Forecasting Climate Change Impacts on Marine Ecosystems and Fisheries using GCMs, Laboratory Experiments, & Ecosystem Modeling

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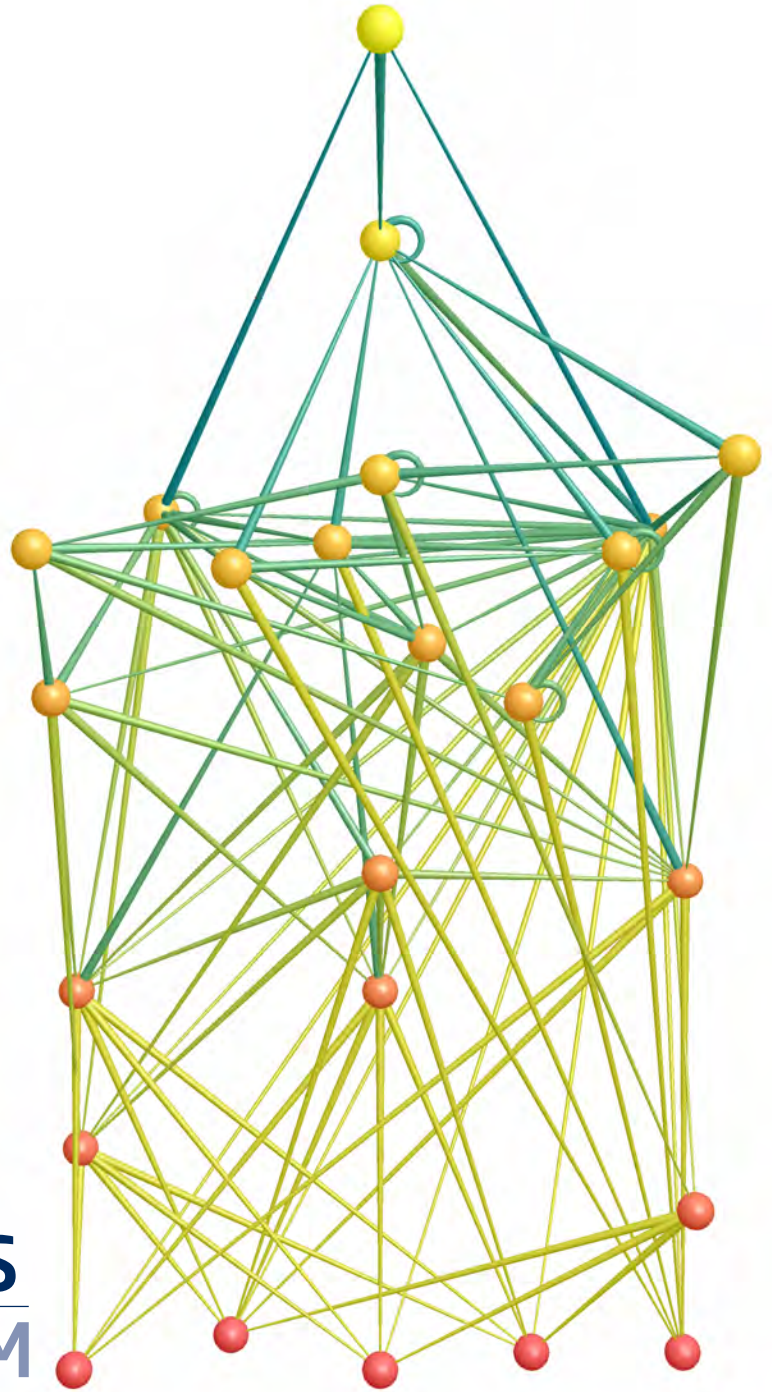


DALHOUSIE UNIVERSITY

ISI-MIP

ICES CIEM

Inter-Sectoral Impact Model Intercomparison Project (ISI-MIP)

RCP climate projections
global: CMIP5
regional: CORDEX

Socio-economic input
SSP populationa & GDP

Impact models global & regional

agriculture
natural ecosystems
coastal infrastructure
energy
water
permafrost
health
fisheries

- Synthesis of impacts at different levels of global warming
- Quantification of uncertainties
- Representation of extreme events
- Model improvement
- Cross-scale intercomparison

Global Circulation Models (GCMs)
- Climate data from 1950 - 2100

Ocean Social Pathways (OSPs)
- Socio-economic scenarios

Marine Ecosystem & Fisheries Models

ISI-MIP

FISH MIP

GLOBAL models

1. POEM
2. BOATS
3. EcoOcean
4. DBEM
5. Madingley
6. Macroecological model
7. DBPM
8. SS-DBEM
9. APECOSM
10. SEAPODYM

REGIONAL models

1. EwE (Ecopath with Ecosim)
2. Atlantis
3. OSMOSE
4. Size-structured
5. End-to-End

⇒ 20 models

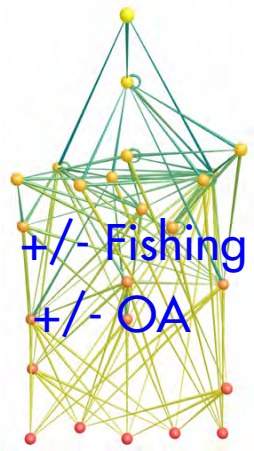
⇒ 13 regions

⇒ 5 regions with model overlap

Approach

Historical Climate PP
- IPSL CM5A
- GFDL reanalysis
- GFDL ESM2
- CESM BGC

Future Climate PP
- IPSL CM5A (RCPs 2.6, 4.5, 6.0, 8.5)
- GFDL ESM2 (RCP 8.5)
- CESM (RCP 8.5)



Ecopath with Ecosim (EwE) Foodweb Model for Cook Strait, New Zealand

Historical Ecosystem Sensitivity to PP & Fishing

Climate Impacts to Future Ecosystem

Global Circulation Models (GCMs) - Climate data from 1950 - 2100

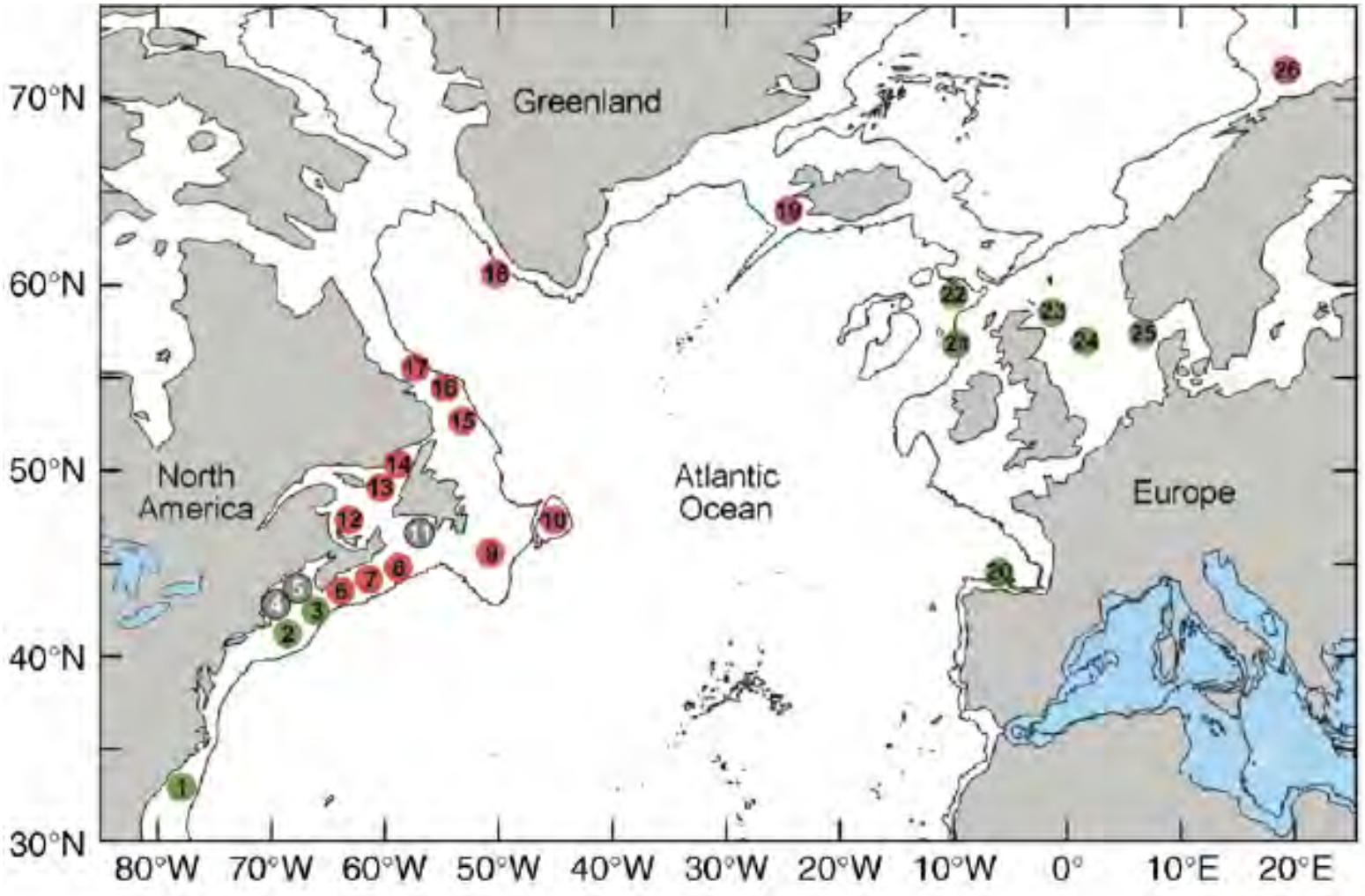
Ocean Social Pathways (OSPs) - Socio-economic scenarios

Marine Ecosystem & Fisheries Models

ISI-MIP

FISH MIP

Bottom-up vs. Top-down Control



● = Top-down

● = Bottom-up

○ = Both

Frank et al. 2007, Trends in Ecology & Evolution

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Lobsters as keystone: Only in unfished ecosystems?

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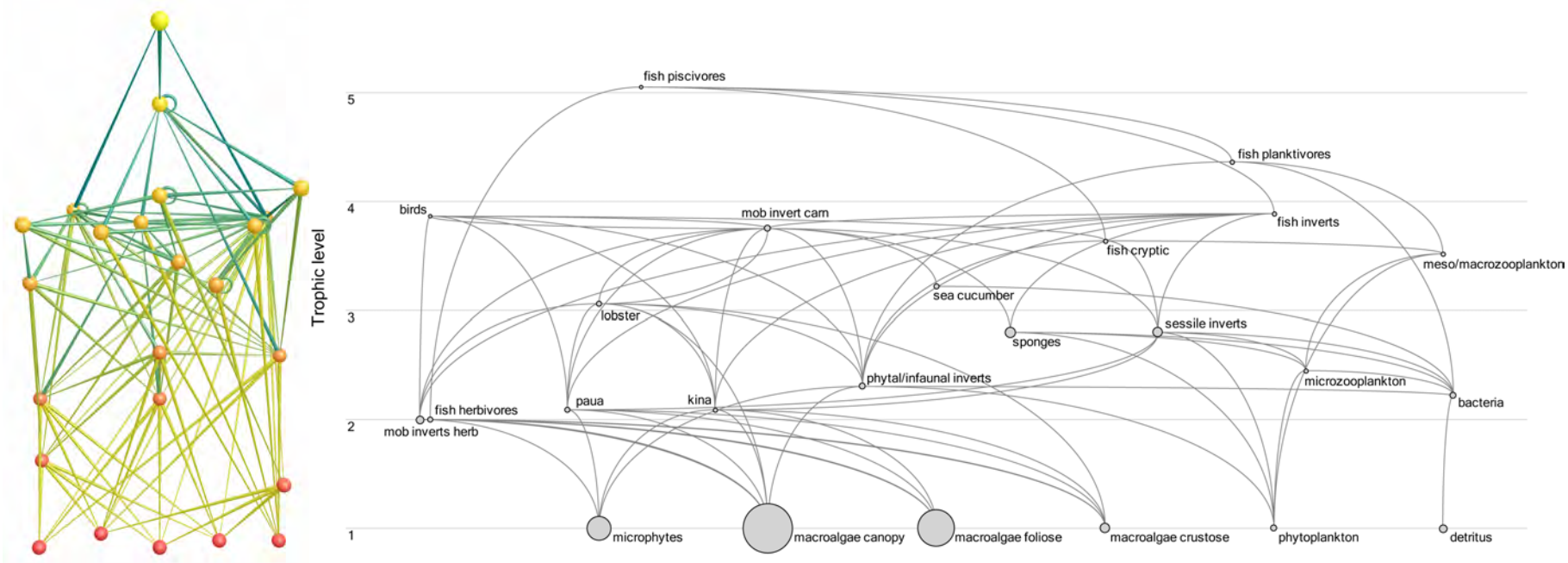
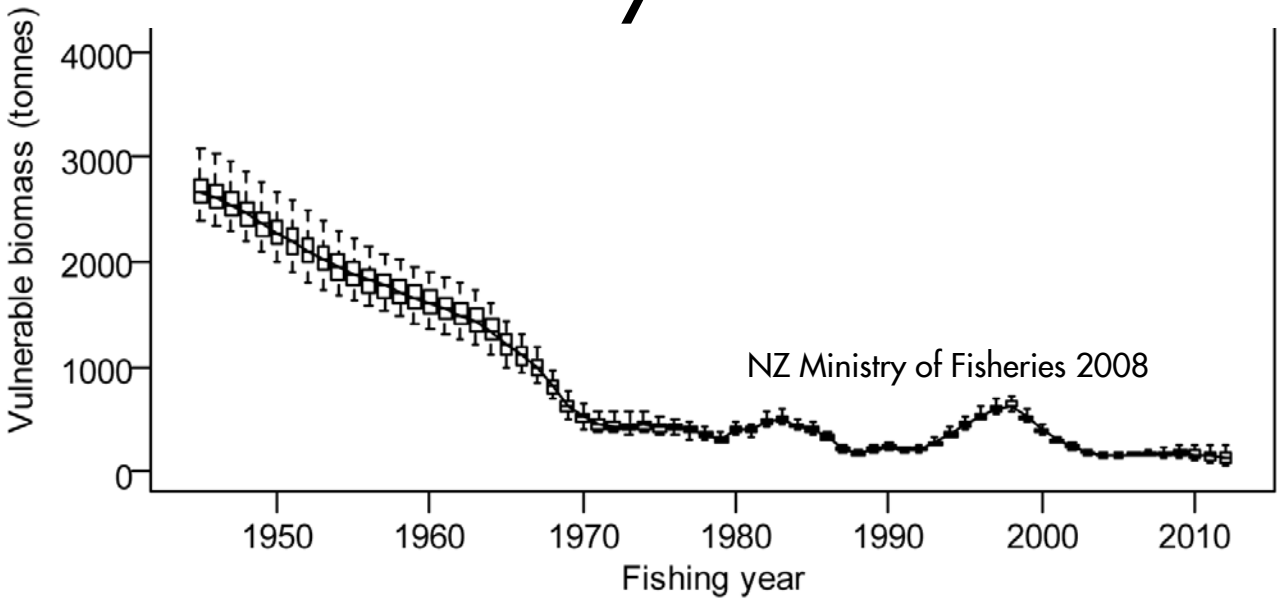
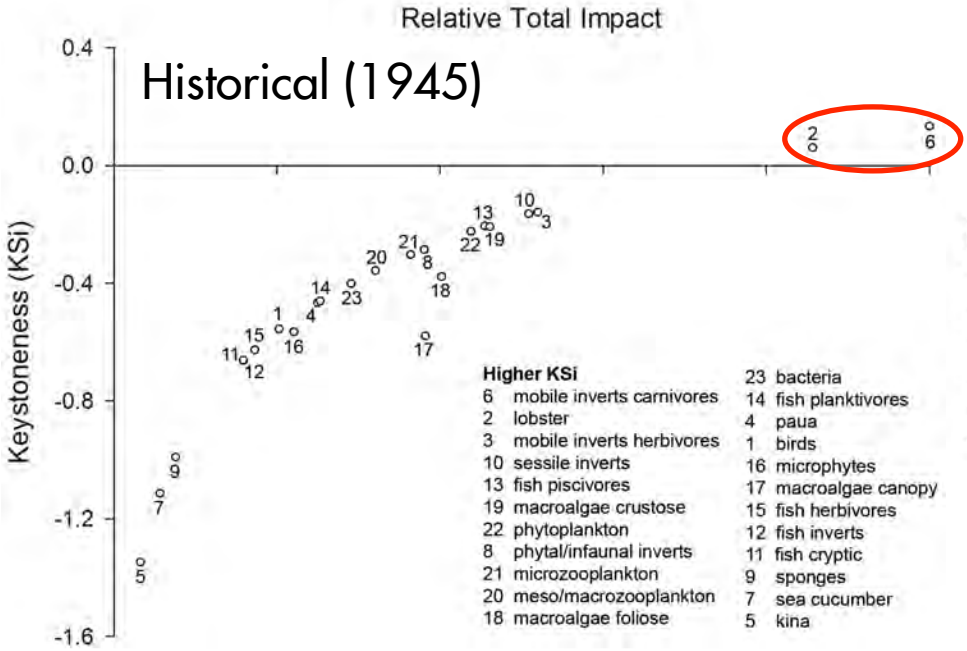
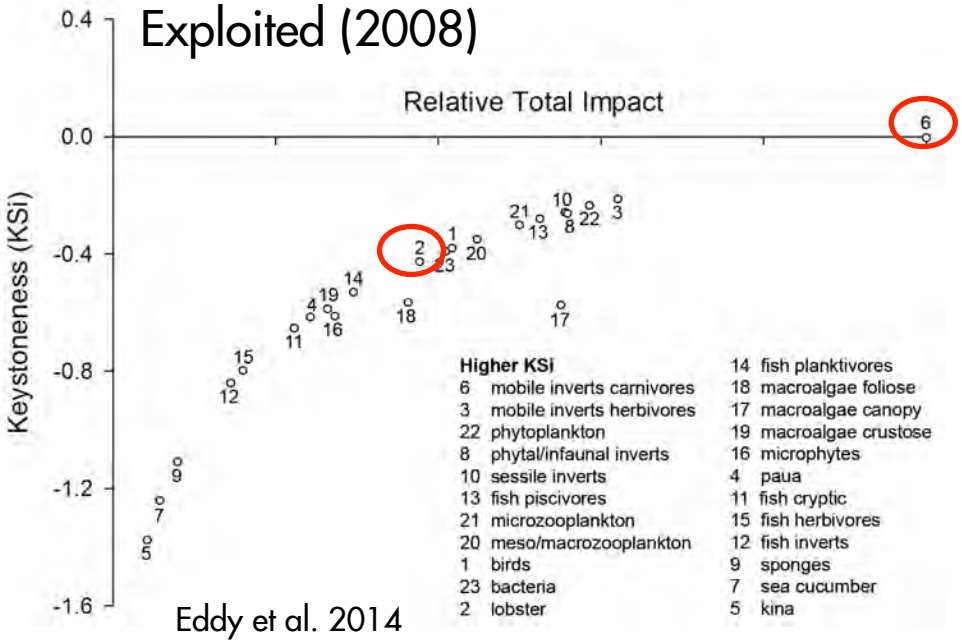


Ecosystem Role of Lobster



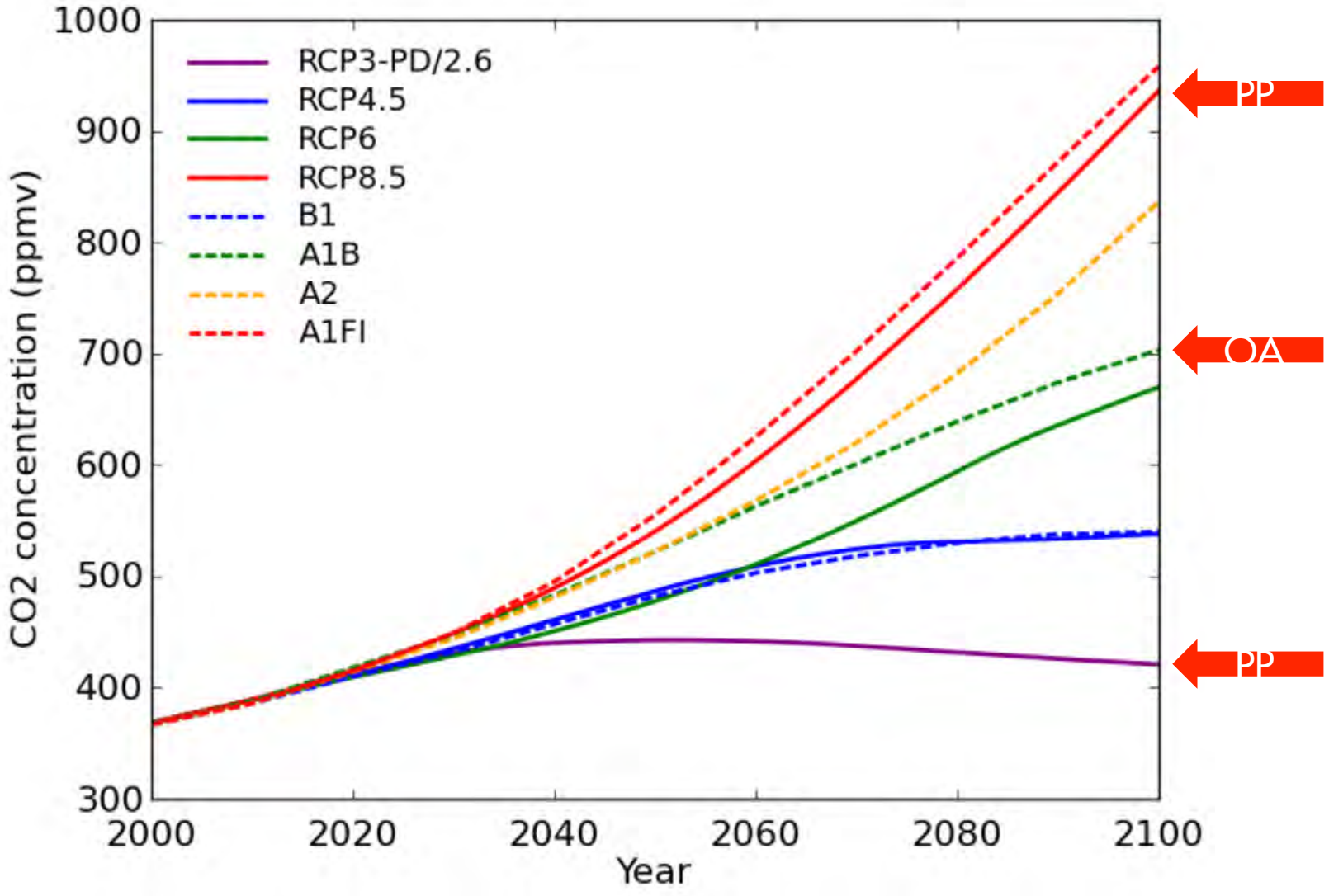
Jasus edwardsii





Eddy et al. 2014

SRES & RCP Scenarios



Ocean Acidification Impacts

- Range of experimental conditions were used
- We calculated responses similar to how effect sizes are calculated for meta-analyses, except they were standardized for carbonate chemistry
- Determine how production (*P/B*), consumption (*Q/B*), and mortality parameters are affected
- Effects determined for IPCC SRES scenario A1b (closest to RCP 6.0) for the year 2050

Conservation Biology

Contributed Paper

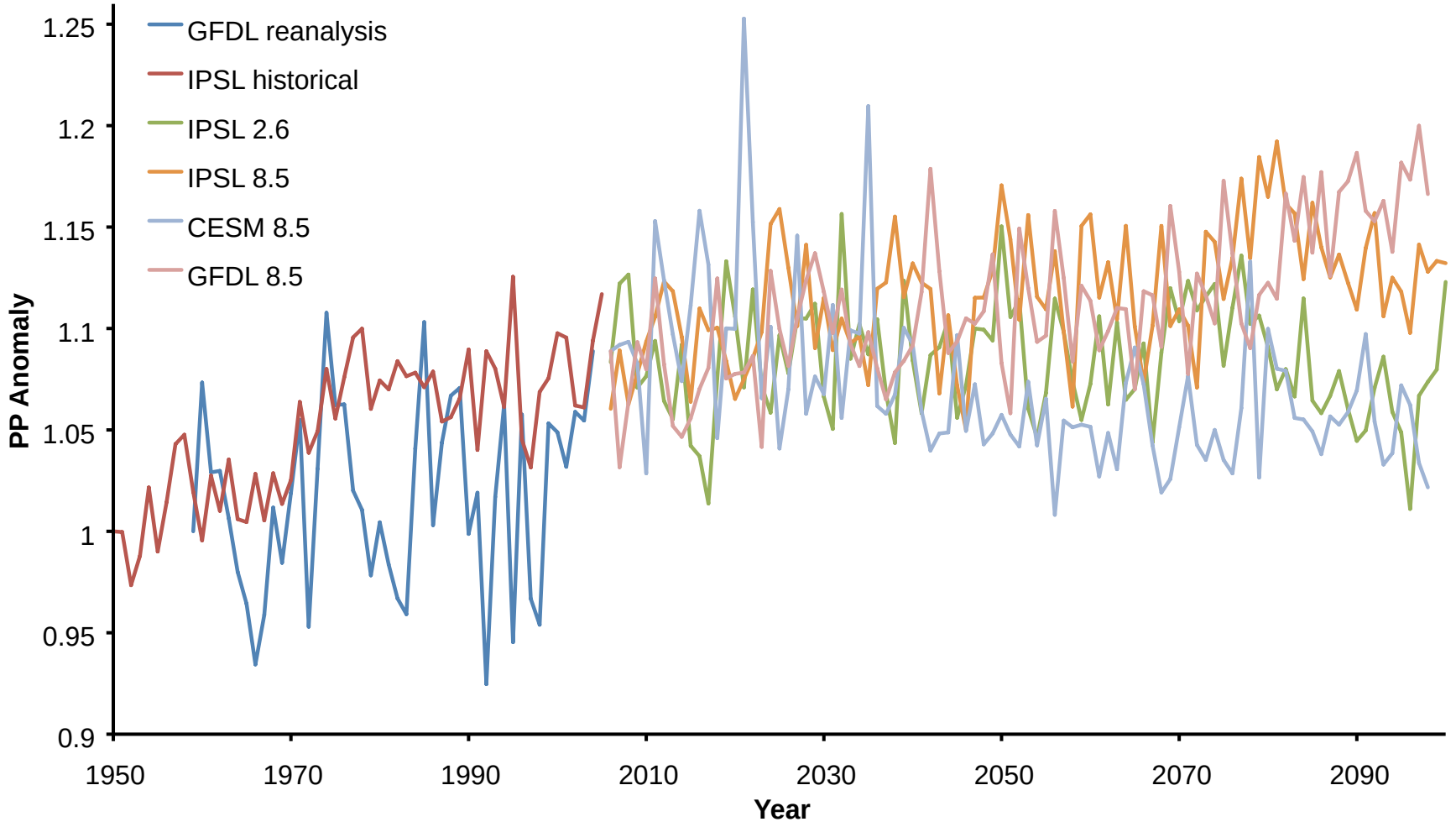
Effects of Near-Future Ocean Acidification, Fishing, and Marine Protection on a Temperate Coastal Ecosystem

CHRISTOPHER E. CORNWALL* AND TYLER D. EDDY†

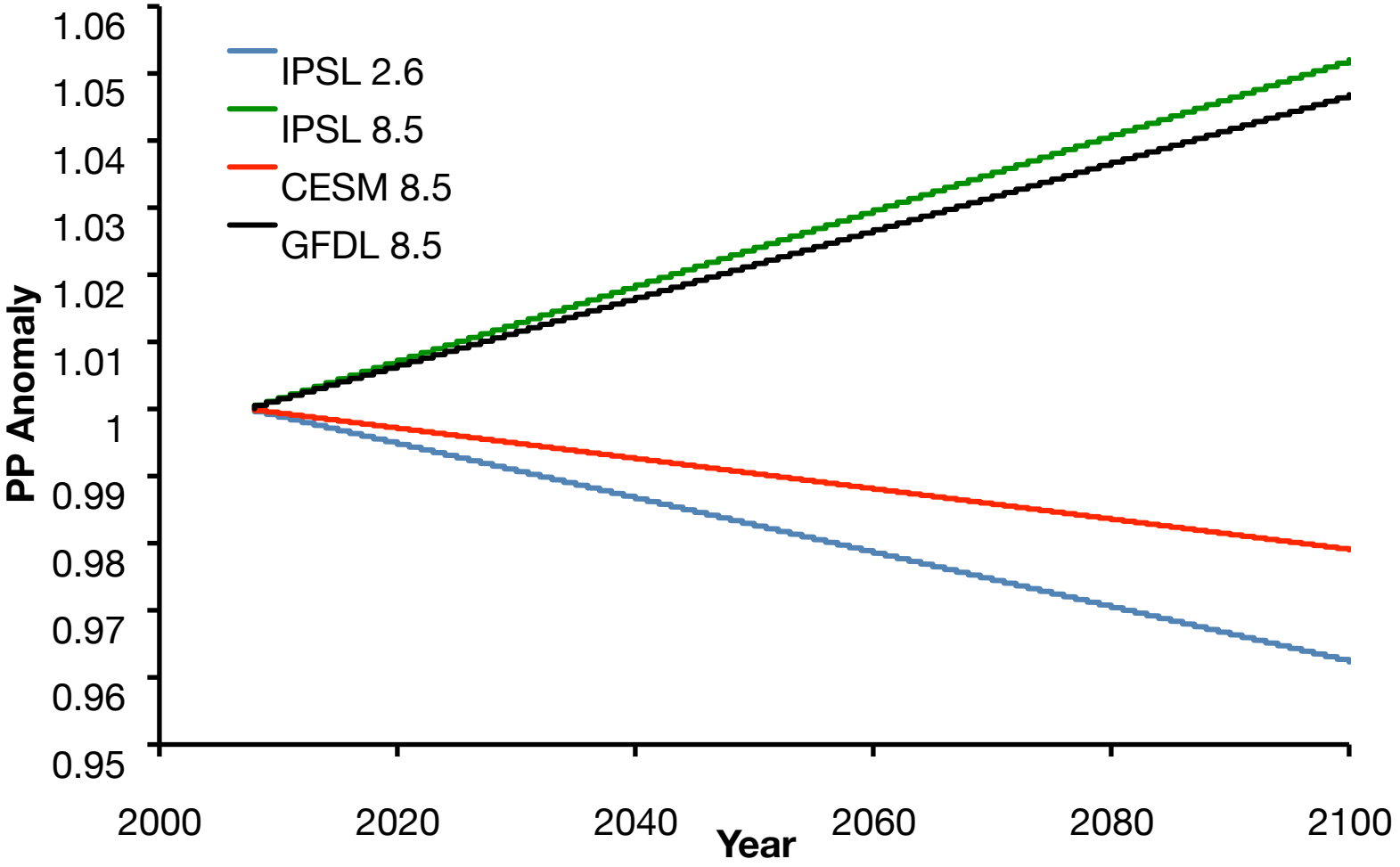
	Trophic group	OA modifier			Fishing mortality (F)
		Mortality (M)	Production/ biomass ratio (P/B)	Consumption/ biomass ratio (Q/B)	
1	birds				
2	lobster	1.09 (0.03)	1.04 (0.03)		0.2
3	mob inverts herb	1.18 (0.04)	0.78 (0.24)		
4	abalone	1.22 (0.24)	0.78 (0.04)		0.15
5	urchin	1.04 (0.04)	0.94 (0.03)		
6	mob invert carn	1.04 (0.05)	0.85 (0.12)	0.99	
7	sea cucumber				
8	phytal/infaunal inverts	1.18	0.99		
9	sponges				
10	sessile inverts	1.09 (0.04)	0.96 (0.05)	0.99	
11	fish cryptic	1	0.98		
12	fish inverts	1	0.98		
13	fish piscivores	1	0.98		0.0025
14	fish planktivores	1	0.98		
15	fish herbivores	1	0.98		0.018
16	microphytes	0.73	0.87 (0.13)		
17	macroalgae canopy	1.04	1.15 (0.19)		
18	macroalgae foliose	1.04	1.38 (0.19)		
19	macroalgae crustose	1.10 (0.12)	0.98 (0.06)		
20	meso/ macrozooplankton	0.99 (0.01)	0.96 (0.07)		
21	microzooplankton				
22	phytoplankton	1.06 (0.06)	1.03 (0.03)		
23	bacteria	0.99 (0.11)	1		
24	detritus				

Ocean Acidification Model Modifiers for 2050

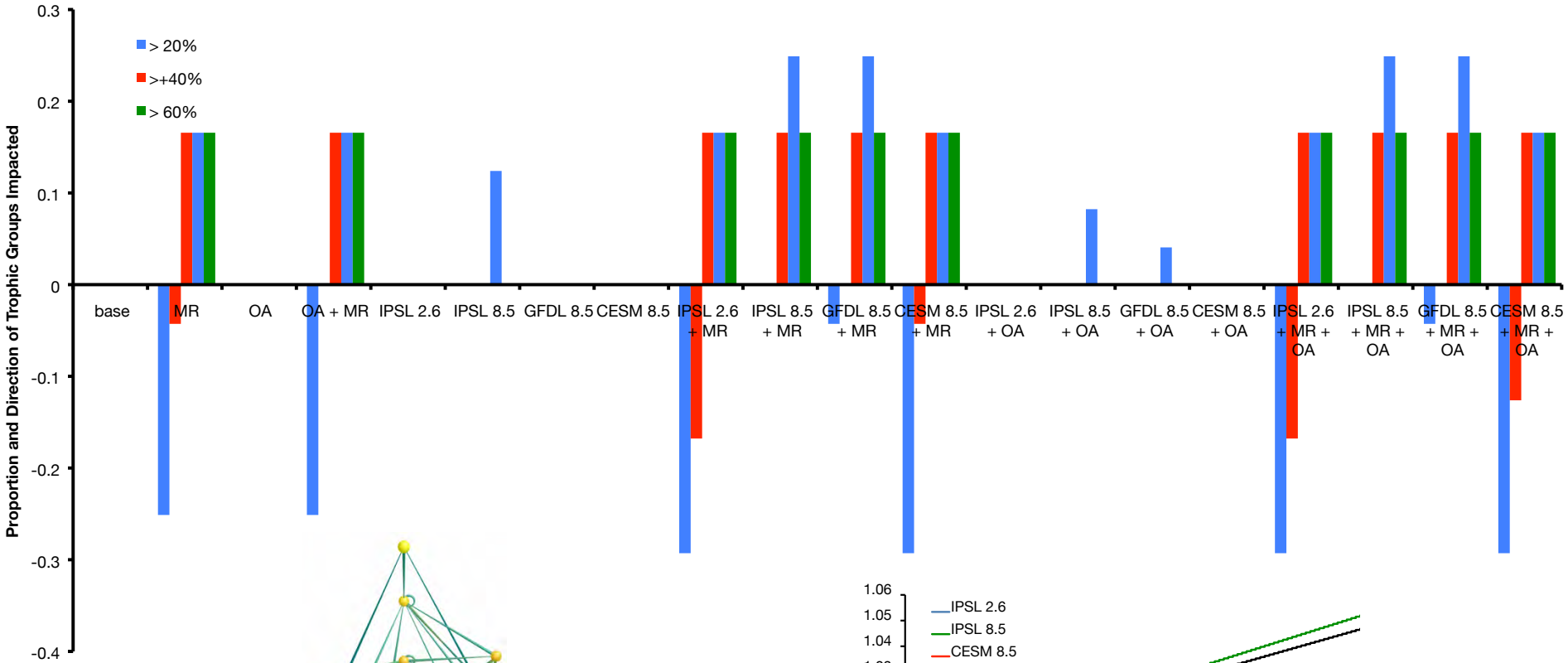
PP Anomaly

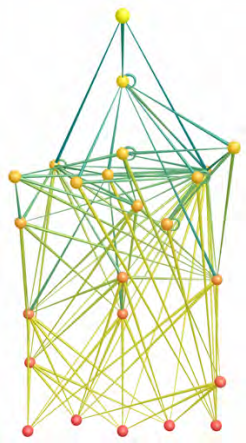

GFDL reanalysis
IPSL historical
IPSL 2.6
IPSL 8.5
CESM 8.5
GFDL 8.5
PP Anomaly
1.25
1.2
1.15
1.1
1.05
1
0.95
0.9
1950
1970
1990
2010
2030
2050
2070
2090
Year

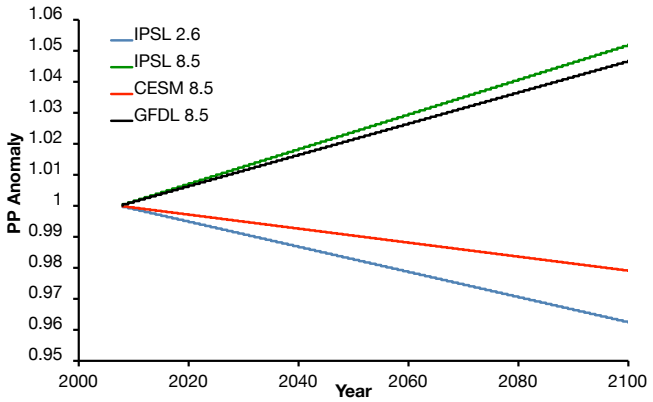
PP Anomaly Trends



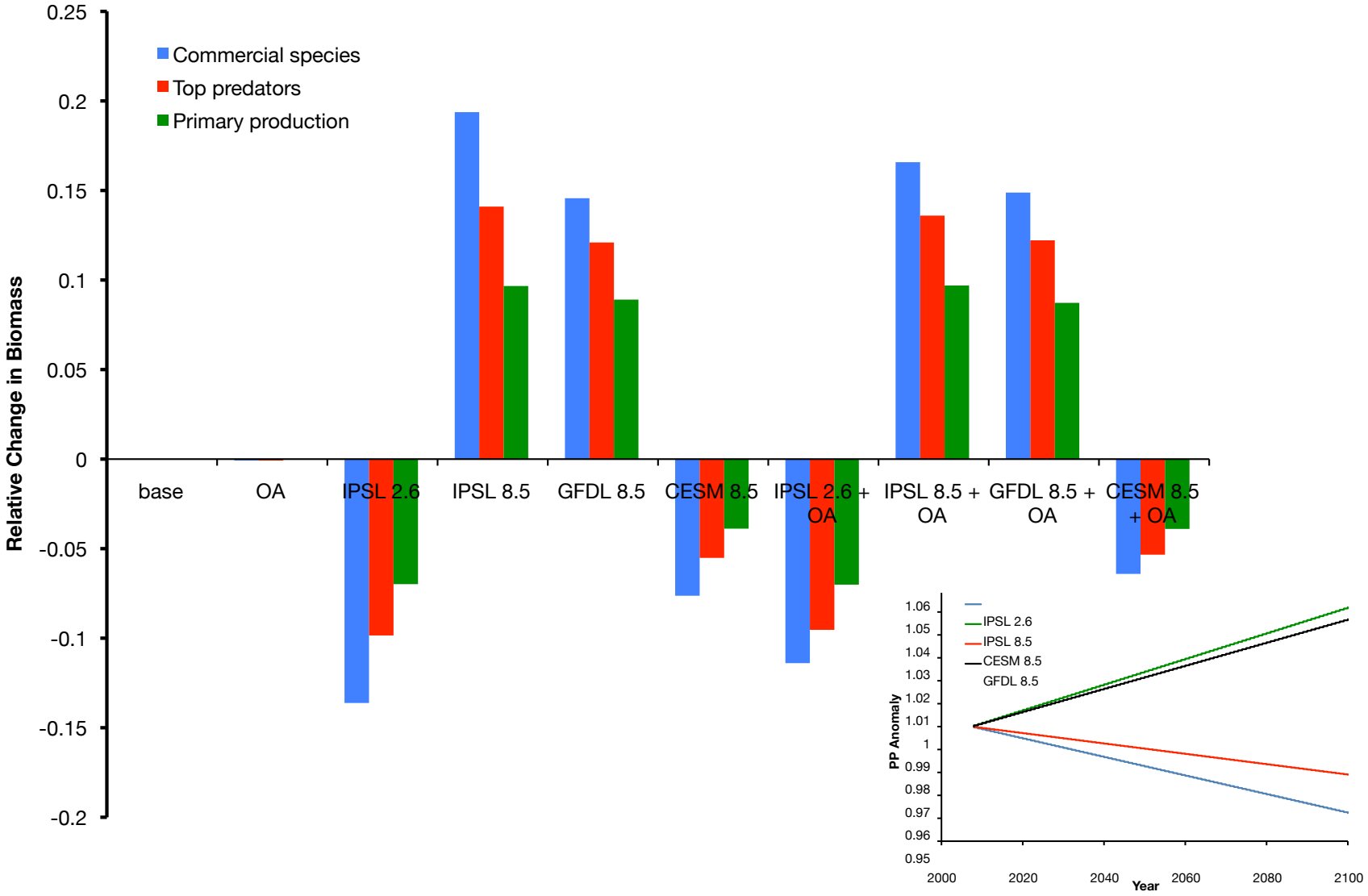
Impacts on Trophic Groups



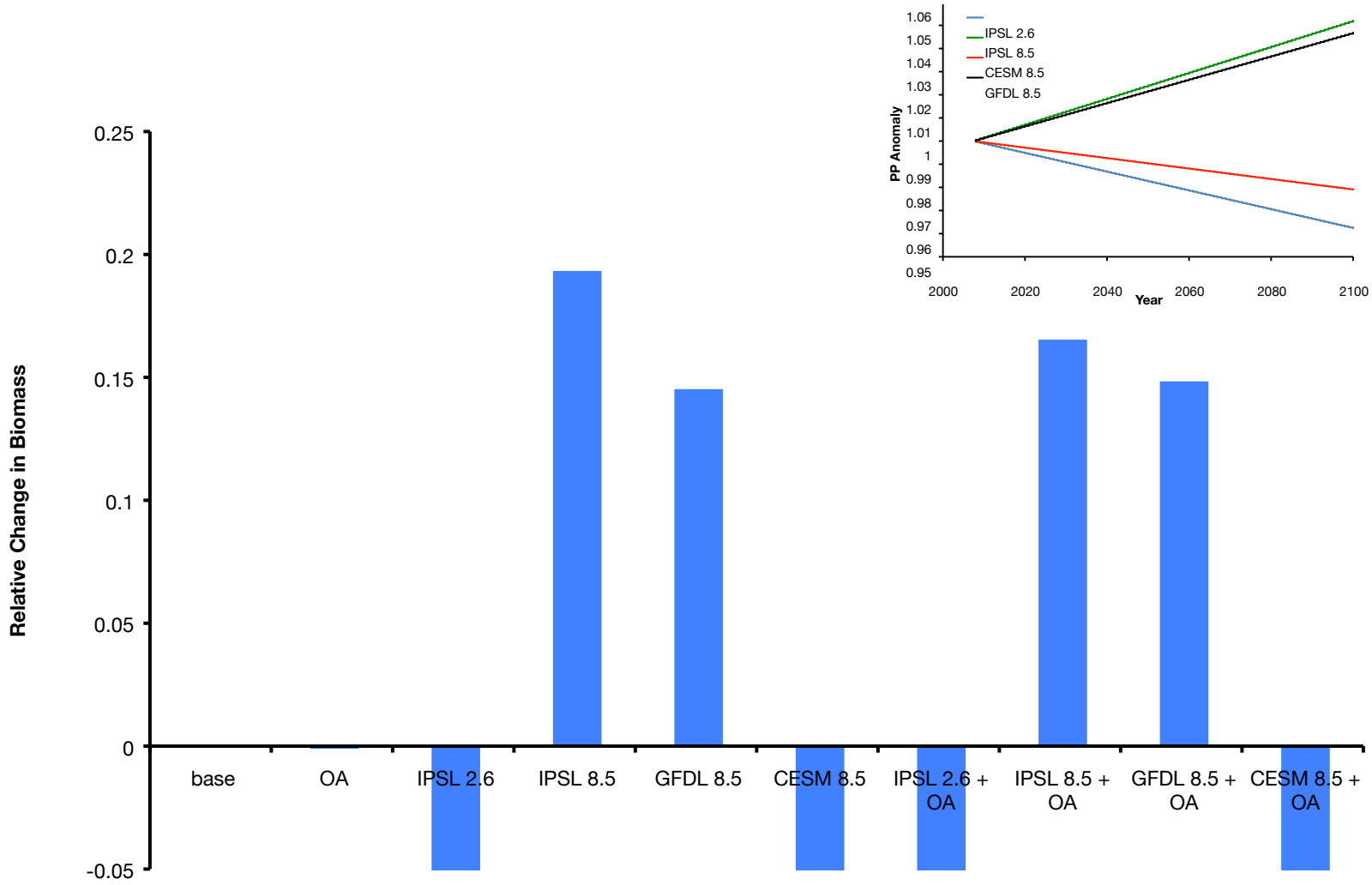




Impacts on Key Groups



Impacts on Commercial Species



Conclusions

- Fishing has the greatest ecosystem effect
- Variability among GCM models is as great as for RCP scenarios
- The predicted direction of commercial fish biomass change is not consistent among GCM models
- Ocean acidification impacts are subtle, and can hinder recovery of exploited species in Marine Reserves

Acknowledgements

- ICES Travel Support