Marine Ecosystems: Under resourced, overlooked and under threat?

Climate Adaptation

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CSIRO

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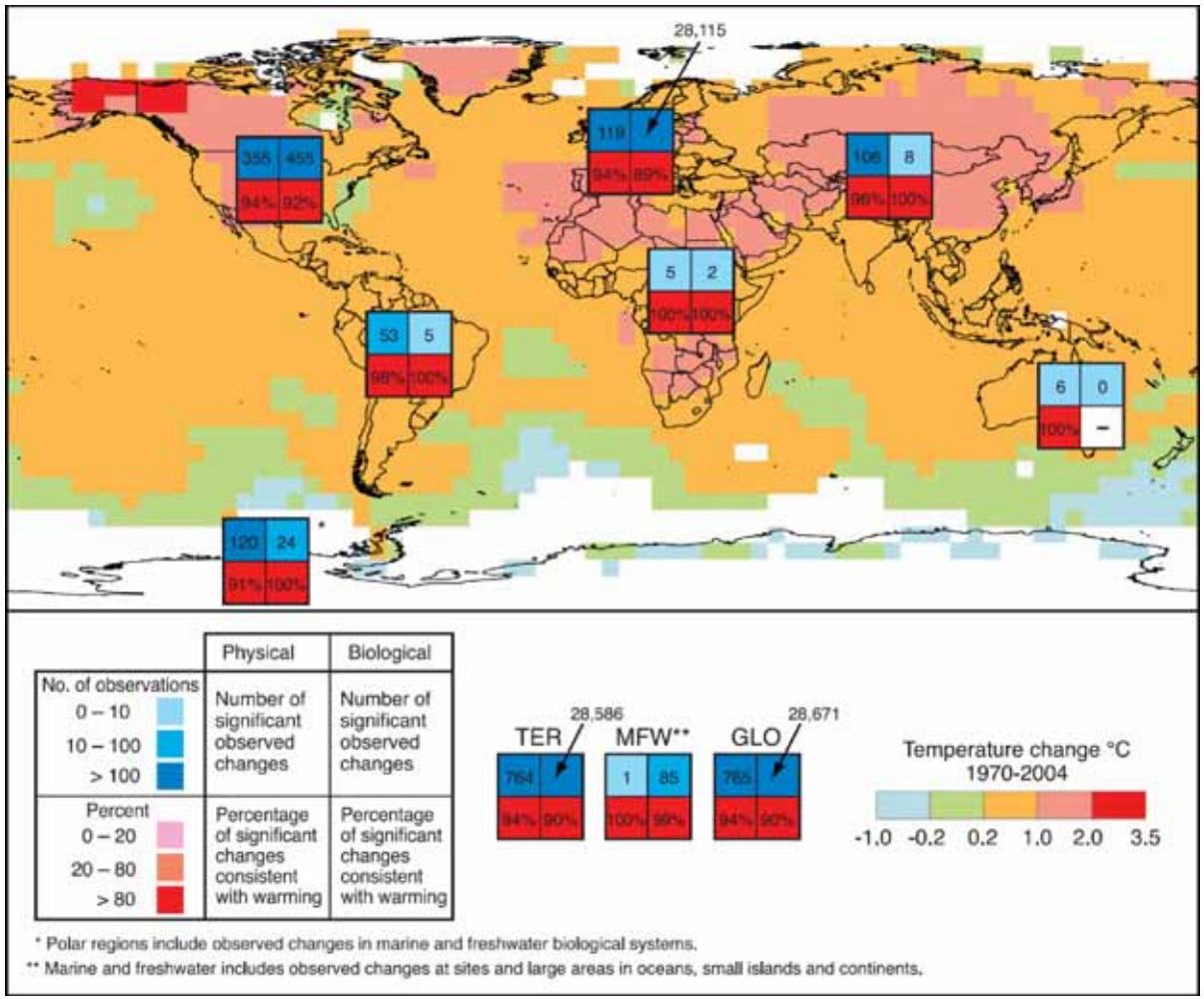
IPCC 4th Assessment, 2007



Terrestrial

764	28586
94%	90%

Marine and Freshwater

1	85
100%	99%

Figure SM-1.4. *Changes in physical and biological systems and surface temperature used in chapter synthesis assessment in Section 1.4.*
At the global scale TER = Terrestrial; MFW = Marine and Freshwater, and GLO = Global.

Biological changes with warming temperatures

Changes Northern Hemisphere terrestrial temperate species (59% of 1598 species) over the past 50 years (Parmesan & Yohe 2003, Nature; Parmesan 2007 Global Chng. Biol.):

6.1 km per decade northwards (poleward)

2.3 – 2.7 days per decade advancement of phenology

(5.1 days per decade advancement for a subset of species)

Marine systems: under threat?

- Sardinella in Mediterranean shifted 200 km in 50 years ~ **40 km** per decade **(Sebates et al 2006)**
- Copepods in the North Atlantic have shifted 1000 km in 50 years ~ **200 km** per decade **(Beaugrand et al 2002)**
- Plankton in the North Sea have advanced by **10-27 days** per decade **(Edwards & Richardson 2004)**

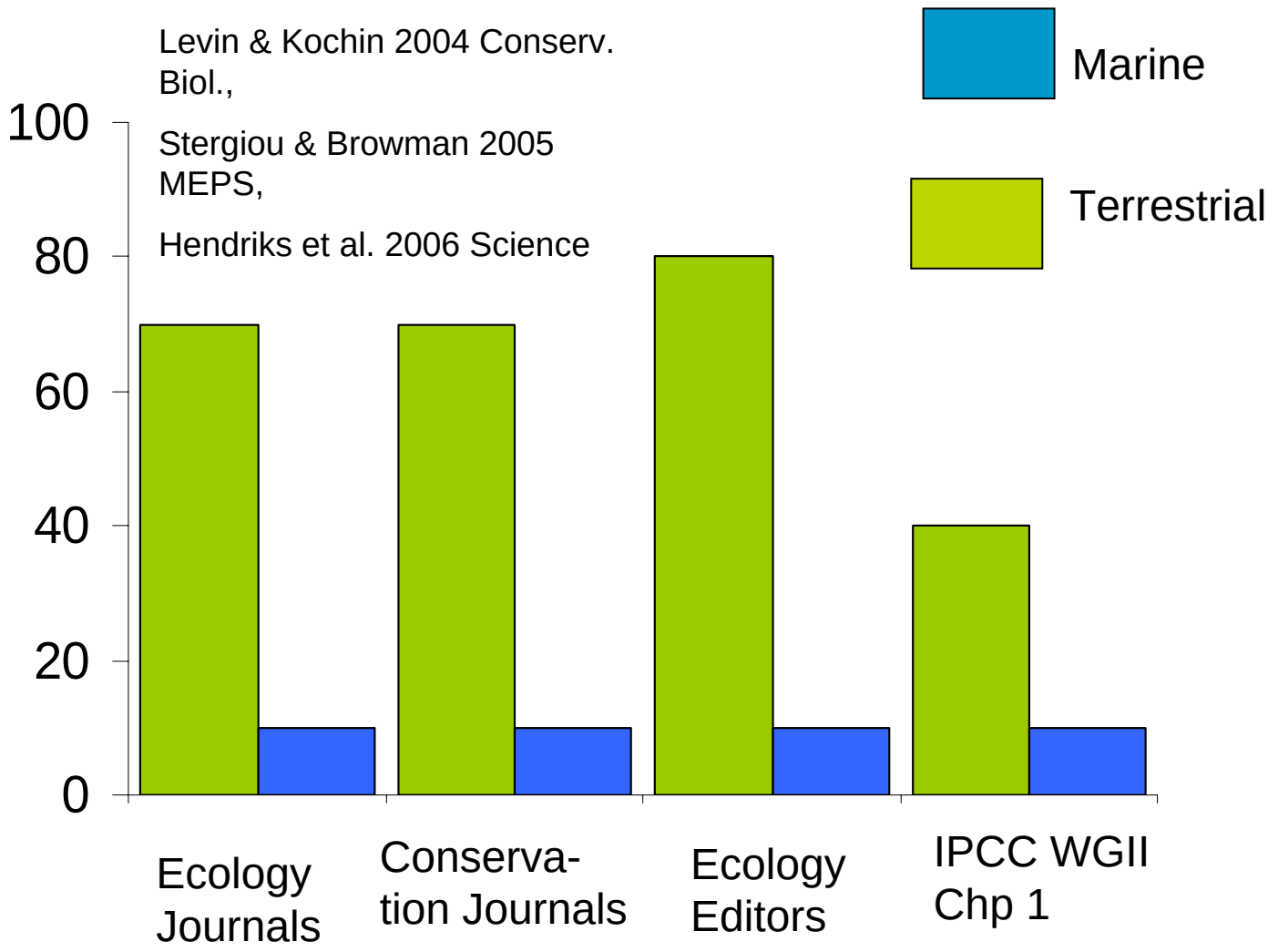
Problems: Marine systems overlooked?

From

Levin & Kochin 2004 Conserv. Biol.,

Stergiou & Browman 2005 MEPS,

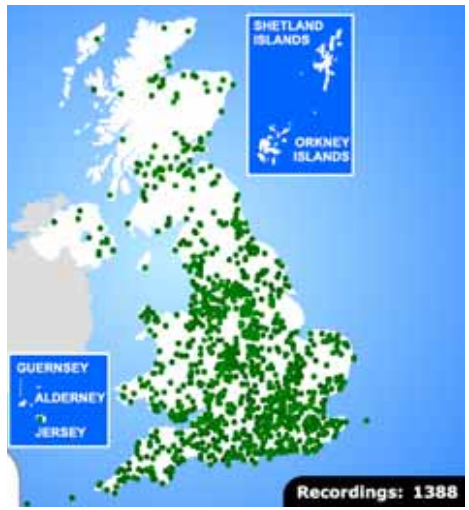
Hendriks et al. 2006 Science



Problems: Reduced Observational Capacity?

- **Most marine systems are fairly inaccessible**
- **Satellite observing systems restricted to surface waters**
- **Few amateur naturalists**
  - **Springwatch Survey (UK) in 2007: 24,453 observations**
  - **Garden bird counts (UK) in 2007: over 400,000 people**
  - **Birds In Backyards survey (Australia) in 2006/07: 987 surveys**

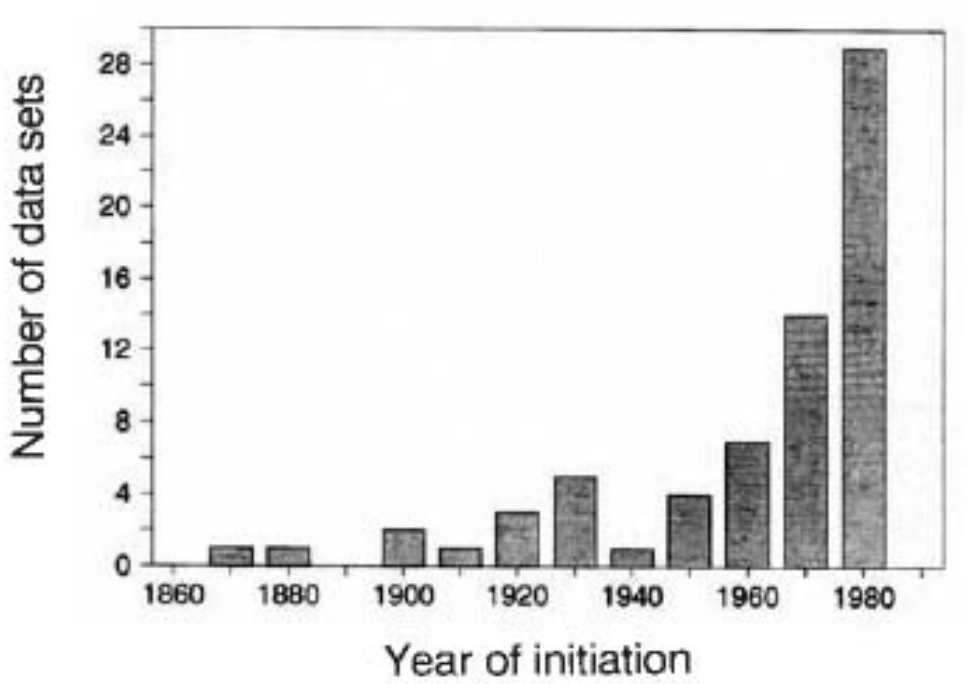
Great Barrier Reef



Snowdrop first flowering observations 2008: Springwatch

Problems: Few and short time series?

- IPCC criteria: 20 years data minimum, end 1990 or later

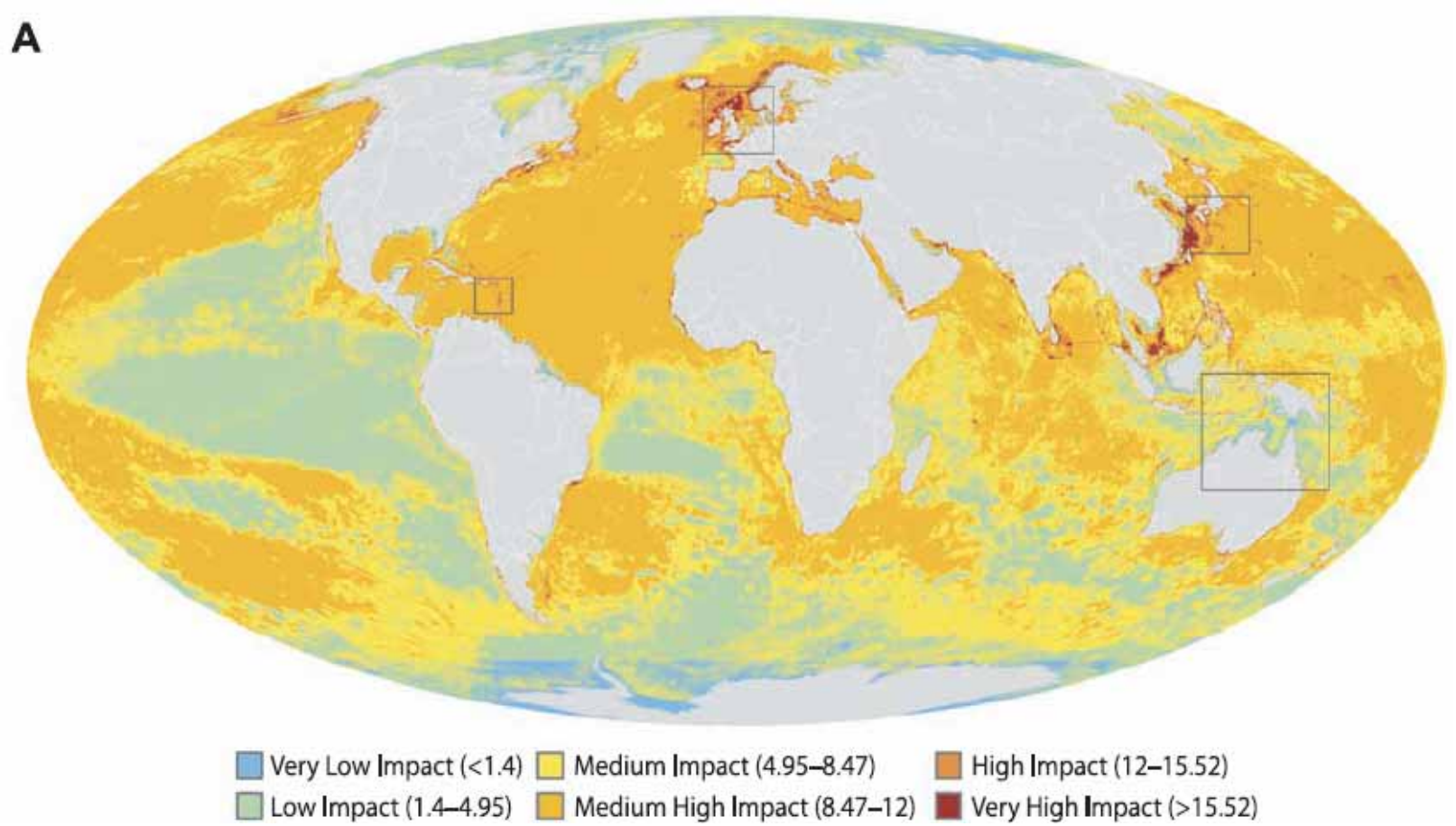


Rate of initiation of long-term monitoring programmes in European marine stations.

Funding crisis 1980s:
40% terminated

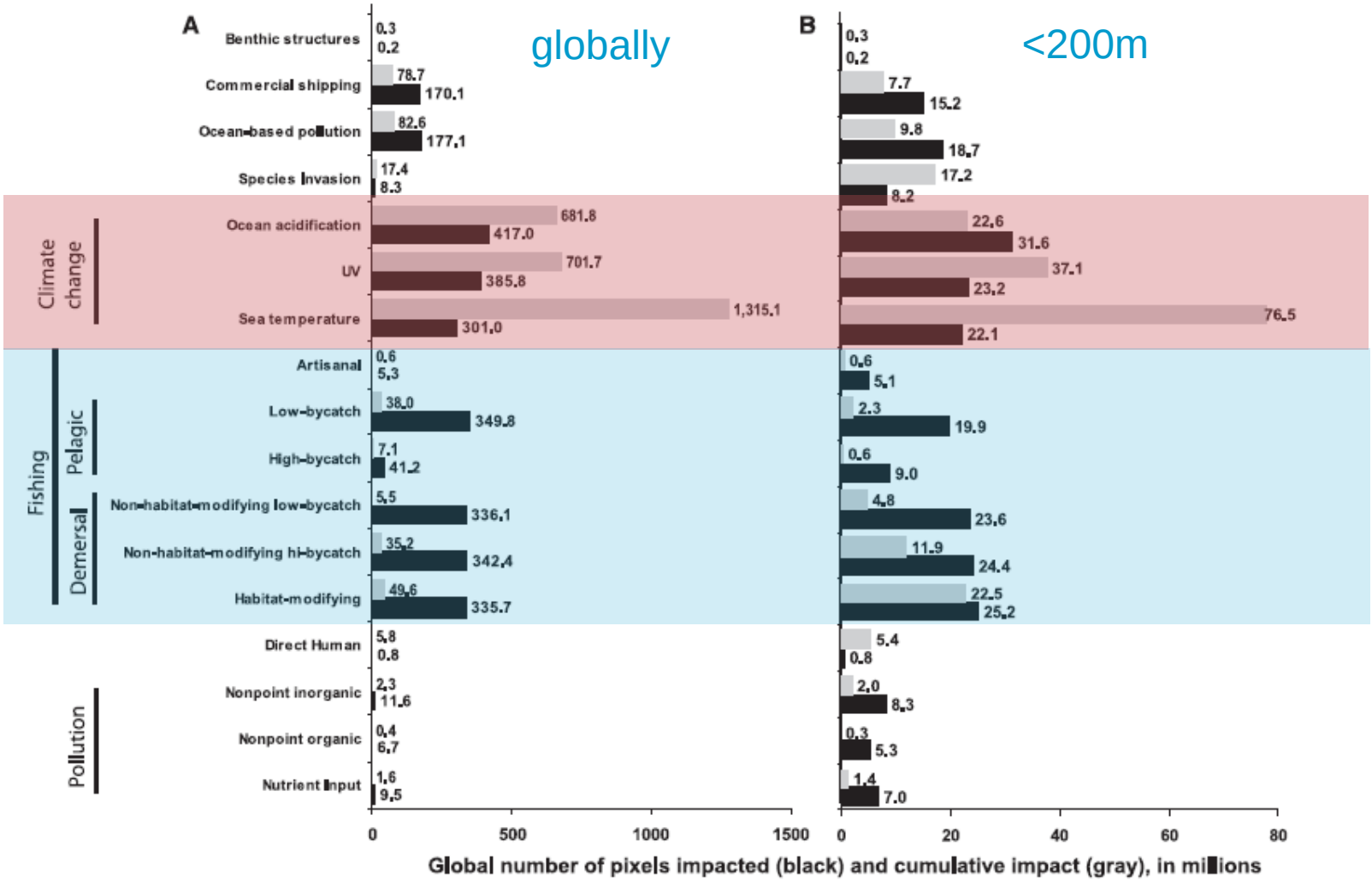
Duarte et al. 1992
Nature

Problems: Multiple Stressors



Halpern et al. (2008) Science

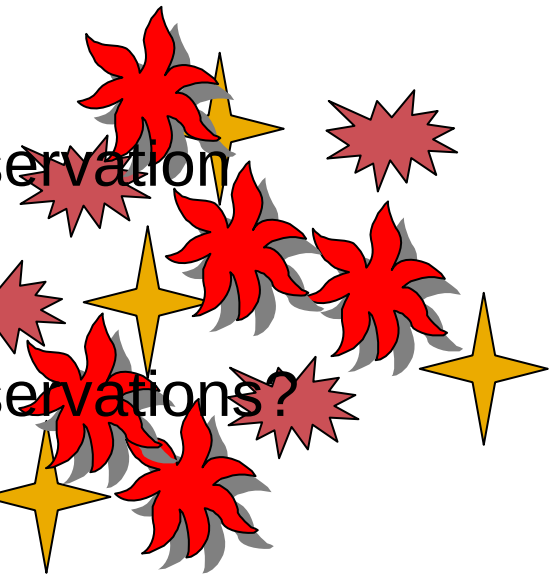
Human Impacts on the World's Oceans



Halpern et al. (2008) Science

Problems: Us!

Latitude



1 observation

OR

3 observations?

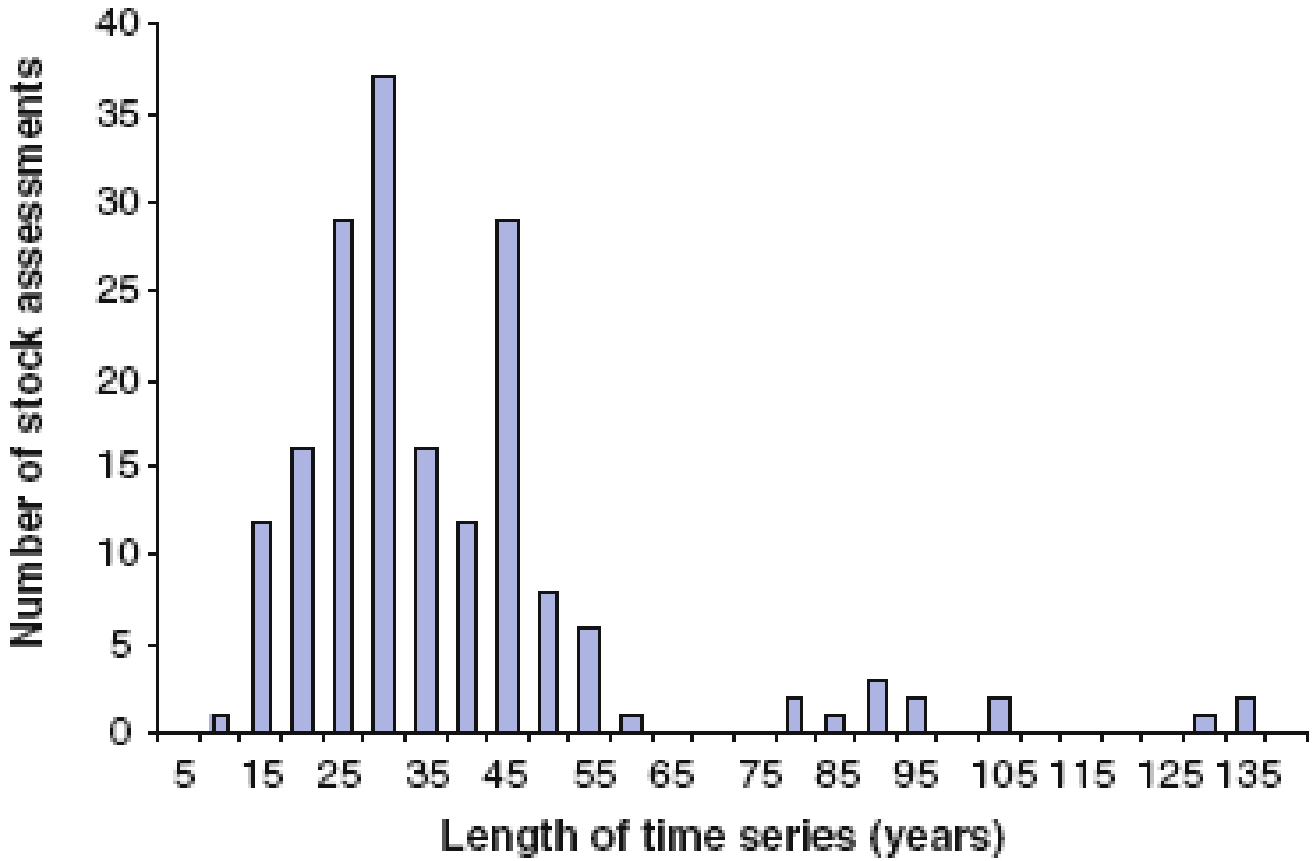
OR

many more?

PAST

PRESENT

Answers: Fishery Stock Assessments



Pinnegar & Engelhard 2008
Rev. Fish Bio. Fisheries

Answers: Data Recovery

- Early data in notebooks and paperfiles
- Past baselines?
- Cost Effective

Guinean Trawling Survey Database:

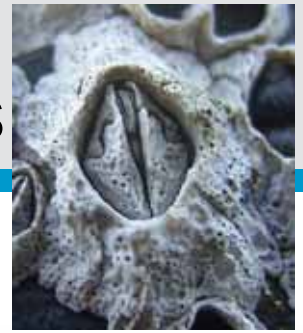
Data Recovery Costs: US$ 20,500

vs

Survey Costs (1960): US$ 17,000,000

Zeller et al. 2005
Marine Policy

Example: Intertidal Historical Reanalyses



1000s vs 2000s
Berge et al. 2005 MEPS

40-125km/dec

1950s vs 2000s
MarClim

1930s vs 1990s
Barry et al. 1995 Science

1950s vs 2000s

30-60km/dec

1930s vs 1990s
Rivadeneira & Fernandez 2005 J. Biogeogr.

Recommendations

- Innovative approaches
- Multi-national observing networks
- Address multiple, interactive stressors
- State observed changes explicitly (km per °C, days per °C) and for species not functional groups
- Encourage better representation by marine biologists in IPCC
- Encourage IPCC to list each observation
- Impacts database?
  - Allow transparency, quality control and gap-filling
  - Underpin adaptation science

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Thank you

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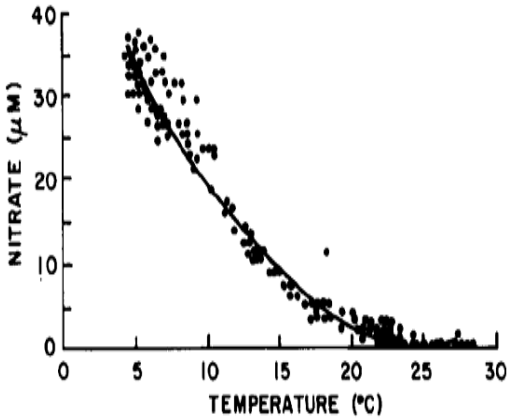
In Hot Water: Marine Systems

- Temperature: proxy & driver for ecosystem state



Ecosystem state

Low N ⟷ High N

warm, stratified, stable
flagellates and gelatinous zooplankton
recycled nitrogen
long, inefficient food web
few higher trophic levels

cold, well mixed, turbulent
diatoms and large copepods
new production high
short, efficient food web
support higher trophic levels

- Land: no direct link between T, nutrients & state

Richardson (in press) ICES J Mar Sci

Climate Change Impacts

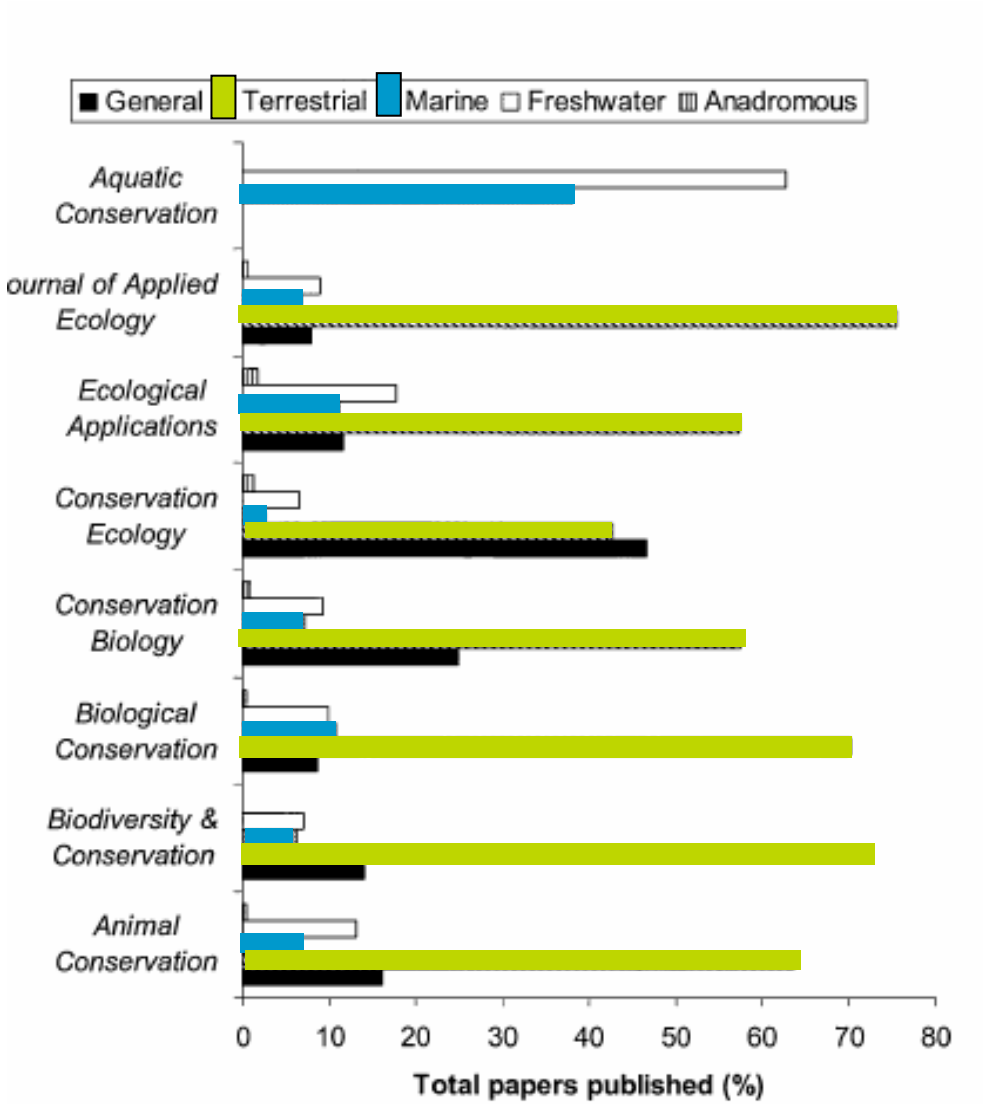
- **Plenary 2.2 Hoegh-Guldberg** – Coral reef ecosystems as casualties of rapid climate change
- **S5.1 Hobday et al.** – Getting hot and bothered about climate change impacts in Australian waters
- **S4.1 Richardson et al.** – The jellyfish joyride: can we stop oceans sliding down the slippery slope to slimy stingers?
- **S5.1 Blanchard et al.** – Predicting climate warming impact on marine fish communities from biogeography

Marine Biota: Canaries of Climate Change

- Distribution
  - **Land:** 6.1 km per decade poleward
  - **Marine:** 100s of kms per decade for phytoplankton, zooplankton, fish and intertidal fauna
- Phenology
  - **Land:** 2.3 days earlier per decade (172 taxa)
  - **Marine:** ~8 days earlier per decade in plankton, marine turtles, and seabirds

Richardson & Poloczanska (unpublished data)

Marine systems overlooked?



Kochin & Levin 2004
Conservation Biol.

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Examples: historical reanalysis

- Migratory bird arrival, Australia; 1960-2004 intermittent
  - Advancement of mean arrival date by 3.5 days/decade (Beaumont et al. 2006)
- Eucalypt flowering, Maryborough, Victoria; 1940-1962
  - Temperature and rainfall influences flowering dates (Keatley et al. 2002)
- Squid immigration English Channel; 1953-1972
  - Up to 150 days earlier in ‘warm’ years (Sims et al. 2001)
- Flatfish emigration English Channel; 1953-1965
  - Up to 1-2 months earlier in ‘cool’ years (Sims et al. 2004)