Ocean Acidification and Pacific Island Coastal Fisheries

Brad Moore
Coastal Fisheries Scientist
Secretariat of the Pacific Community

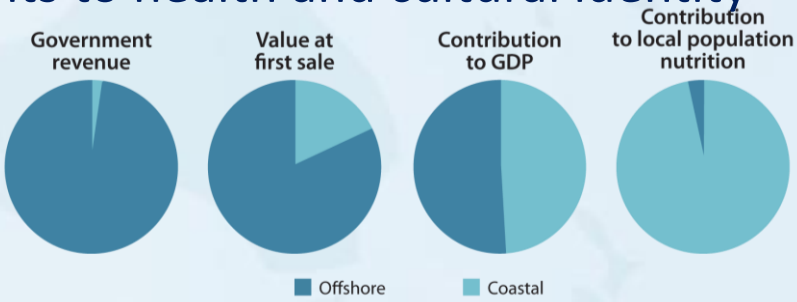
Outline

- Importance and nature of coastal fisheries
- OA and potential impacts to Pacific coastal fisheries
  - Direct effects
  - Indirect effects
- Other threats to coastal fisheries
- Key knowledge gaps

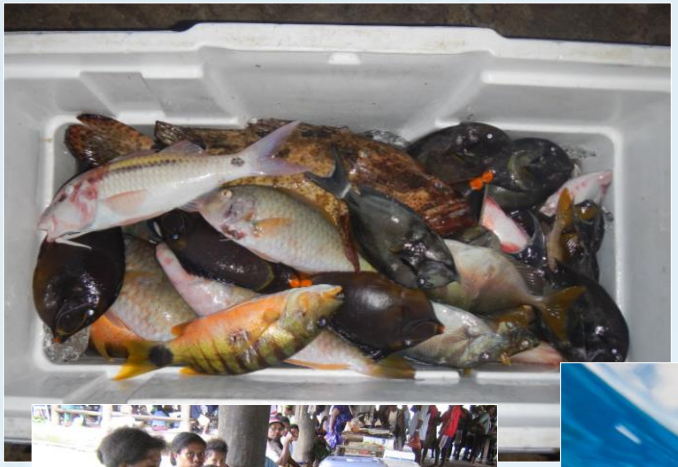
- Considered: fisheries that harvest wild finfish and invertebrates from inshore coastal habitats to coral reefs to 50 m
- Not considered: deepwater snappers, sharks, marine reptiles, freshwater fisheries, adaptation options

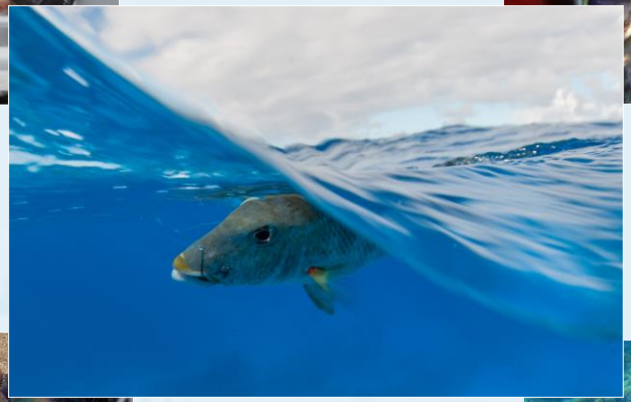
Coastal fisheries in the Pacific

- Consumption rates of fresh fish among Pacific coastal communities among the highest in the world, > 70 kg/yr in at least 10 PICTs, and up to 150 kg/yr in some
- Coastal fisheries provide 50% - 90% of protein intake for coastal communities
- Very important for local incomes (provides around 50% of coastal households with 1st or 2nd source of income)
- Subsistence fishery valued at USD 200 million per annum, commercial valued at USD 160 million per annum
- Benefits to health and cultural identity



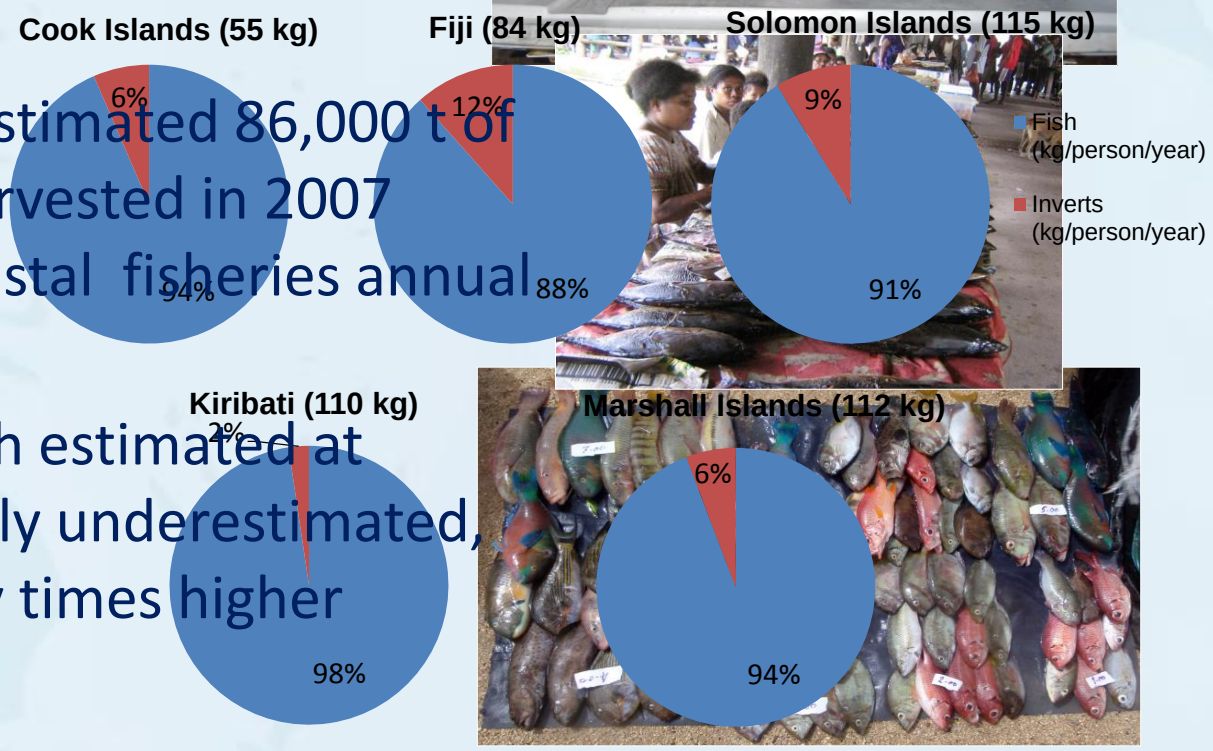
Demersal fishes





Demersal fishes

- 100s of species
- Multiple fishing methods
- Numerous habitats
- Highly important for food security and livelihoods
- Data deficient; estimated 86,000 t of demersal fish harvested in 2007 (55% of total coastal fisheries annual catch)
- Subsistence catch estimated at 59,000 t; probably underestimated, likely to be many times higher



Nearshore pelagics

Nearshore pelagics

- Hugely important for food security and local economy
- Approx. 43,000 t landed in 2007 (30% of total coastal catch)
- Support valuable tourism in many PICTs

Shallow subtidal and intertidal invertebrates

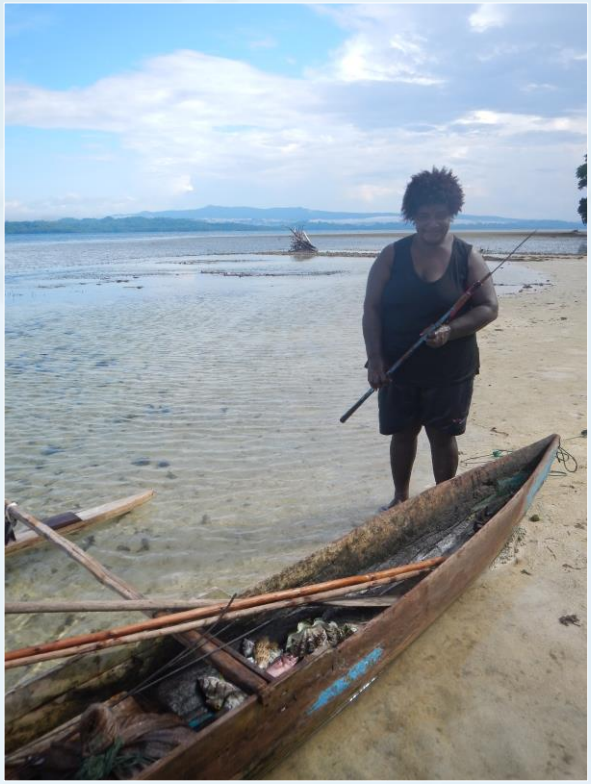
Shallow subtidal and intertidal invertebrates

- Massively important to national and local economies
  - Exports of beche-de-mer in New Caledonia in 2007 worth USD 5.3 million (twice that of countries' tuna exports)
  - Combined harvest of trochus in Fiji, PNG and SI to date worth USD 200 million [illegible] collected from Ai[illegible]rch 2015, worth a[illegible]
  - [illegible]pu[illegible]D 5




Shallow subtidal and intertidal invertebrates

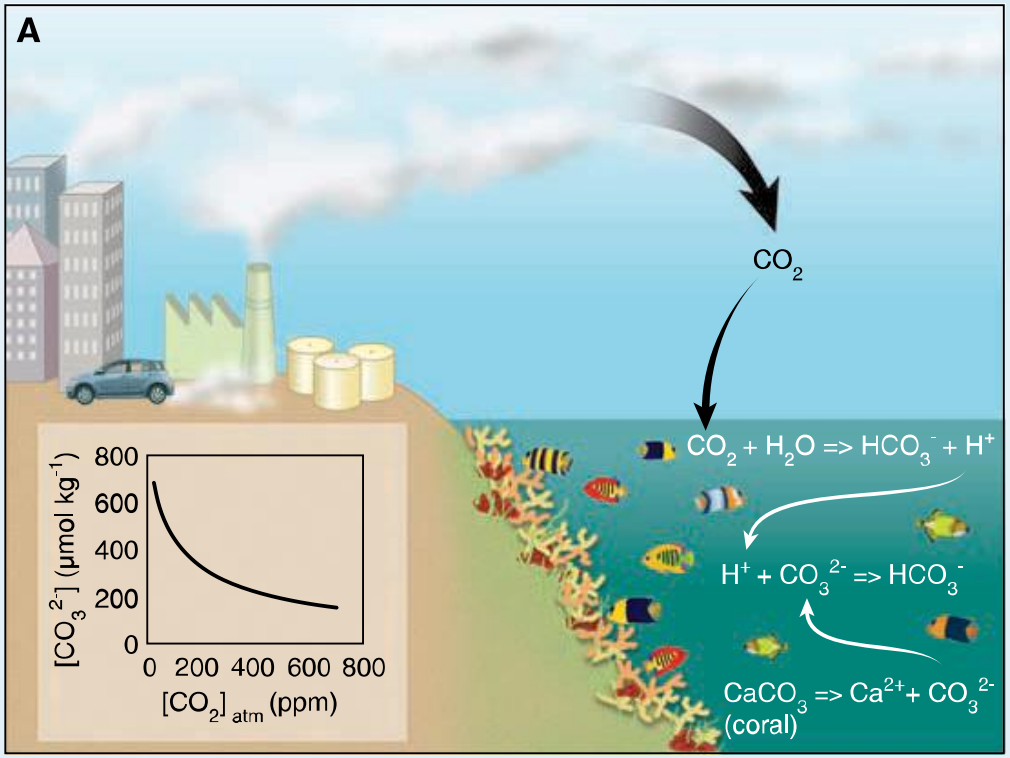
- Highly important protein source and for food security, local economy and cultural identity
  - Approx. 26,000 harvested in 2007 (17% of total coastal catch)



Ocean acidification

pCO2, carbonic acid, bicarbonate, H^+

- 30% of excess CO_2 absorbed by the ocean
- Ocean becomes more acidic and changes carbonate chemistry (decrease aragonite saturation state)
- Acidification independent of global warming

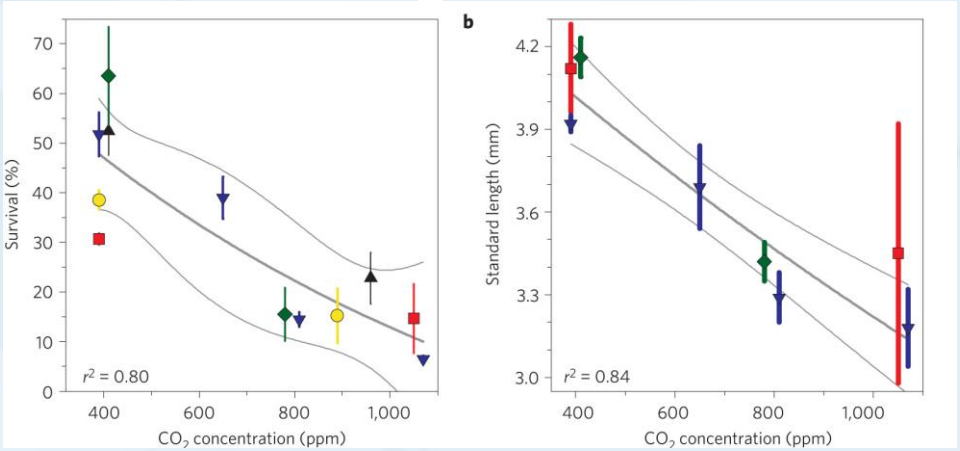


Hoegh-Guldburg et al. 2007

carbonate, pH (-logH^+)

Direct effects of OA: Demersal fishes

- Adult fish good at regulating acid-base balance
- Effects likely to be greatest on early life history stages:
  - Survival
  - Rate of development
  - Growth
  - Metabolic rate
  - Reproductive schedules / Mortality rates ?



Baumann et al. 2012 Nature Climate Change

Direct effects of OA: Demersal fishes

- Adult fish good at regulating acid-base balance
- Effects likely to be greatest on early life history stages
  - Increased boldness & activity
  - Impaired ability to discriminate between chemical cues
  - Altered auditory preferences
  - Declines in recruitment and survival


PNAS

Ocean acidification impairs olfactory discrimination and homing ability of a marine fish

Philip L. Munday[a,b,1], Danielle L. Dixson[a,b], Jennifer M. Donelson[a,b], Geoffrey P. Jones[a,b], Morgan S. Pratchett[a], Galina V. Devitsina[c], and Kjell B. Døving[d]

[a]Australian Research Council Centre of Excellence for Coral Reef Studies, [b]School of Marine and Tropical Biology, James Cook University, Townsville, QLD 4811, Australia; [c]Ichthyology Department, Faculty of Biology, Moscow MV Lomonosov State University, Moscow 119992, Russia; and [d]Physiology Program, Institute of Molecular Bioscience, University of Oslo, N-0316 Oslo, Norway

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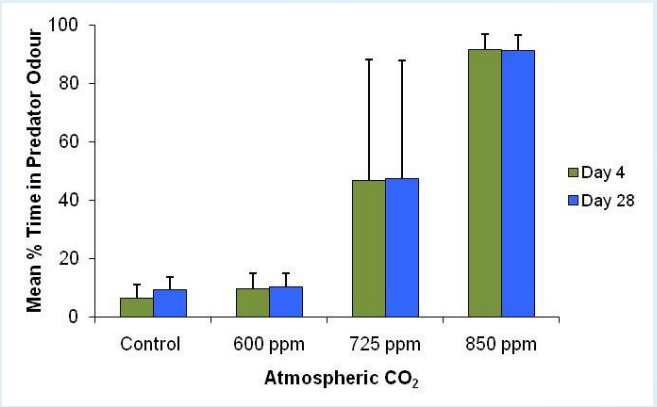
ECOLOGY LETTERS

Ecology Letters, (2010) **13**: 68–75 doi: 10.1111/j.1461-0248.2009.01400.x

LETTER

Ocean acidification disrupts the innate ability of fish to detect predator olfactory cues



Munday et al. 2013 Marine Biology 160: 2137-2144

Direct effects of OA: Nearshore pelagics

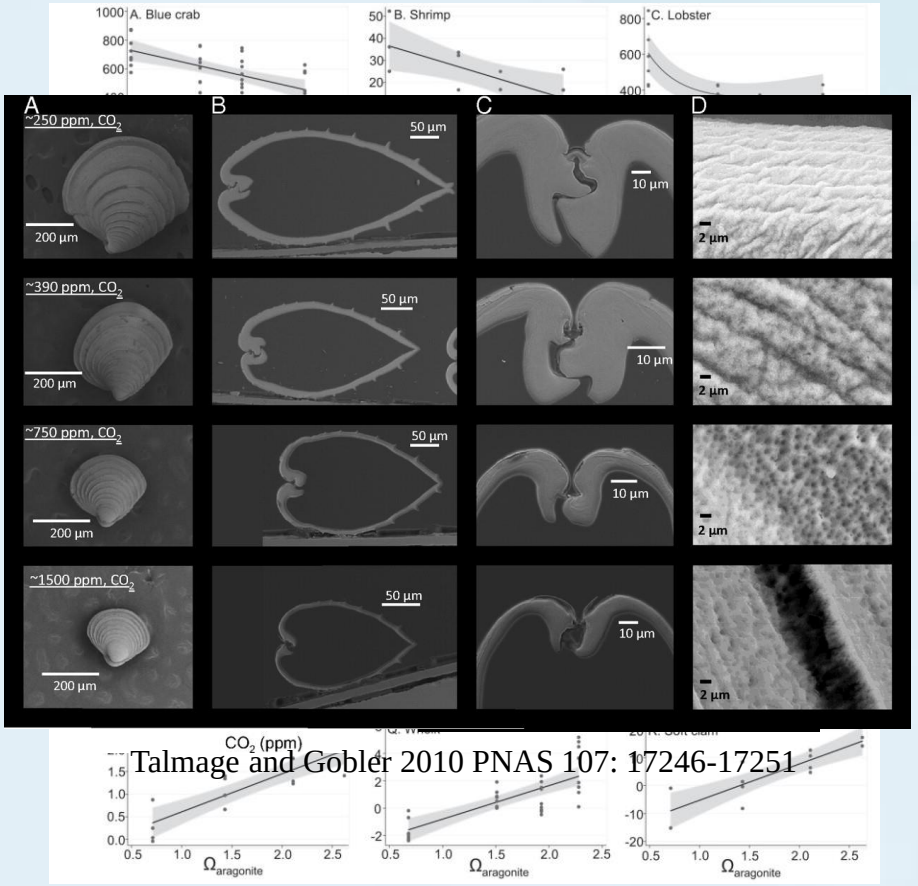
- Direct effects largely unknown
- Indirect effects likely to be similar to those projected for offshore fisheries (discussed by Valerie):

Photo: Dom Bromhead

Direct effects of OA: Invertebrate fisheries

- Effects felt across all life history stages

- Slower larval growth
- Lower calcification rates
- Thinner shells
- Malformed hinge structure
- [illegible]picule [illegible]



Talmage and Gobler 2010 PNAS 107: 17246-17251

Ries et al. 2009 Geology 37:1131

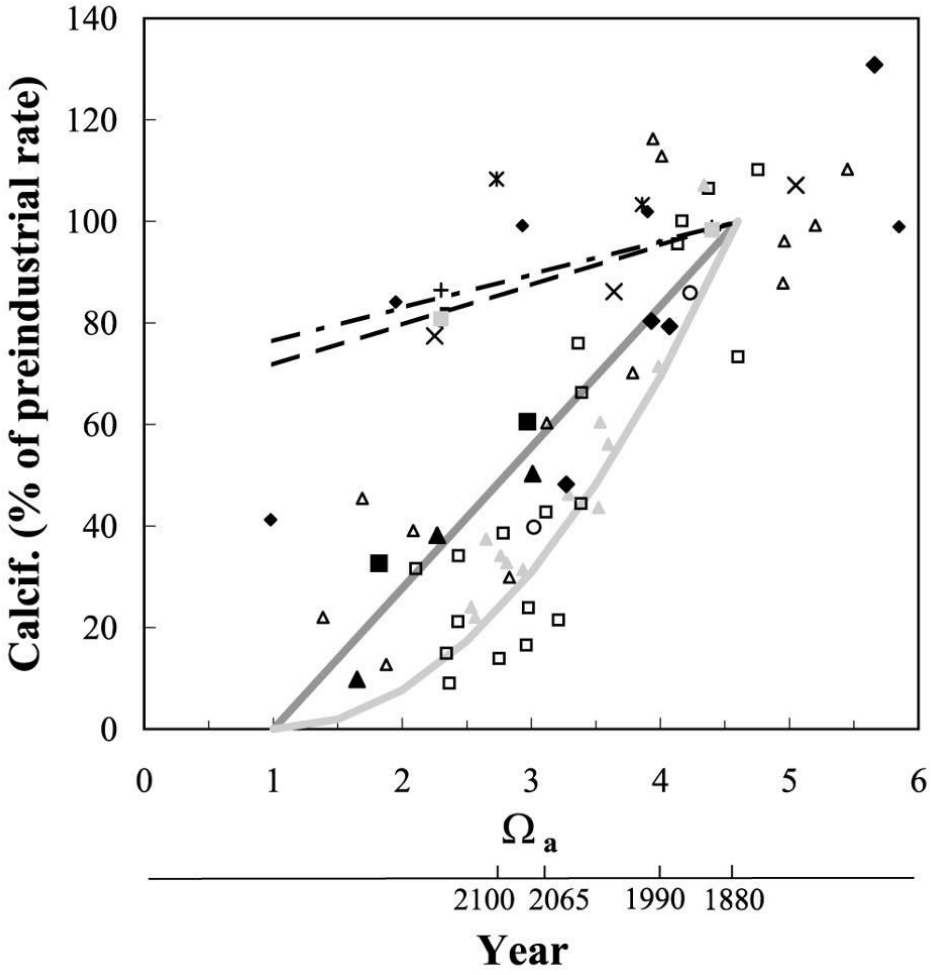
There is some hope

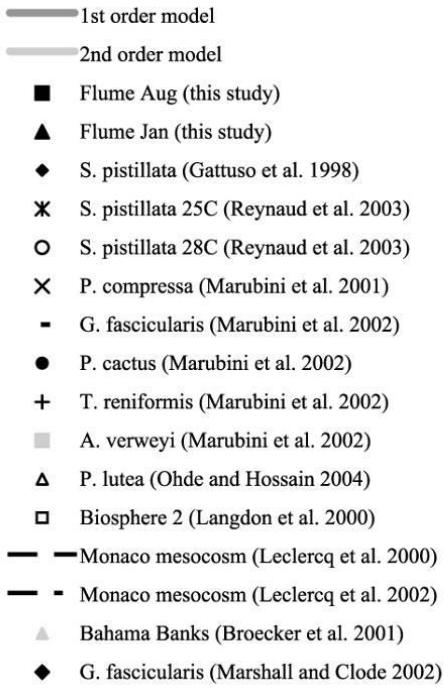
- Most studies conducted on small species that benthic eggs – implications for fished species?
- Effects beyond one generation?

Indirect effects of OA: Effects on coastal habitats

- Coral reefs, mangroves and seagrass habitats support the bulk of coastal fisheries in the region

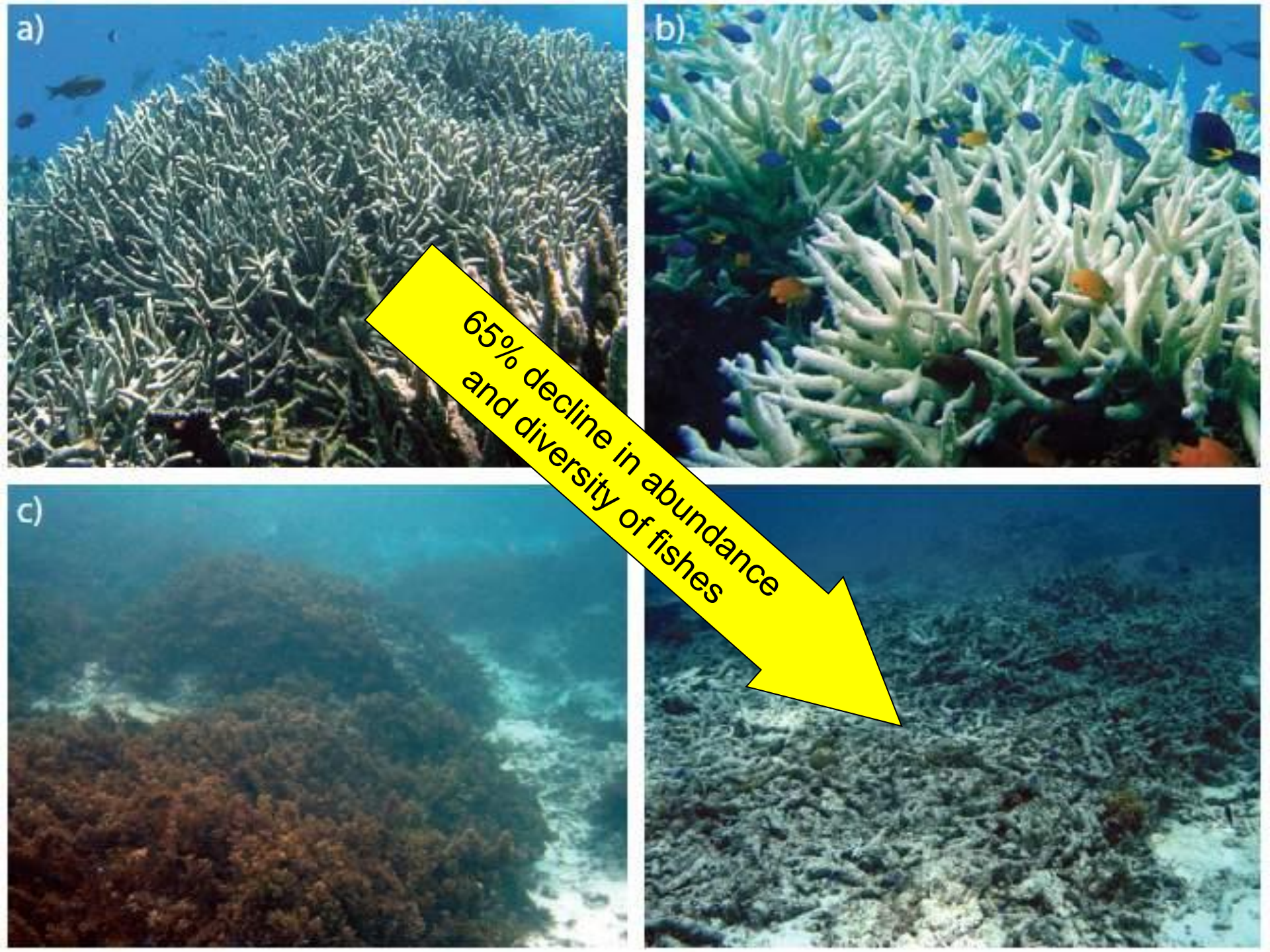
Corals - Calcification rates





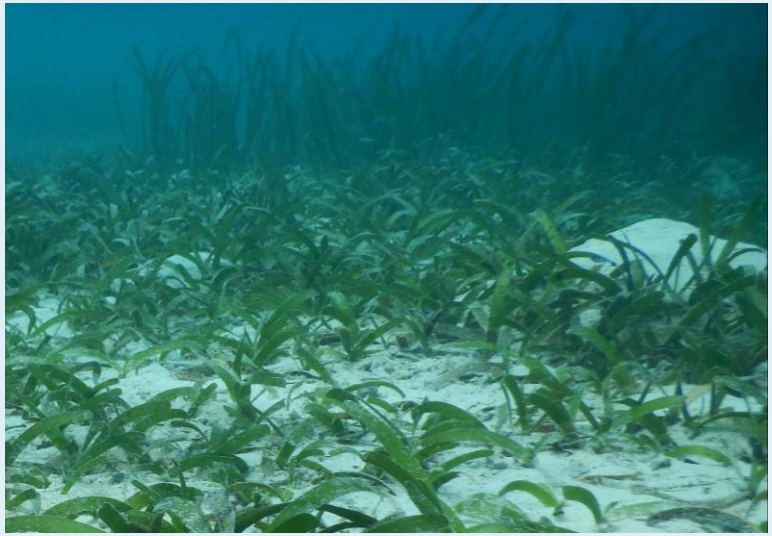
~10-30% reduction in calcification rates with doubling of CO_2

Langdon and Atkinson 2005. Journal of Geophysical Research 110. C09S07, doi: 10.1029/2004JC002576


a)
b)
65% decline in abundance
and diversity of fishes
c)

Mangroves, seagrasses and intertidal flats

- Low direct sensitivity to OA
- Increased plant productivity & biomass with increased atmospheric CO_2
- Lower calcification rates may decrease carbonate sediment build – implications with sea level rise?
- Key for mitigation

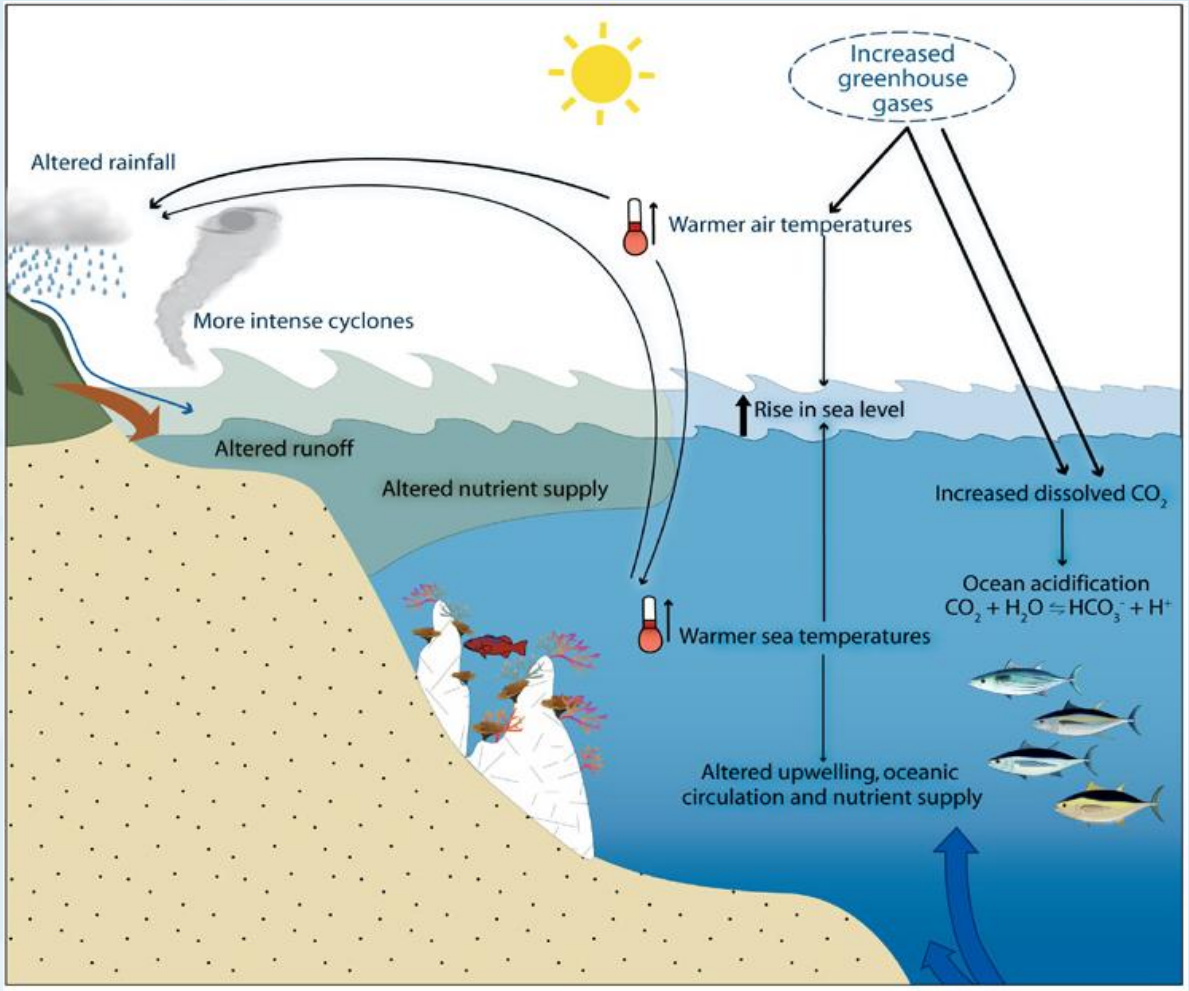


Consequences of OA to Pacific coastal fisheries

- Overall reductions in fish numbers (lower recruitment, survival and potentially higher mortality)
- Reductions in coral-dependent fishes and invertebrates
- Changes in fish communities

- Fewer fish to harvest
- Altered biology – growth, reproduction(?) = implications for quotas, size limits
- Altered target species (focus towards more generalist species)
- Changes in fisher behaviour, fishing gears (to target generalist species) → further impacts to habitats?
- Lower quality products (e.g. mother-of-pearl fisheries)

Other Threats – warmer air and sea surface temperatures



Interactive effects – OA & SST

- Elevated CO_2 lowers bleaching thermal threshold & increases bleaching risk
- Coralline algae highly susceptible
- Variation among/within taxa
- Other impacts - nutrients, sediments, over-fishing?

ICES Journal of Marine Science

ICES CIEM

ICES Journal of Marine Science; doi:10.1093/icesjms/fsv127

Ocean acidification affects productivity but not the severity of thermal bleaching in some tropical corals

Sam H. C. Noonan* and Katharina E. Fabricius

Australian Institute of Marine Science, PMB 3, Townsville MC, QLD 4810, Australia

**Corresponding author: tel: + 61 7 4753 4131; fax: + 61 7 4772 5852; e-mail: s.noonan@aims.gov.au*

Noonan, S. H. C., and Fabricius, K. E. Ocean acidification affects productivity but not the severity of thermal bleaching in some tropical corals. – ICES Journal of Marine Science, doi: 10.1093/icesjms/fsv127.

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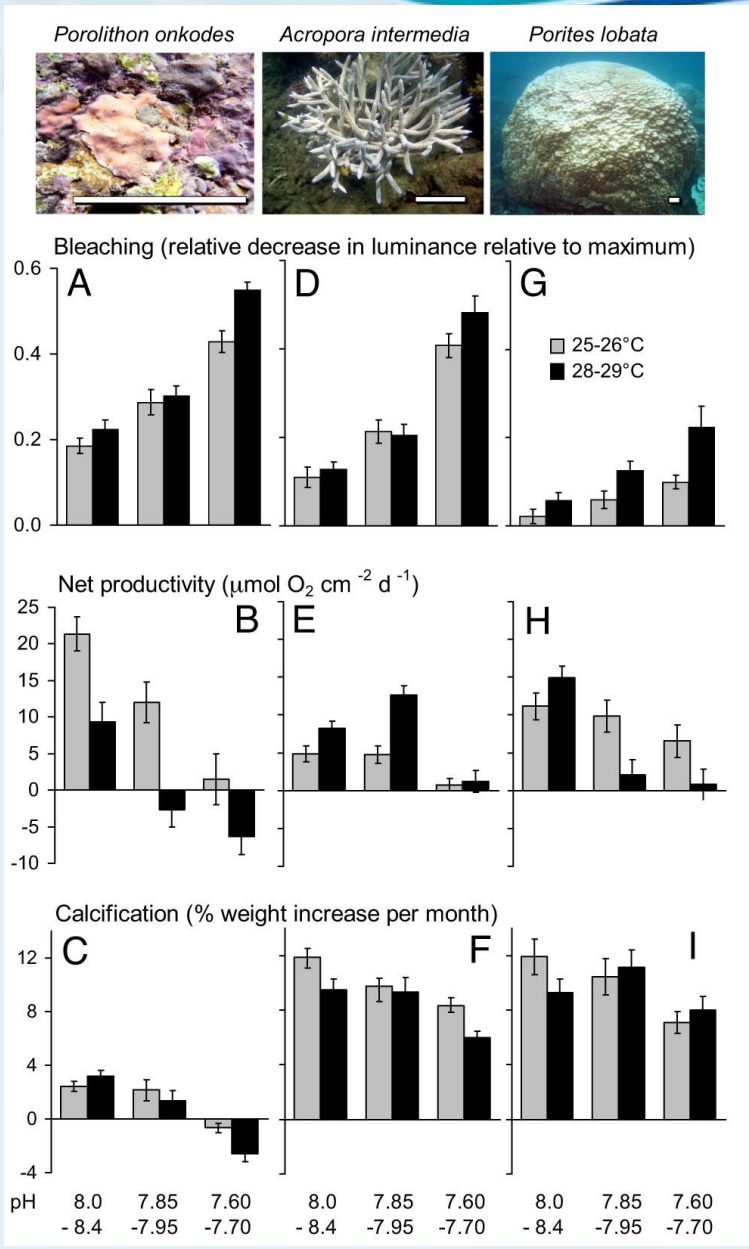
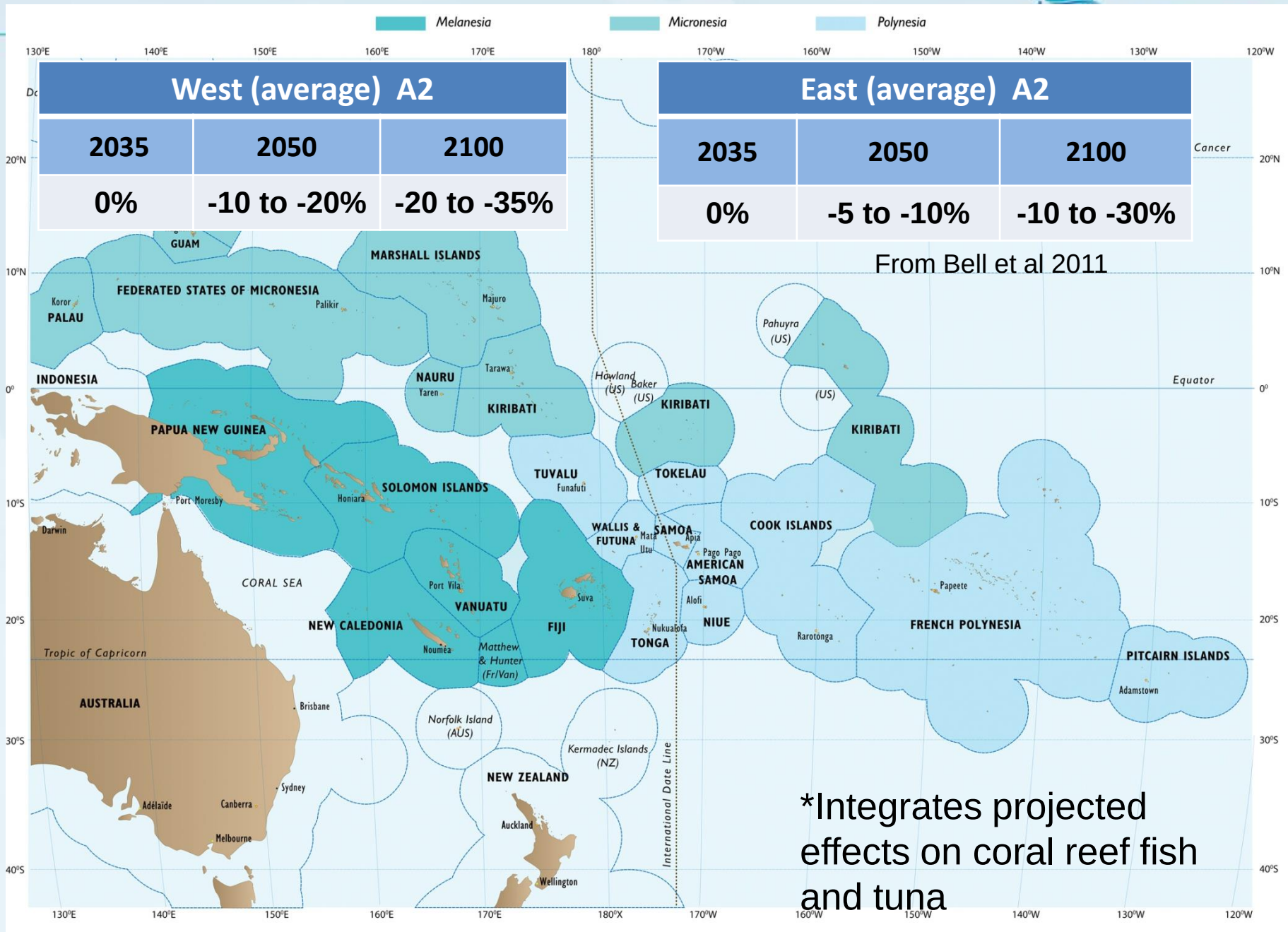


Anthony et al 2008 PNAS 105: 17442-17446


Melanesia
Micronesia
Polynesia
West (average) A2
2035
2050
2100
0%
-10 to -20%
-20 to -35%
East (average) A2
2035
2050
2100
0%
-5 to -10%
-10 to -30%
From Bell et al 2011
*Integrates projected effects on coral reef fish and tuna
GUAM
MARSHALL ISLANDS
FEDERATED STATES OF MICRONESIA
PALAU
Koror
Palikir
Majuro
INDONESIA
NAURU
Yaren
Tarawa
KIRIBATI
Hawland (US)
Baker (US)
KIRIBATI
Pahuyra (US)
(US)
KIRIBATI
PAPUA NEW GUINEA
Port Moresby
SOLOMON ISLANDS
Honiara
TUVALU
Funafuti
TOKELAU
Darwin
WALLIS & FUTUNA
Mata Utu
SAMOA
Apia
COOK ISLANDS
Pago Pago
AMERICAN SAMOA
CORAL SEA
Port Vila
VANUATU
Suva
Alofi
Papeete
NEW CALEDONIA
FIJI
NIUE
Nukualofa
TONGA
Rarotonga
FRENCH POLYNESIA
Noumea
Matthew & Hunter (Fr/Van)
Tropic of Capricorn
PITCAIRN ISLANDS
Adamstown
AUSTRALIA
Brisbane
Norfolk Island (AUS)
Kermadec Islands (NZ)
NEW ZEALAND
Sydney
Adélaïde
Canberra
Melbourne
Auckland
Wellington
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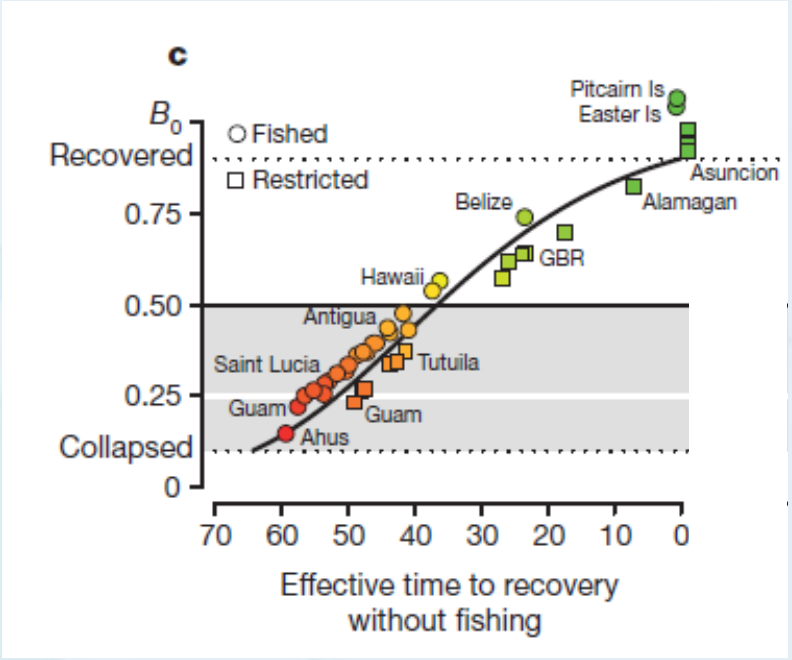
160°W
150°W
140°W
130°W
120°W
20°N
10°N
0°
10°S
20°S
30°S
40°S

Other Threats – Overfishing

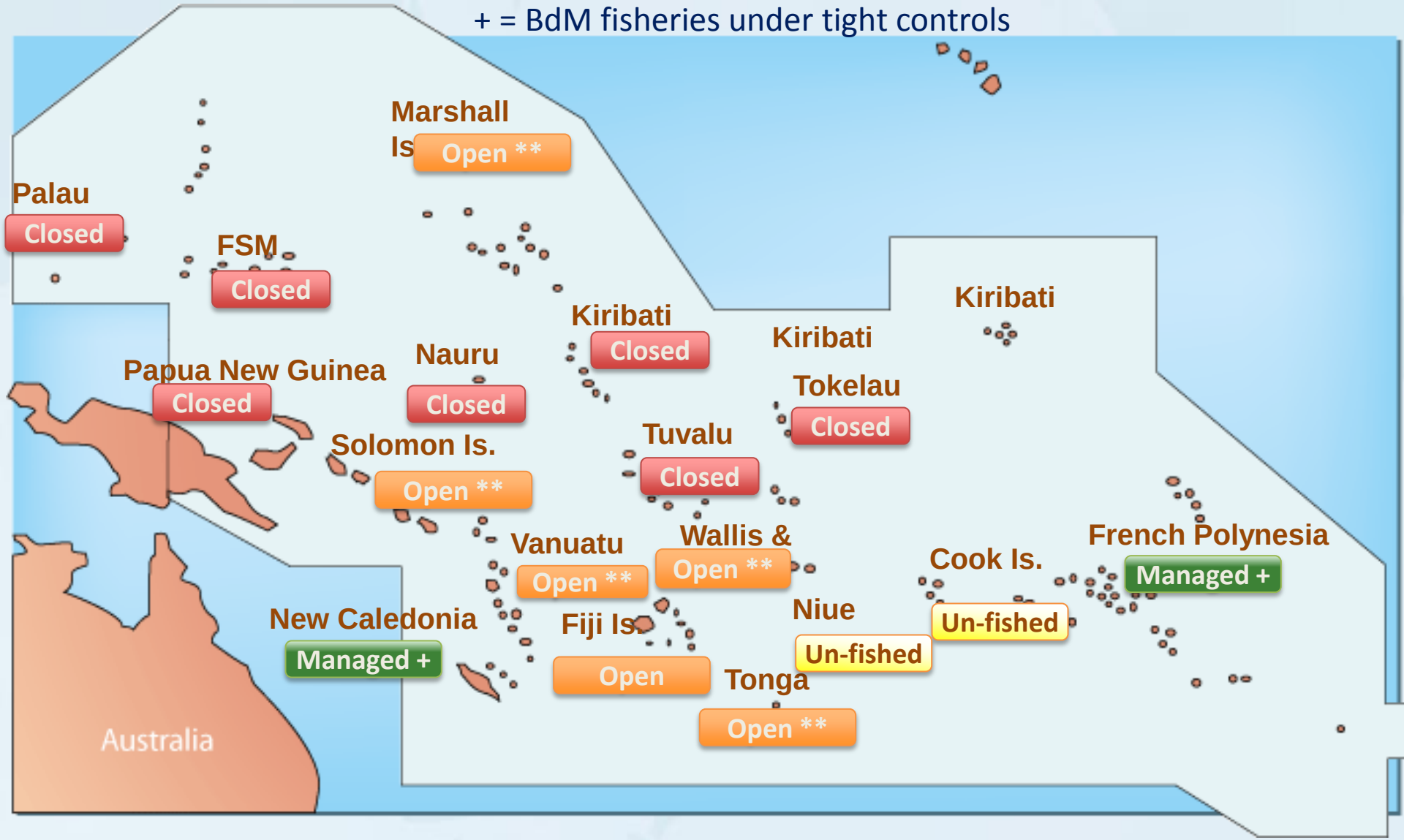
- Fish assemblages at 54% of sites surveyed during SPC PROCFish project in average-to-poor condition
- Recent global study revealed sites in Pacific with lowest relative biomass and long recovery times (MacNeil et al. 2015)



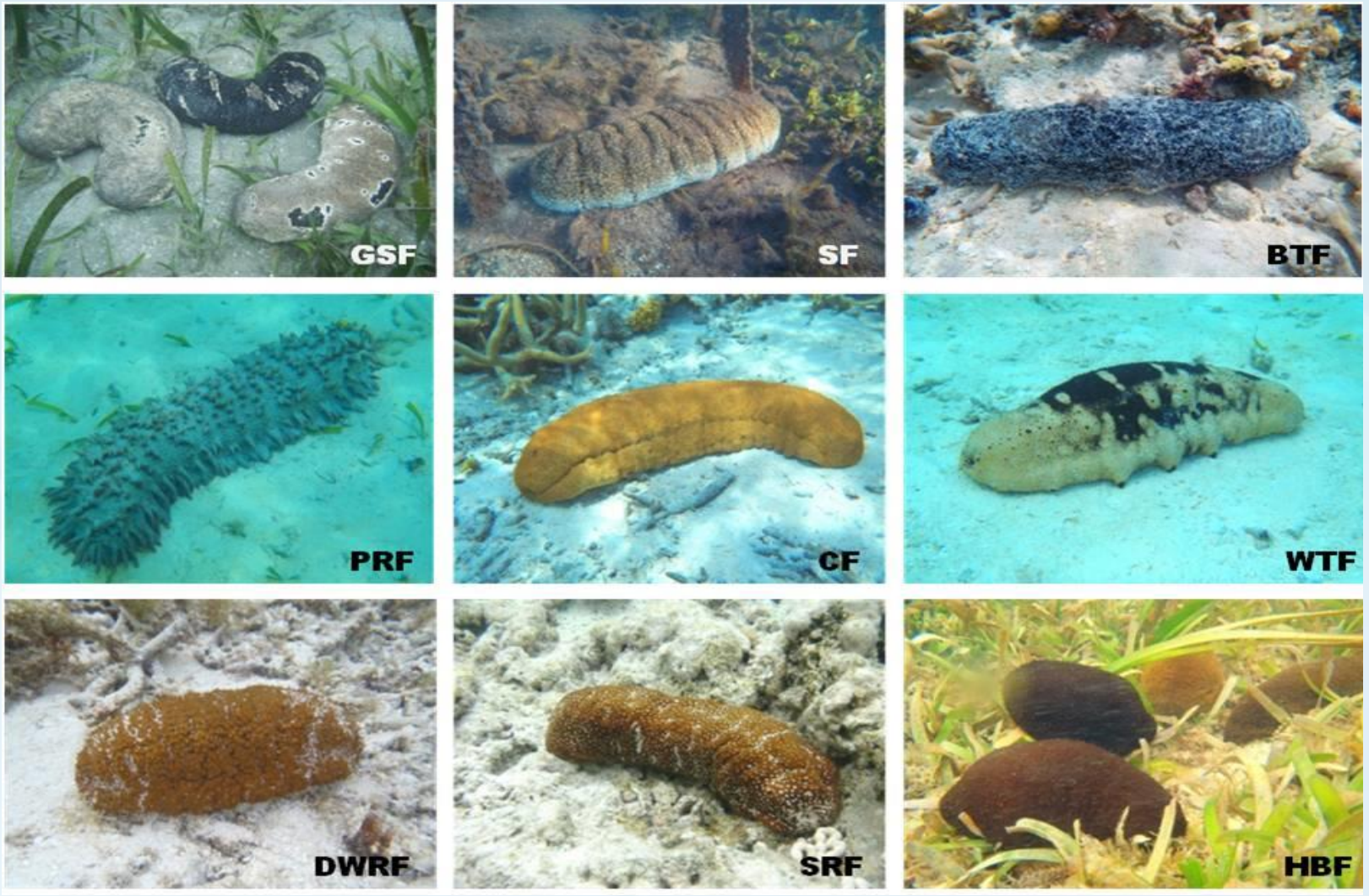
Many BdM fisheries are closed due to overfishing

** = BdM fisheries are open for short periods or have limited access

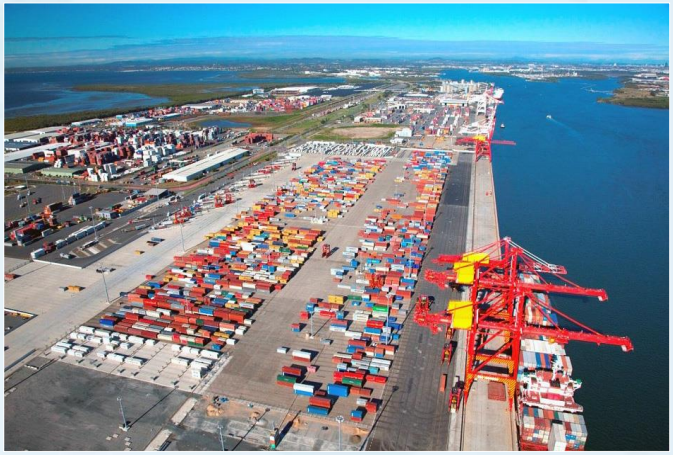
+ = BdM fisheries under tight controls



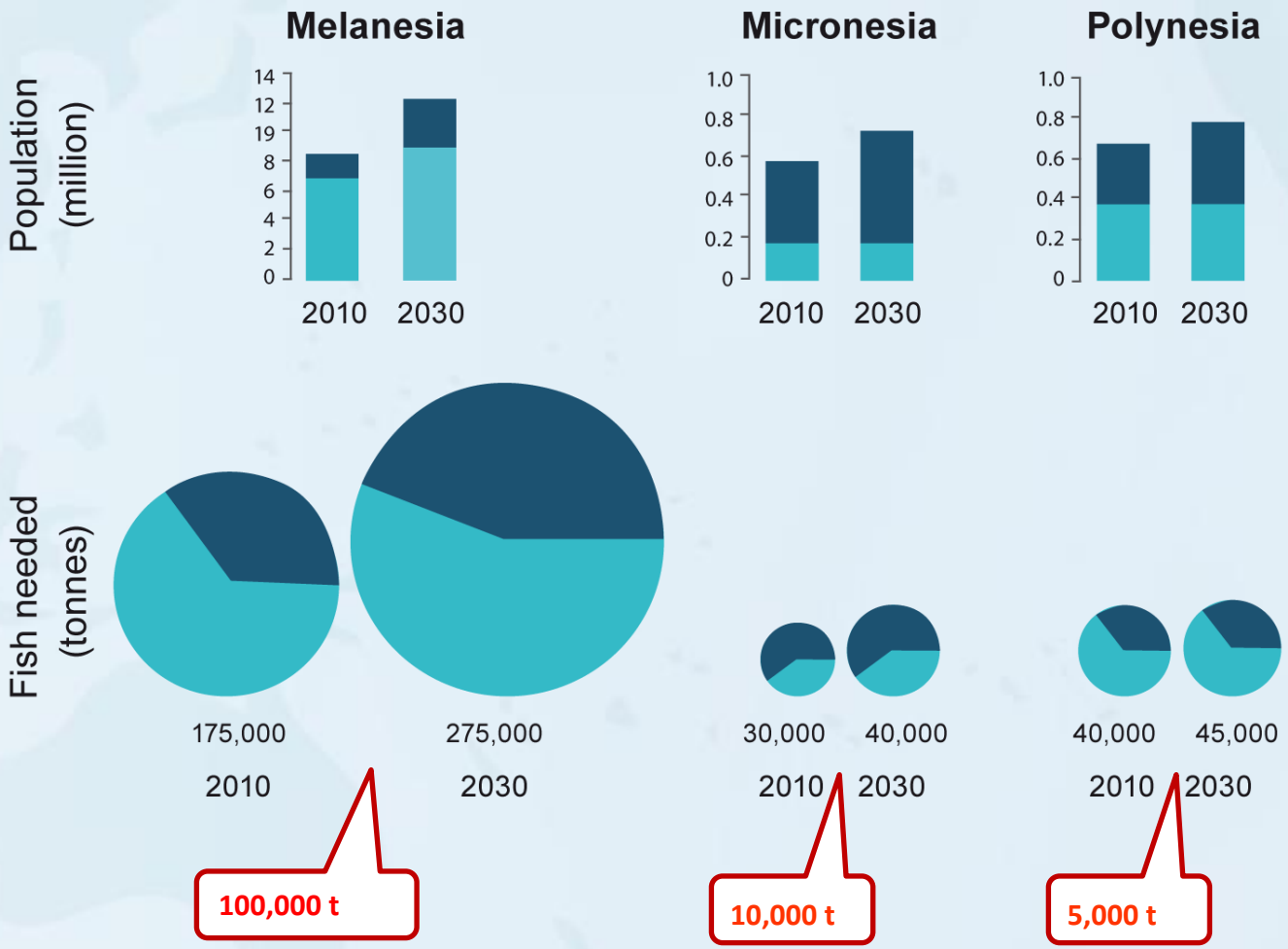
Nine species of sea cucumber in PICTs Red Listed by IUCN as either Vulnerable or Endangered



Other Threats – poor land management practices



Other Threats – growing human populations



Other Threats – ineffective coastal fisheries management

- Wide range of species harvested
- Geographical scale of region
- Lack of or outdated coastal fisheries management policy/plans/regulations
- Lack of monitoring, control, and surveillance (MCS) measures
- Limited cooperation between regional agencies and NGOs
- Lack of capacity (especially financial) and resources dedicated to coastal fisheries
- Focus on increasing production and not on reducing fishing effort
- Limited empowerment of coastal communities
- Limited political will and support

Future of Coastal Fisheries workshop, Noumea 2015

Key knowledge gaps & priorities for future research

- Examining the effects of OA and rising temperature on the biology and ecology of coastal finfish, invertebrates and habitats in synergy with each other and with other anthropogenic stressors, and assessing the ability of target fisheries species to adapt to these changes

- Evaluating species, habitats/ecosystems and human communities that are most at risk in the region

- Monitoring changes in coastal ecosystems, and how these manifest in fisheries productivity and socio-economic systems

- Monitoring effectiveness of adaptation/mitigation strategies

Thank you

Questions?