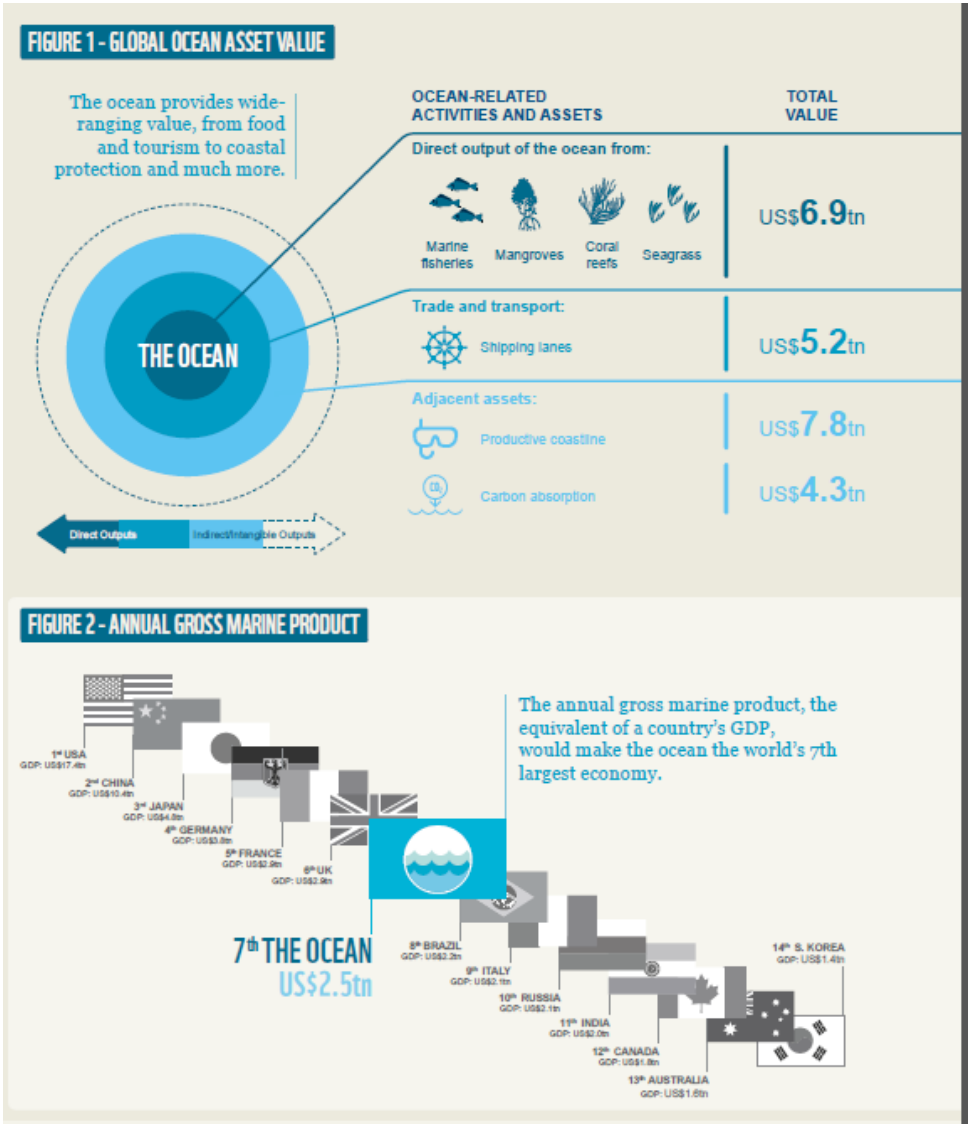
Grand Challenges Facing Our Oceans : The Role of Science and Engineering in Providing Solutions.

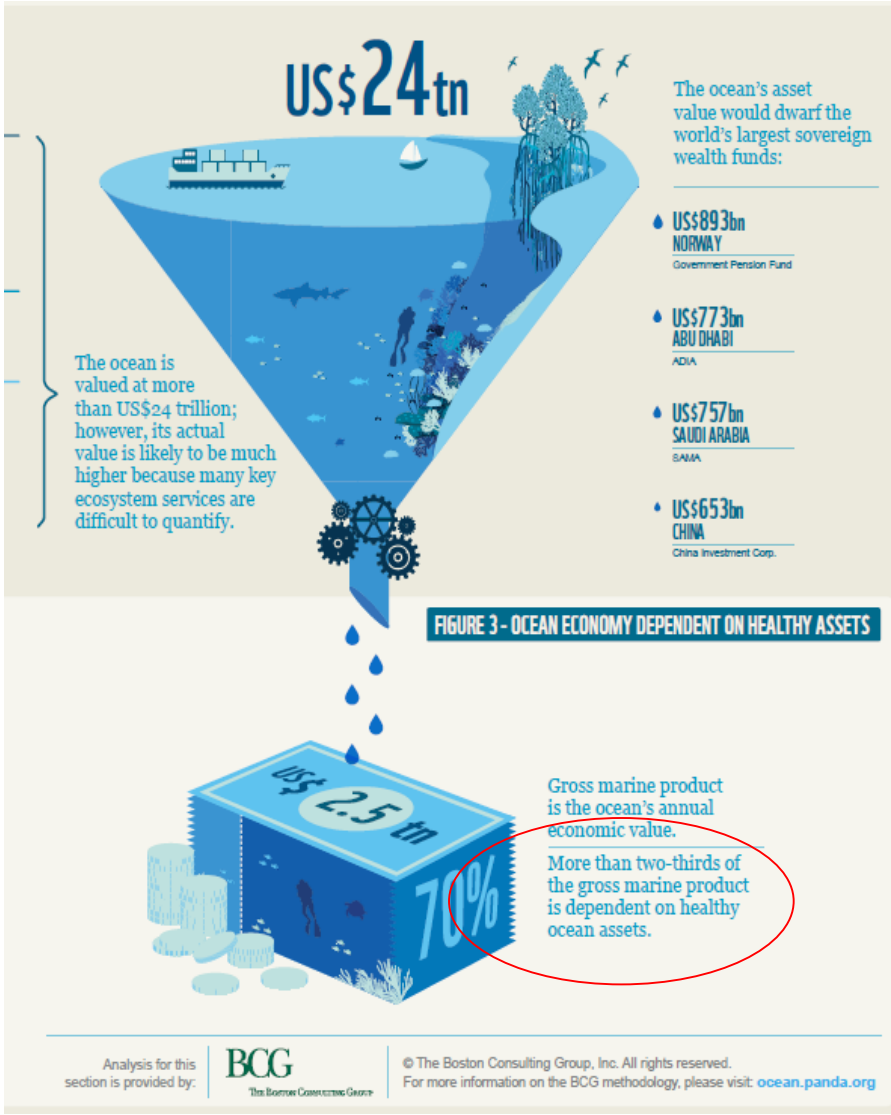
John Gunn

Outline

1. Economic Value of Ocean Industries and Ecosystem Services
2. Challenges to our Oceans and Coasts in the Anthropocene
3. UN Sustainable Development Goal 14 (Oceans)
4. Meeting the plethora of Challenges : What is required of science and engineering?
   - Global Ocean Observing
   - National Marine Science Plan
   - A Case Study - The Great Barrier Reef

The Global "Blue Economy" (WWF, 2015)





AIMS Index of Marine Industries

- Growing 2.5x faster than national economy
- Predicted to be worth $100 billion in 2025
- > Agriculture in economic value add

One planet, one ocean

Climate

Water

Oxygen

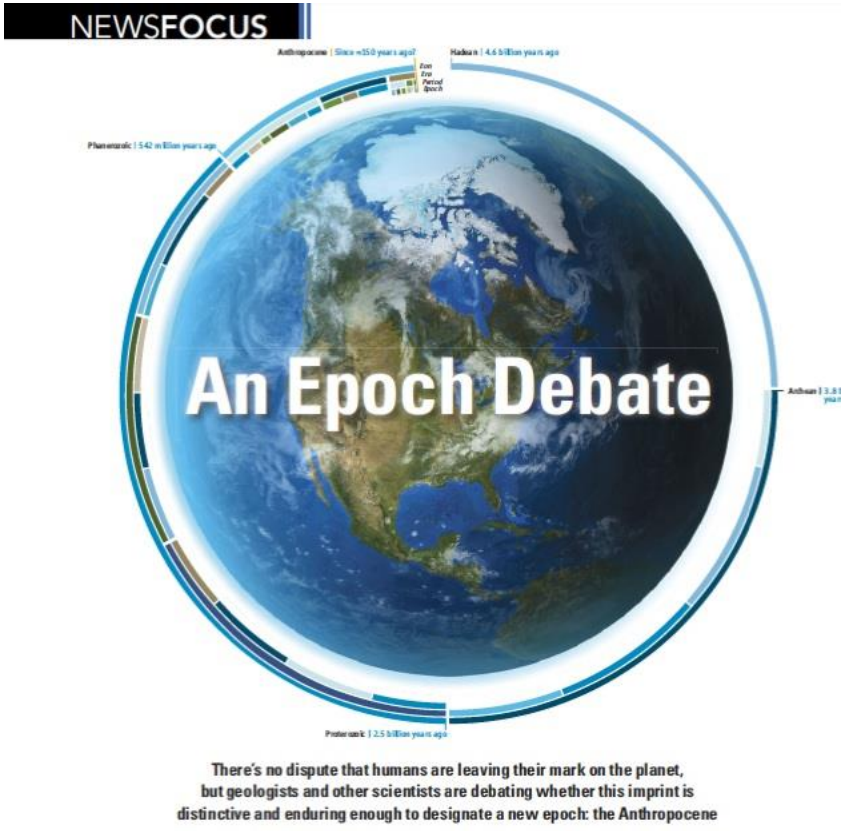
All the Cycles of Life

Nitrogen

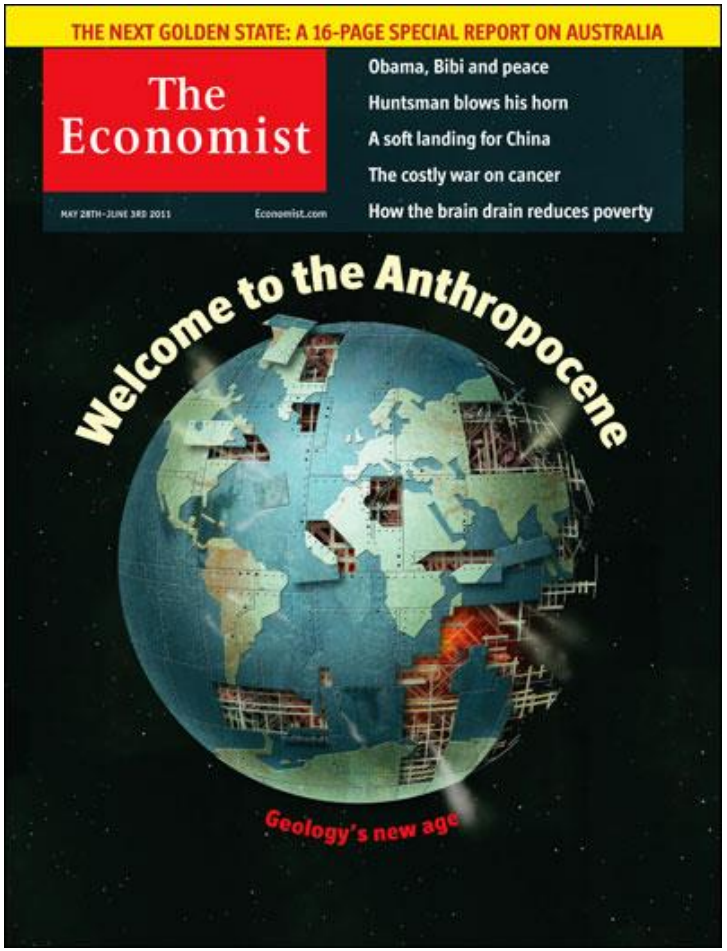
Carbon

The anthropocene

A new age of human impact



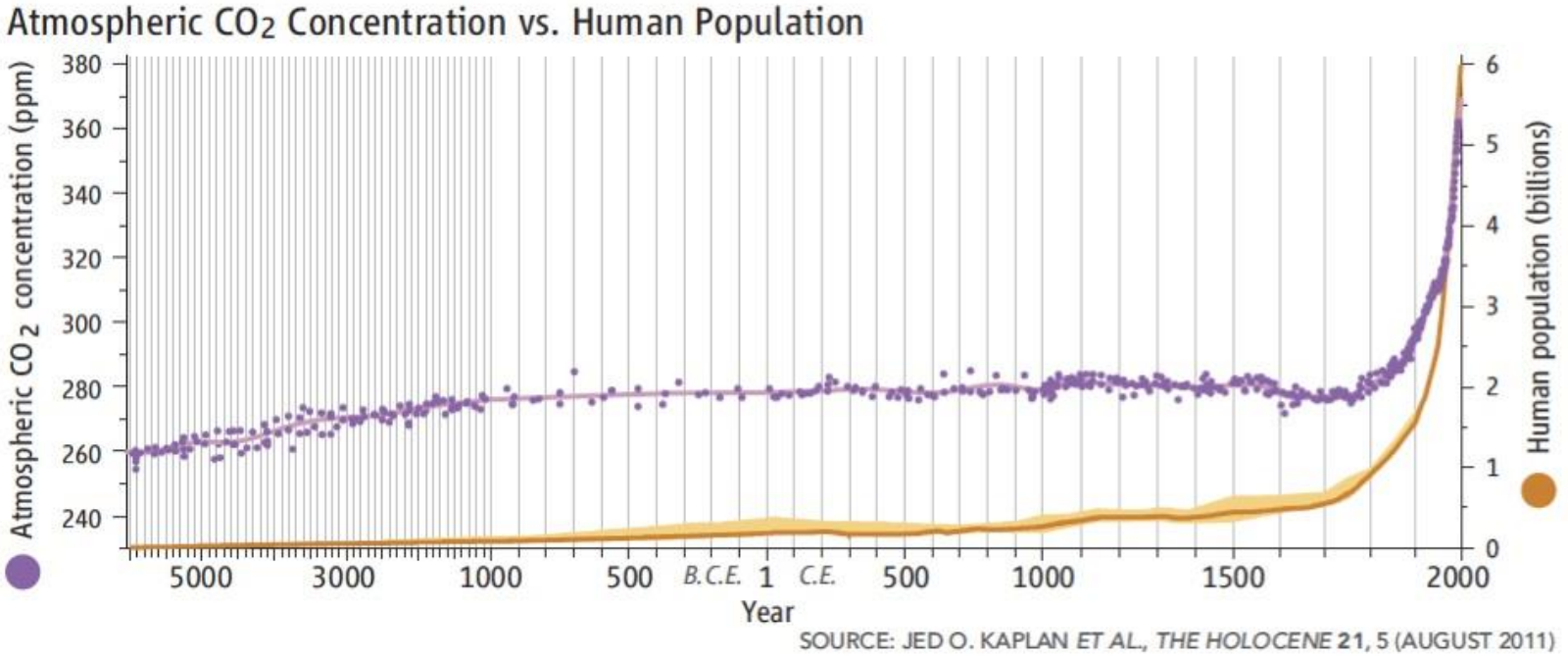
Science *7 October 2011*



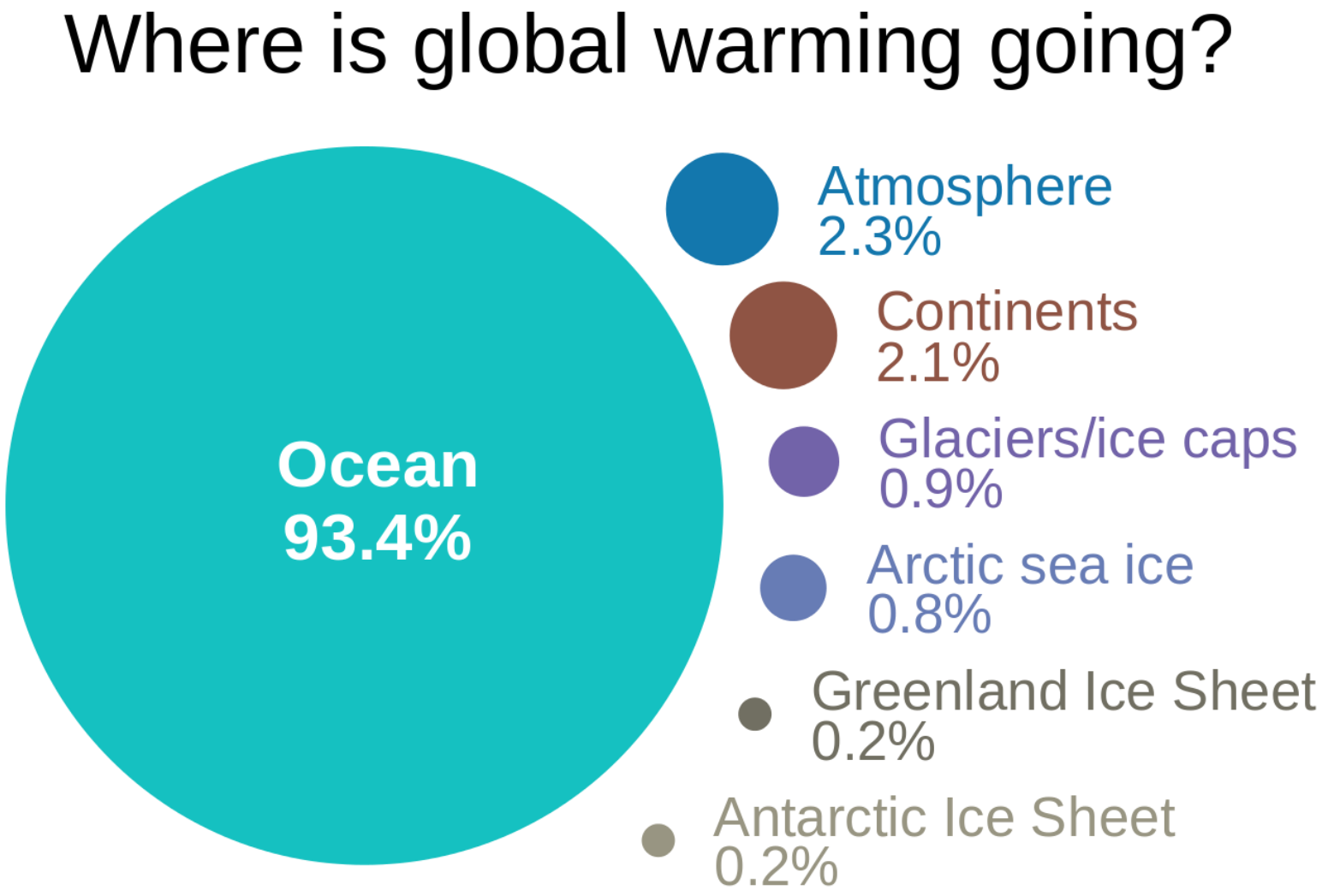
26 May 2011

The anthropocene

Population and CO_2



Earth has warmed by 0.8 C since 1880

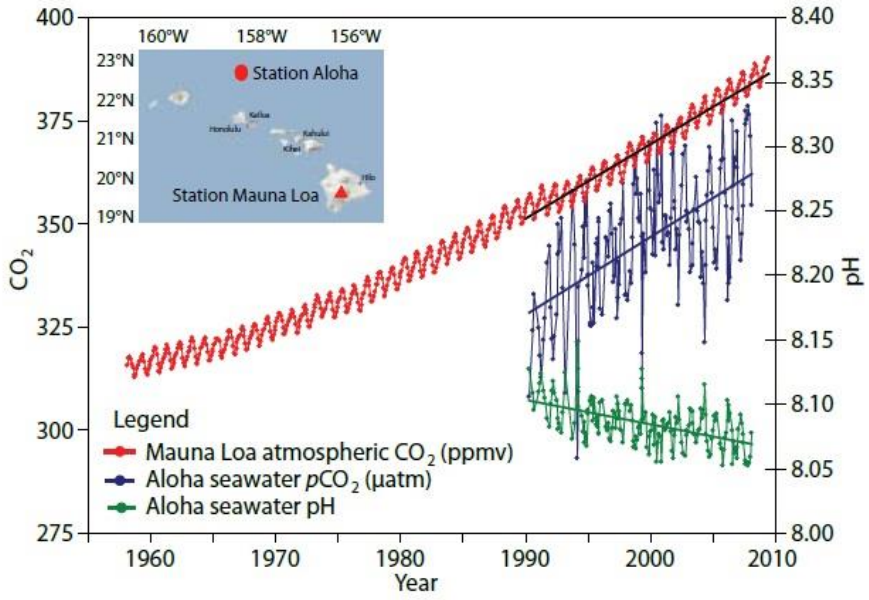


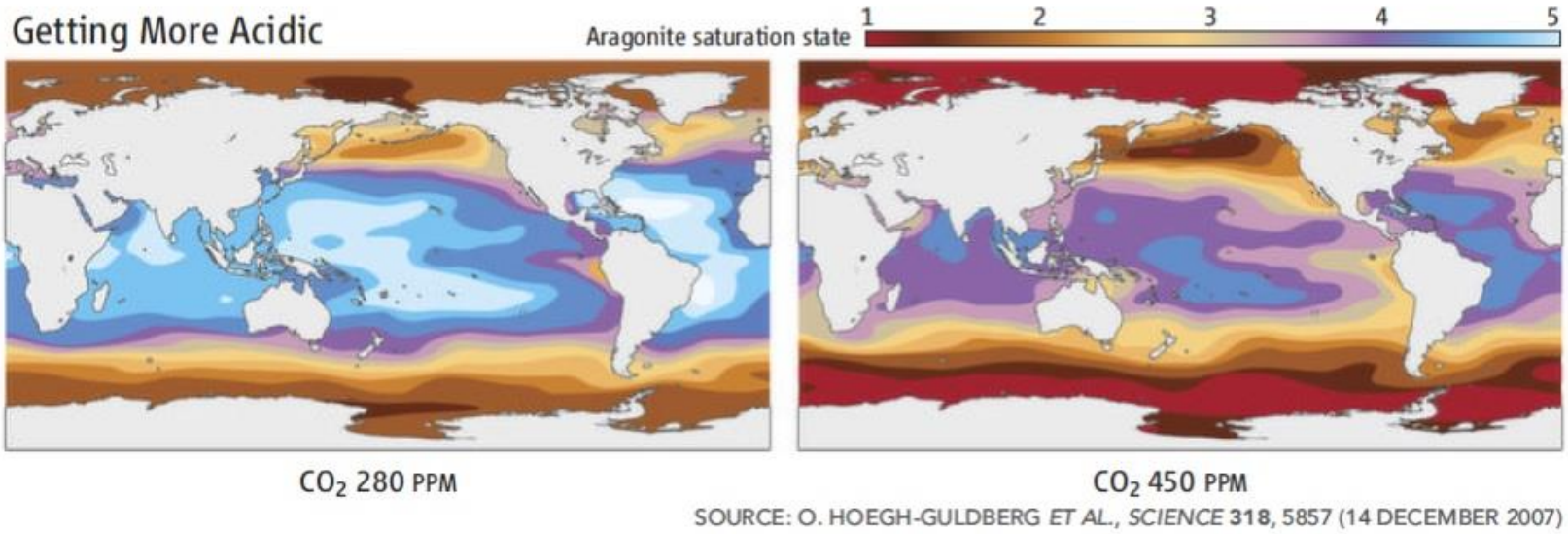
The anthropocene: changing ocean environment

Hot

The anthropocene: changing ocean environment

Sour:
Ocean acidification

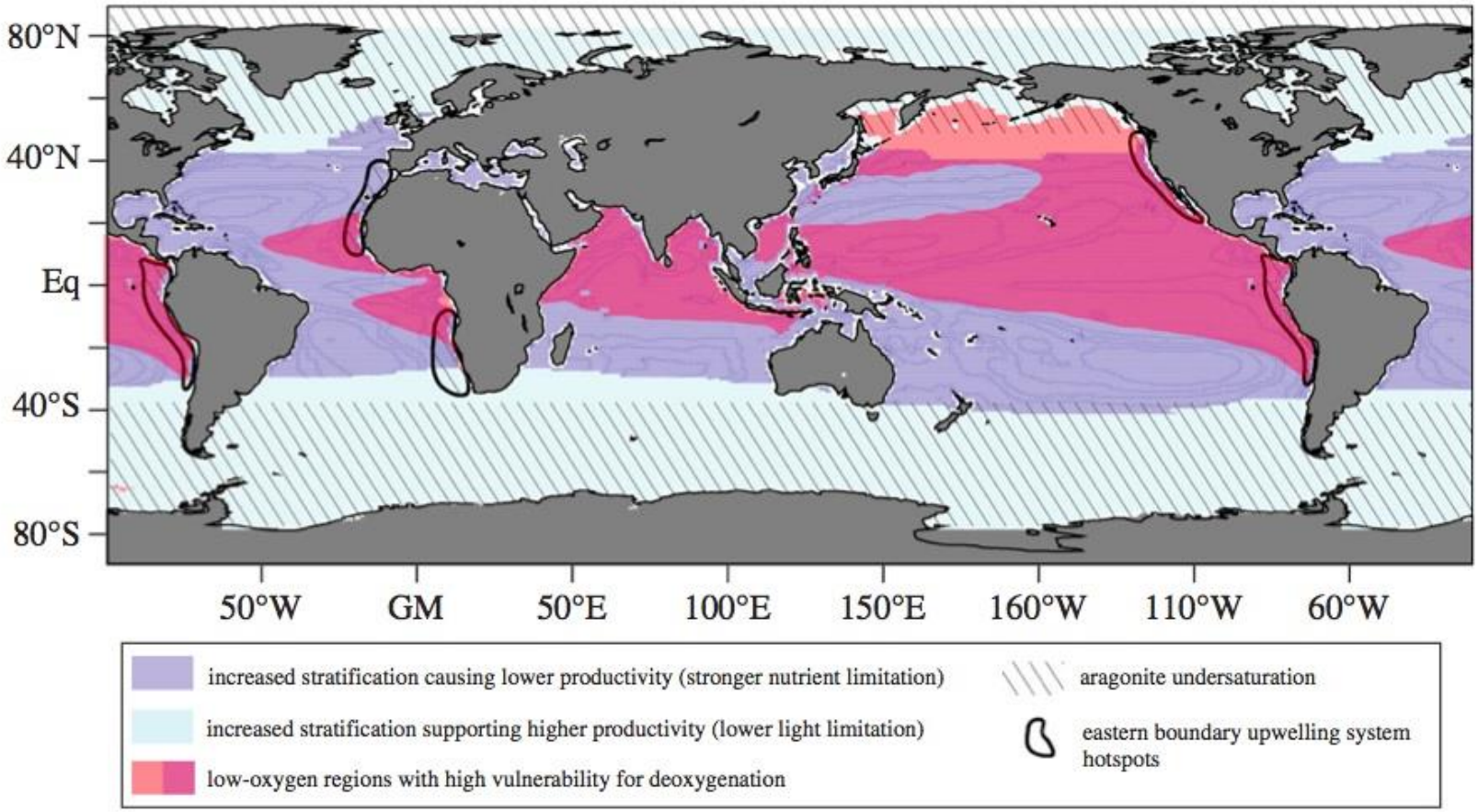




*above: Doney et al., **Oceanography**, 2009*

The anthropocene: changing ocean environment

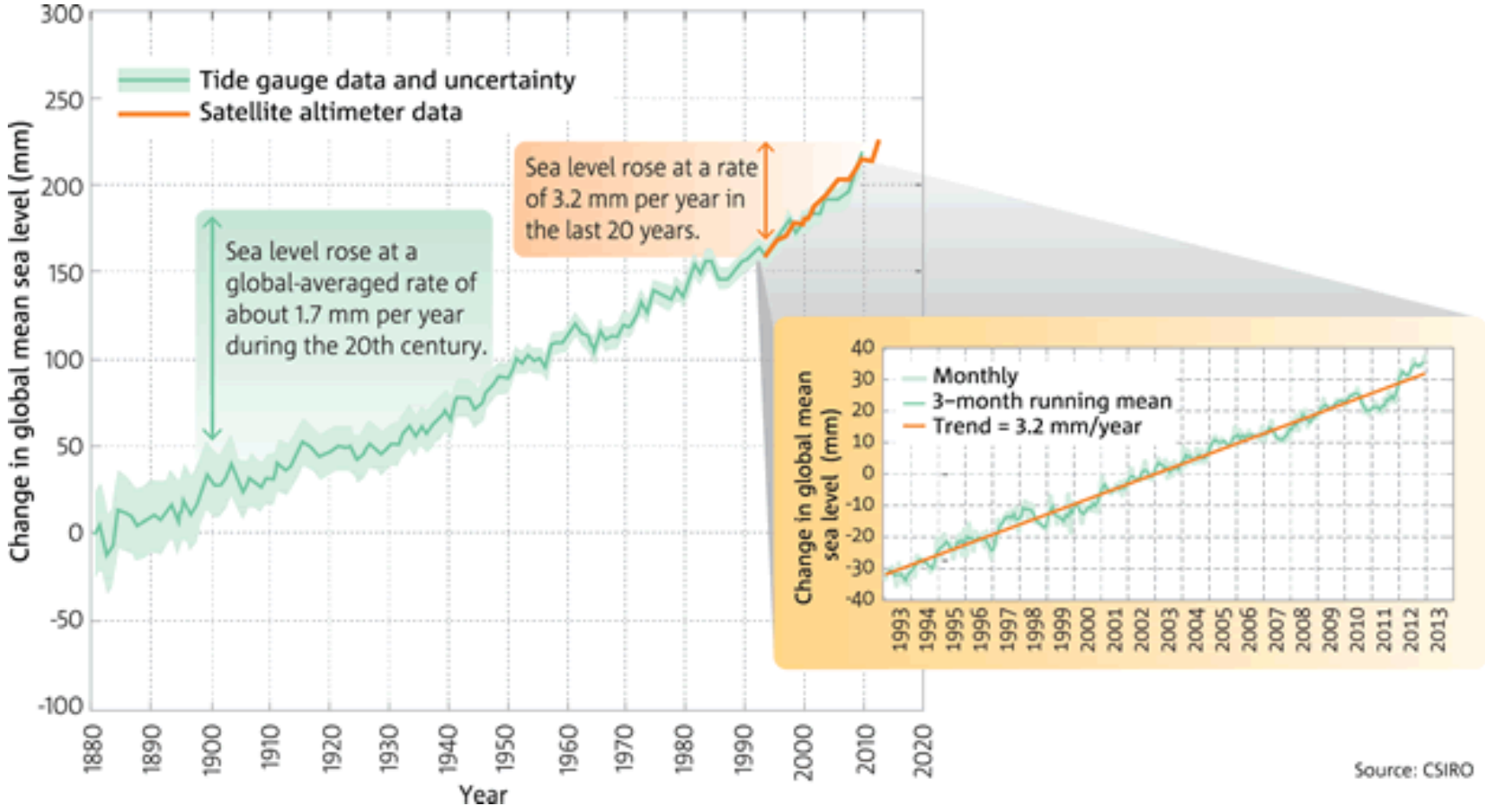
Breathless: deoxygenation



Gruber, Phil. Trans. R. Soc. A, 2011

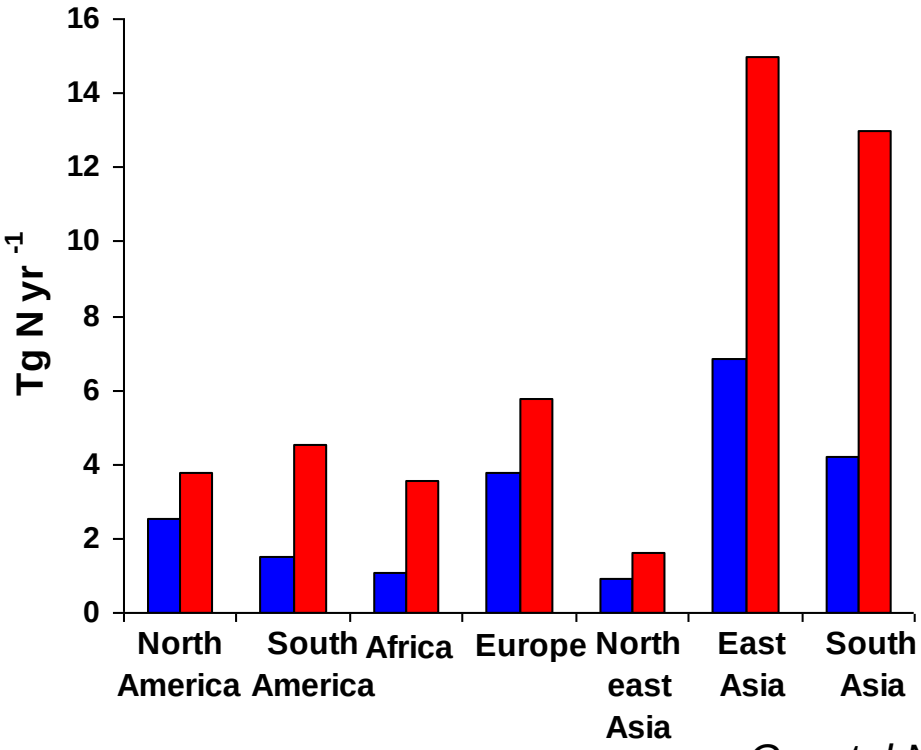
The anthropocene: changing ocean environment

Rising Sea Level



The anthropocene

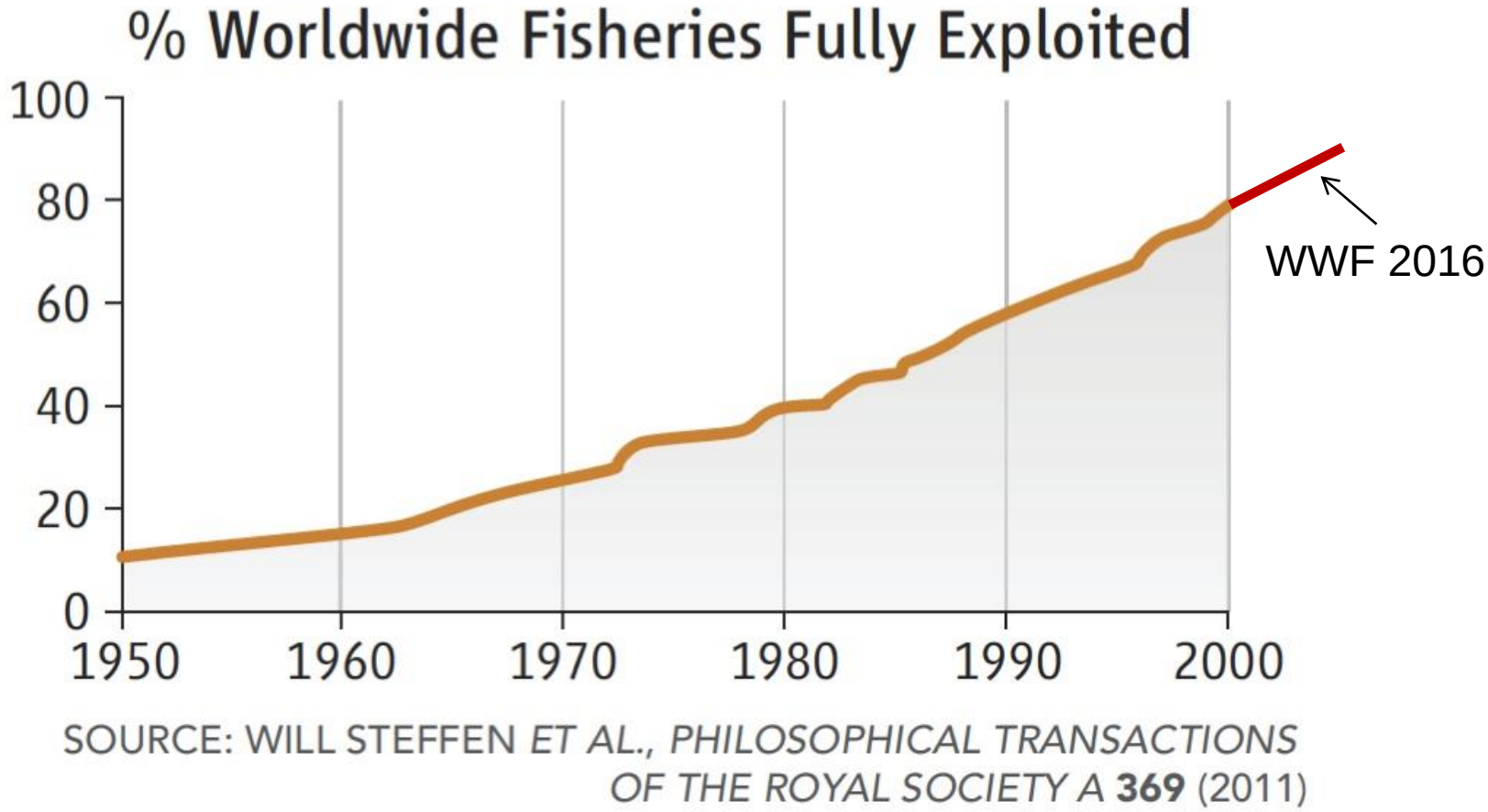
Population and nutrients



Coastal Nitrogen Loading : 1990 (in Blue) and 2050 (Business-as-Usual Scenario) (in Red)

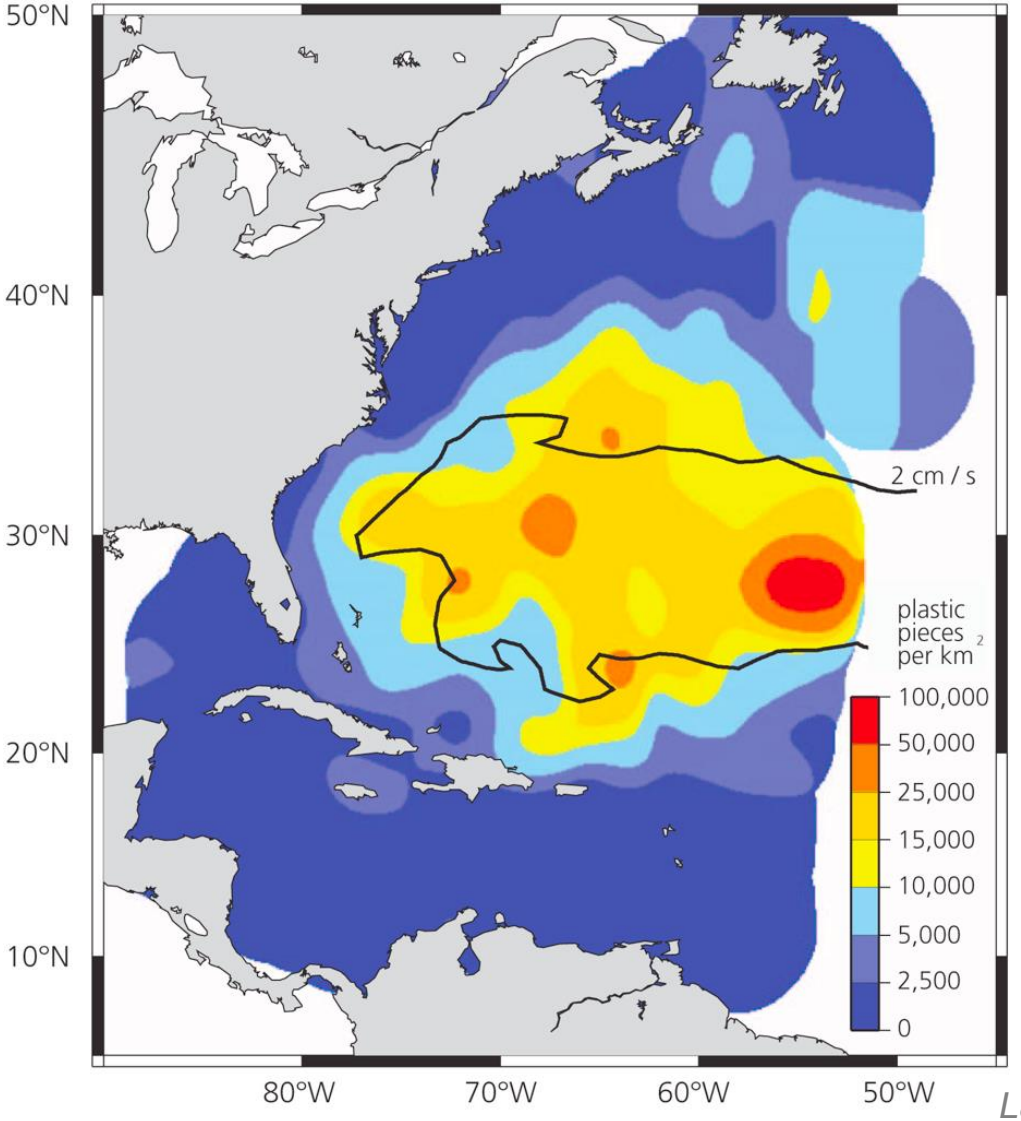
The anthropocene

Fishing



The anthropocene

Plastics



Law et al., Science, 2010

The anthropocene

Sound

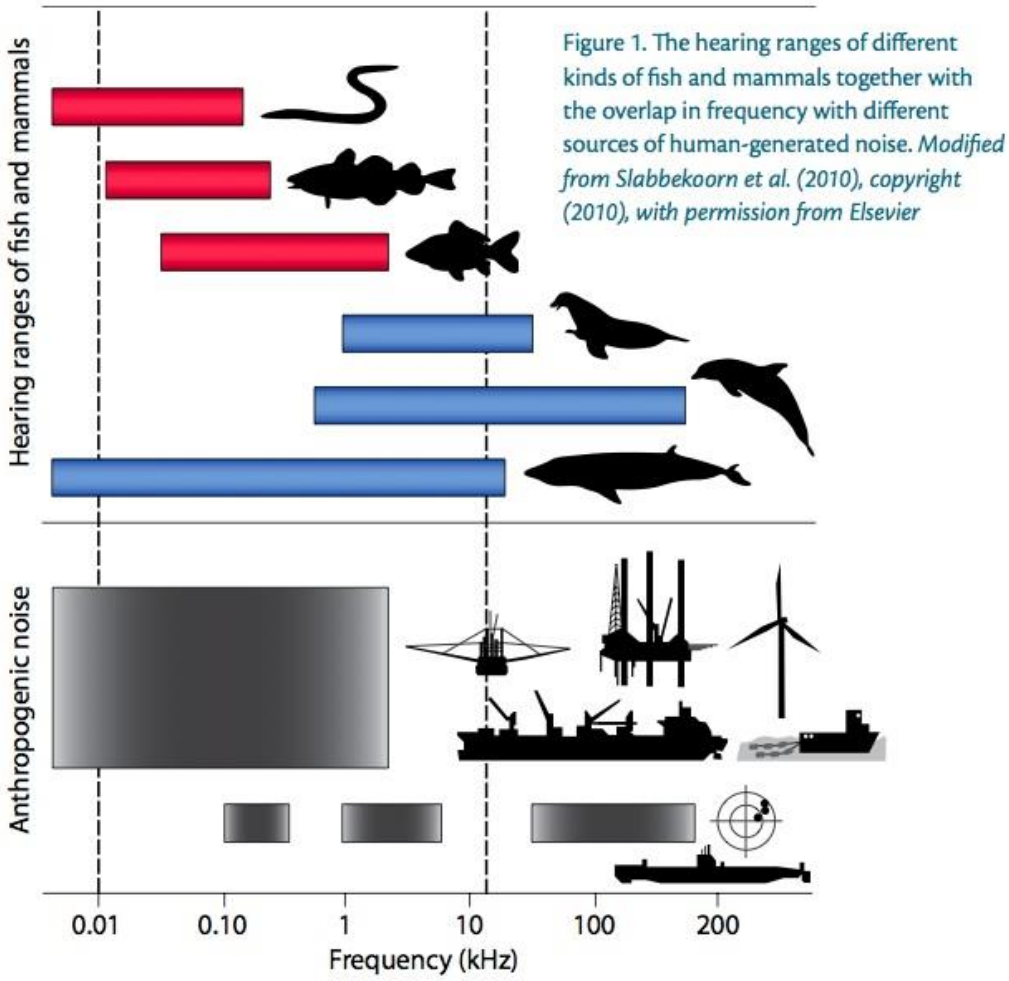


Figure 1. The hearing ranges of different kinds of fish and mammals together with the overlap in frequency with different sources of human-generated noise. *Modified from Slabbekoorn et al. (2010), copyright (2010), with permission from Elsevier*

Boyd et al., Oceanography, 2011

Human vulnerability and the ocean

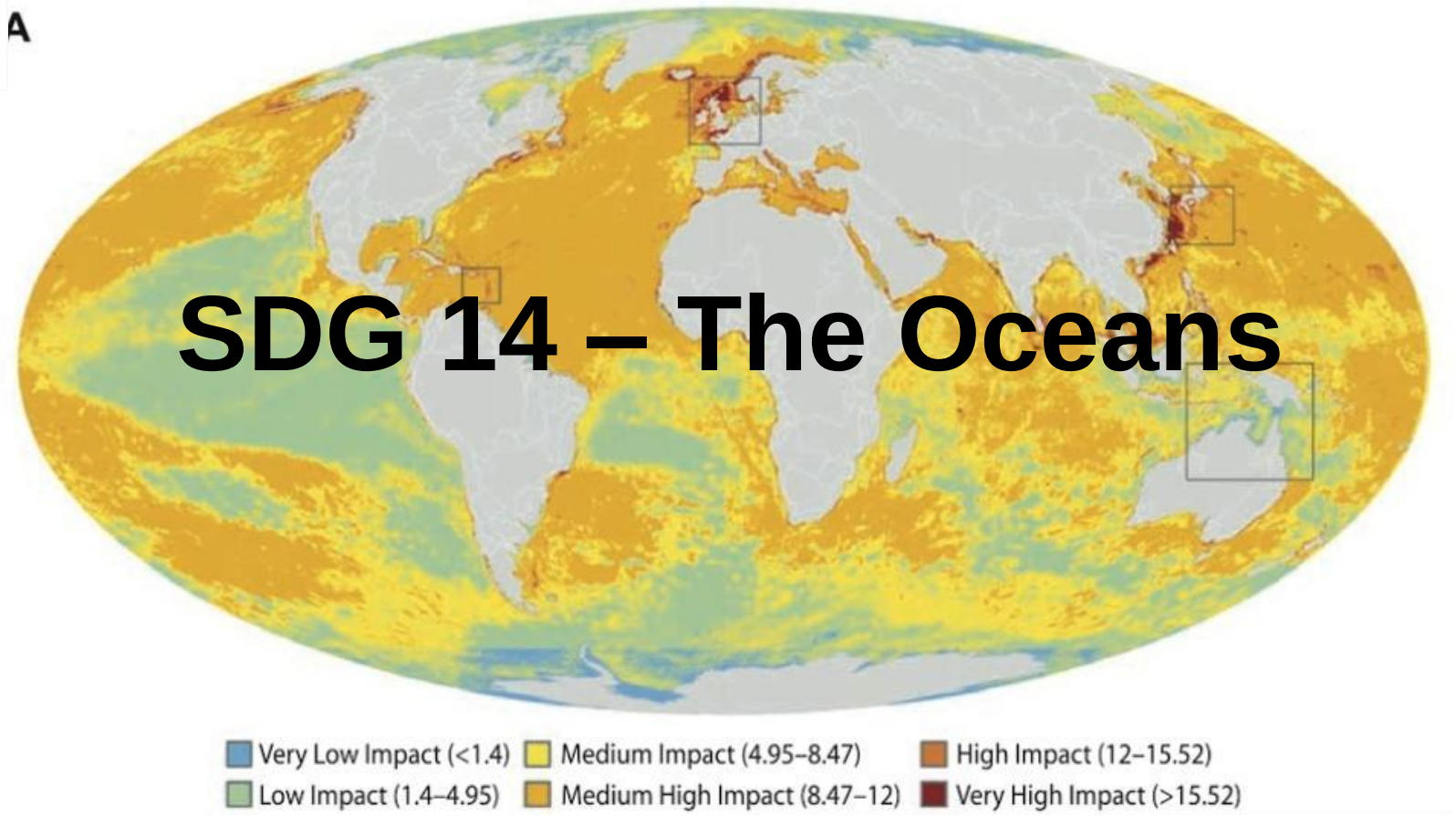
Coastal livelihoods and ocean economy

Human vulnerability and the ocean

Ecosystem health

The anthropocene

Cumulative impact



SDG 14 – The Oceans

Halpern et al., Science, 2008

SDG 14 Challenges?

- Economic and Social Drivers V Long Term Sustainability.
- Governance (in all its guises) : Local, National, Regional, “High Seas”
- Poorly defined management objectives, strategies and measures. Lack of Effective Assessment E.g. 2014 World Ocean Assessment.
- Legacy of systemic and long term underinvestment in preventing and restoring ecosystem degradation.
- Grossly inadequate observing/monitoring/modelling of most components of marine systems (incl. socio- economic) to inform policy-makers, investors and managers in both the private and public sectors.

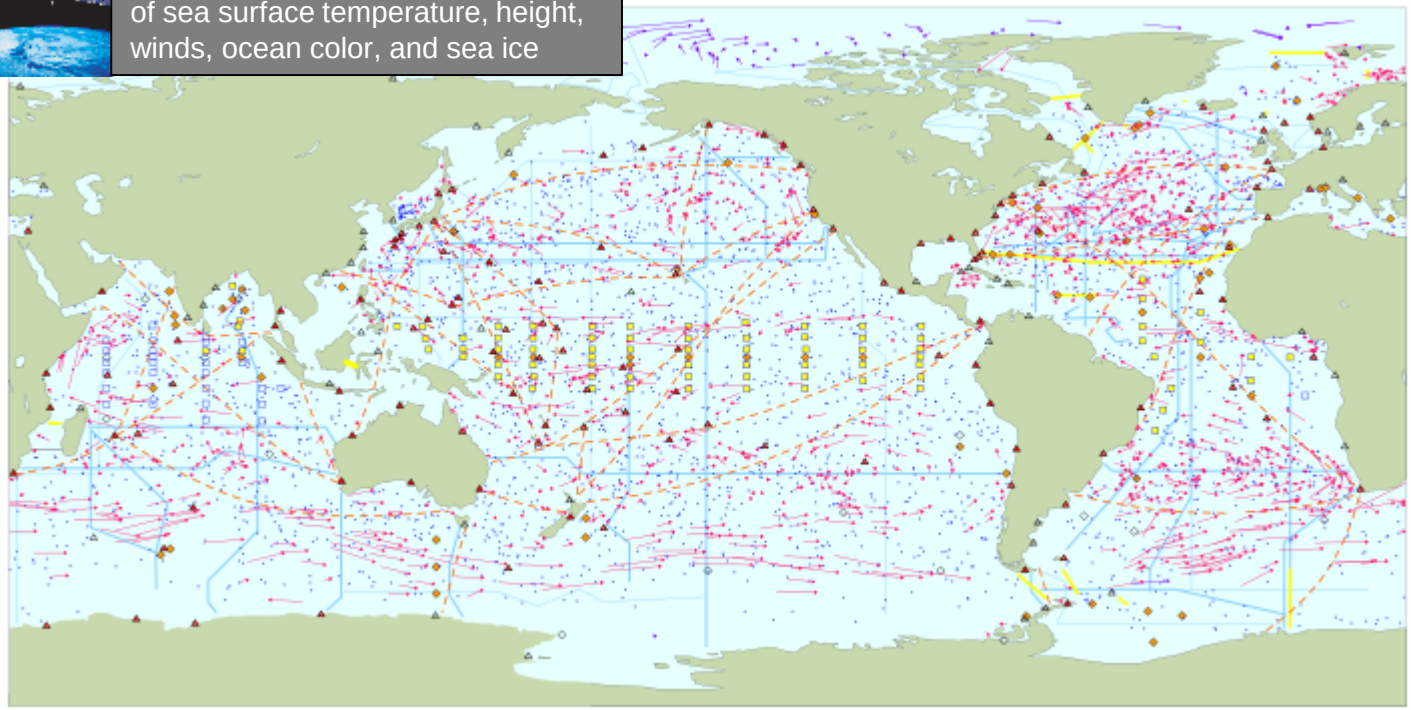
Global Ocean Observations

GOOS/GCOS 2010 implementation goals

Australian Government | Australian Institute of Marine Science

Total in situ networks 63% Dec 2014

continuous satellite measurements of sea surface temperature, height, winds, ocean color, and sea ice



100% **Surface measurements** from volunteer ships (VOS)

250 ships in VOSclim pilot project

100% Global **drifting surface buoy** array

ice buoys

5° resolution array: 1250 floats

40% **Tide gauge** network (GLOSS committed)

Fast data | Slow/no data | GPS

300 real-time reporting gauges

39% **XBT** sub-surface temperature section network

37000 XBTs deployed

100% Argo **profiling float** network

3° resolution array: 3200 floats

62% Repeat **hydrography** and **carbon inventory**

(Planned)

Full ocean survey in 10 years

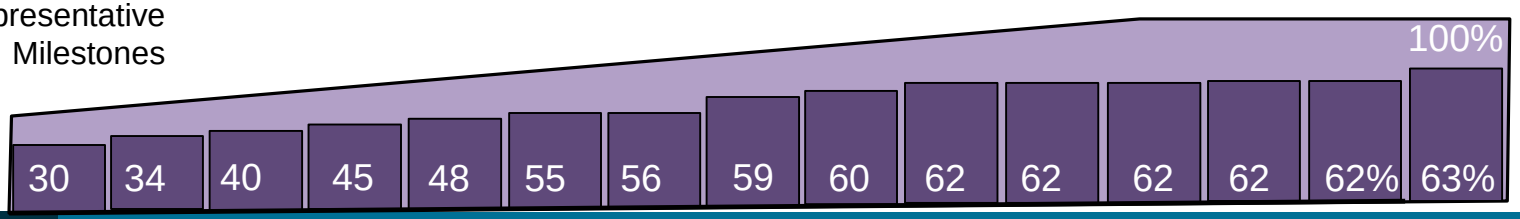
66% Global **time series** network

87 combined sites

76% Global tropical **moored buoy** network

125 moorings planned

Representative Milestones

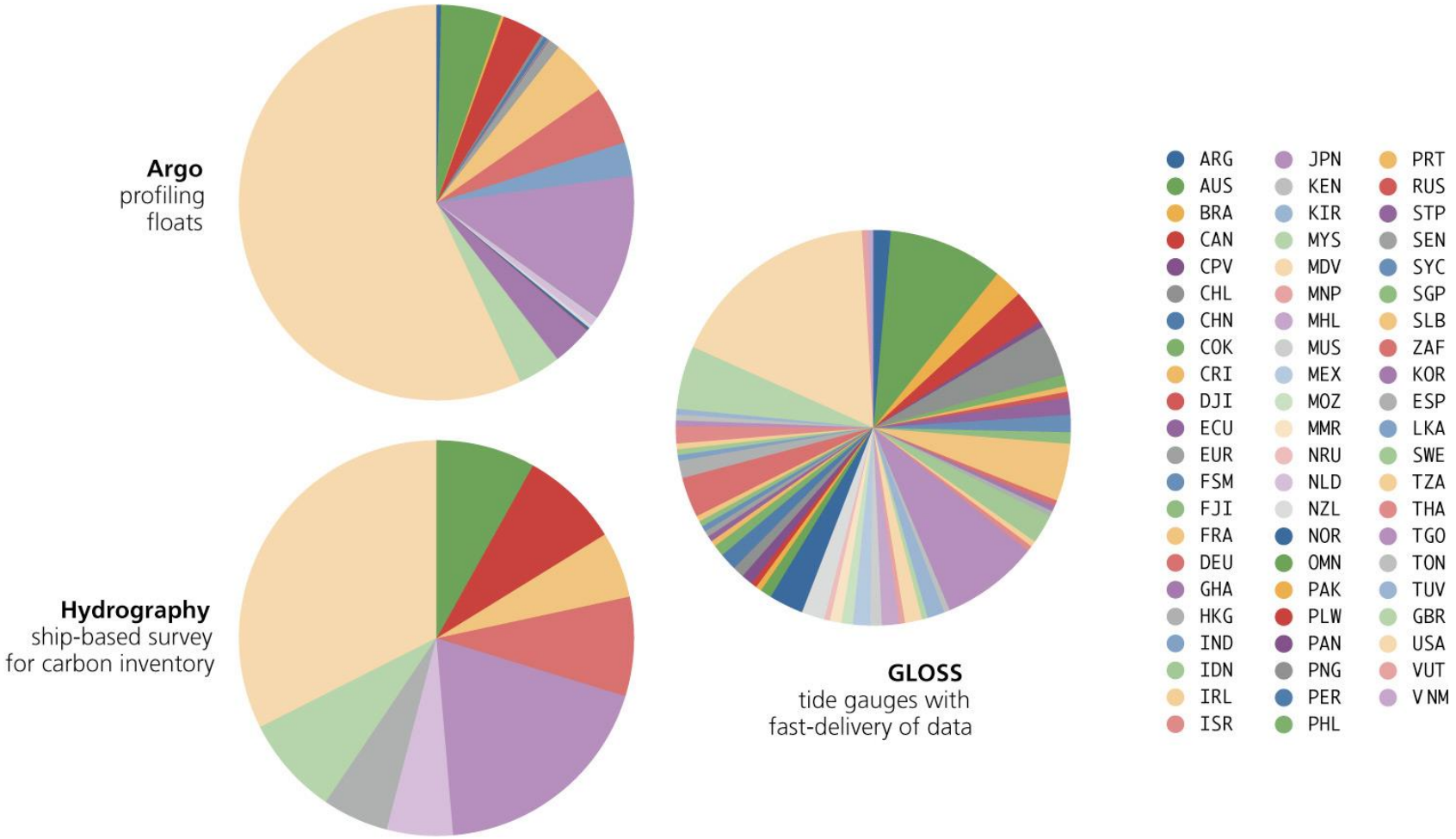


Original goal for full implementation by 2010

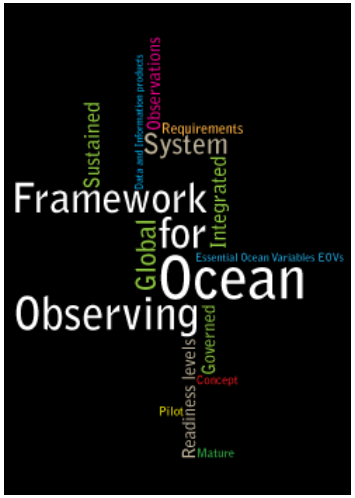
System % sustained, of initial goals

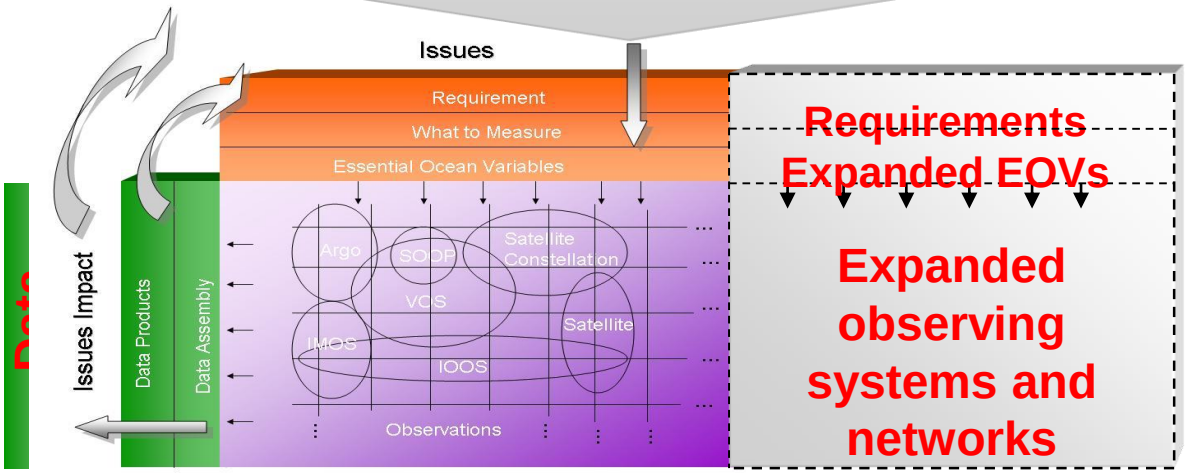
GOOS for climate

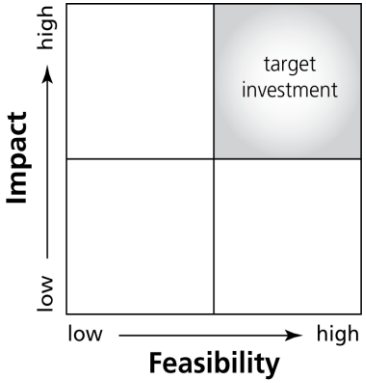
global participation varies by network



Framework for Ocean Observation







EOVs and readiness level

CONCEPT PILOT MATURE *also ECV ** First tranche of bEOVs

Physics

- Sea State*
- Ocean surface vector stress*
- Sea Ice*
- Sea level*
- SST*
- Subsurface temperature*
- Surface currents*
- Subsurface currents*
- SSS*
- Subsurface salinity*

Biogeochemistry

- Oxygen*
- Inorganic macro nutrients*
- Carbonate system*
- Transient tracers*
- Suspended particulates
- Nitrous oxide*
- Carbon isotope (^{13}C)
- Dissolved organic carbon

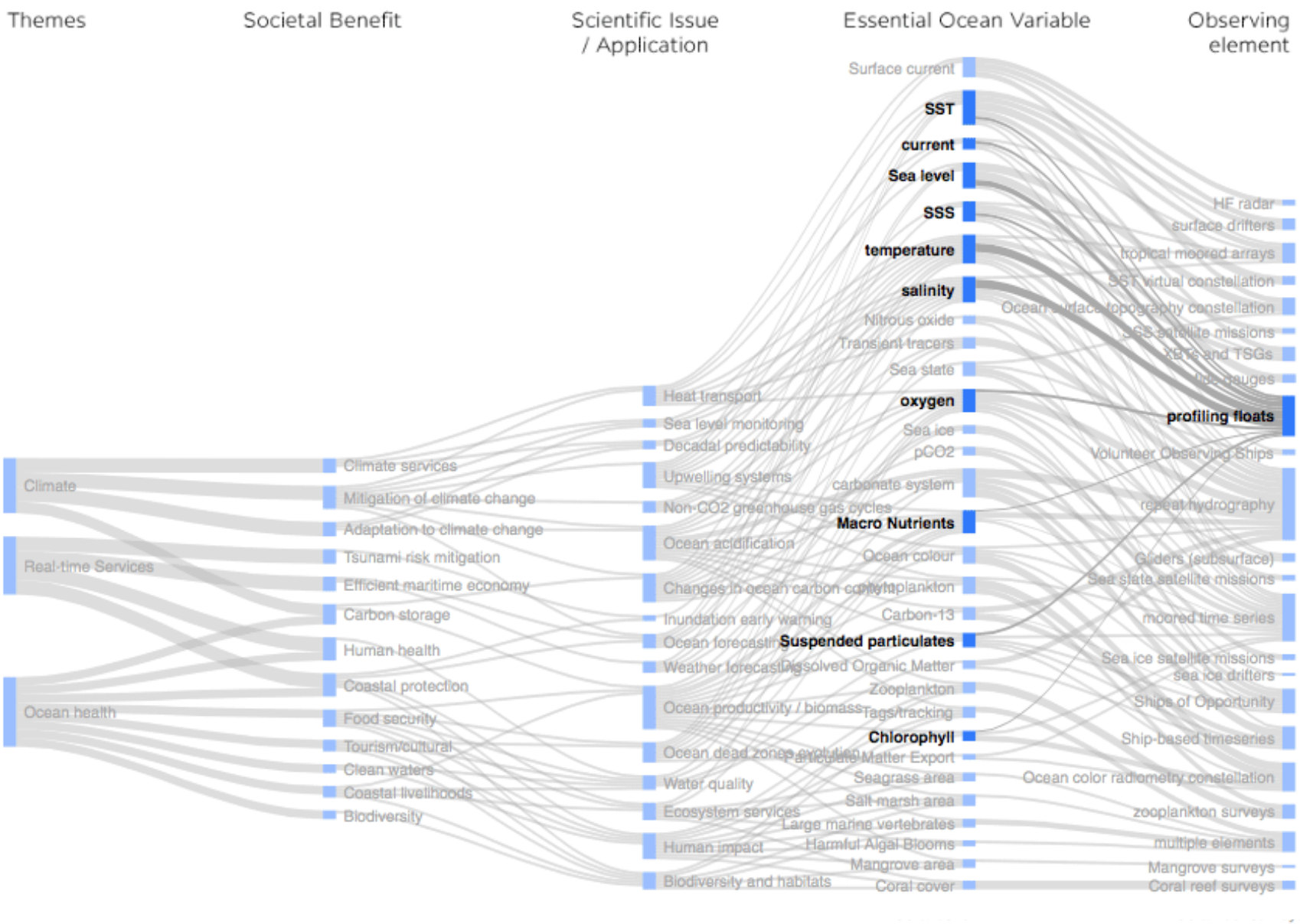
Biology and Ecosystems**

- Phytoplankton* biomass and productivity
- HAB incidence
- Zooplankton diversity
- Fish abundance and distribution
- Apex predator abundance and distribution
- Live coral cover
- Seagrass cover
- Mangrove cover
- Macroalgal canopy cover

Framework for Ocean Observing

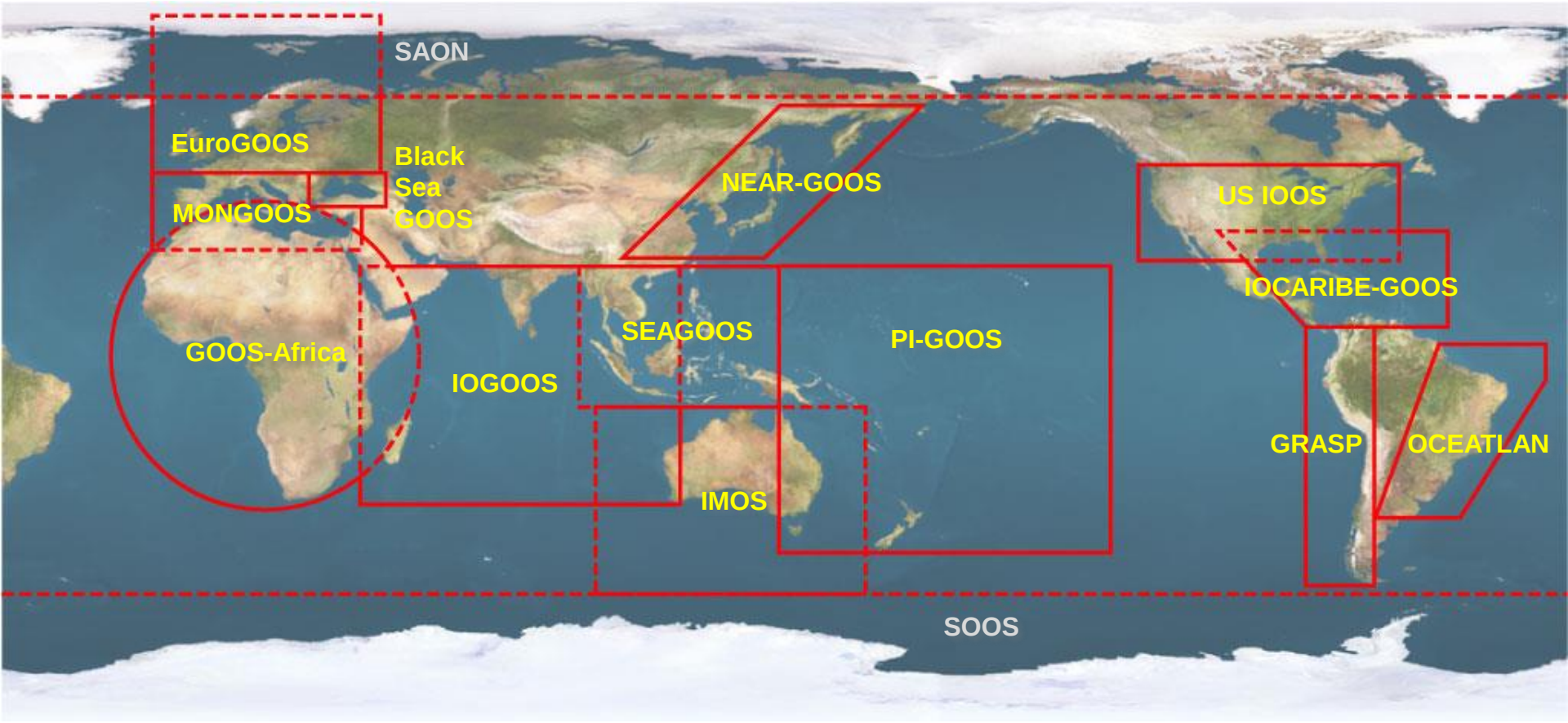
REQUIREMENTS

OBSERVATIONS



GOOS Regional Alliances

and collaborating regional observing systems

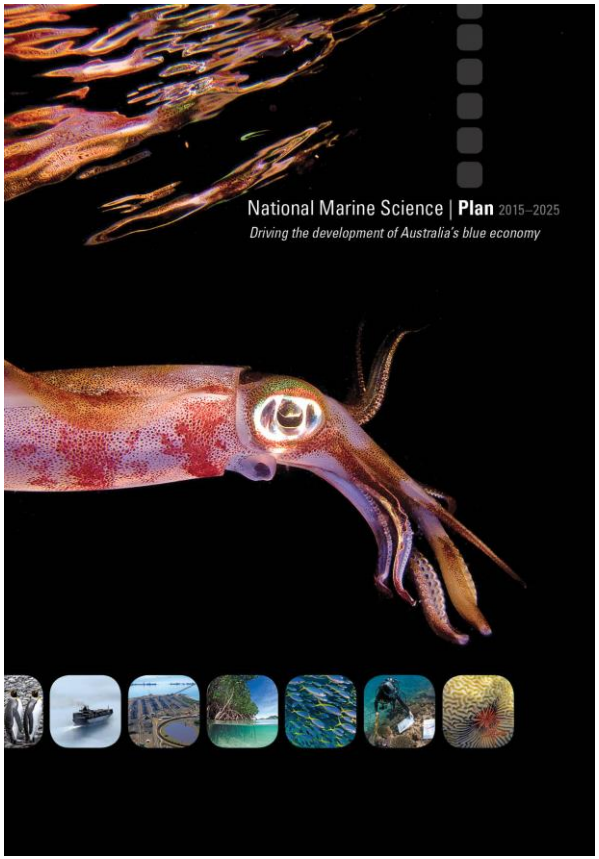


Future of Global Ocean Observations & Information Services ?

- Momentum from SDG 14, G7 Science Priorities, WOA2 …..
- Increased Investment by China, India, Korea, Europeans
- Committed OO community, better coordinated than ever.

BUT

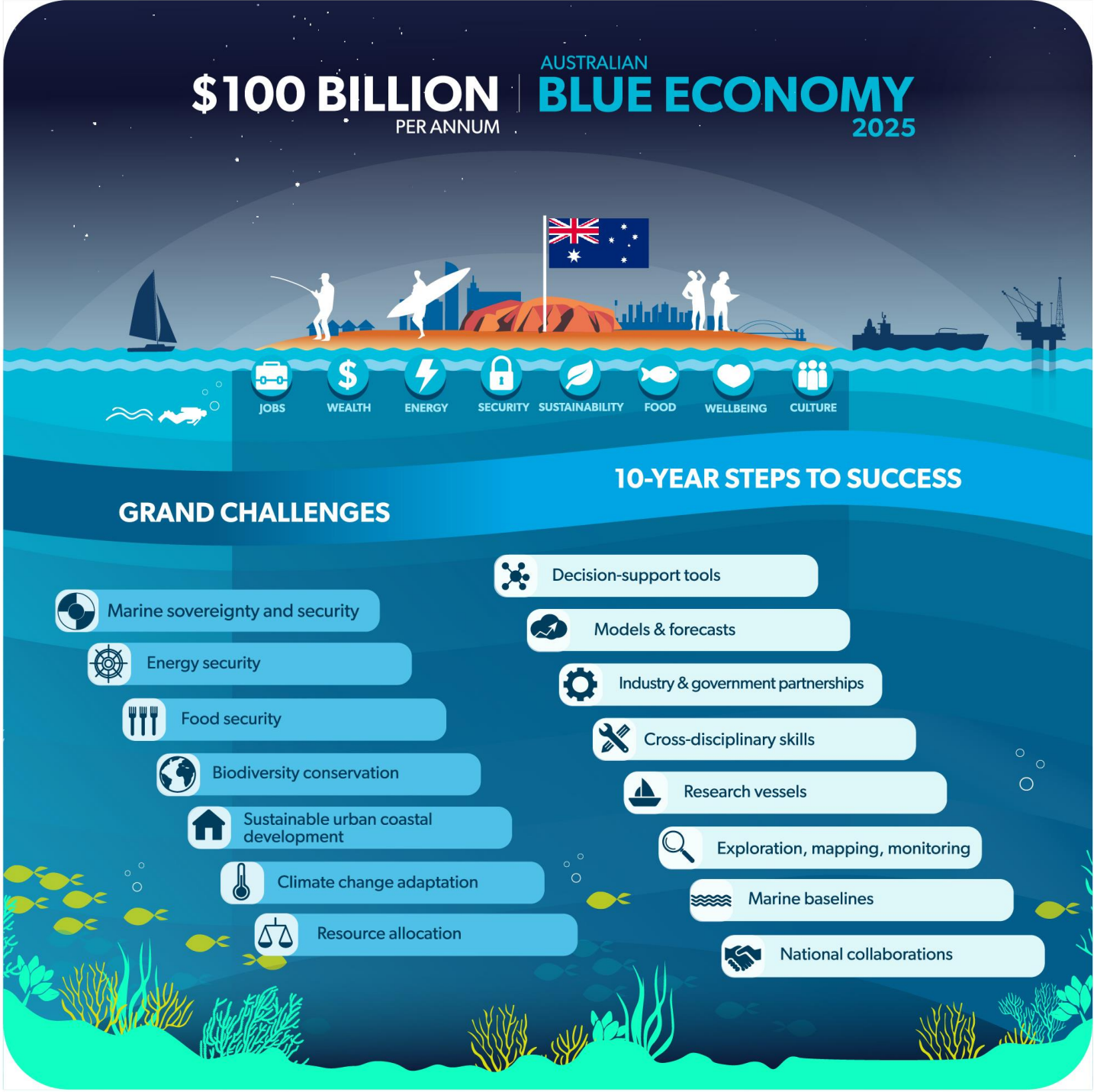
- **Lack of user pull/real commitment to ensure OO data are critical, fit for purpose, available for all.**
- **Lack of a Global Strategy linking Ocean Data, Modelling and Services.**
- **Government investment by a number of developed states reducing in real terms + threat of US withdrawal.**
- **Very little integration across Private/Industry interests.**
- **Critical capability/capacity limited across globe.**



NATIONAL MARINE SCIENCE COMMITTEE

National Marine Science Plan

- Focused on addressing National “Grand Challenges”
- 500+ Scientists & end users collaborated on Plan
- Stressed nationally coordinated approaches essential for delivering the Plan.


$100 BILLION
PER ANNUM
AUSTRALIAN
BLUE ECONOMY
2025
JOBS
WEALTH
ENERGY
SECURITY
SUSTAINABILITY
FOOD
WELLBEING
CULTURE
GRAND CHALLENGES
Marine sovereignty and security
Energy security
Food security
Biodiversity conservation
Sustainable urban coastal development
Climate change adaptation
Resource allocation
10-YEAR STEPS TO SUCCESS
Decision-support tools
Models & forecasts
Industry & government partnerships
Cross-disciplinary skills
Research vessels
Exploration, mapping, monitoring
Marine baselines
National collaborations

Fundamental → Applied Science and Engineering focussed on challenges & end-users

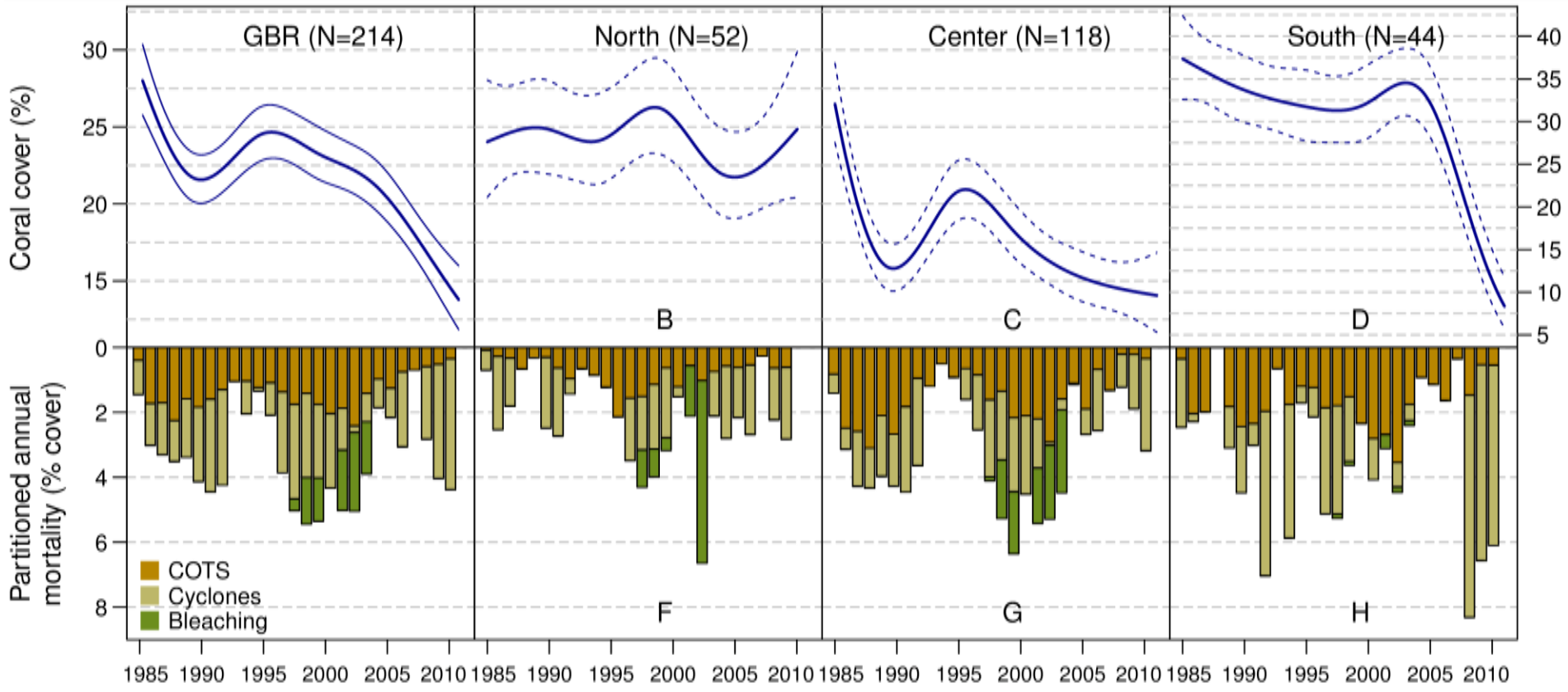
In $ constrained operating environment : Strategic thinking, planning & investment + Partnerships and Critical

- National Baselines, Observation Systems & Core Modelling frameworks to service multiple end users.
- New technology and innovation required to describe & monitor environment, boost marine industries, & adapt to climate change.
- It's not just about biophysical science – engineering and socio-economics critical.
- Marine science education requires a rethink

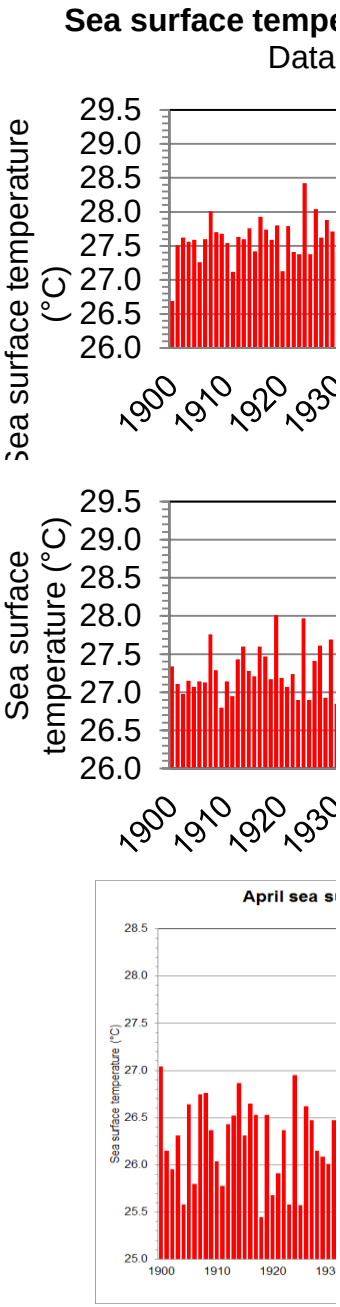
FOO is a great start!!

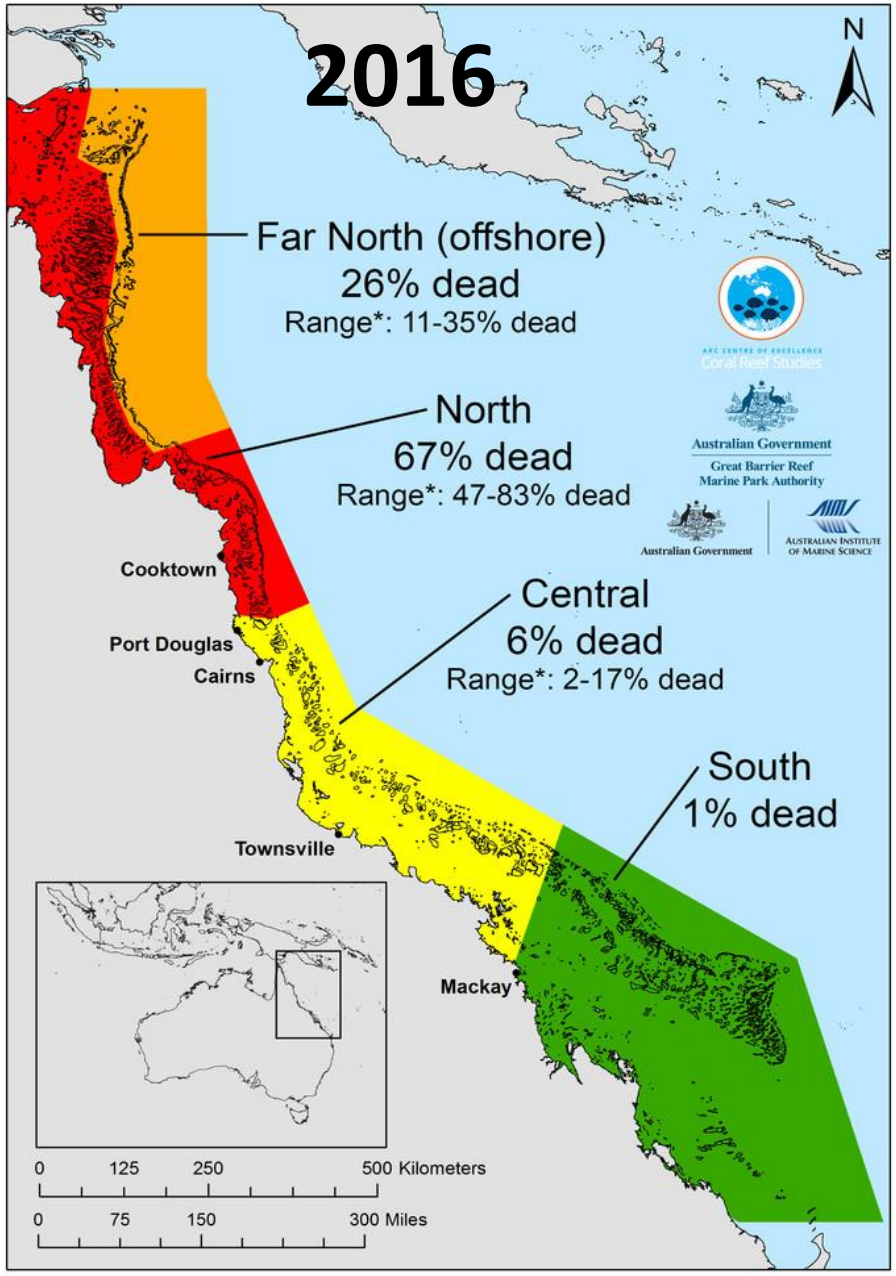

The Great Barrier Reef Challenge
Moving from Discovery &
Problem Identification
to Solutions

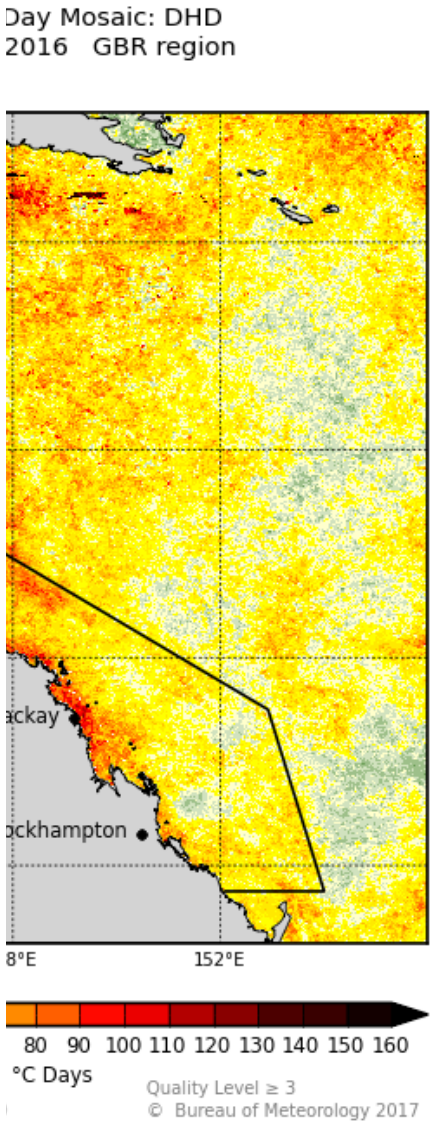
Cumulative pressures



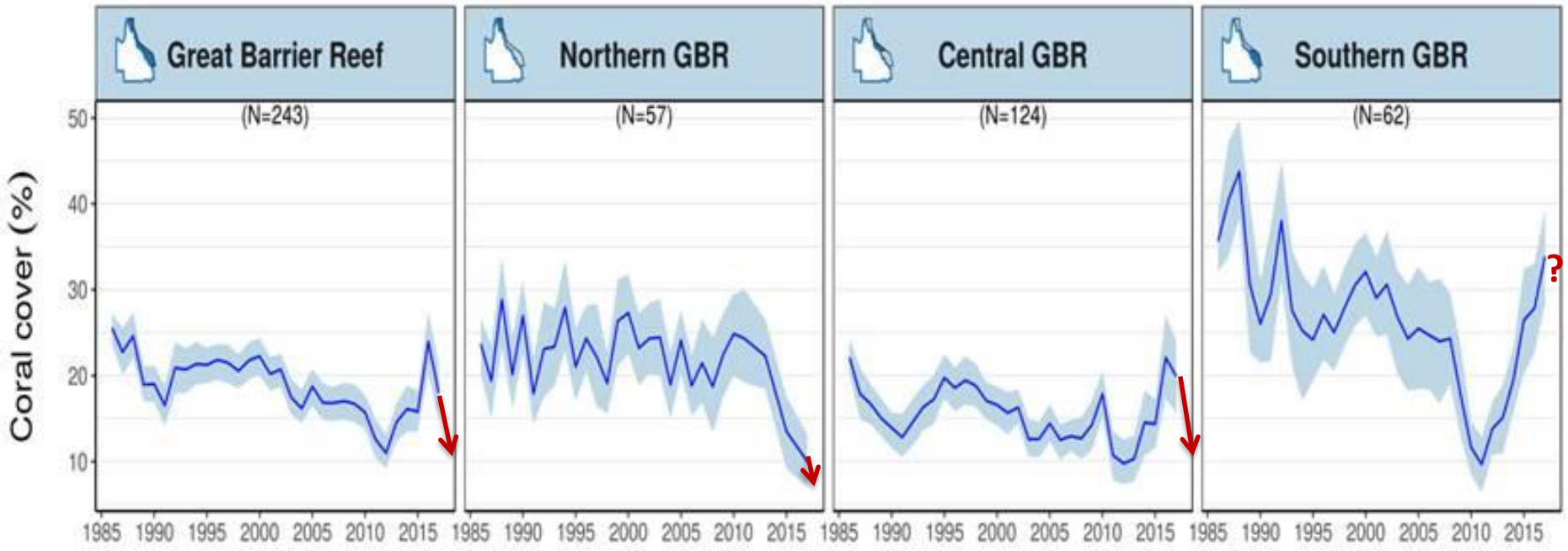
D'Eath et al. 2012


Sea surface tempe
Data
Sea surface temperature (°C)
29.5
29.0
28.5
28.0
27.5
27.0
26.5
26.0
1900
1910
1920
1930
Sea surface temperature (°C)
April sea s
Sea surface temperature (°C)
28.5
28.0
27.5
27.0
26.5
26.0
25.5
25.0
1900
1910
1920
193


2016
N
Far North (offshore)
26% dead
Range*: 11-35% dead
North
67% dead
Range*: 47-83% dead
Central
6% dead
Range*: 2-17% dead
South
1% dead
Cooktown
Port Douglas
Cairns
Townsville
Mackay
Australian Government
Great Barrier Reef Marine Park Authority
Australian Government
Australian Institute of Marine Science
0
125
250
500 Kilometers
0
75
150
300 Miles
*upper and lower quartiles


Day Mosaic: DHD
2016 GBR region
ackay
ockhampton
8°E
152°E
80 90 100 110 120 130 140 150 160
°C Days
Quality Level ≥ 3
© Bureau of Meteorology 2017

Coral cover on the GBR 1985-2016



Independent Expert Panel May 2017

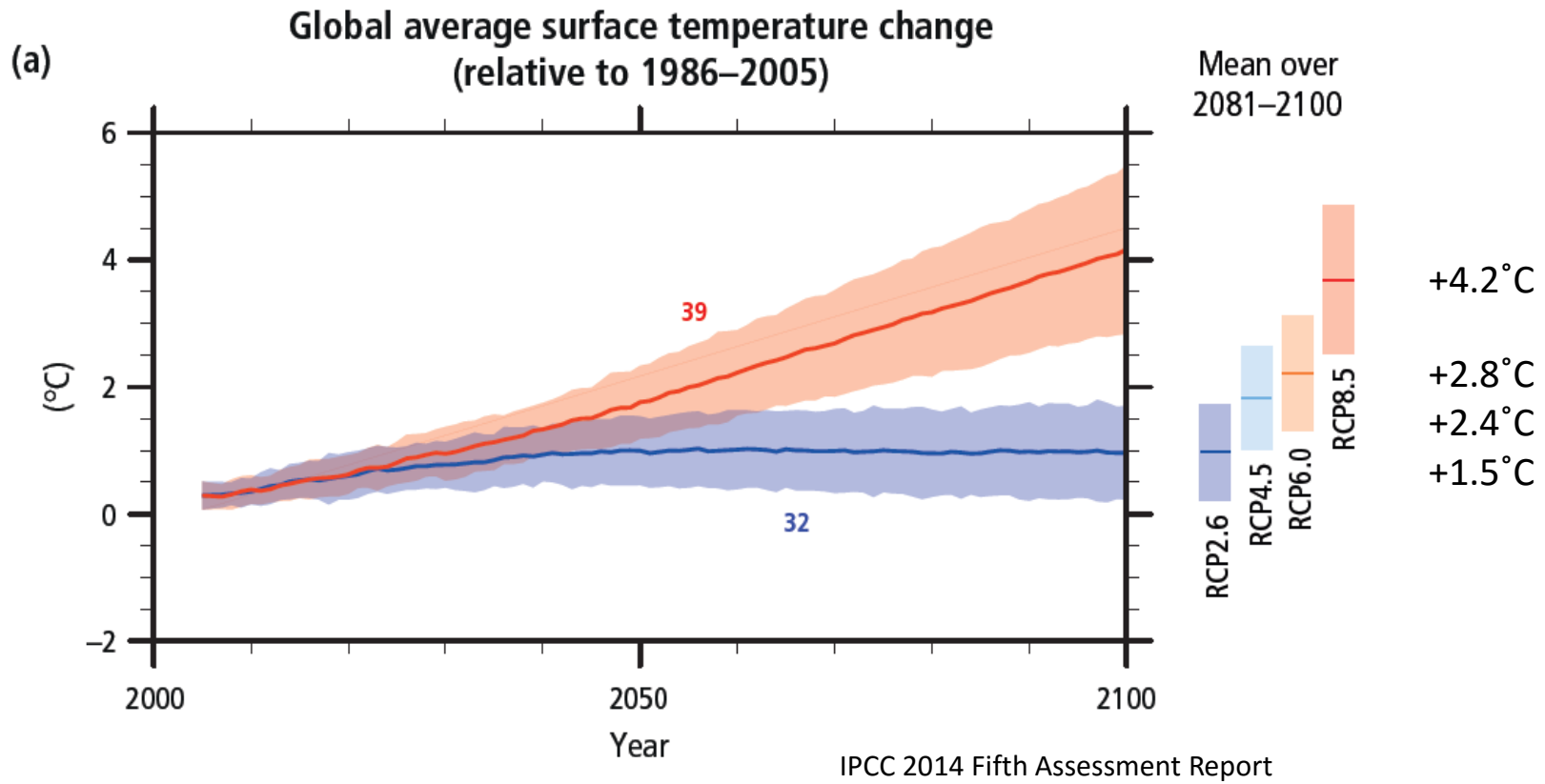
"Members agree that in our lifetime and on our watch, substantial areas of the Great Barrier Reef and the surrounding ecosystems are experiencing major long-term damage which may be irreversible unless action is taken now".

AIMS Executive

"It's time for reef science/scientists to make the shift from defining problems in more and more detail, to developing and implementing solutions"

What to do?

- Mitigation critical - to avoid ocean temperatures warming above 1.2-1.5C.



IPCC 2014 Fifth Assessment Report

What else?

- Amplifying existing measures to increase the resilience of the GBR is also important

  - Improving water quality through improved land use practices
  - Eradicating Crown of Thorns Starfish*
  - Reducing poaching on Green Zone Reefs through enhanced monitoring and compliance
  - Ensuring coastal development does not impact the GBR lagoon.

* Current methods unlikely to be effective for anything other than localised control – chemical, genetic, robotic improvements required.

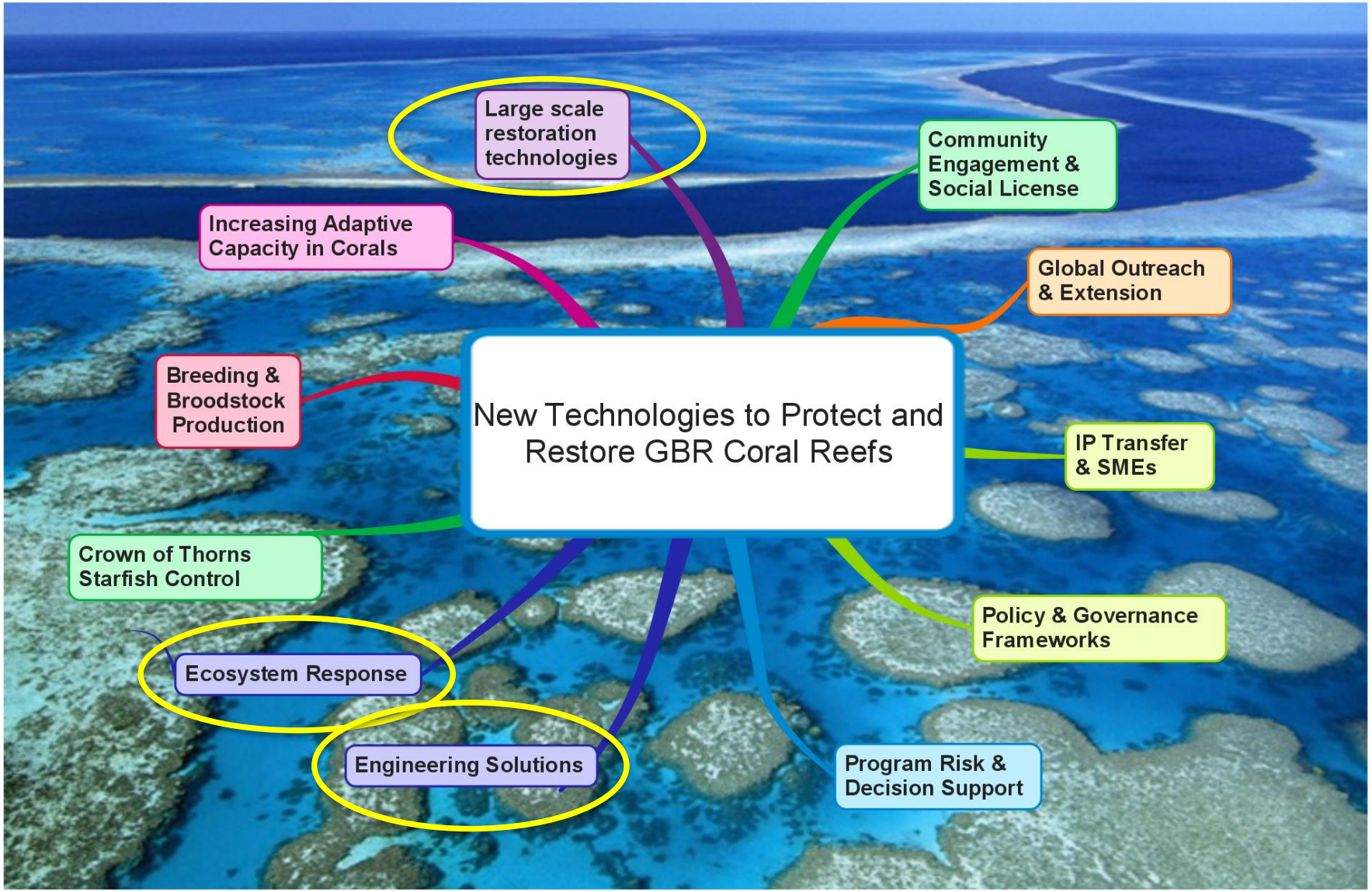
New intervention approaches required

- Mitigation + Enhancing Resilience are critical but are likely to be insufficient to halt further declines in the GBR and coral reefs world wide.

- Rapidly growing realization that we need new methods for active intervention, to increase resistance of corals to climate change, restore/rehabilitate reefs at large scale, reduce heat stress.

- And that these are needed within the next 15-20 years.

The GBR Innovation Challenge



Thank you

Australian Government

Australian Institute of Marine Science

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