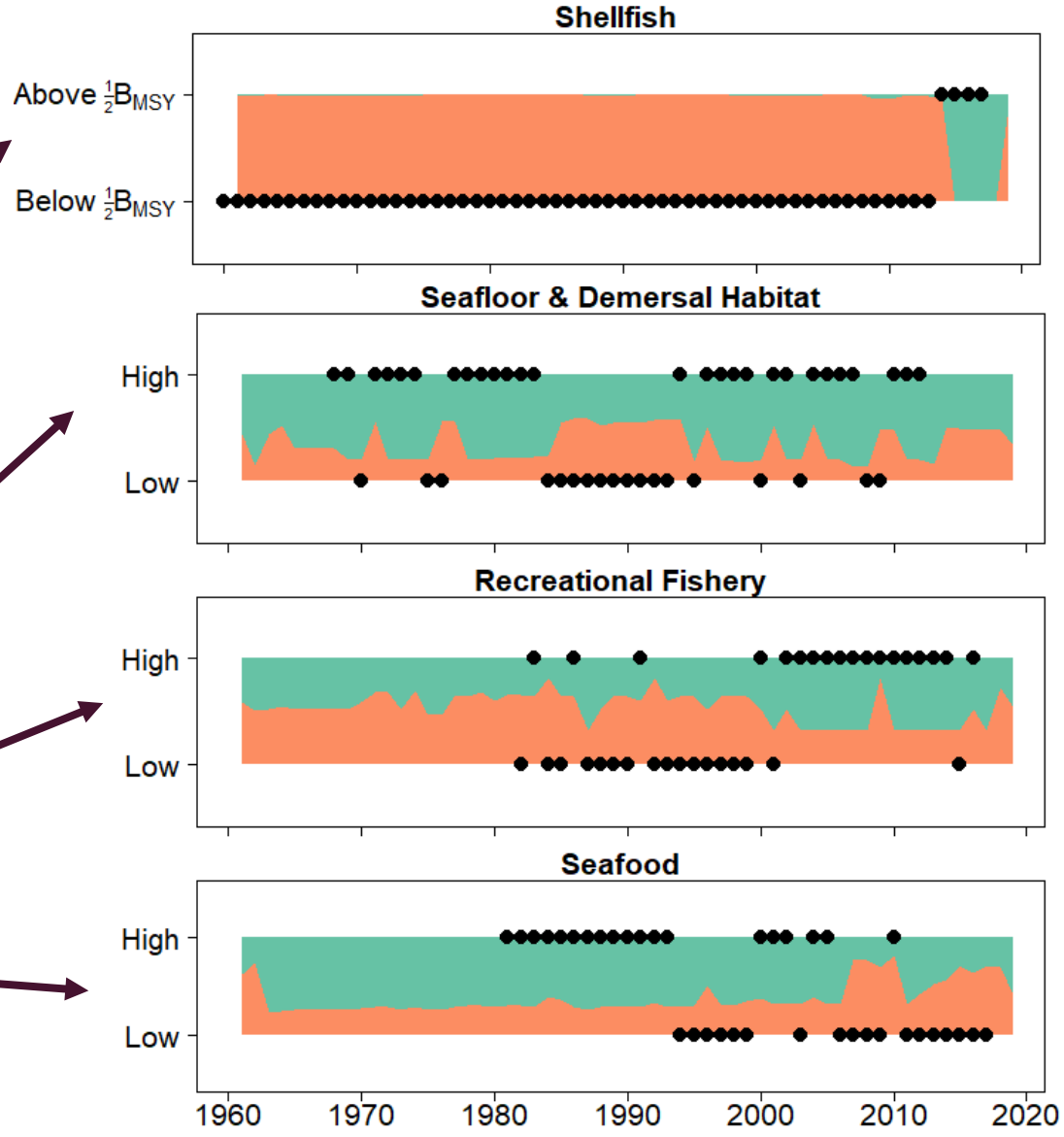
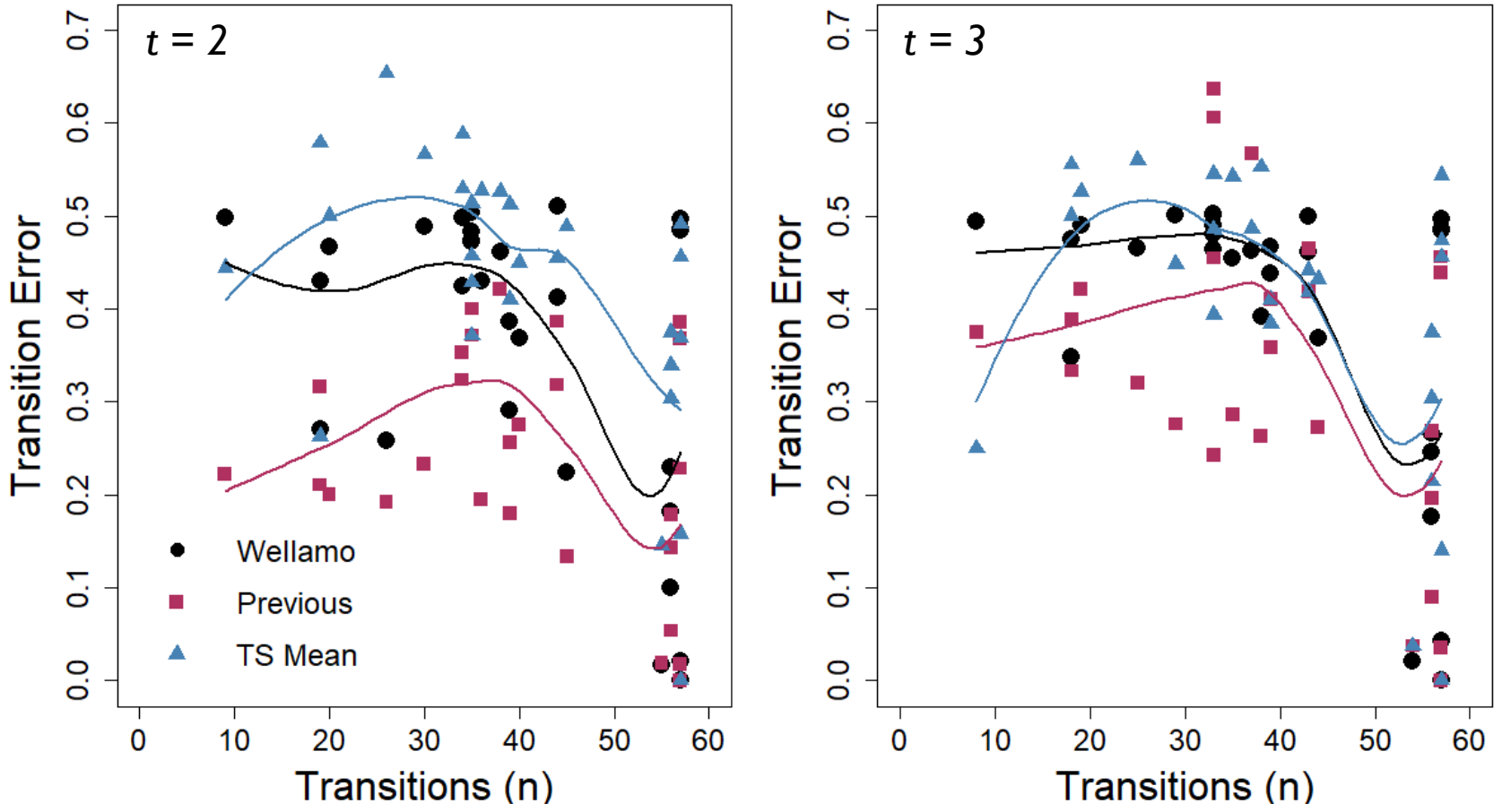




Wellamo predictive performance

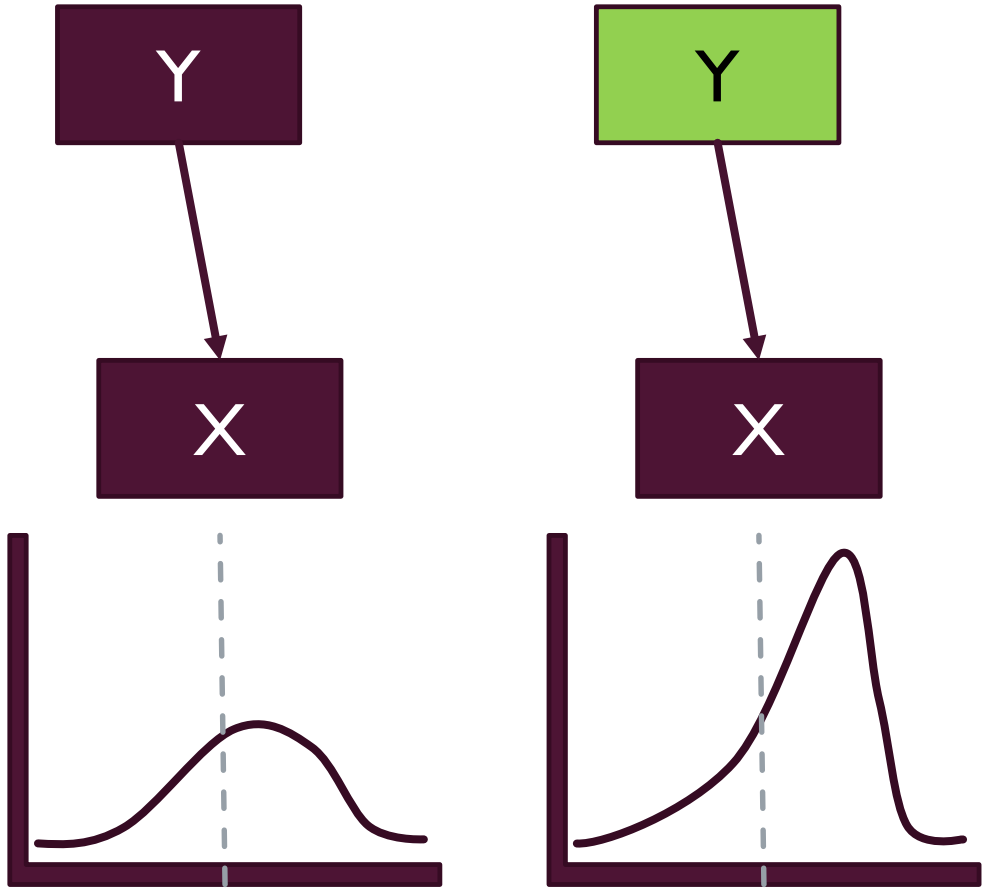
Data

- Predictions using previous observed state had lower error than *Wellamo*



Variance reduction indicates **potential leading indicators** and **indirect correlations**

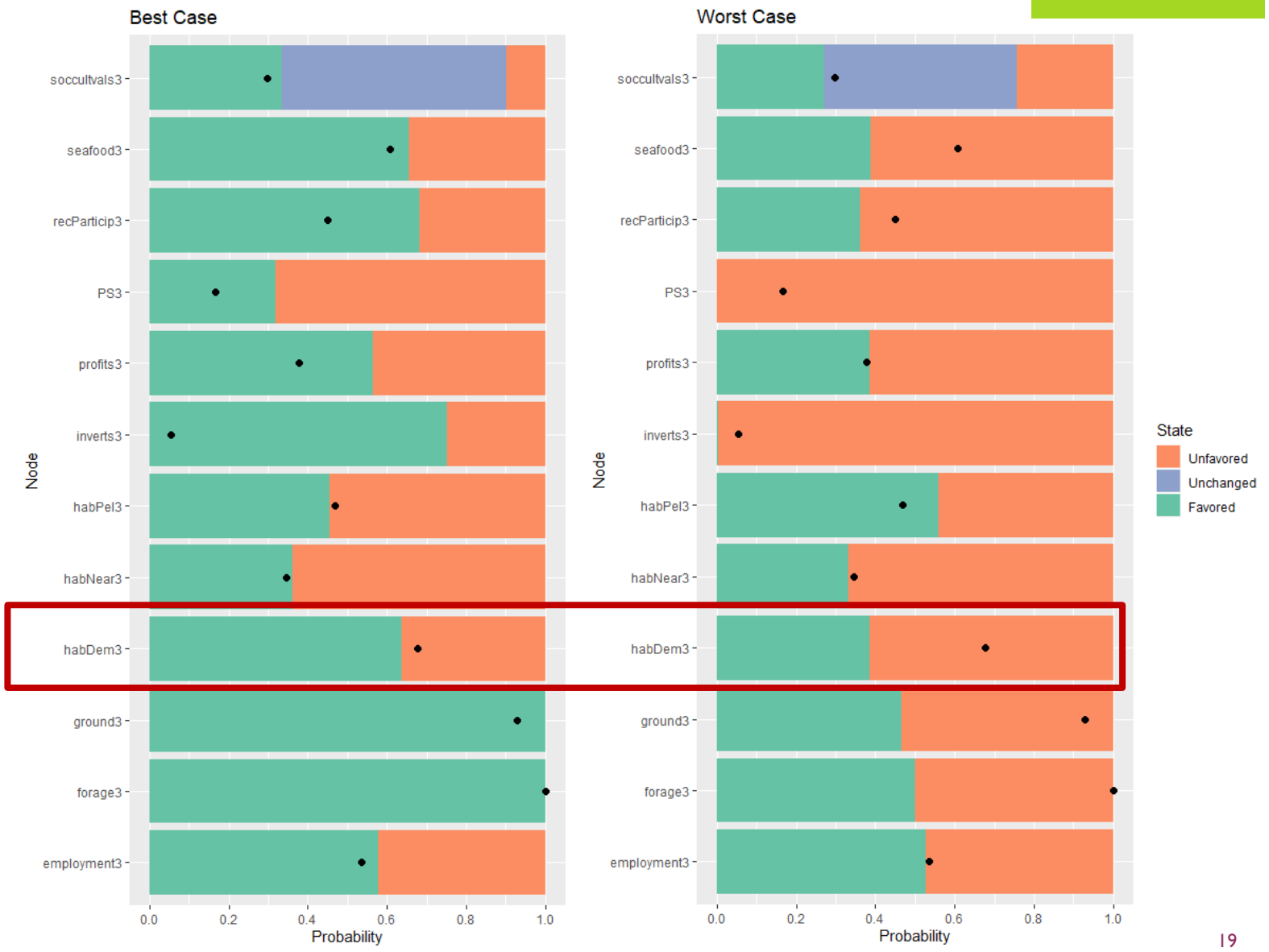
Structure



Findings Node	Queried Node	VR	VR %
$Benthos_{t=1}$	$Shellfish_{t=3}$	0.00073	2.2%
$PP_{t=1}$	$Shellfish_{t=3}$	0.00049	1.5%
$GFFishery_{t=1}$	$Seafood_{t=2}$	0.11	3.7%
$Winds_{t=1}$	$Seafood_{t=2}$	0.032	1.1%
$MidAtlGF_{t=2}$	$Profits_{t=3}$	0.048	1.7%
$RecFish_{t=3}$	$Profits_{t=3}$	0.57	19.9%
$Profits_{t=3}$	$RecFish_{t=3}$	0.22	20.2%

Influence analysis can reveal **unexpected outcomes**

- 12 "What-if scenarios"
- Dot indicates posterior predicted probability of favored state
- Demersal Habitat reduced in Best Case scenario



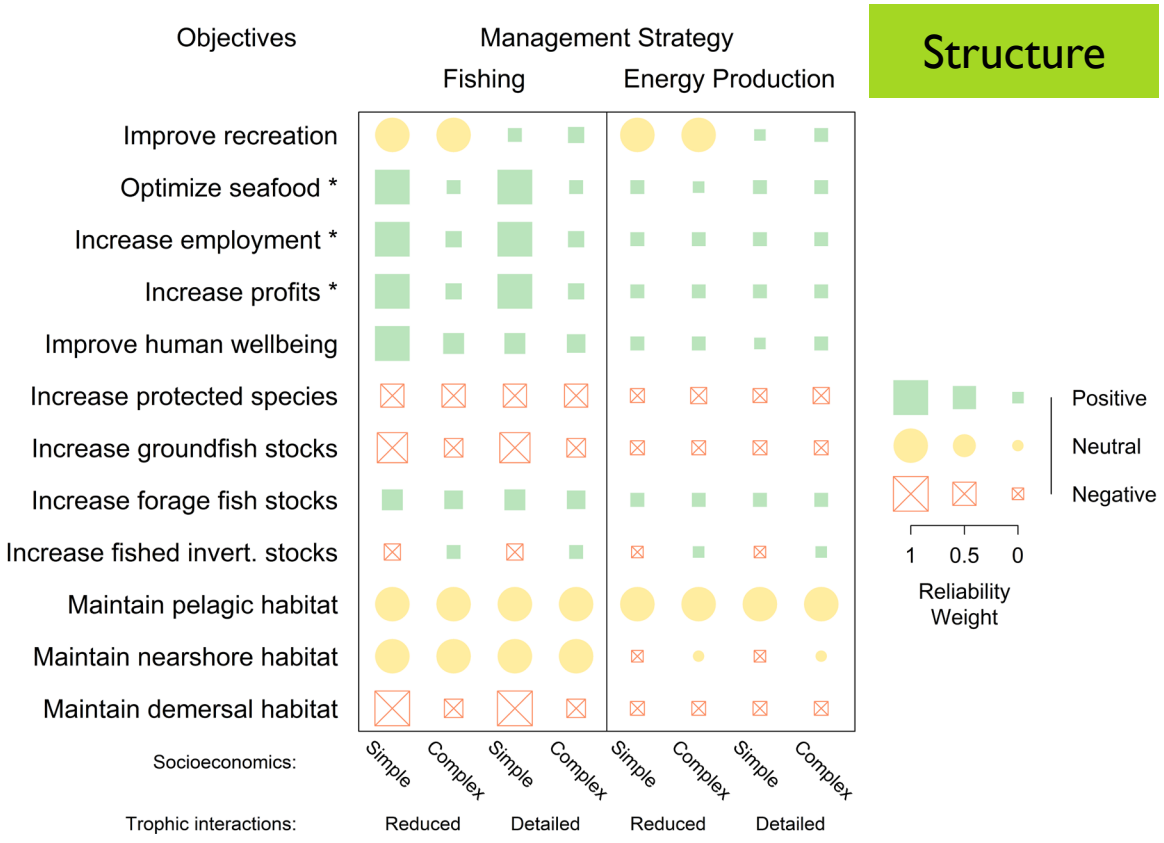
TAKE-HOME MESSAGES

- Additional correlation between Recreational Fishing and Profits
- Overall, ~70% of observed data predicted accurately
- These may be driven by autocorrelation in the time series
- Unexpected outcomes for Seafloor & Demersal Habitat in tested scenarios

NEXT STEPS: SENSITIVITY TO STRUCTURAL UNCERTAINTY

Hierarchical evaluation:

- State threshold choices (subset of nodes)
- Dynamic feedback structure
- Addition of trophic interactions
- Aggregation of Fishery component(s)



Wildermuth et al. 2018 CJFAS

THANK YOU!

I welcome comments and questions

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