The changing Pacific:

A strategic collaboration for assessing climate impacts & developing policy for adaptation

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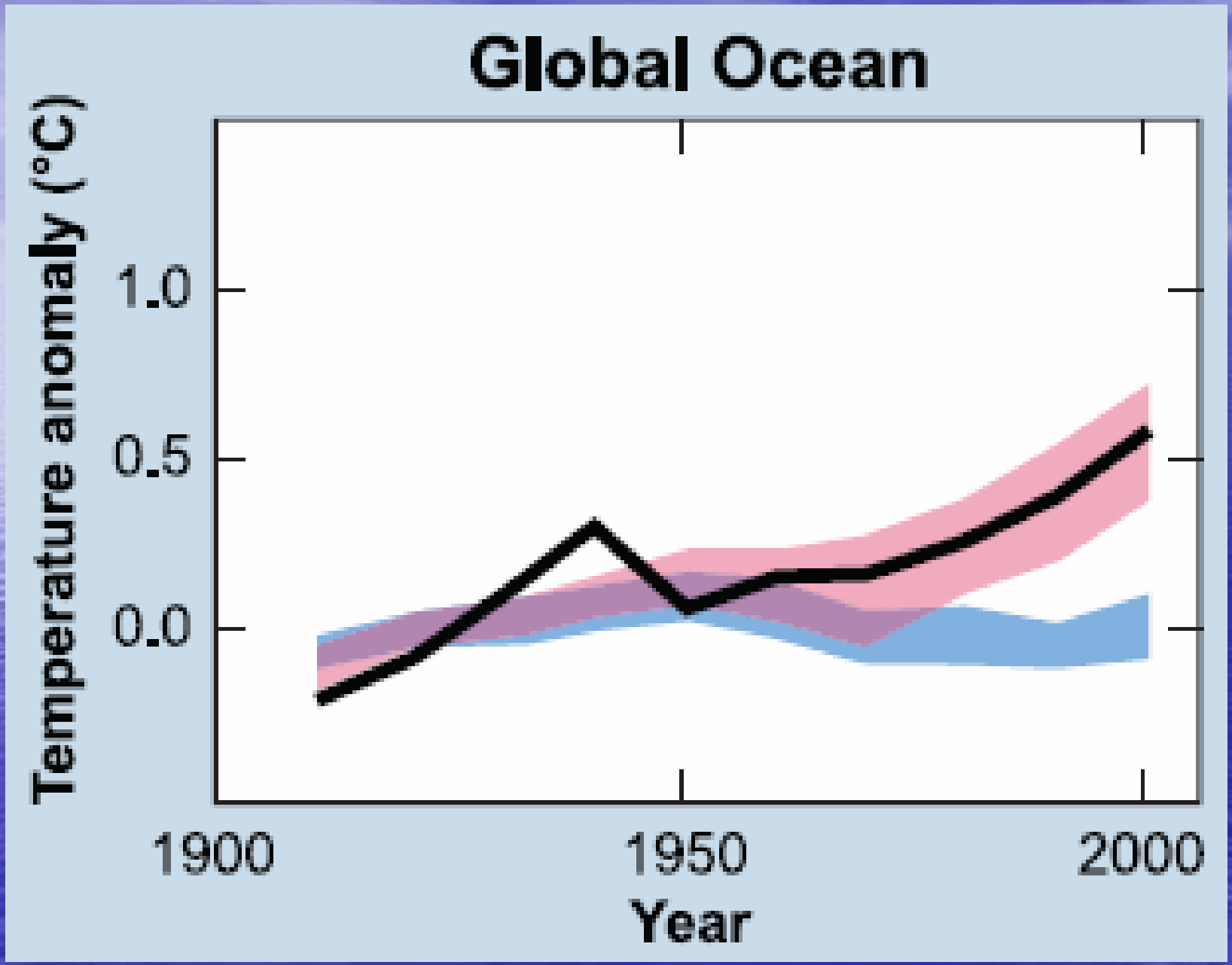
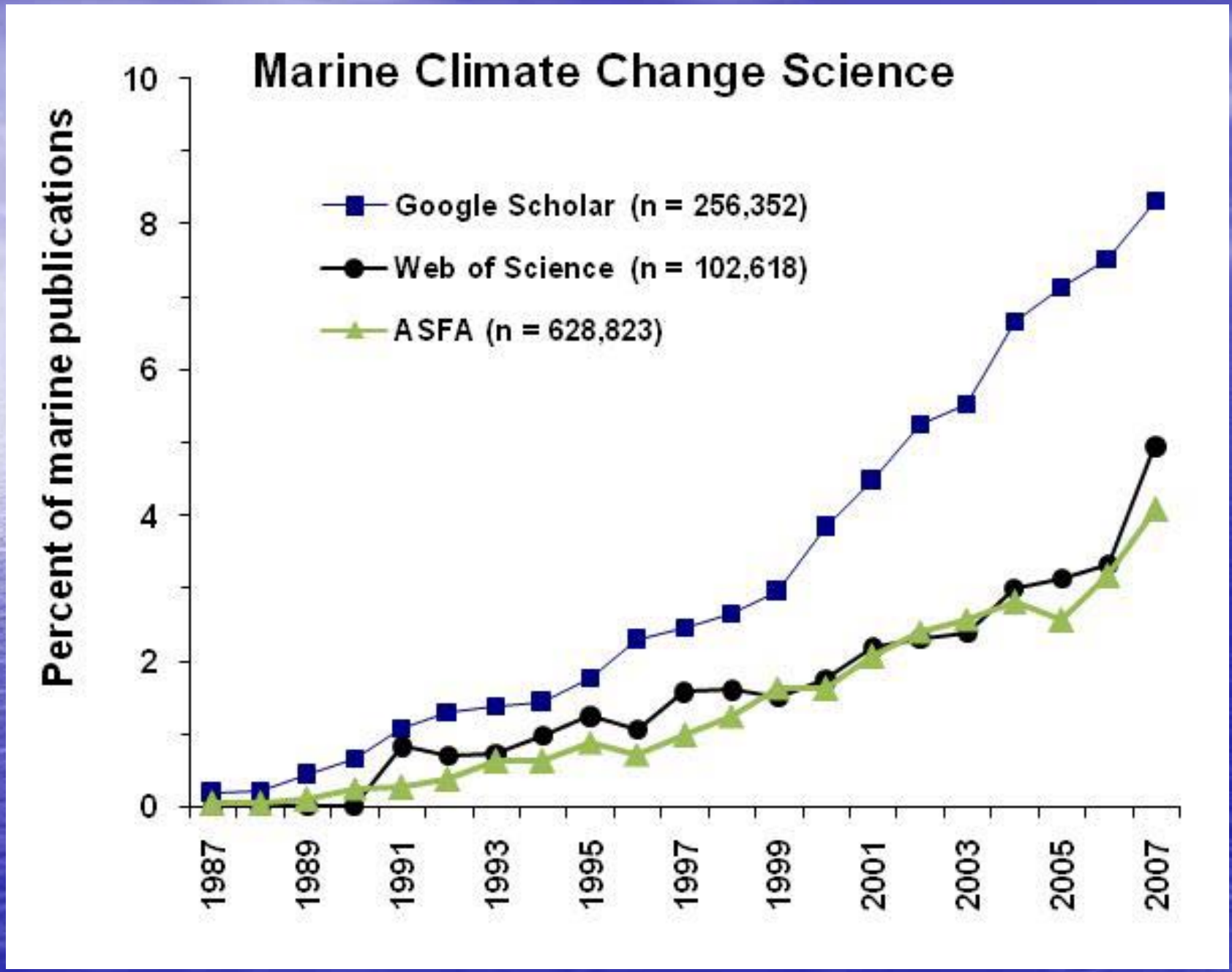
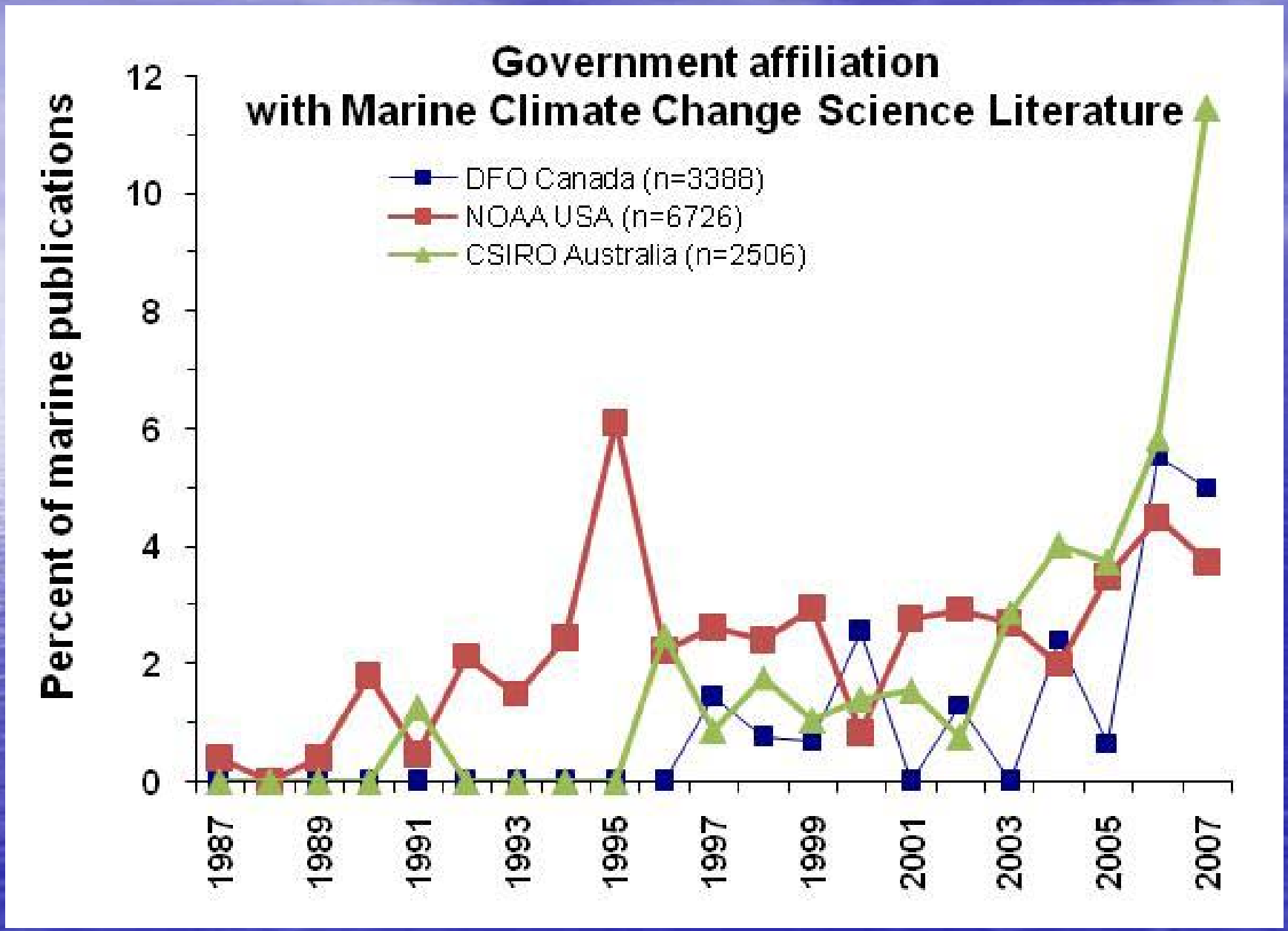

Global Ocean
Temperature anomaly (°C)
1.0
0.5
0.0
1900
1950
2000
Year

General questions

- Responsiveness of science?
- What do we know about impacts?
- How can we measure change?
- How can we predict change?
- What policies and management strategies will work? (Objectives?)


Marine Climate Change Science
Percent of marine publications
10
8
6
4
2
0
Google Scholar (n = 256,352)
Web of Science (n = 102,618)
ASFA (n = 628,823)
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007

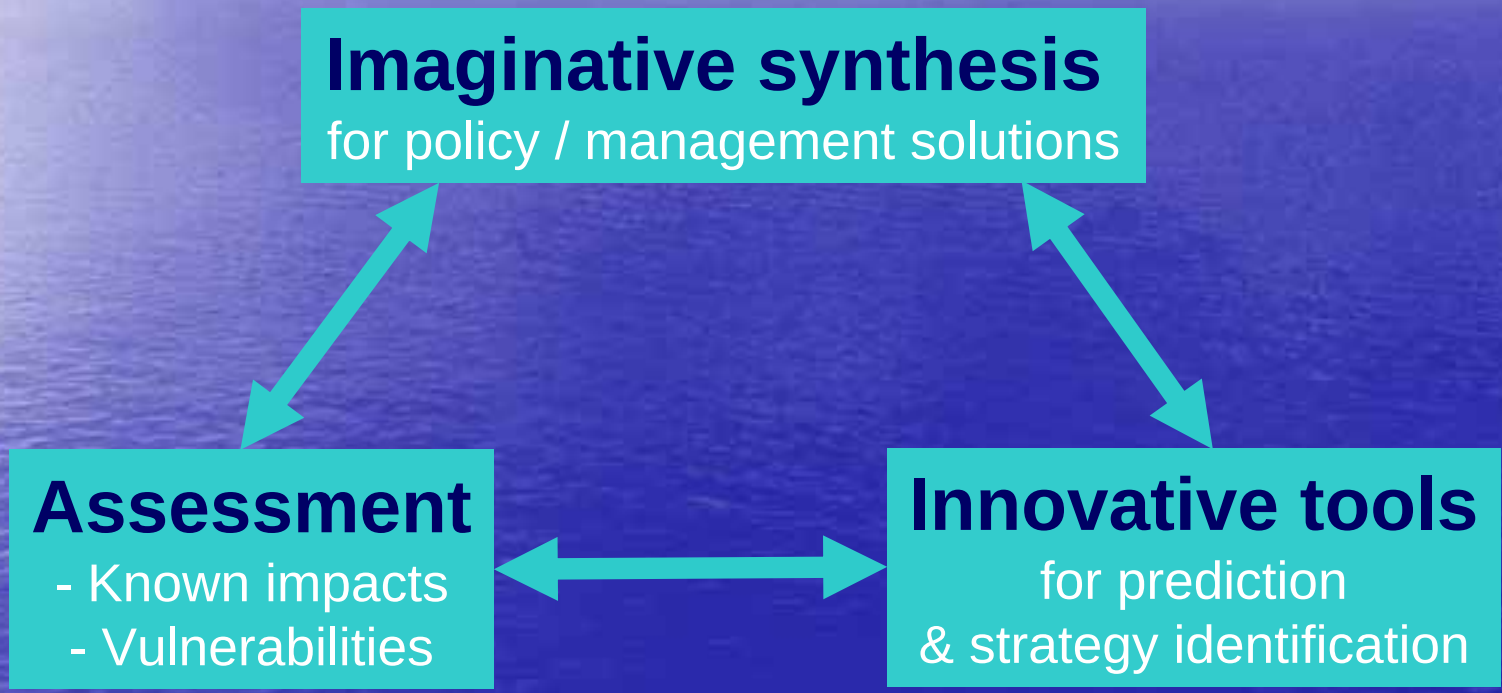

Government affiliation
with Marine Climate Change Science Literature
DFO Canada (n=3388)
NOAA USA (n=6726)
CSIRO Australia (n=2506)
Percent of marine publications
0
2
4
6
8
10
12
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007

Question for you

- What other indicators could I use?
  - Changes in budgets?
  - Agency directives?
  - Presentations at PICES?

Suggestions: tokey@bms.bc.ca

Climate impacts framework



Proposal to NCEAS

Climate change impacts on Pacific marine ecosystems: Coordinated marine science and policy development

- WG1 – Known impacts, indicators, vulnerabilities
- WG2 – Innovative analytical approaches
- WG3 – Imaginative synthesis for solutions
- Building on collaborations (PICES, CLIOTOP, BEST, etc)
- Pacific-wide synthesis
- Special issue of peer-reviewed journal
- Book for broader general public
- Positive reviews, but too big and need better connection to the policy solutions part

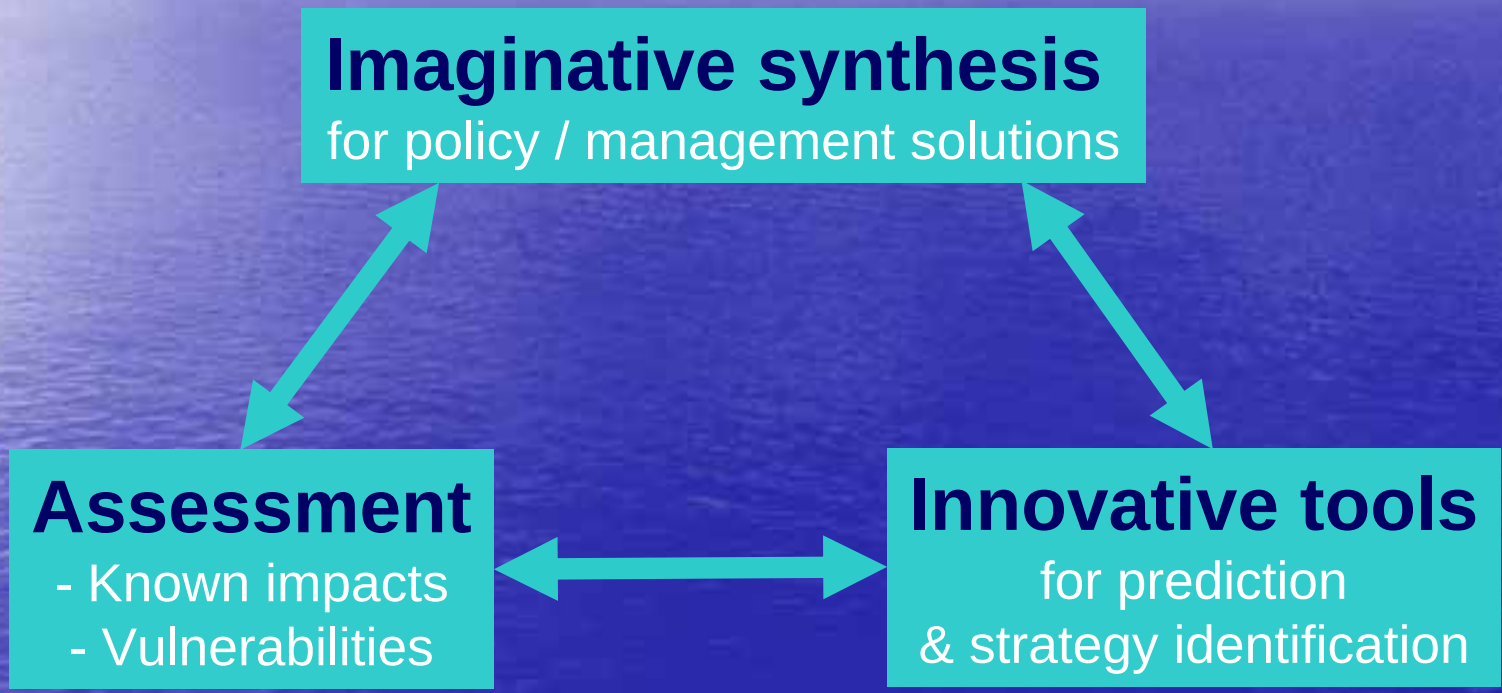
Effects of Climate Change on the World's Oceans

Gijon, Spain, May 19-23 2008

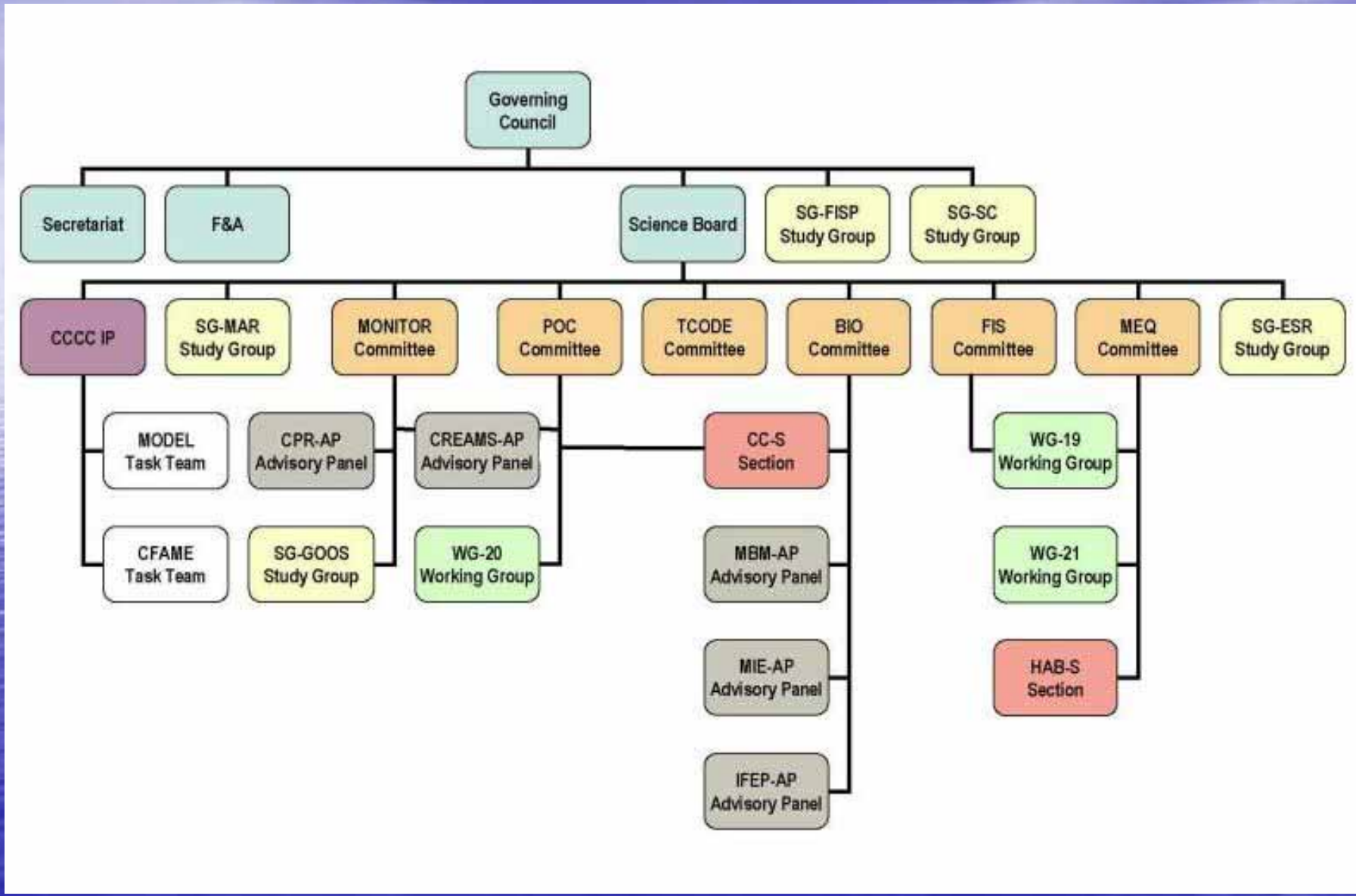
Workshop 2:

From the physical to the ecological: Screening approaches and linking Global Climate Model output with ecosystem and population models

Climate impacts framework



PICES structure



Questions for you

- Is this suggested approach valuable?
- How should this interface with PICES?
- What, in your view, is really needed?

Assess the current knowledge of the ecological impacts of climate change on Pacific Ocean ecosystems, identify useful marine ecological indicators of climate change, and assess vulnerability

ASSESSMENT

Future ocean changes

Physical:

- Temperature (+)
- Sea ice cover (-)
- Sea level (+)
- Hydrological cycle (intensified)
- Turbidity (+ and -)
- Light supply (+ and -)
- Salinity (+ and -)
- Stratification (+)
- Winds (+ and -)
- Storm event intensification
- Upwelling (+ and -)
- Currents (e.g., ocean conveyor belt)

Chemical:

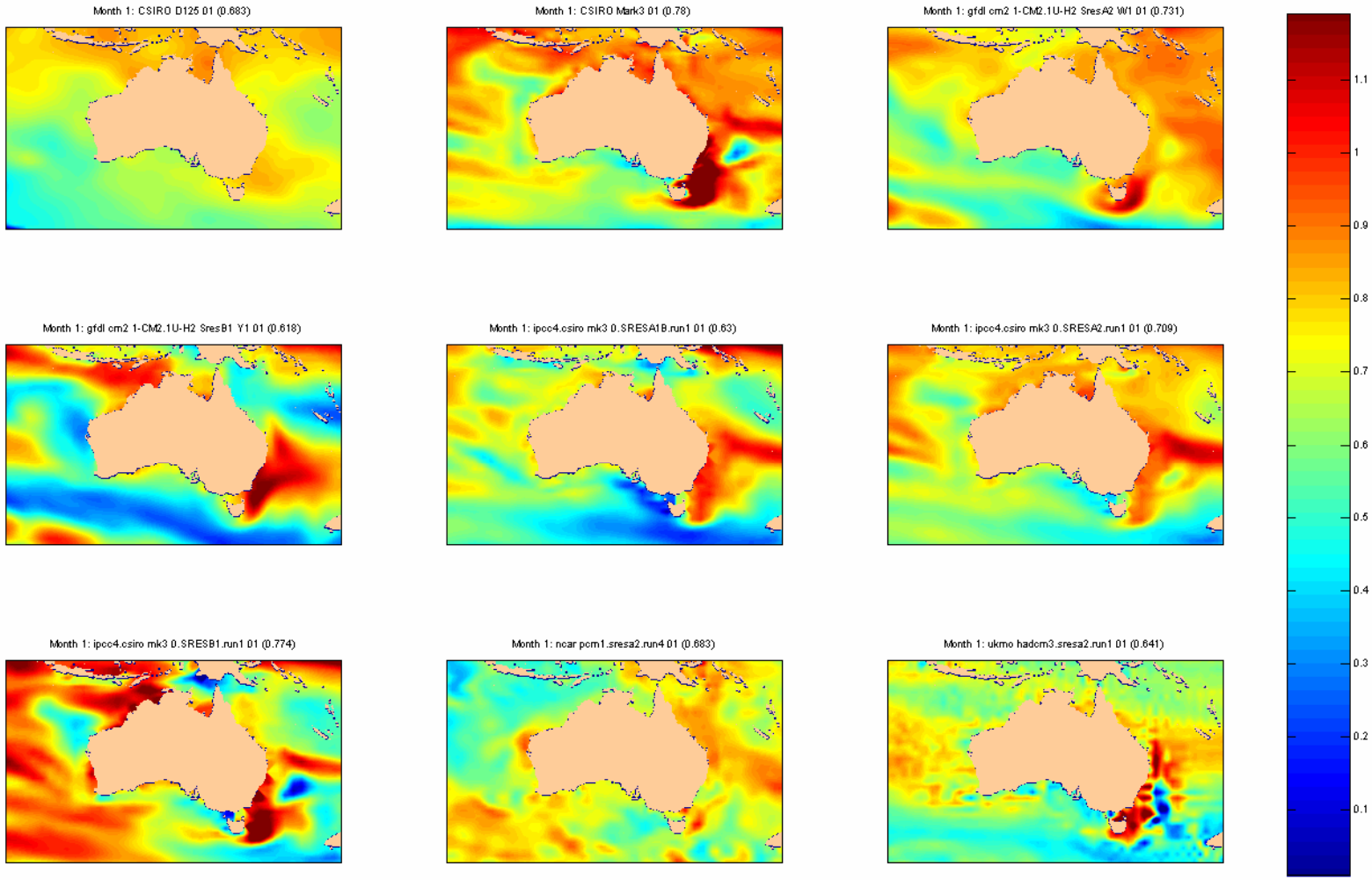
- pH (-)
- Aragonite saturation (-)
- Oxygen (-)
- Nutrients (+ and -)

Biological:

- Changes in primary production
- Population range shifts
- Extirpations and extinctions
- Community composition
- Changes in species interactions
- Decreased community resilience

Today, biological examples

Temperature to 2070 -- model variation



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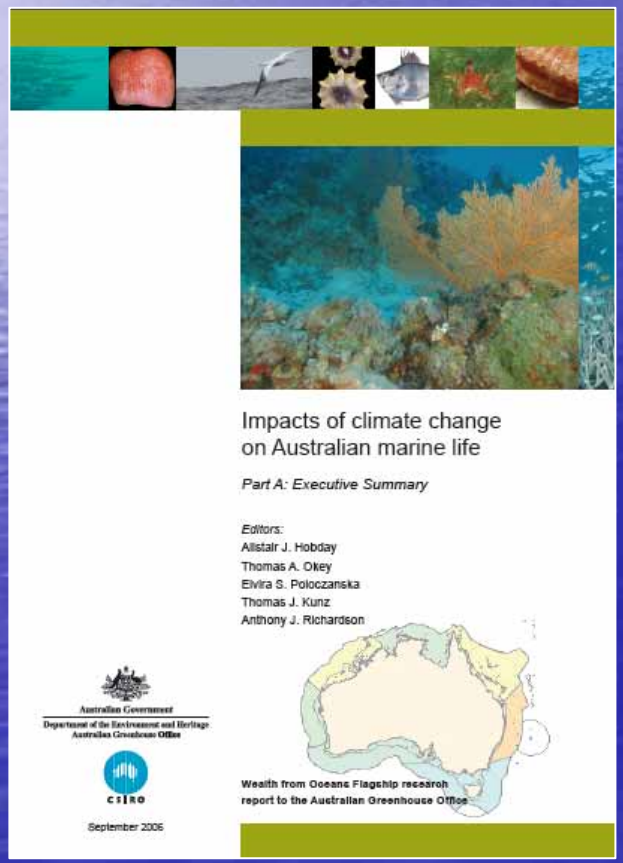
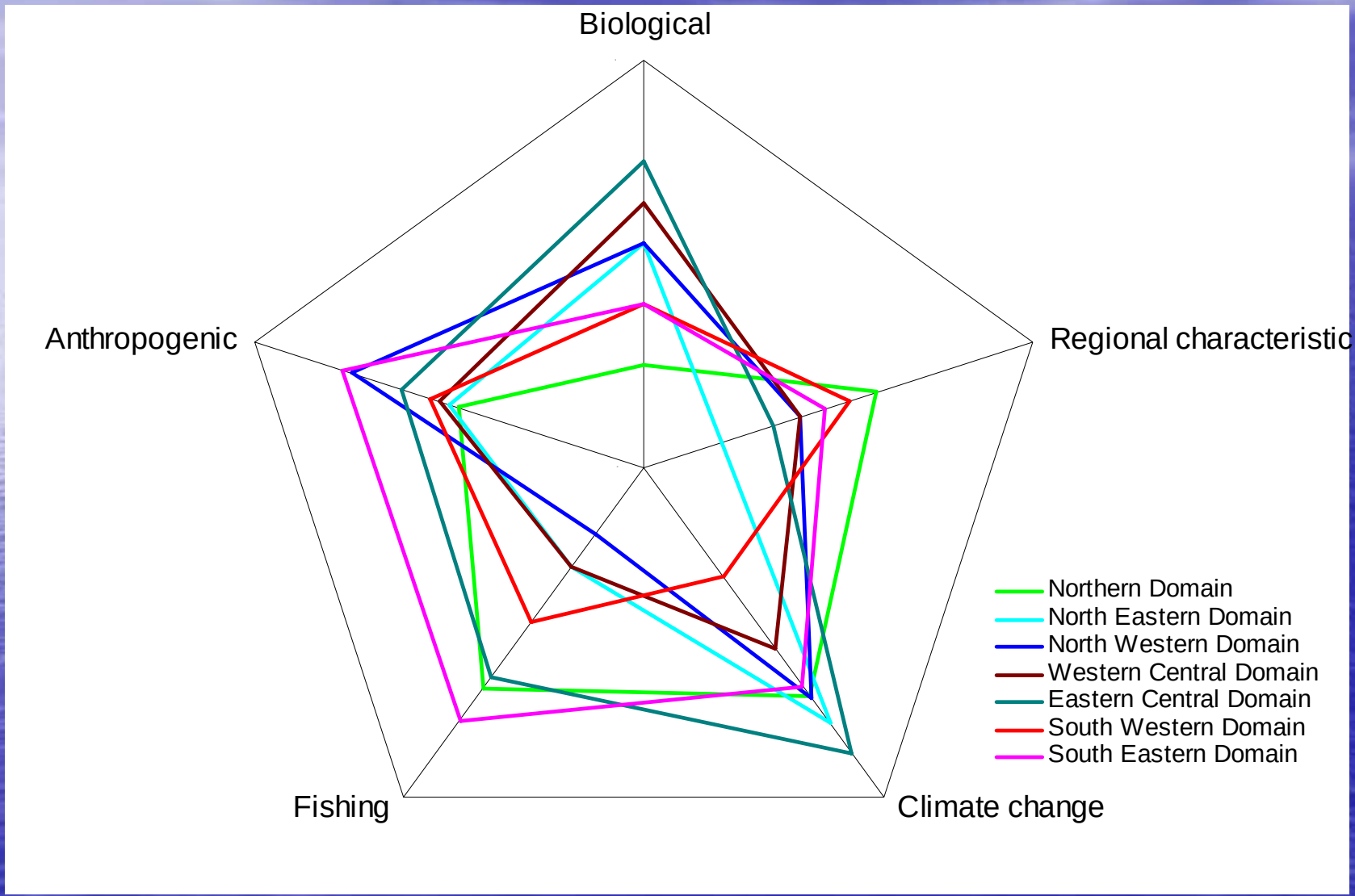
High vulnerability

- Distribution (8)
- Phenology (2)
- Physiology (5)
- Community-level (7)

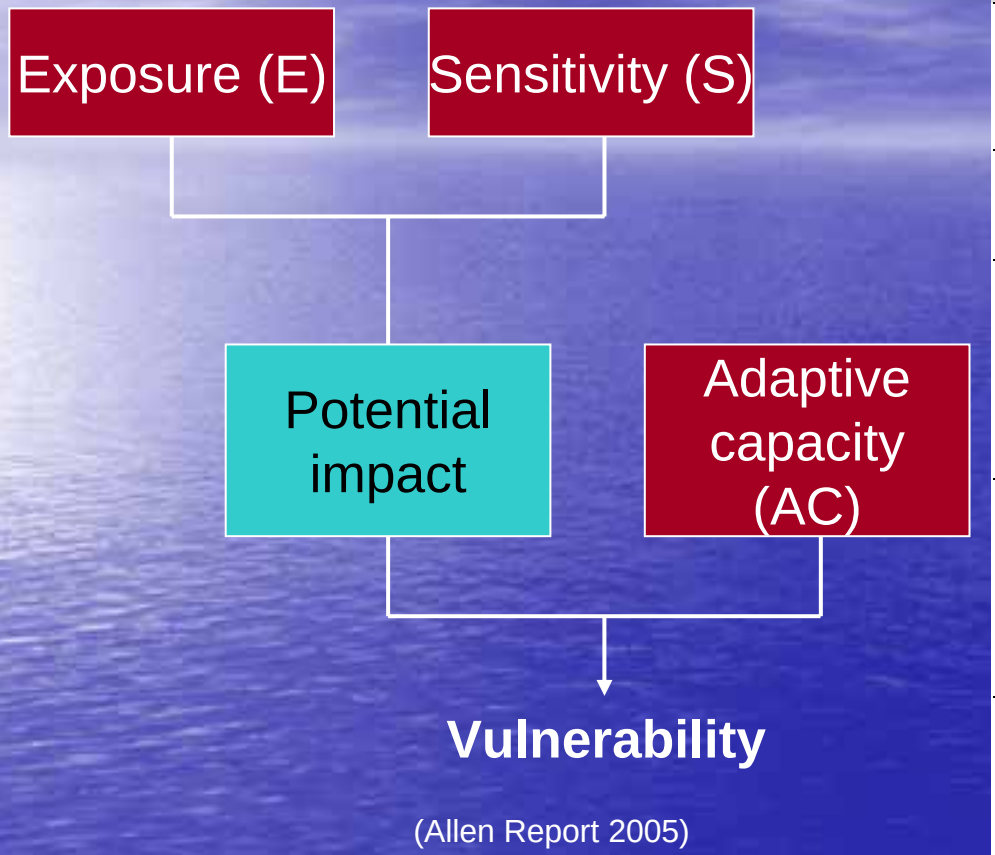


Groups	Distribution / abundance	Phenology	Physiology/ morphology / behaviour	Impacts on biological communities	Example impact
Phytoplankton	High	High	Medium	High	Temperate phytoplankton province will shrink considerably
Zooplankton	High	High	Medium	High	Acidification will dissolve planktonic molluscs
Seagrasses	Medium	Low	High	Medium	Increased dissolved CO_2 may increase productivity
Mangroves	Medium	Low	Medium	High	Sea level rise will destroy mangrove habitat
Kelp	High	Medium	High	High	Ranges will shift southwards as SST warms
Rocky reefs	High	Medium	High	Low	Species ranges will shift southwards as temperatures warm
Coral reefs	High	Medium	High	High	Acidification and warming will cause calcification problems and coral bleaching
Cold water corals	High	Low	Low	High	Ocean acidification will dissolve reefs
Soft bottom fauna	Medium	Medium	Medium	Medium	Modified plankton communities or productivity will reduce benthic secondary production
Benthic and demersal fishes	High	Medium	Medium	High	Southward movement of species along the east and west coast of Australia
Pelagic fishes	Medium	Low	Medium	Low	Pelagic tunas will move south with warming
Turtles	High	Medium	High	Low	Warming will skew turtle sex ratios
Seabirds	Medium	Medium	Low	Low	Shift in timing of peak breeding season as temperatures warm
Total number of high impact habitats or species groups	8	2	5	7	High impacts are expected for distribution, physiology, and community processes

Estimating vulnerability quantitatively



Vulnerability & its components

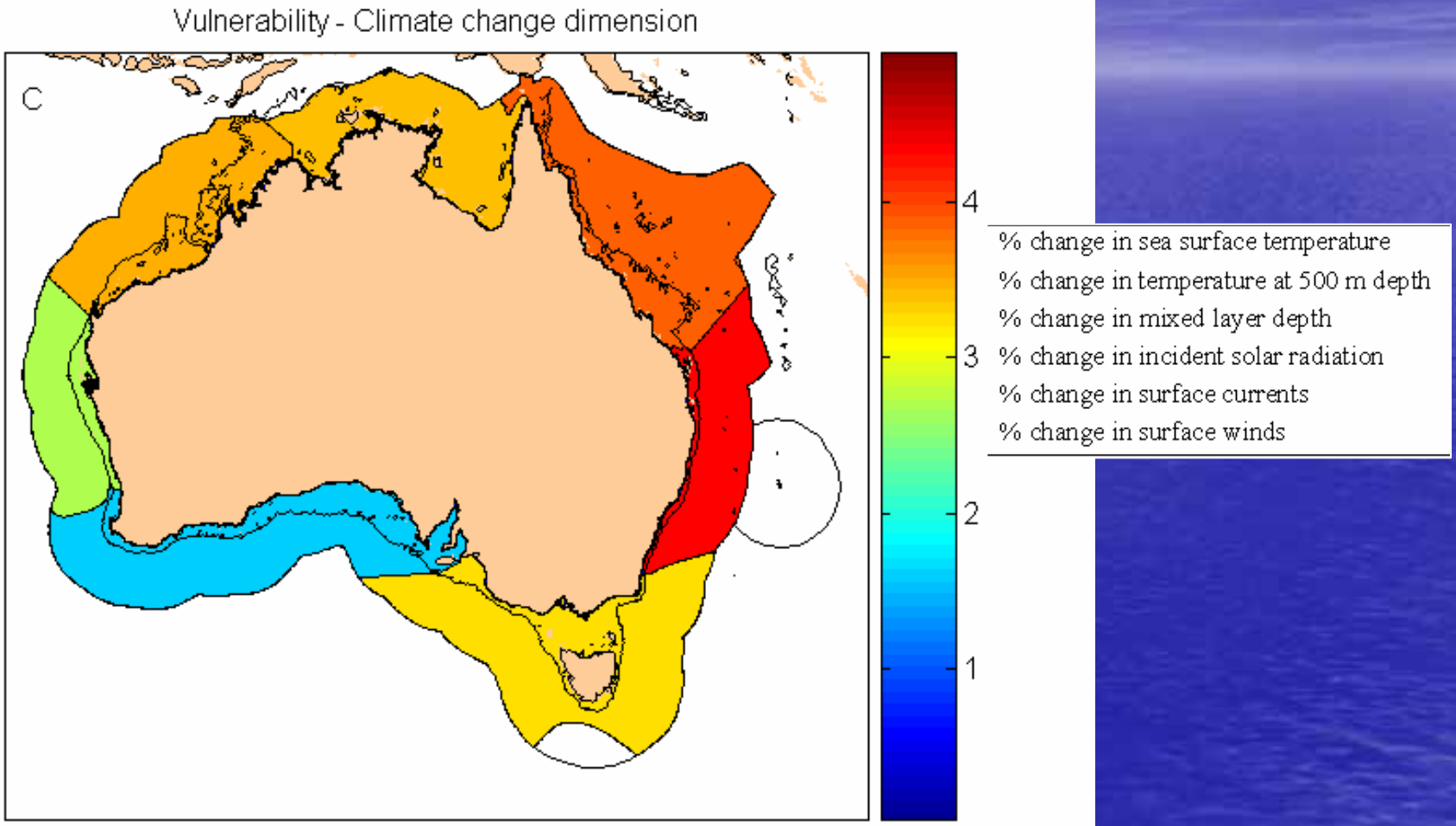


(Allen Report 2005)

Dimension	*Indicator*	*Vulnerability Component*
Biological	Threatened, endangered and protected (TEP) species	S
	Number of endemic demersal slope fish	S
	% introduced species per port	S
	TEP uniqueness	S
Regional	Area (square degrees)	S
	Foundational area (% < 50 m depth)	S
	Poleward boundedness	S
Climate Change	% change in sea surface temperature	E
	% change in temperature at 500 m depth	E
	% change in mixed layer depth	E
	% change in incident solar radiation	E
	% change in surface currents	E
	% change in surface winds	E
Fishing	Fisheries gear impact – habitat	AC
	Fisheries gear impact – bycatch	AC
	Overexploited fisheries	AC
	Number of fisheries hours	AC
	Number of AFMA fisheries	AC
	Recreational fishing index (1000 days per degree)	AC
Other Anthropogenic	Population within 200km of coast (1996)	AC
	Organic compounds	AC
	Chemical compounds	AC
	Heavy metals	AC
	Chemical dumps	AC
	Ship visits	AC
	Oil and gas wells	AC
	Seismic surveys	AC

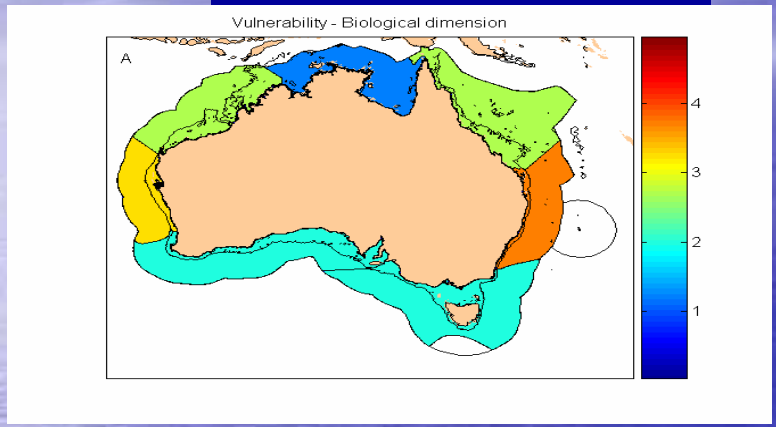
Vulnerability: *Potential to be damaged or altered*

Climate Change Dimension

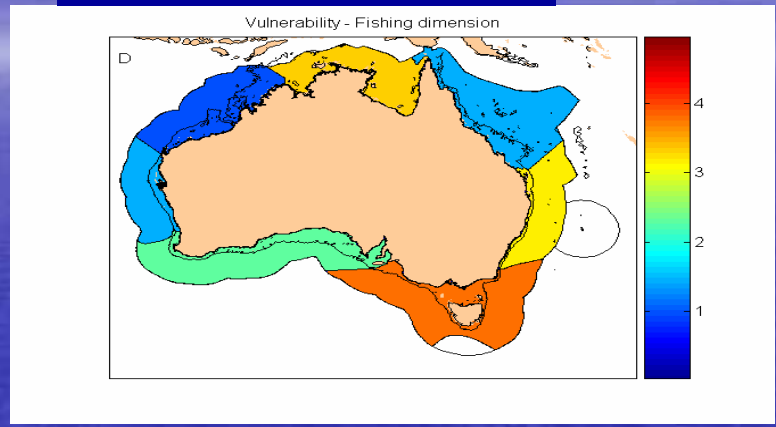


Other dimensions

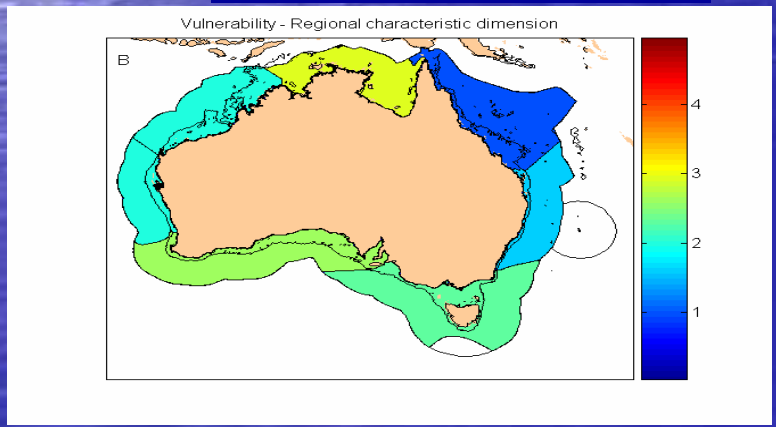
Biological



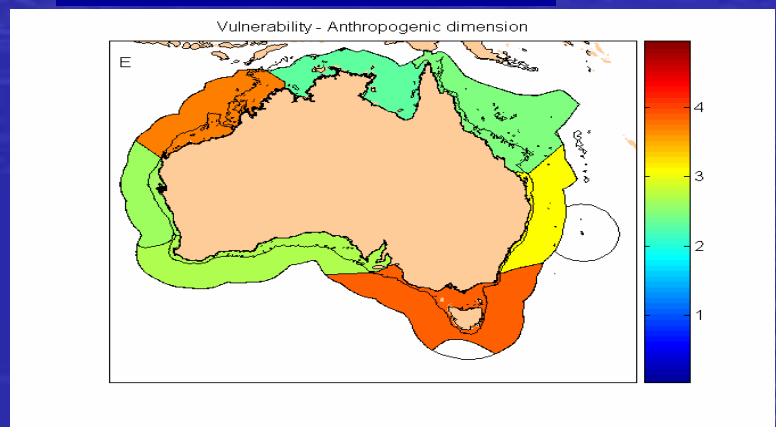
Fishing



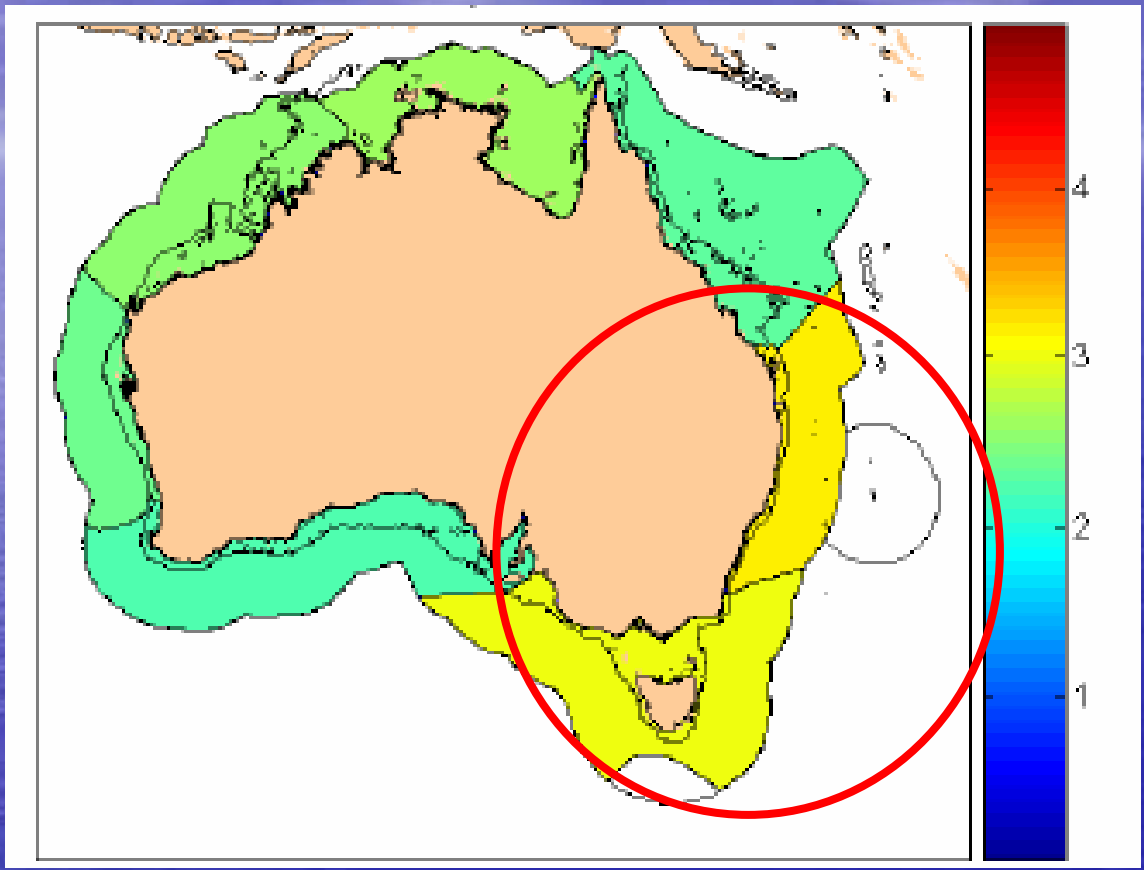
Regional



Other anthropogenic



Overall Vulnerability – marine life

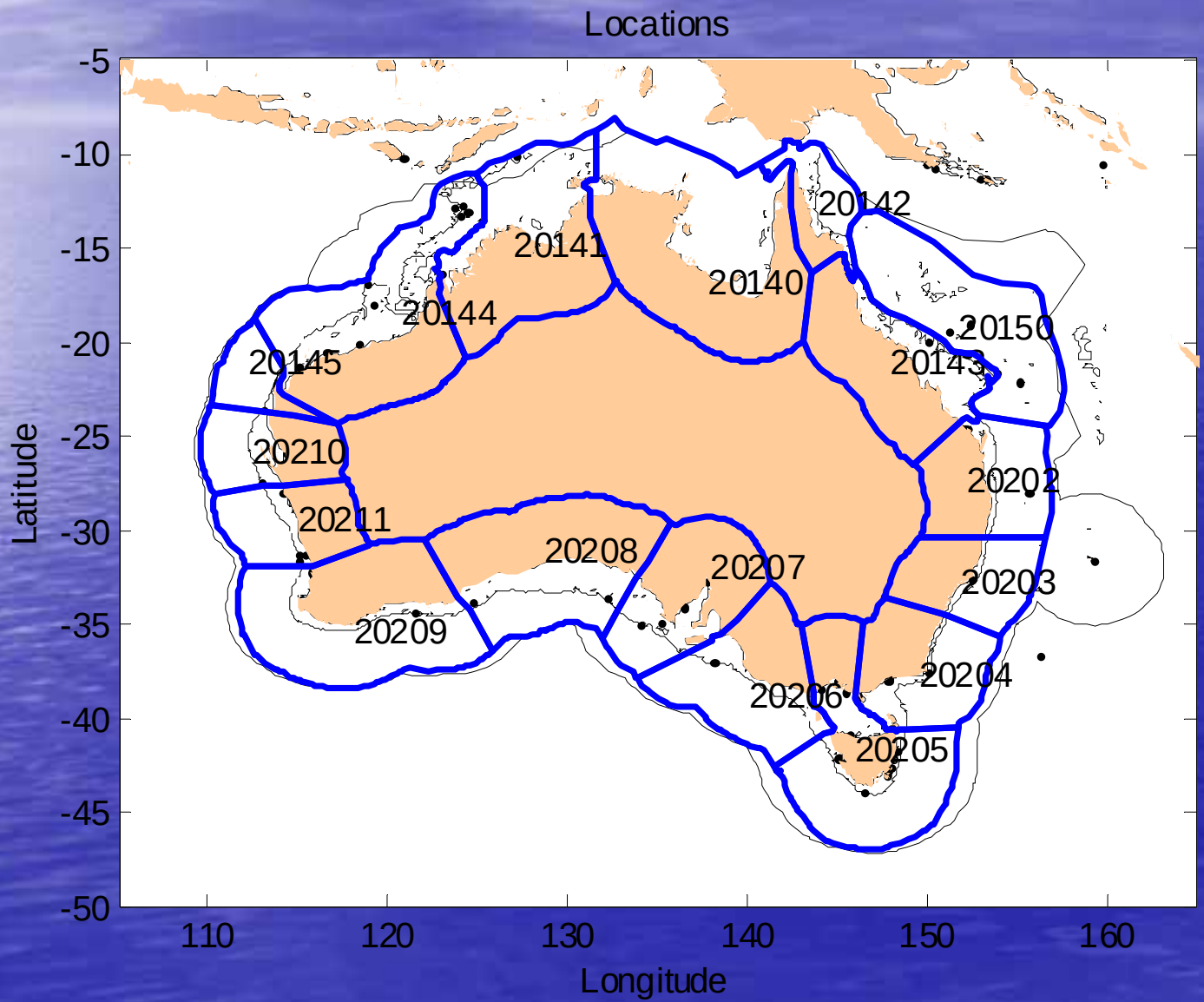


East-central most vulnerable with respect to climate change indicators (SST, temp 500m & surface winds) and biological indicators (TEP & TEP uniqueness) as well as overall exposure.

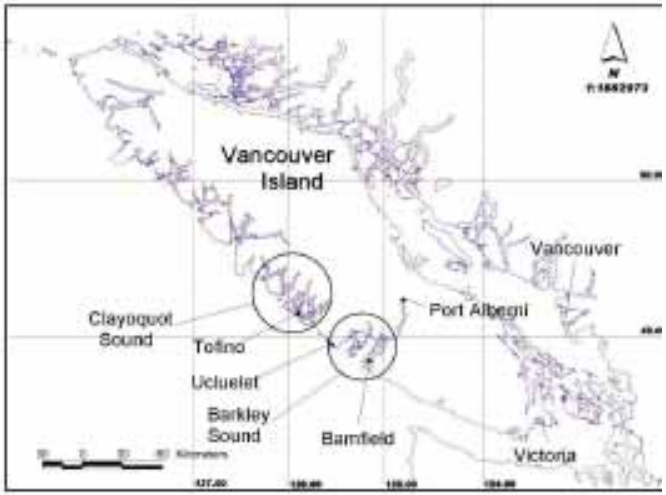
South-east most vulnerable with respect to fishing indicators (overexploited fisheries, number of fisheries hours & number of AFMA fisheries) and other anthropogenic indicators (heavy metals & chemical dumps)

South-west least vulnerable with respect to overall exposure and to climate change indicators

Using MEOW – WWF regions



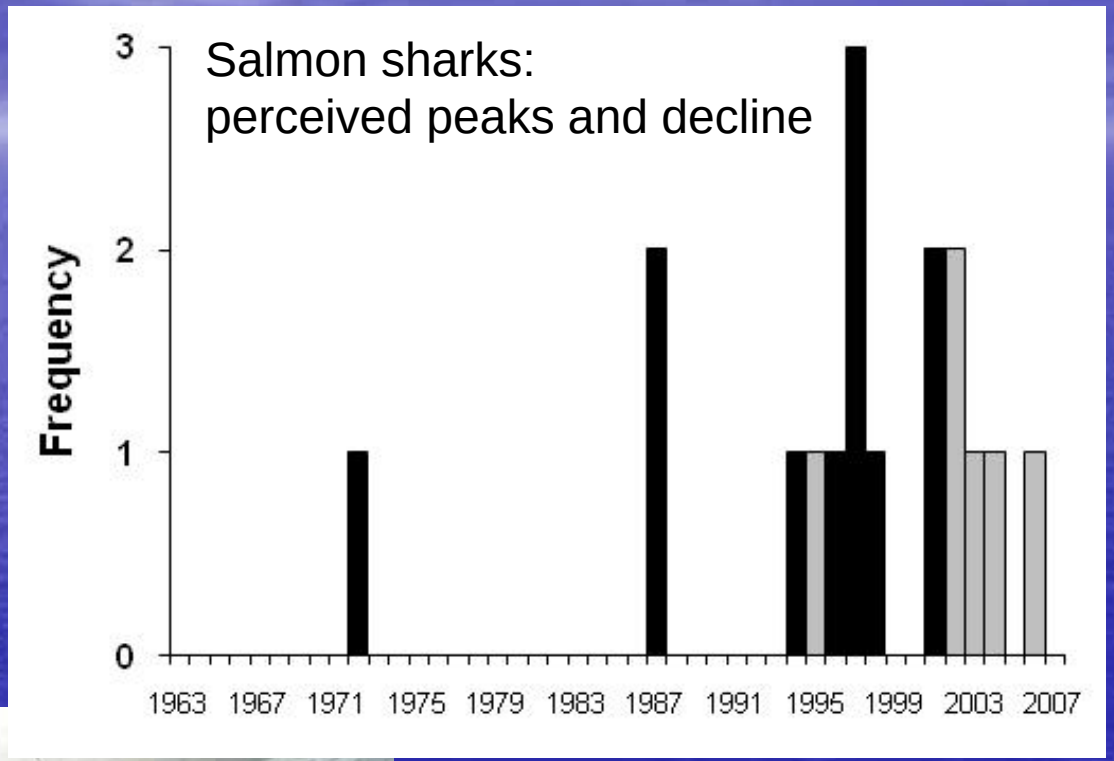
Choosing case studies in N Pacific



Component	Duration (years)	Contact	Institution
Temp., Sal., Weather	70	Amphitrite Lighthouse	DFO
Weather	40	Peter Janitis	(deceased)
Carnation Creek watershed	37	see Hogan et al. 1998	BMSC / BC Forests
Algae and invert species list	37	William Austin	BMSC
Temp., Sal., Weather	28	Cape Beale Lighthouse	DFO
Marine algae	28	Louis Druehl	SFU
Zoops; SW Van. Isl. Shelf	22	Dave Mackas	DFO-IOS
Intertidal community & waves	20	Carlos Robles	CSULA
Plants on islands	20	Martin Cody	UCLA
Purple sea urchin	20	Michael Russell	Villanova Univ.
Seabirds	20	Ed Paleczny	Parks Canada
Christmas bird count	20	Anne Stewart	BMSC
Primary prod. (Line P)	20	Frank Whitney	DFO-IOS
LaPerouse Buoy data	19	Richard Thompson	DFO
Kelp forests and sea otters	19	Jane Watson	Malaspina Collage
Zooplankton	18	Ron Tanasichuk	DFO
Marine invertebrates	18	Don Levitan	Florida State Univ.
Killer whales	17	Rod Palm	Strawberry Isl. Res.
Seabirds	14	Alan Burger	UVic
Littorina spp.	14	Liz Boulding	U of Guelph
Benthic cores	12	Rod Palm	Strawberry Isl. Res.
Sealions	11	Rod Palm	Strawberry Isl. Res.
Forest	10	Tom Herman	Acadia
Whistle Buoy BMSC CTD	10	Bruce Cameron	BMSC
Physical oceanography	5	Rich Pawlowicz	UBC
Eelgrass	5	Ramona de Graaf	Huu ay aht / BMSC
Local wave force	5	Palmer and DeWreede	UA & UBC
Seawater intake CTD	1	Tom Bird	BMSC

Collaboration beyond western science

Collaboration beyond western science



- 13 fishermen
- 344 combined years
- maximum 44 years
- mean and median 26 years

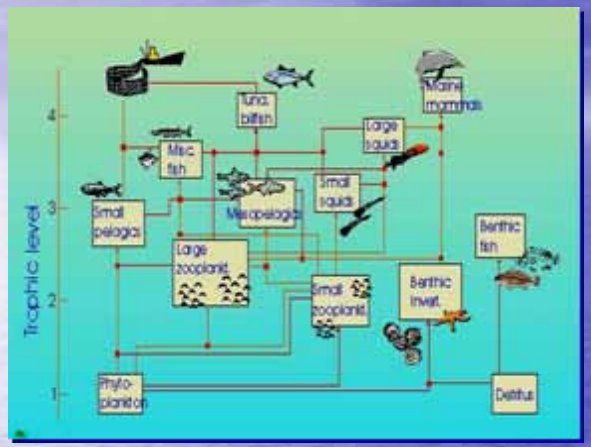
Questions for you

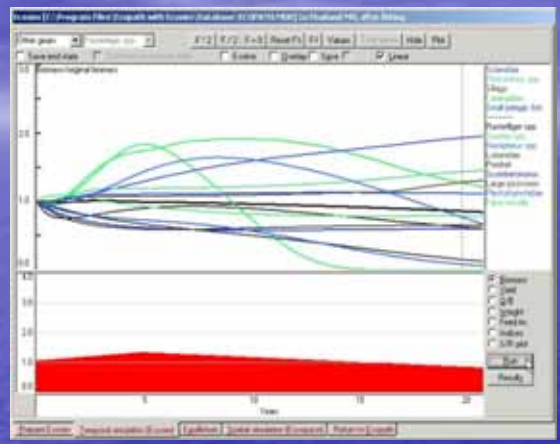
- Should such approaches be applied in the North Pacific?
- Should they be part of integrated ecosystem assessments?

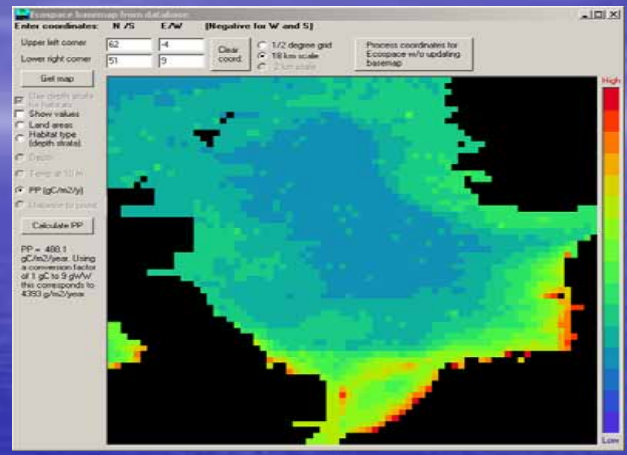
Linking global climate model output with ecosystem models

INNOVATIVE TOOLS

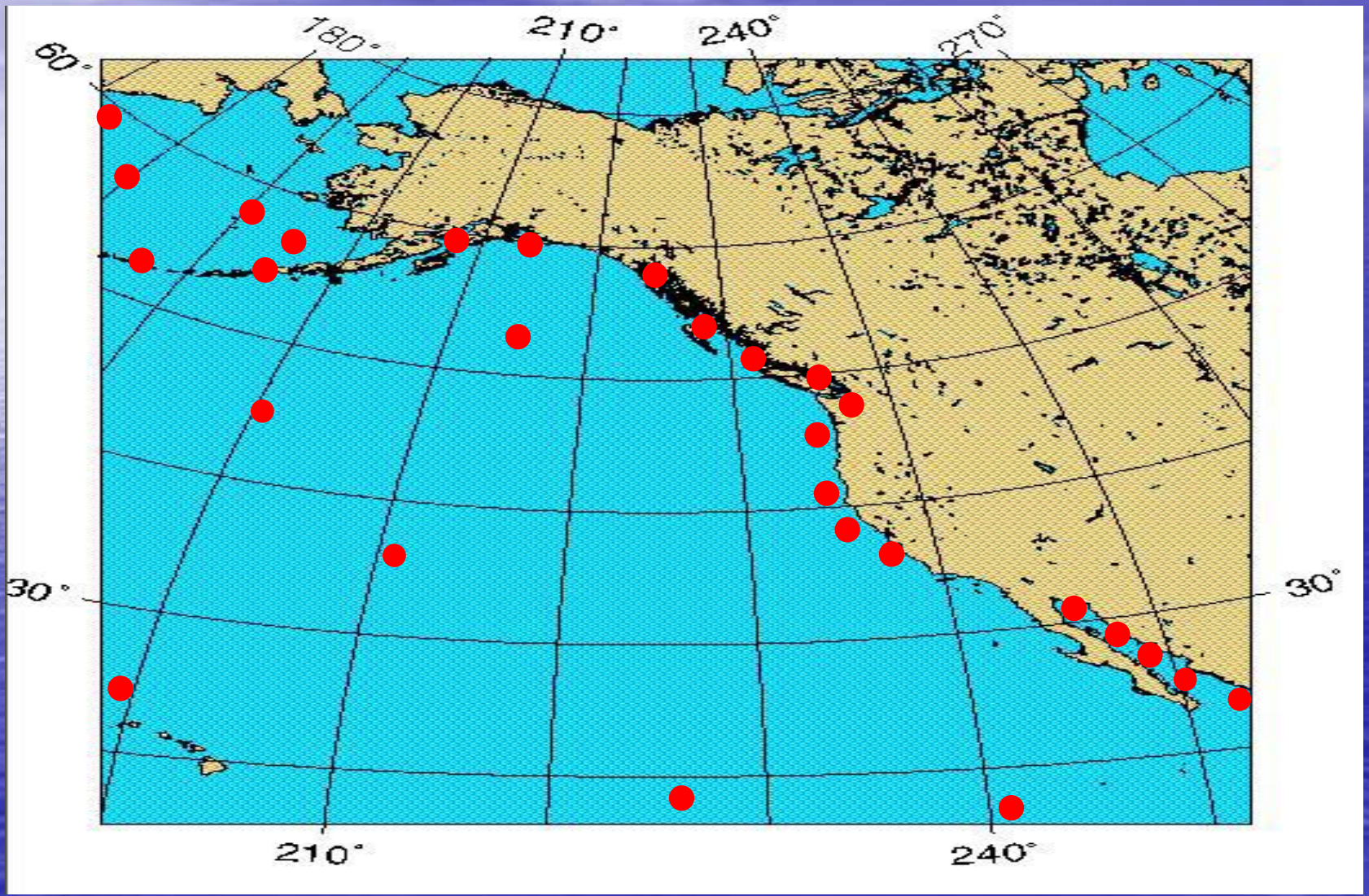
Ecopath with Ecosim



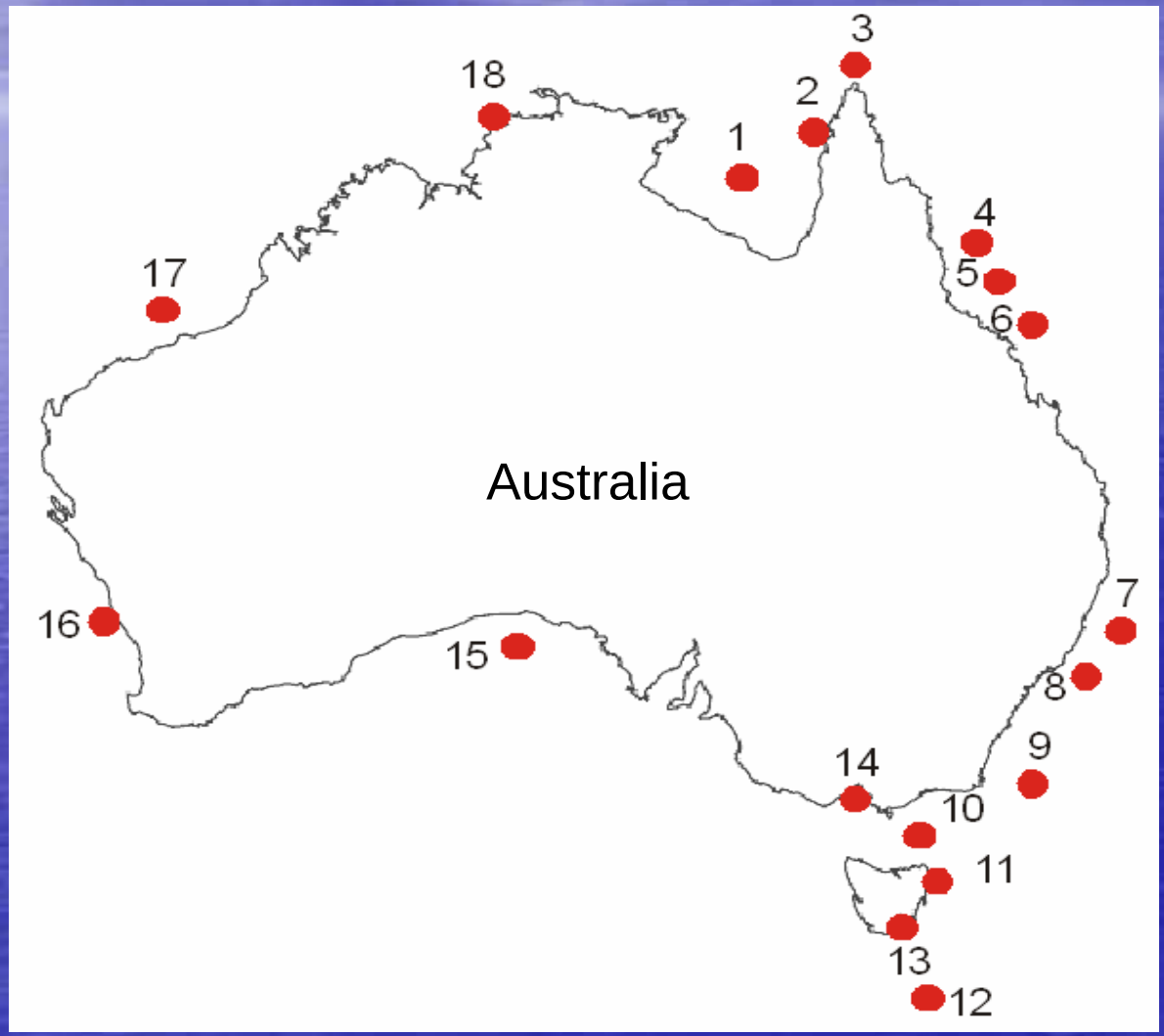




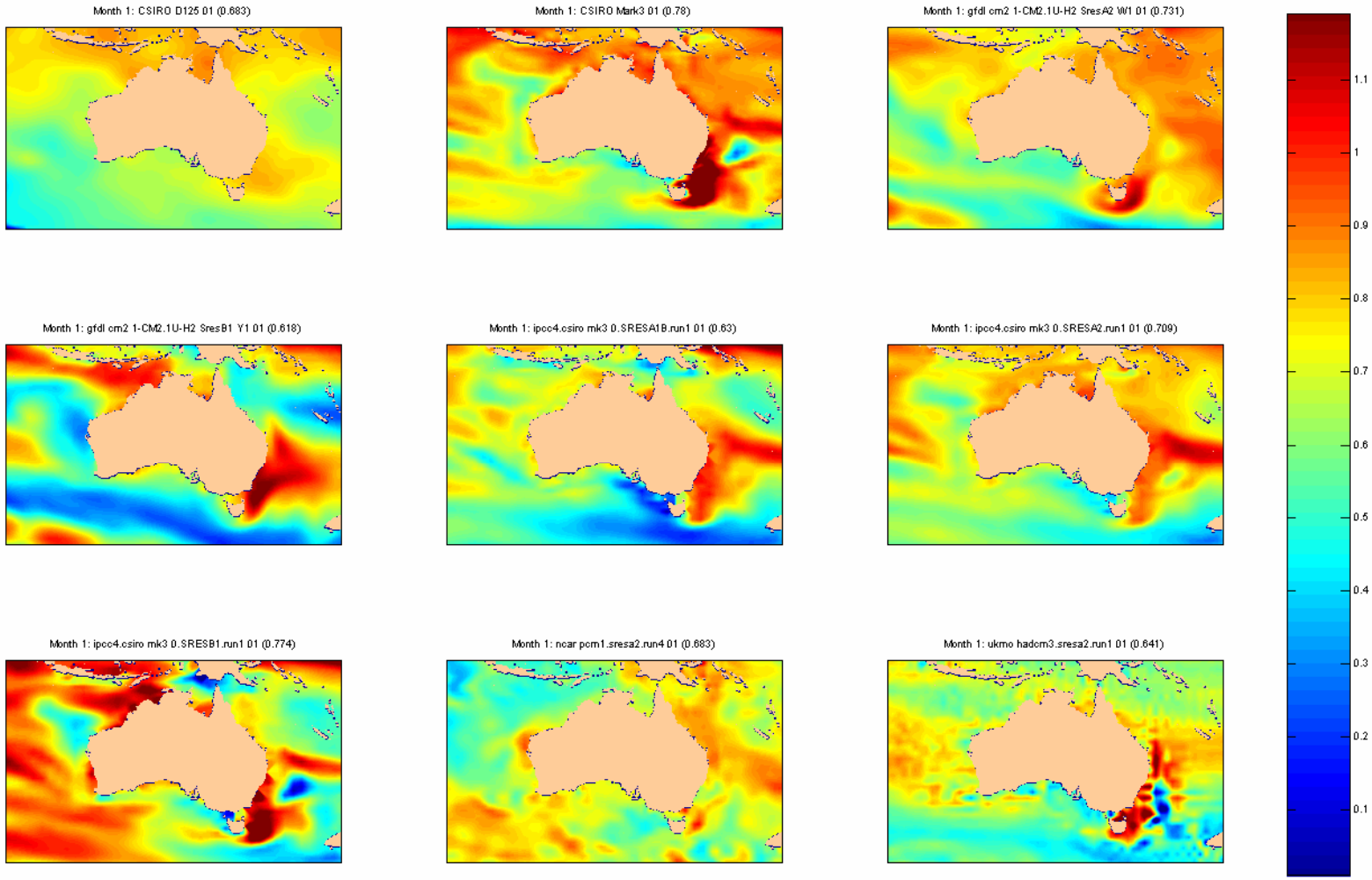
Networks of ecosystem models



Networks of ecosystem models



Temperature to 2070 -- model variation



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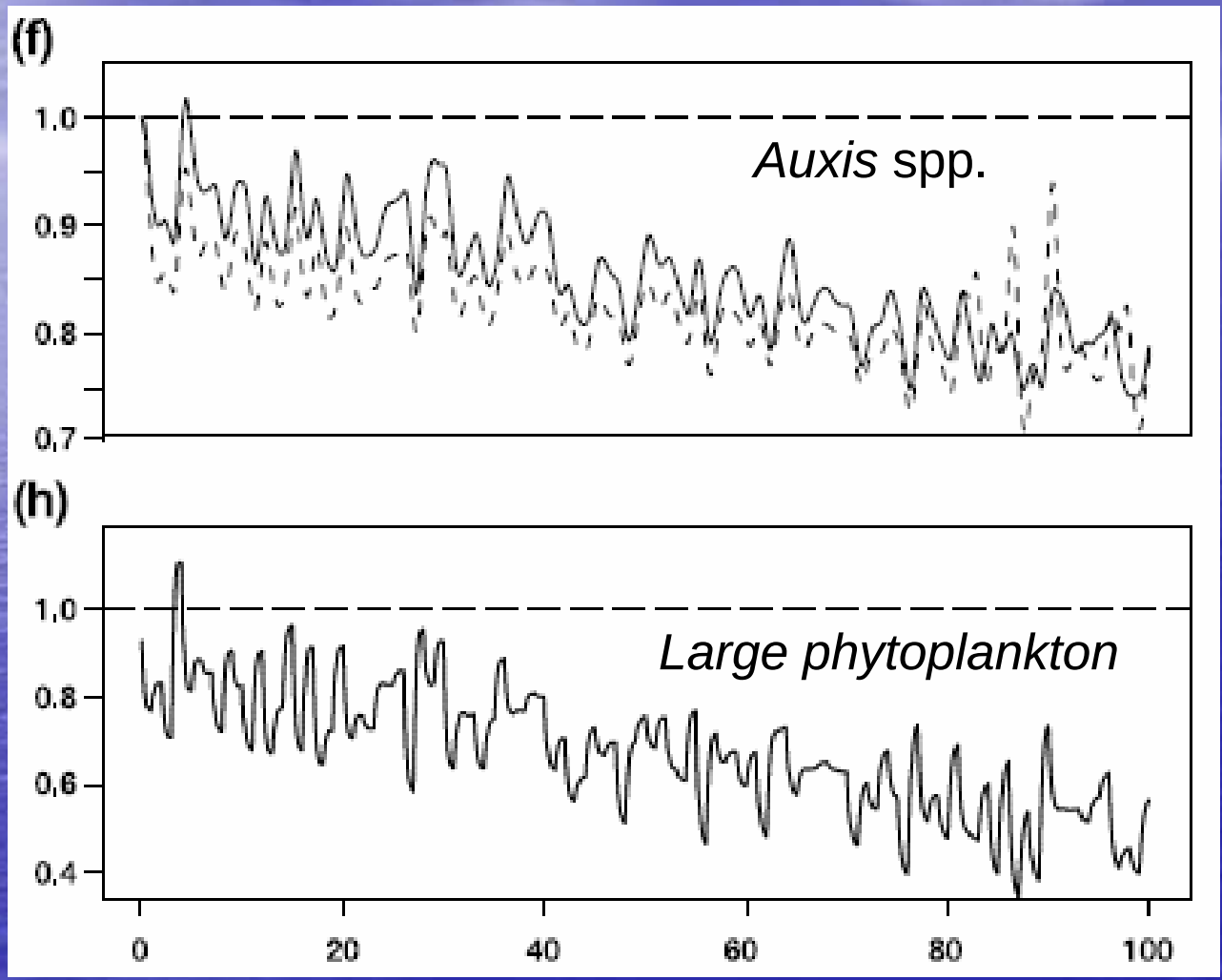
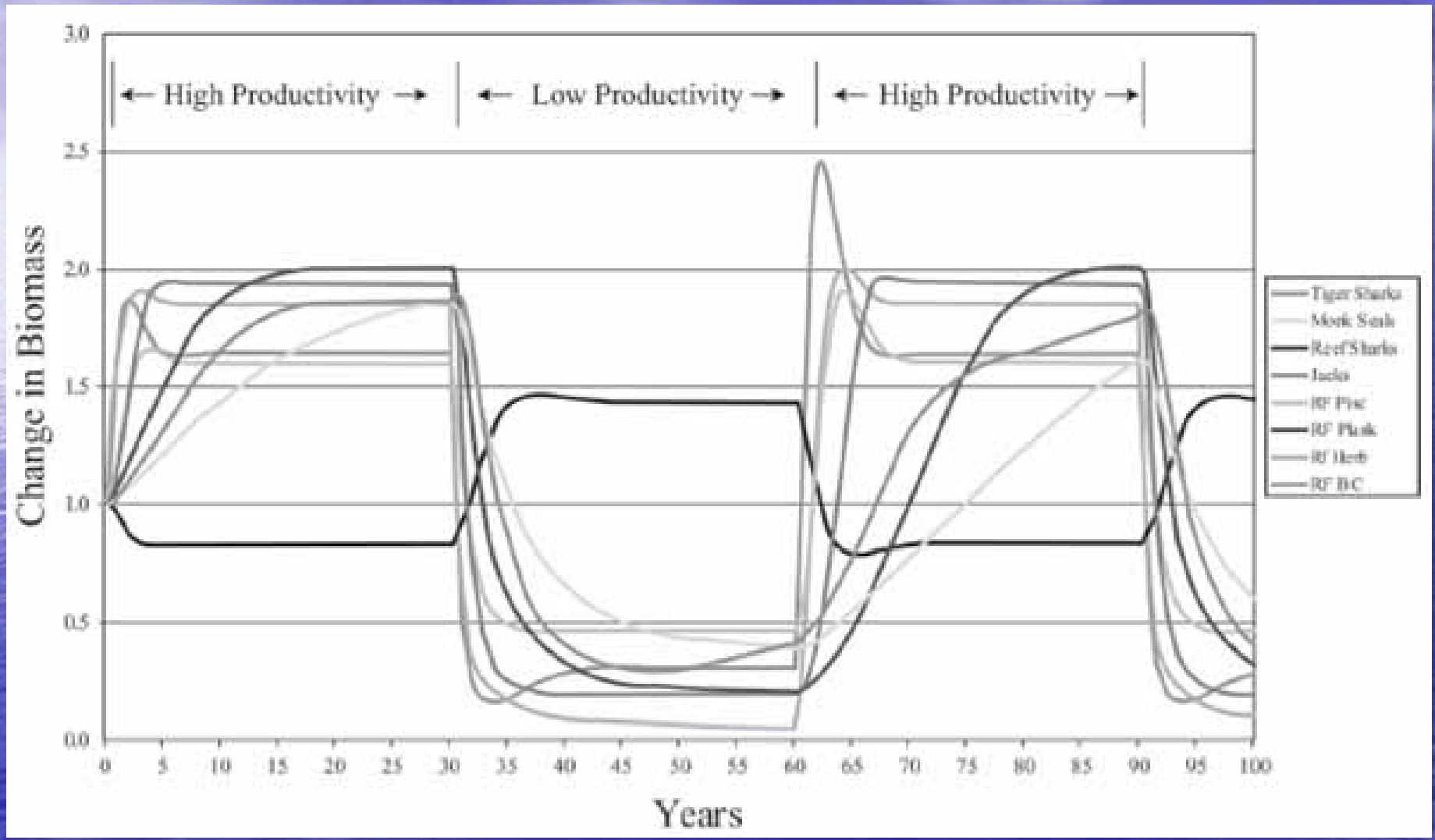
Eastern tropical Pacific

Watters et al 2003

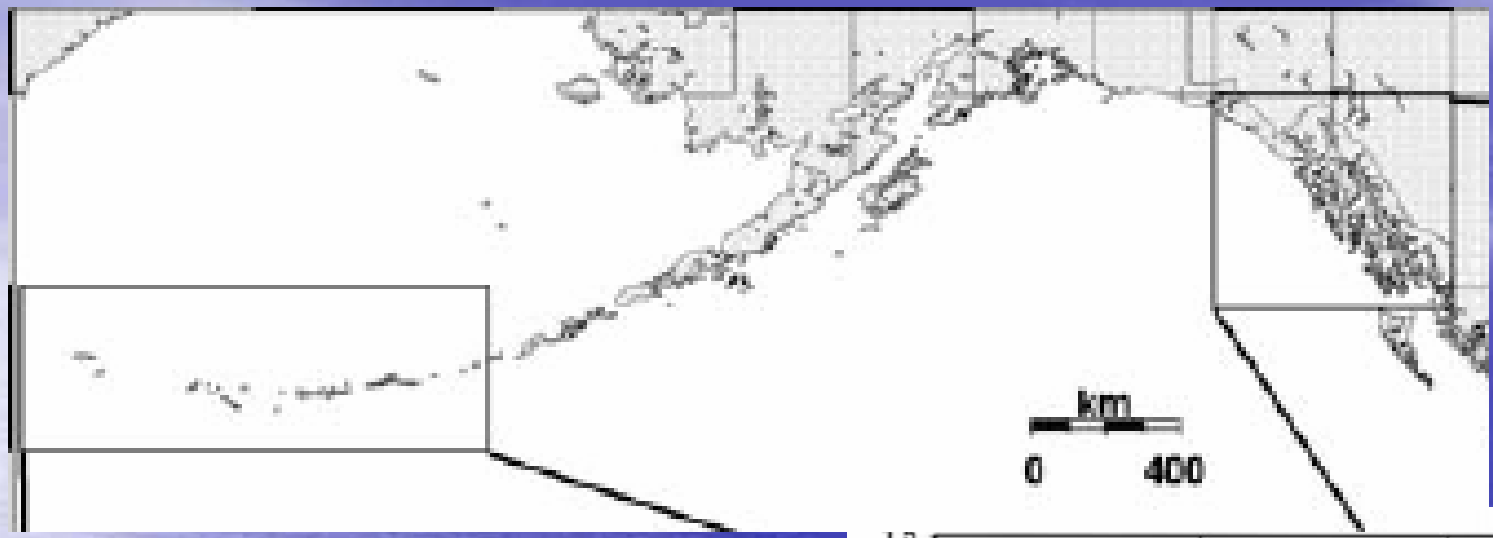


Northwest Hawaiian Islands

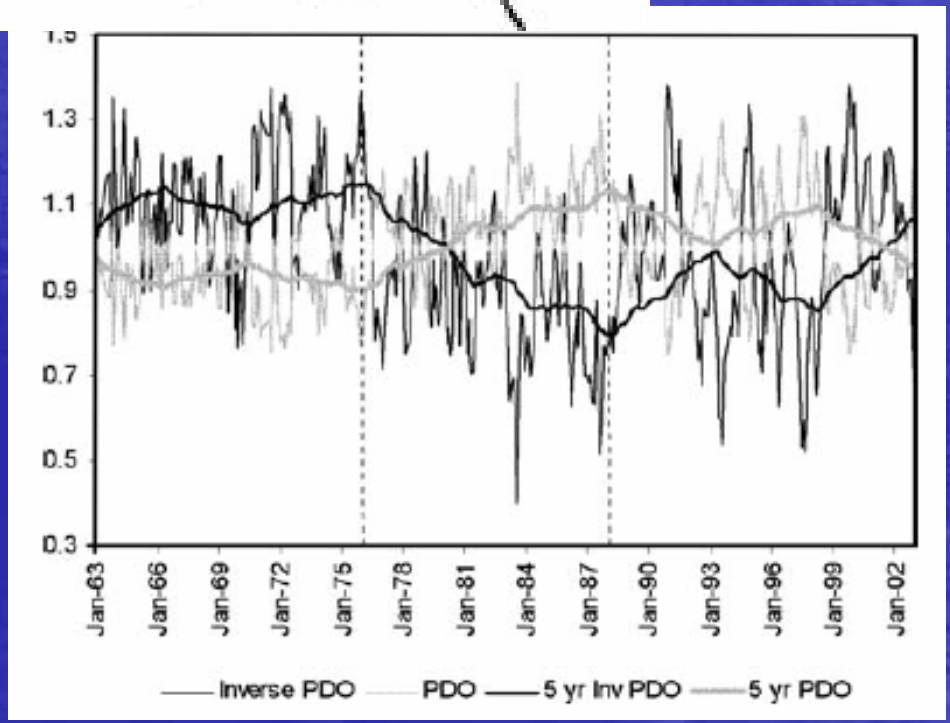


Polovina 2005

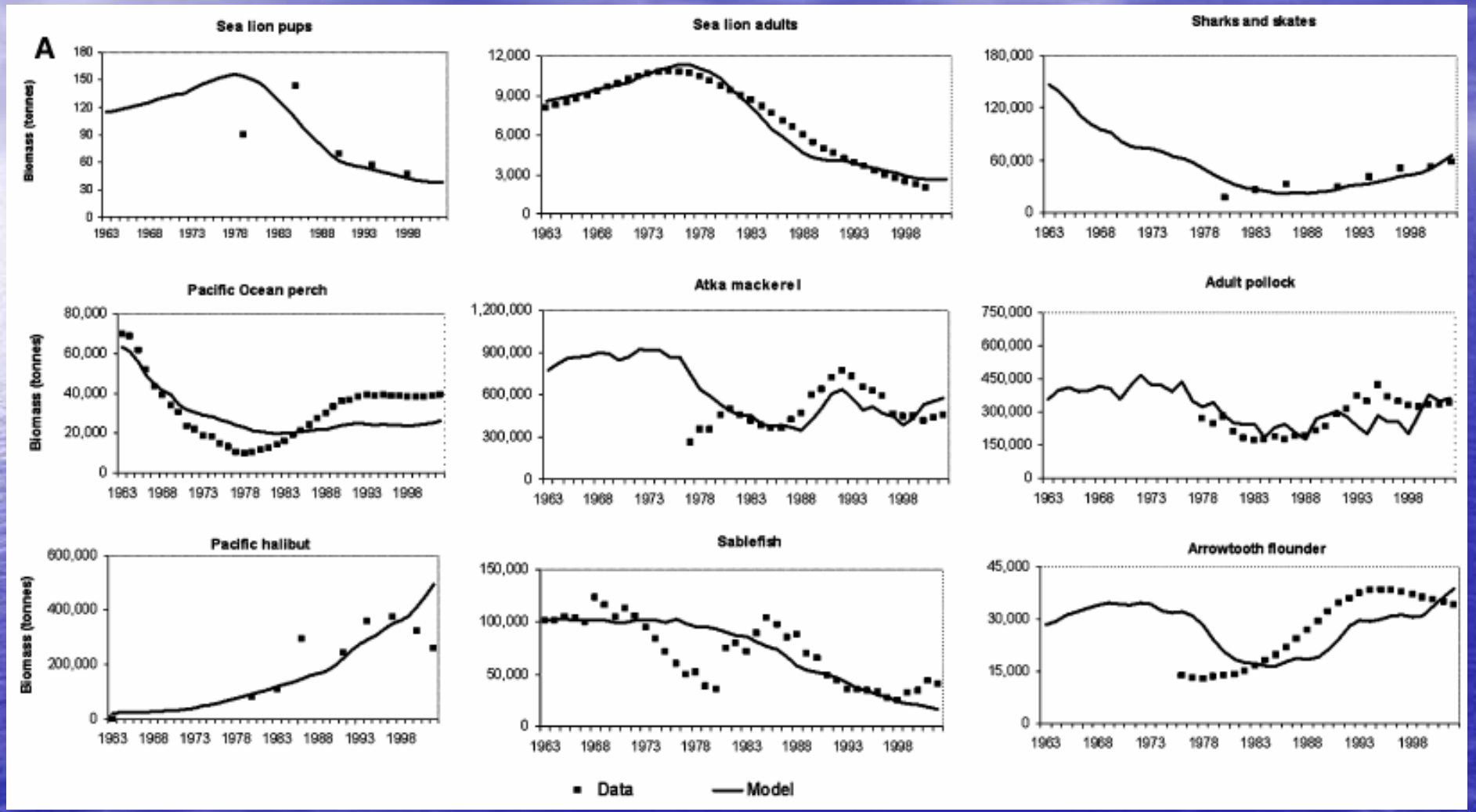
Network indicators in NE Pacific



Heymans et al. 2007

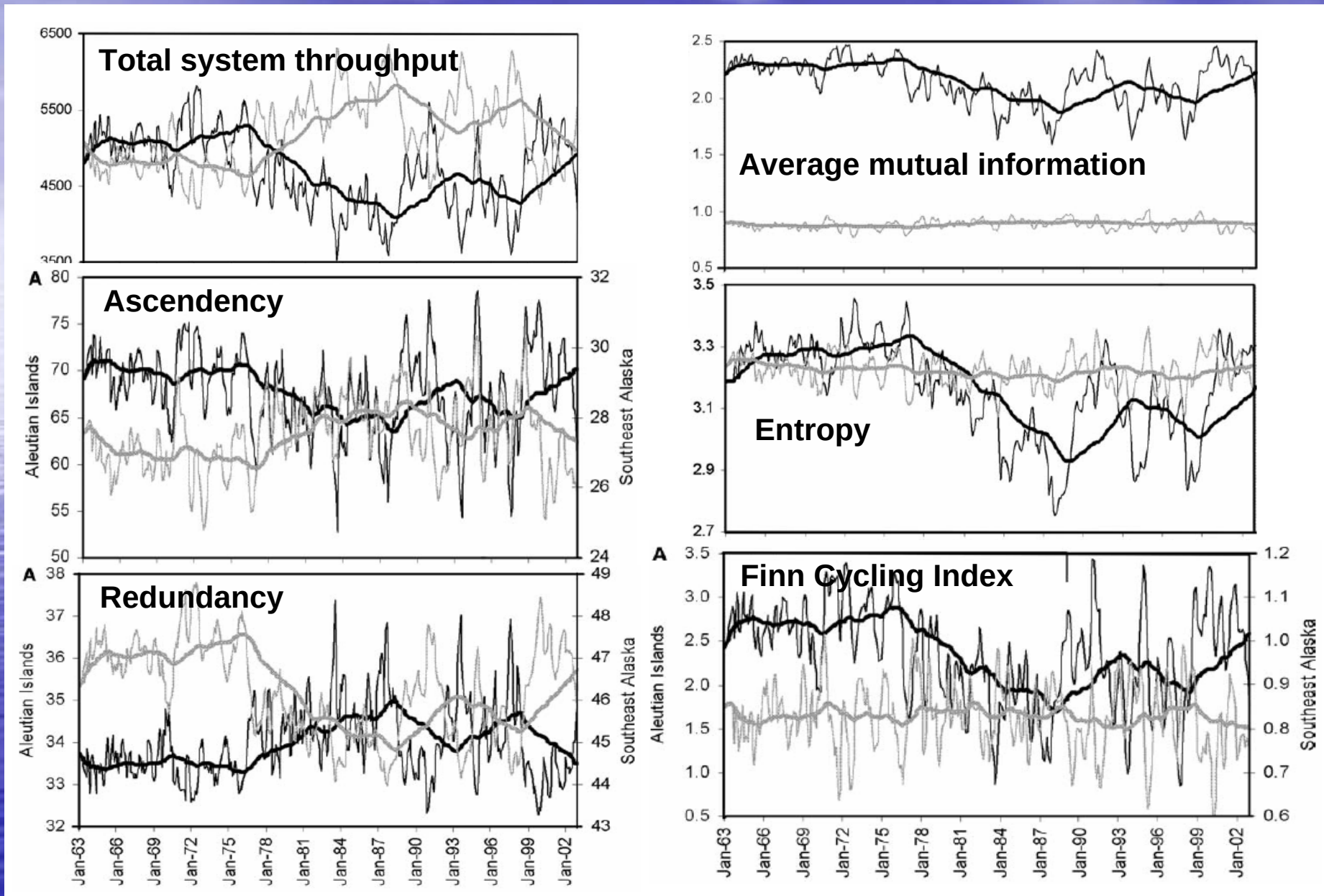


Reconstructing past ecosystem changes



Heymans et al. 2007

Dynamic prediction of indicators



Heymans et al. 2007

Other ecosystem models

- Atlantis
- Bioclimatic envelope models
- Approaches discussed in PICES task teams CFAME and MODEL
- Elements of the new FUTURE initiative?

PewTURE?

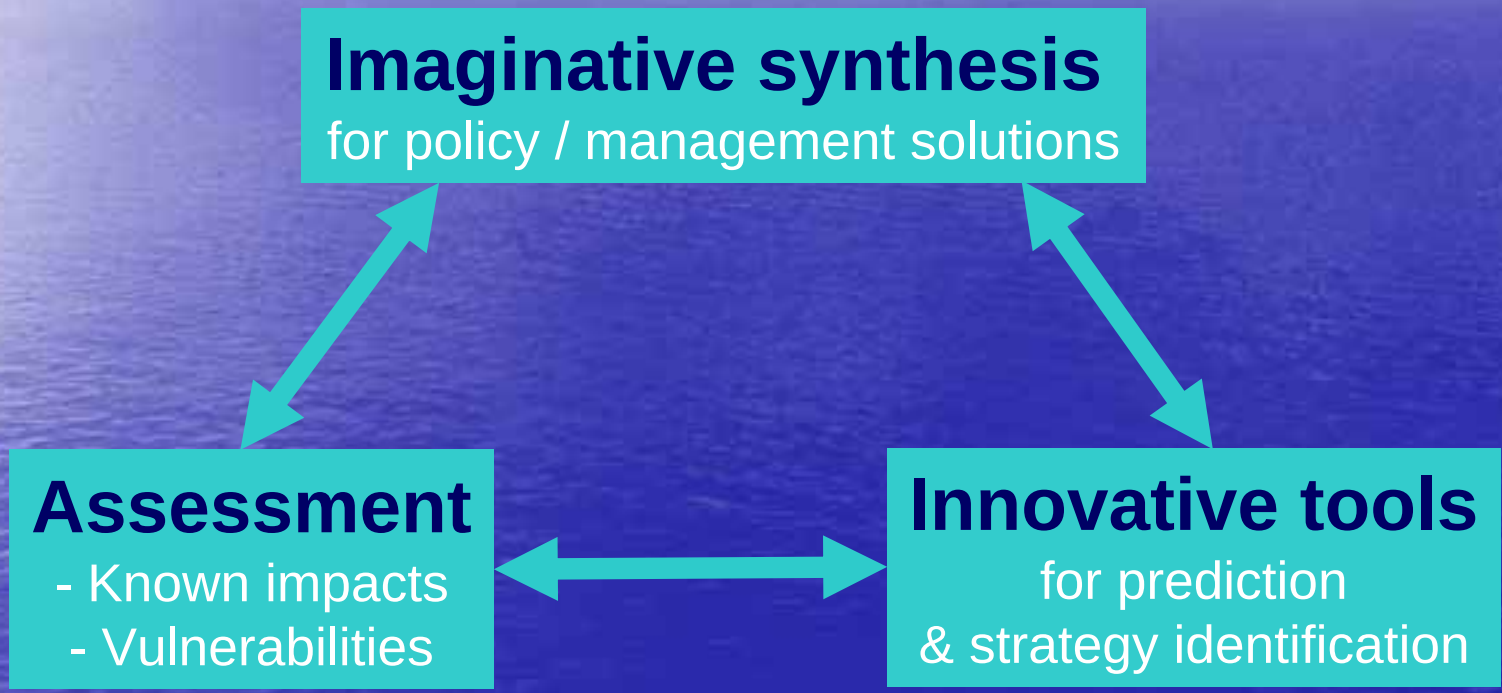
Finding workable management strategies and policies in the context of identified objectives and available approaches to assessment & prediction

IMAGINATIVE SYNTHESIS FOR POLICY SOLUTIONS

Policy working group

- What is the best way?
- Size and composition?
- Interface with the science groups?
- Best kind of setting?

Climate impacts framework



Acknowledgements

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- Alaska fishermen
- John Volpe

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