CORAL TRIANGLE INITIATIVE
ON CORAL REEFS, FISHERIES AND FOOD SECURITY

Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security (CTI-CFF) Measures and Steps in Addressing Climate-Change Related Coral Reef Issues in the Region

Segment 2: Cooperation and Coordination in Addressing the Effects of Climate Change on Oceans: Current Action and Opportunities for Further Enhancement

MUHAMMAD LUKMAN*, Widi A. Pratikto, Destyariani L. Putri
Presented by Technical Program Senior Manager, CTI-CFF Regional Secretariat

United Nation 18th Open-ended Informal Consultative Process on Oceans and the Law of the Sea
UNHQ, New York, 17 May 2017

Outline

A. Significance of the CT region and Its Challenges on Climate Change Impacts

B. CTI-CFF and conservation investment

C. CTI measures and steps towards the impact

CTI-CFF Headquarter and Regional Secretariat, Manado, Indonesia (only the globe-shaped) - dedicated by Ministry of Marine Affairs and Fisheries in 2015

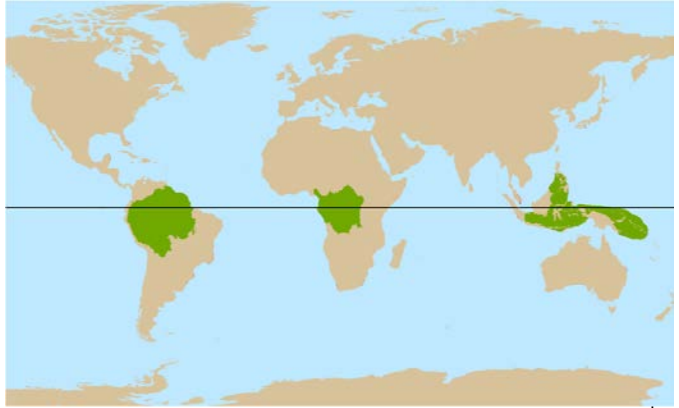
A

Significance of the CT region and Its Challenges on Climate Change Impacts

The Coral Triangle

Small (2%), but "the global center of marine diversity"…
(Veron et al., 2009)

World Biodiversity Hotspots



Land	Amazon, Congo Basin
Marine	Coral Triangle

CORAL TRIANGLE AND PATTERNS OF DIVERSITY IN REEF-BUILDING SCLERACTINIAN CORALS

The Coral Triangle

Legend

Coral Triangle

Number of species

Over 500
301 - 500
201 - 300
101 - 200
50 - 100
Less than 50

Sources:
1. Coral triangle: Delineating the Coral Triangle, its ecoregions and functional seascapes. Based on an expert workshop held at the TNC Coral Triangle Center, Bali, Indonesia, April 30 - May 2, 2003, and on expert consultations held in June - August 2005 (Green, A. and Mous, P., 2006)
2. Coral diversity: Modified from J.E.N. Veron and Mary Stafford-Smith - Reefs at Risk in Southeast Asia (Burke, L., Selig, E. and Spalding, M., 2002), combined with preliminary findings from a survey in the Solomon Islands (Green, A., 2005)

Photo: Wawan – MaCSI UNHAS

Coral Reefs:
33% of the world coral area
76% of the world coral species

Coral Fishes:
37% of the world coral fish species

Seagrass:
≈15 Species

CTI-CFF Fisheries

Support livelihood & food security for ca. **393 million** people In CT 6 countries: Indonesia, Malaysia, Papua New Guinea, Philippines, Solomon Islands, and Timor-Leste

FAO (2014): average consumption ca. 28.2 kg/capita/year of fish supply in the CT6 countries; CT-6 Demand: indicative ca. 11.1 Mio tons/year

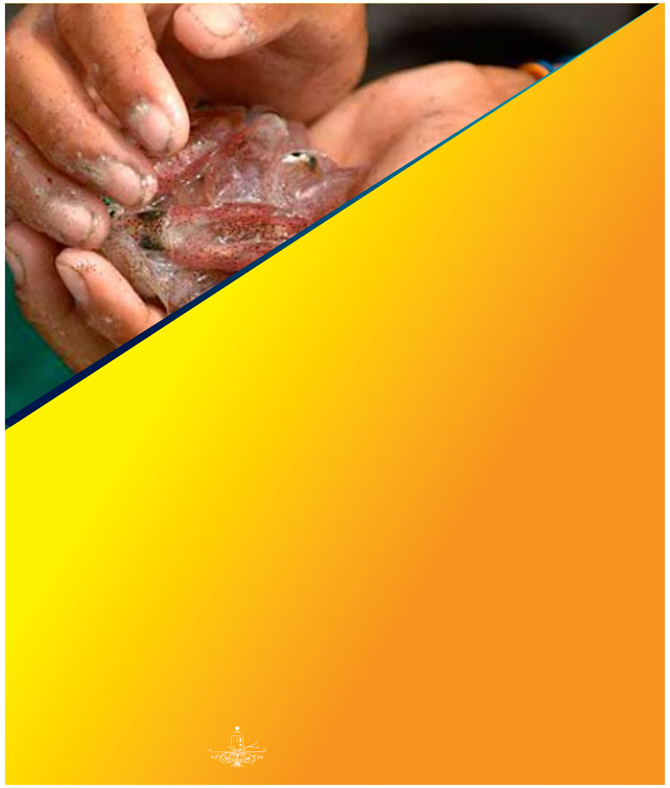
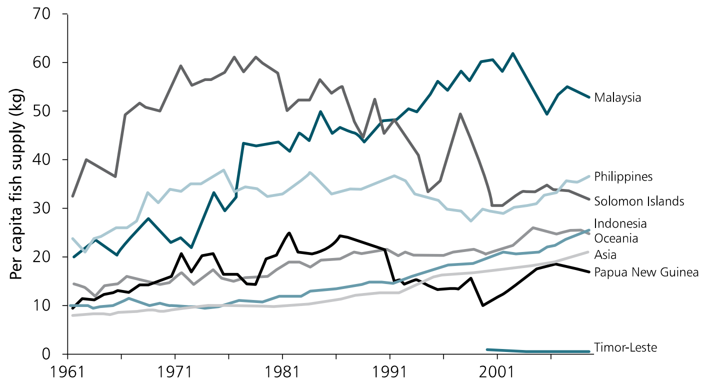
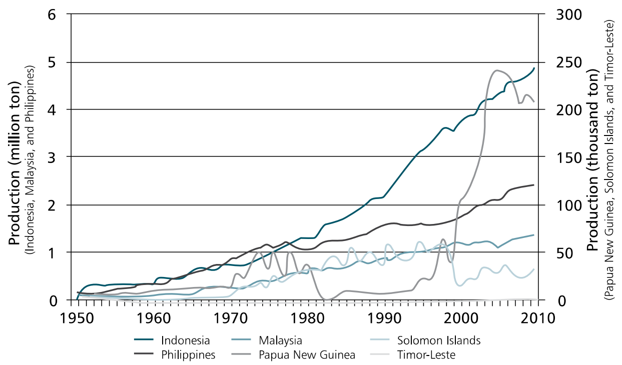


Figure 12 Per Capita Fish Supply in CT6 Countries, Asia, and Oceania, 1961–2009



kg = kilogram.
Source: Laurenti (2012).

Figure 5 Estimated Marine Capture Fisheries Production in CT6 Countries, 1950–2010

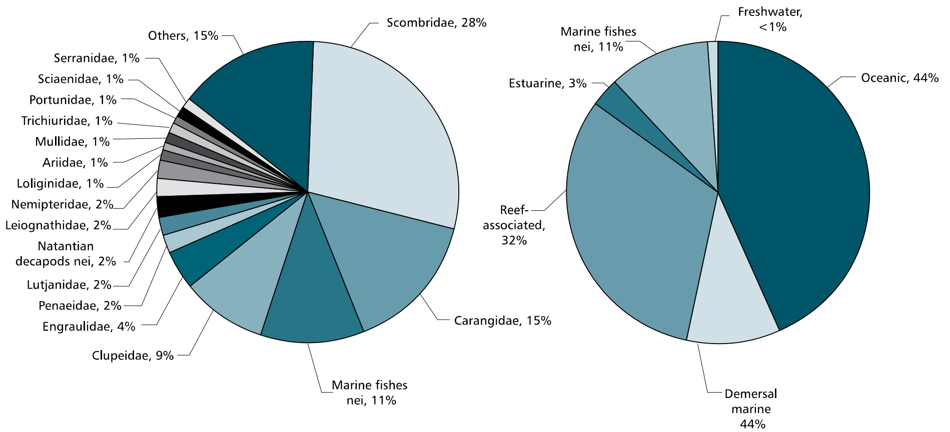


Note: The secondary vertical axis (right) corresponds to the data for Papua New Guinea (PNG), Solomon Islands, and Timor-Leste. Data for PNG and Solomon Islands exclude catches from foreign-based fleets that, in 2007, contributed 52.8% of the total capture fisheries production of PNG (619,568 t), and 70.1% to that of Solomon Islands (139,892 t).
Sources: FAO (2011b) and Gillett (2009).

Production

2010: **13.2** Mio T
2020: **17.1** Mio T (Est.)

Figure 6 Aggregate Marine Fish Catch Composition in CT6 Countries, 2009



nei = not elsewhere included.
Notes: Left: Using Aquatic Sciences and Fisheries Information System (ASFIS) family classification; Right: Based on ecosystem association of catches. Ecosystem category per species group can be found in the appendix.
Source: FAO (2011b).

Mackarel, Anchovies, Sardines
(Scombrids, Sarangidae, Clupeoids)= 53%
Reef-associated species = 32%

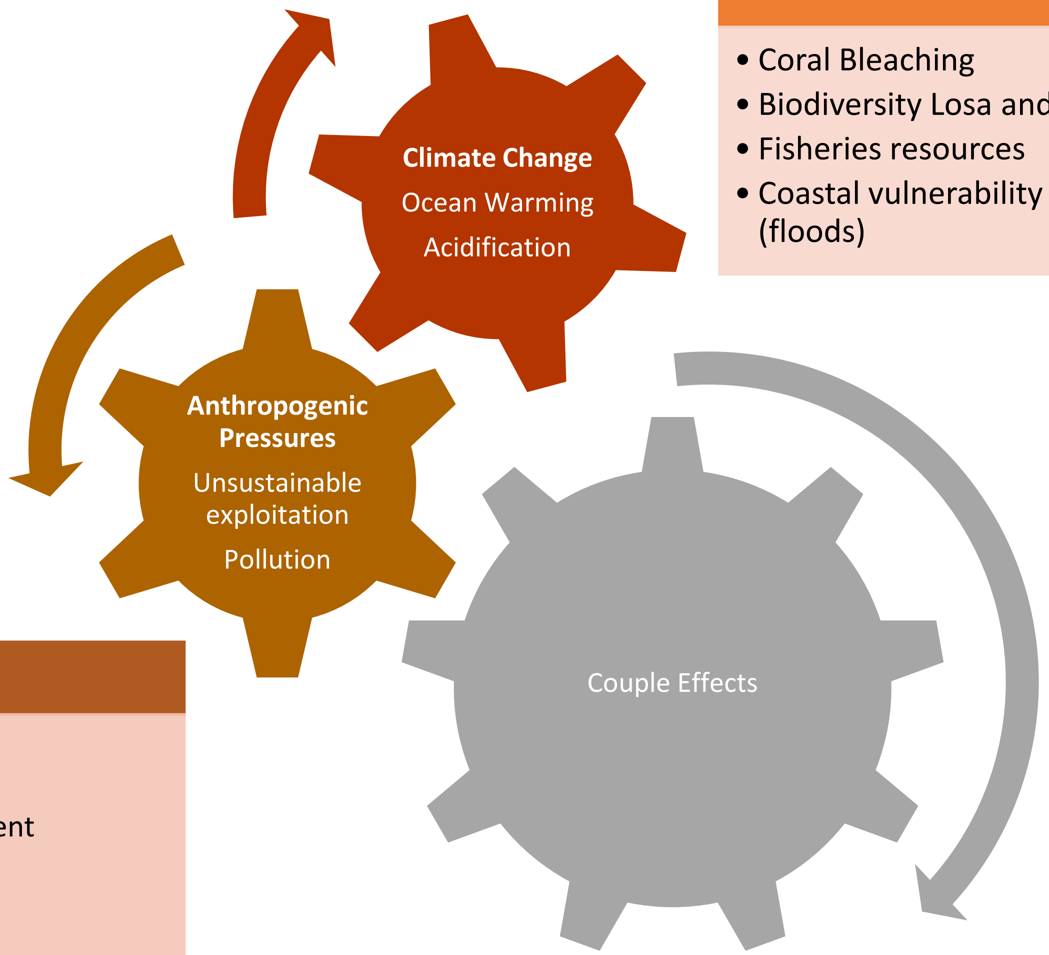
Capture Fisheries
ca.US $ 10 billion

Reef-associated fishes
ca.US $ 3 billion

Tuna Catch (National Fleets)
ca. **1.3 billion**

ADB, 2014
https://www.adb.org/sites/default/files/publication/42411/economics-fisheries-aquaculture-coral-triangle.pdf

Climate Change Impacts in the CT Region



Climate-related impacts

- Coral Bleaching
- Biodiversity Losa and Vulnerable Ecosystem
- Fisheries resources
- Coastal vulnerability due to sea level rise, extreme weather and disasters (floods)

Anthropogenic pressures

- Overexploitation of economic species
- Destructive fisheries
- Unenvironmentally-friend Coastal development
- Watershed-based and Marine Pollution, i.p.
  - Marine debris
  - Nutrient – Eutrophication
  - Oil spills

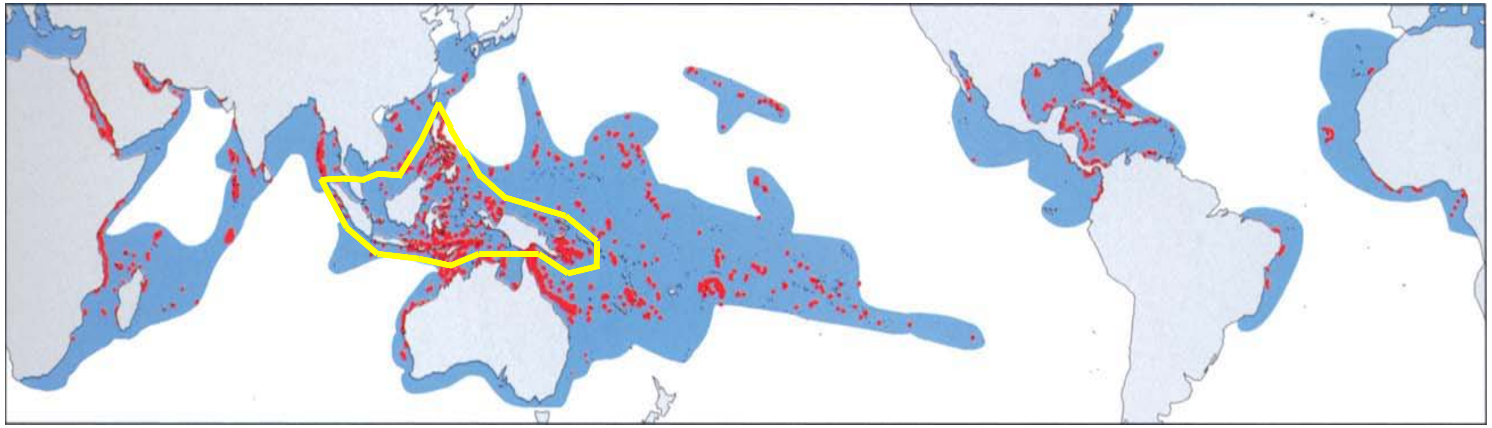
Couple-impacts

- Resource sustainability
- Ecosystem and Community Resilience
- Economic loss and Social Problems

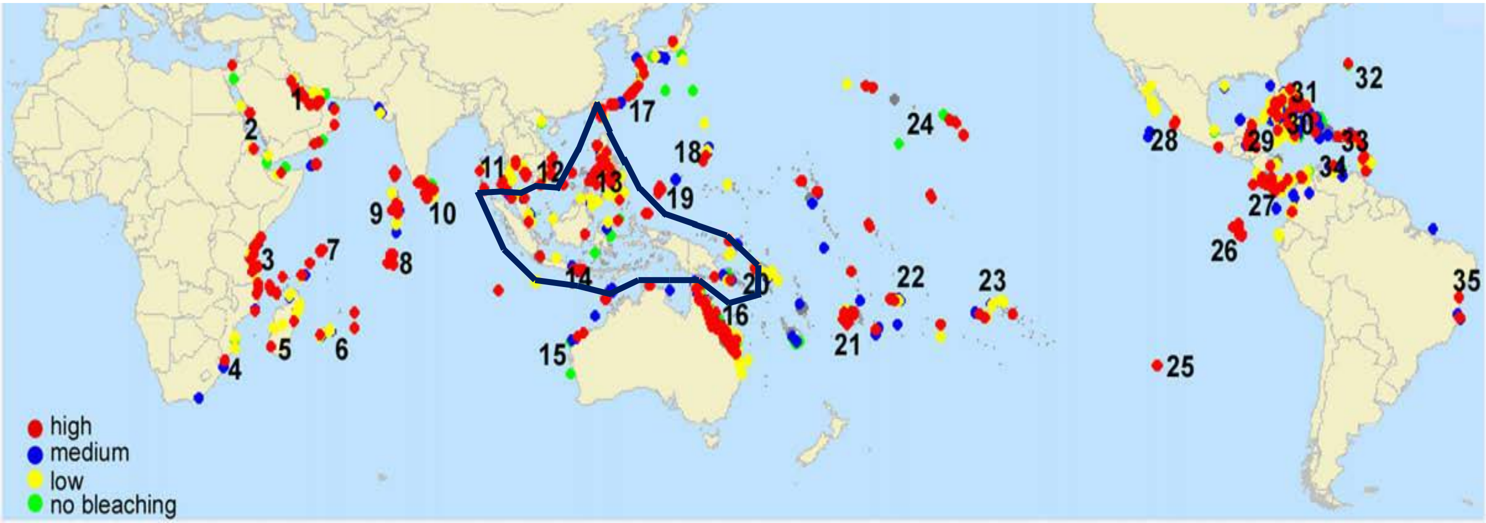
CORAL TRIANGLE INITIATIVE ON CORAL REEFS, FISHERIES AND FOOD SECURITY

Frequent and Severe Coral Bleaching

THE WORLDWIDE CORAL REEFS [(a)]



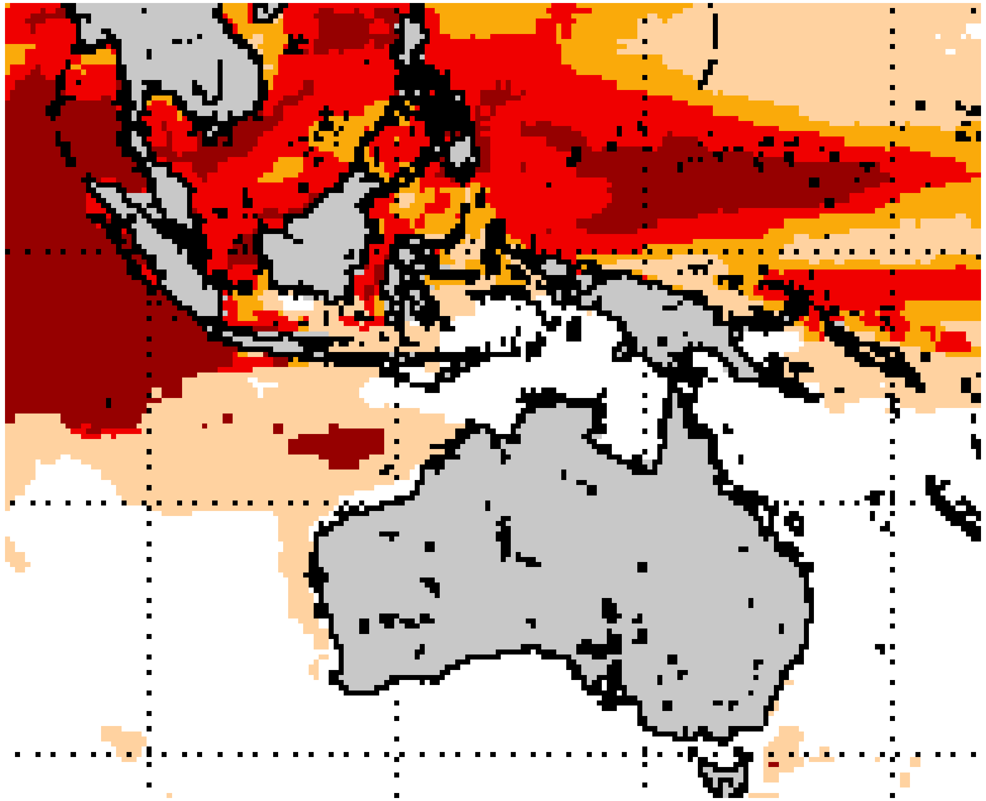
THE WORLDWIDE CORAL BLEACHING [(b)]



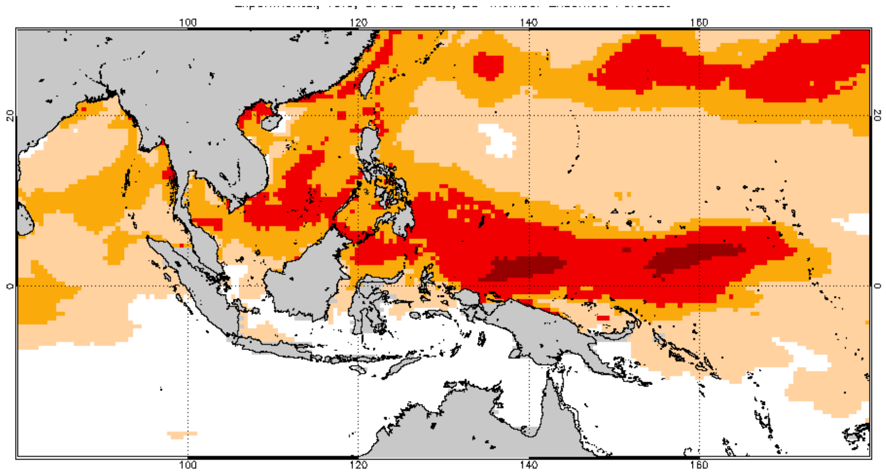
(a) Burkepile, E. D. and Hay, E. M., 2008, *Ecosytems*, Coral Reefs, pg. 784-796.
(b) Baker, C. Andre , et. Al., 2008, *Estuarine, Coastal and Shelf Science*, Climate change and coral reef bleaching: An ecological assessment of long-term impacts, recovery trends and future outlook, Vol. 80, pg. 435-471
This slide is inspired by the presentation of MMAF Indonesia

Frequent and Severe Coral Bleaching

2016 May 3, NOAA Coral Reef Watch 60% Probability Coral Bleaching Thermal Stress for May – Aug 2016 [c]



2017 May 9, NOAA Coral Reef Watch 60% Probability Coral Bleaching Thermal Stress for May – Aug 2017 [a]

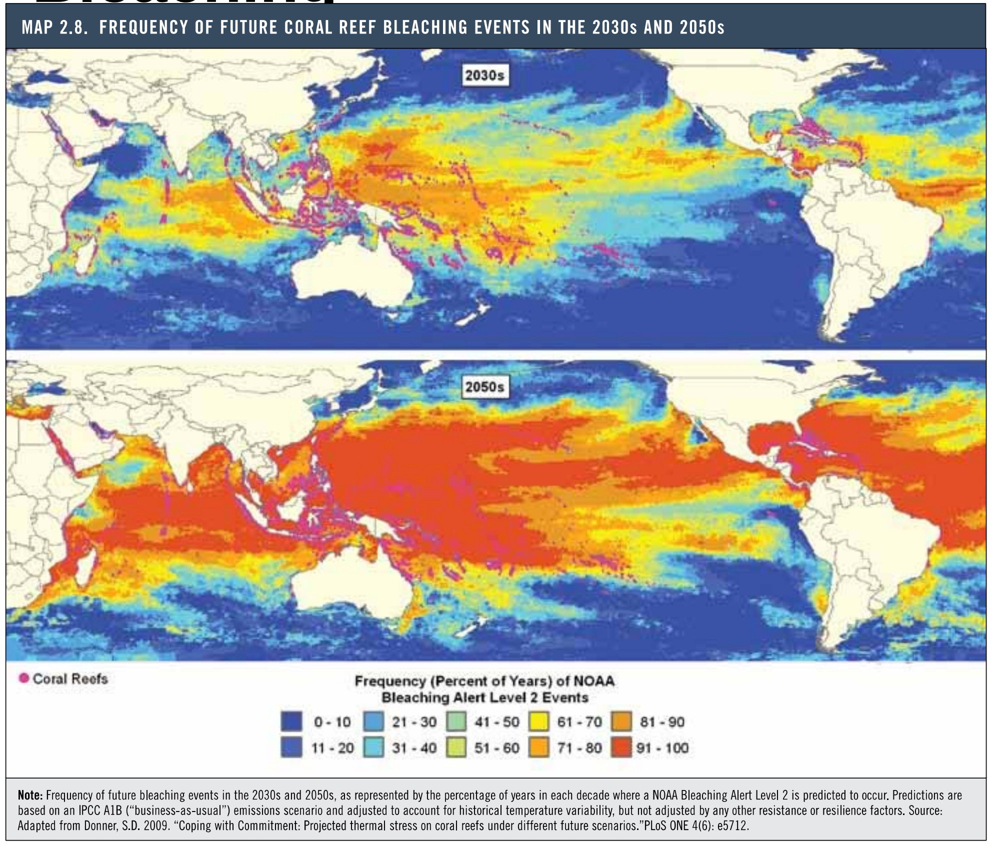


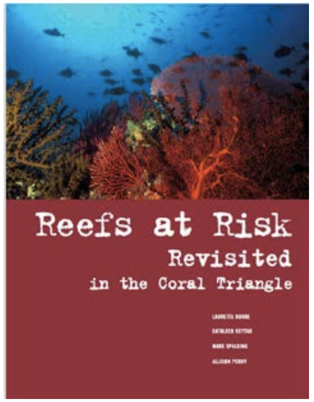
Potential Stress Level:

Watch Warning Alert Level 1 Alert Level 2

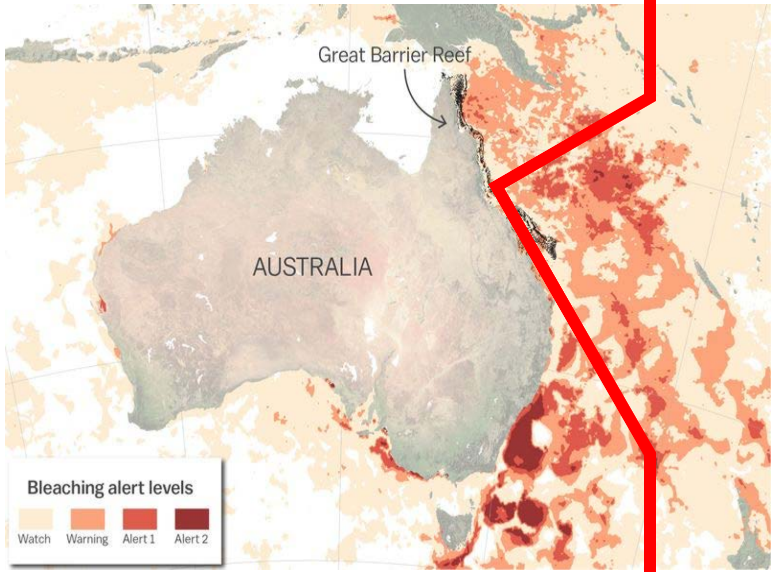
Source: www.coralreefwatch.noaa.gov

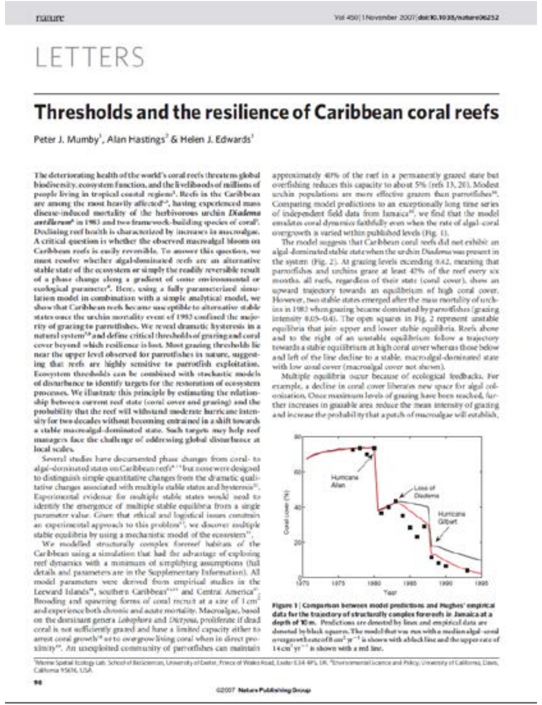
Frequent and Severe Coral Bleaching





The Great Barrier Reef's in 2017 [(a)]

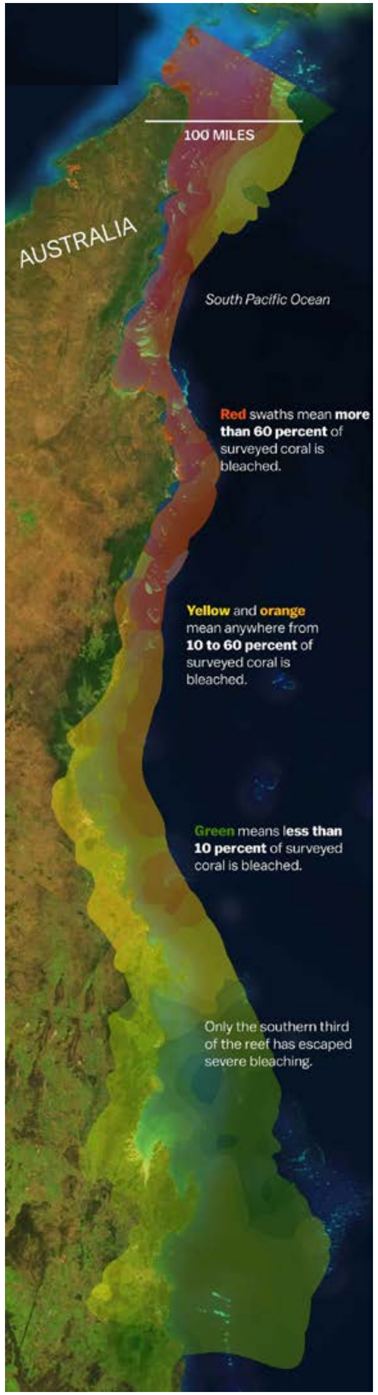



nature Vol 450 | 1 November 2007 | doi:10.1038/nature06252

LETTERS

Thresholds and the resilience of Caribbean coral reefs

Peter J. Mumby[1], Alan Hastings[2] & Helen J. Edwards[1]



(a) https://www.vox.com/science-and-health/2017/4/18/15272634/catastrophic-coral-bleaching-great-barrier-reef-map

(b) Burke, L., Reytar, K., Spalding, M., Perry, A., 2012, *Reefs at Risk Revisited in the Coral Triangle*, Washington DC., USA

Ocean Acidification

Coral Reefs Under Rapid Climate Change and Ocean Acidification

O. Hoegh-Guldberg,[1*] P. J. Mumby,[2] A. J. Hooten,[3] R. S. Steneck,[4] P. Greenfield,[5] E. Gomez,[6] C. D. Harvell,[7] P. F. Sale,[8] A. J. Edwards,[9] K. Caldeira,[10] N. Knowlton,[11] C. M. Eakin,[12] R. Iglesias-Prieto,[13] N. Muthiga,[14] R. H. Bradbury,[15] A. Dubi,[16] M. E. Hatziolos[17]

Atmospheric carbon dioxide concentration is expected to exceed 500 parts per million and global temperatures to rise by at least 2°C by 2050 to 2100, values that significantly exceed those of at least the past 420,000 years during which most extant marine organisms evolved. Under conditions expected in the 21st century, global warming and ocean acidification will compromise carbonate accretion, with corals becoming increasingly rare on reef systems. The result will be less diverse reef communities and carbonate reef structures that fail to be maintained. Climate change also exacerbates local stresses from declining water quality and overexpl... toward the tipping point for functional collapse. This re... predict increasingly serious consequences for reef-associ... people. As the International Year of the Reef 2008 beg... decisive action on global emissions are required if the lo...

Coral reefs are among the most biologically diverse and economically important ecosystems on the planet, providing ecosystem services that are vital to human societies and industries through fisheries, coastal protection, building materials, new biochemical compounds, and tourism (1). Yet in the decade since the inaugural International Year of the Reef in 1997 (2), which called the world to action, coral reefs have continued to deteriorate as a result of human influences (3, 4). Rapid increases in the atmospheric carbon dioxide concentration ($[CO_2]_{atm}$), by driv-

[1]Centre for Marine Studies, The University of Queensland, St. Lucia, 4072 Queensland, Australia. [2]Marine Spatial Ecology Laboratory, School of BioSciences, University of Exeter, Prince of Wales Road, Exeter EX4 4PS, UK. [3]AJH Environmental Services, 4900 Auburn Avenue, Suite 201, Bethesda, MD 20814, USA. [4]University of Maine, School of Marine Sciences, Darling Marine Center, Walpole, ME 04573, USA. [5]The Chancellery, University of Queensland, St. Lucia, 4072 Queensland, Australia. [6]Marine Science Institute, University of the Philippines, Diliman, Quezon City, Philippines. [7]Ecology and Evolutionary Biology, E321 Corson Hall, Cornell University, Ithaca, NY 14853, USA. [8]International Network on Water, Environment and Health, United Nations University, 50 Main Street East, Hamilton, Ontario L8N 1E9, Canada. [9]School of Biology, Ridley Building, University of Newcastle, Newcastle upon Tyne, NE1 7RU, UK. [10]Department of Global Ecology, Carnegie Institution of Washington, 260 Panama Street, Stanford, CA 94305, USA. [11]National Museum of Natural History, Smithsonian Institution, Washington, DC 20013, USA. [12]National Oceanic and Atmospheric Administration, Coral Reef Watch, E/RA31, 1335 East West Highway, Silver Spring, MD 20910–3226, USA. [13]Unidad Académica Puerto Morelos, Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México, Apdo. Postal 1152, Cancún 77500 QR, México. [14]Wildlife Conservation Society, 2300 Southern Boulevard, Bronx, New York, NY 10460, USA. [15]Resource Management in Asia-Pacific Program, Australian National University, Canberra, 0200 Australia. [16]Institute of Marine Sciences, University of Dar es Salaam, Tanzania. [17]Environment Department, MCS-523, The World Bank, 1818 H Street, NW, Washington, DC 20433, USA.

*To whom correspondence should be addressed. E-mail: oveh@uq.edu.au

ing a mean temperature of 25°C during the past 420,000 years (Fig. 1B). The results show a tight cluster of points that oscillate (temperature ±3°C; carbonate-ion concentration ±35 μmol kg^{-1}) between warmer interglacial periods that had lower carbonate concentrations to cooler glacial periods with higher carbonate concentrations. The overall range of values calculated for seawater pH is ±0.1 units (10, 11). Critically, where coral reefs occur, carbonate-ion concentrations over the past 420,000 years have not fallen below 240 μmol kg^{-1}. The trends in the Vostok ice core data have been verified by the EPICA study (6), which involves a similar range of temperatures and $[CO_2]_{atm}$ values and hence extends the conclusions derived from the Vostok record to at least 740,000 years before the present (yr B.P.). Conditions today ($[CO_2]_{atm}$ ~380 ppm) are significantly

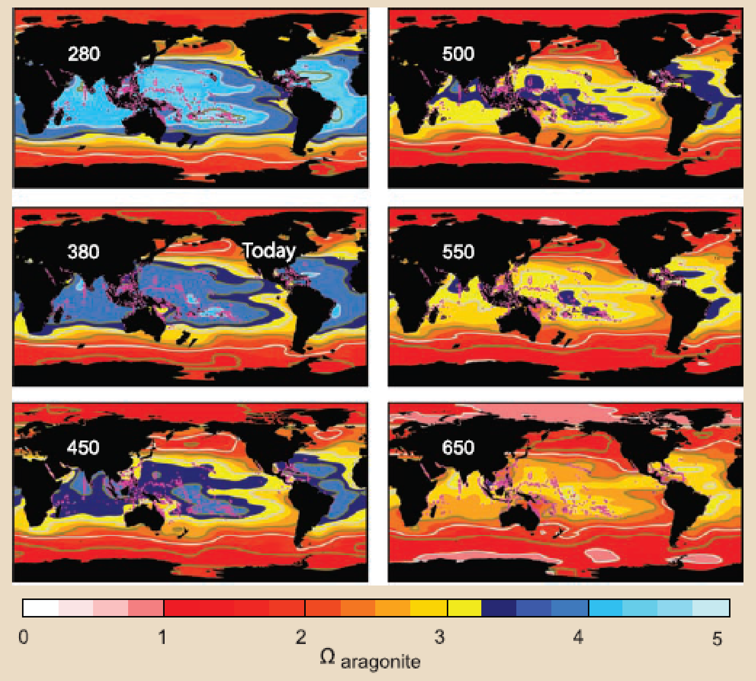


Fig. 4. Changes in aragonite saturation {$\Omega_{aragonite} = ([Ca^{2+}][CO_3^{2-}])/K_{sp\ aragonite}$} predicted to occur as atmospheric CO_2 concentrations (ppm) increase (number at top left of each panel) plotted over shallow-water coral reef locations shown as pink dots (for details of calculations, see the SOM). Before the Industrial Revolution (280 ppm), nearly all shallow-water coral reefs had $\Omega_{aragonite}$ > 3.25 (blue regions in the figure), which is the minimum $\Omega_{aragonite}$ that coral reefs are associated with today; the number of existing coral reefs with this minimum aragonite saturation decreases rapidly as $[CO_2]_{atm}$ increases. Noticeably, some regions (such as the Great Barrier Reef) attain low and risky levels of $\Omega_{aragonite}$ much more rapidly than others (e.g., Central Pacific).

Effect of Ocean Acidification on Iron Availability to Marine Phytoplankton

Dalin Shi,* Yan Xu, Brian M. Hopkinson, François M. M. Morel

The acidification caused by the dissolution of anthropogenic carbon dioxide (CO_2) in the ocean changes the chemistry and hence the bioavailability of iron (Fe), a limiting nutrient in large oceanic regions. Here, we show that the bioavailability of dissolved Fe may decline because of ocean acidification. Acidification of media containing various Fe compounds decreases the Fe uptake rate of diatoms and coccolithophores to an extent predicted by the changes in Fe chemistry. A slower Fe uptake by a model diatom with decreasing pH is also seen in experiments with Atlantic surface water. The Fe requirement of model phytoplankton remains unchanged with increasing CO_2. The ongoing acidification of seawater is likely to increase the Fe stress of phytoplankton populations in some areas of the ocean.

The dissolution of additional atmospheric carbon dioxide (CO_2) in the ocean will lead to predictable changes in the chemistry of seawater, including an increase in partial pressure of CO_2 (P_{CO_2}), a decrease in pH, and a decrease in the carbonate ion concentration, $[CO_3^{2-}]$. The possible biological consequences of these changes, all described by the term "ocean acidification," are being extensively studied (1–4). In particular, the effects of increasing P_{CO_2} and decreasing $[CO_3^{2-}]$ on phytoplankton have received some attention (1, 4–6) but not, so far, the potential effects of the decrease in pH, which is nearly 0.3 pH units for a doubling of P_{CO_2}.

Iron (Fe) is the biologically important element whose chemistry is most sensitive to pH. The bulk of Fe(III) in the ocean is known to be chelated by organic compounds (7, 8), and the fraction that is not chelated is present as hydrolyzed species, $Fe(OH)_x^{(3-x)+}$, with the neutral tri-hydroxy species, $Fe(OH)_3$, being very insoluble. As ocean waters acidify, decreasing the hydroxide ion concentration, Fe's speciation and solubility will be altered. A decrease in pH by 0.3 unit should slightly increase iron's solubility in seawater (9). The hydroxide ion and organic chelators compete for binding Fe(III) so that a decrease in pH should affect the extent of organic chelation of Fe and hence its availability to ambient organisms. At the same time that a decrease in pH may affect the availability of Fe to phytoplankton, an increase in P_{CO_2} may change their Fe requirements. For example, increasing the extracellular concentration of CO_2 should decrease the need to operate a carbon-concentrating mechanism (CCM) for CO_2 fixation (10, 11) and hence may allow an economy in the Fe involved in the photosynthetic or respiratory processes that provide energy for the CCM. Through changes in Fe availability and requirements, ocean acidification may affect primary production and the ecology of phytoplankton. Here, we present data on the effect of acidification on Fe availability and requirements in laboratory cultures of diatoms and coccolithophores and on the uptake of Fe bound to natural ligands

Department of Geosciences, Princeton University, Princeton, NJ 08544, USA.

*To whom correspondence should be addressed. E-mail: dshi@princeton.edu

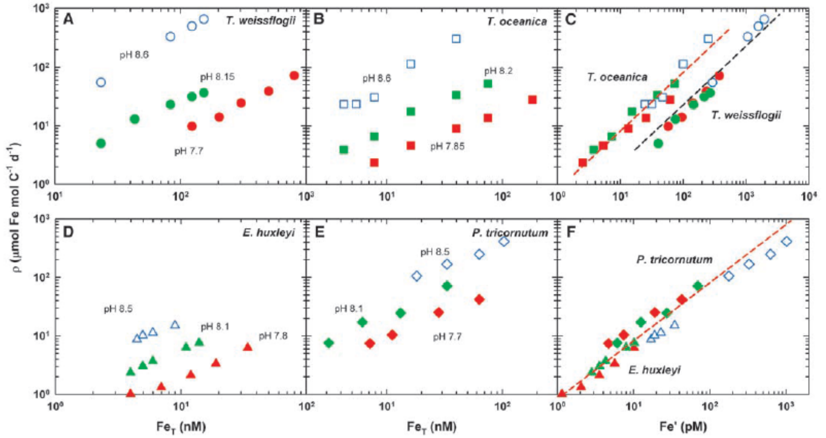
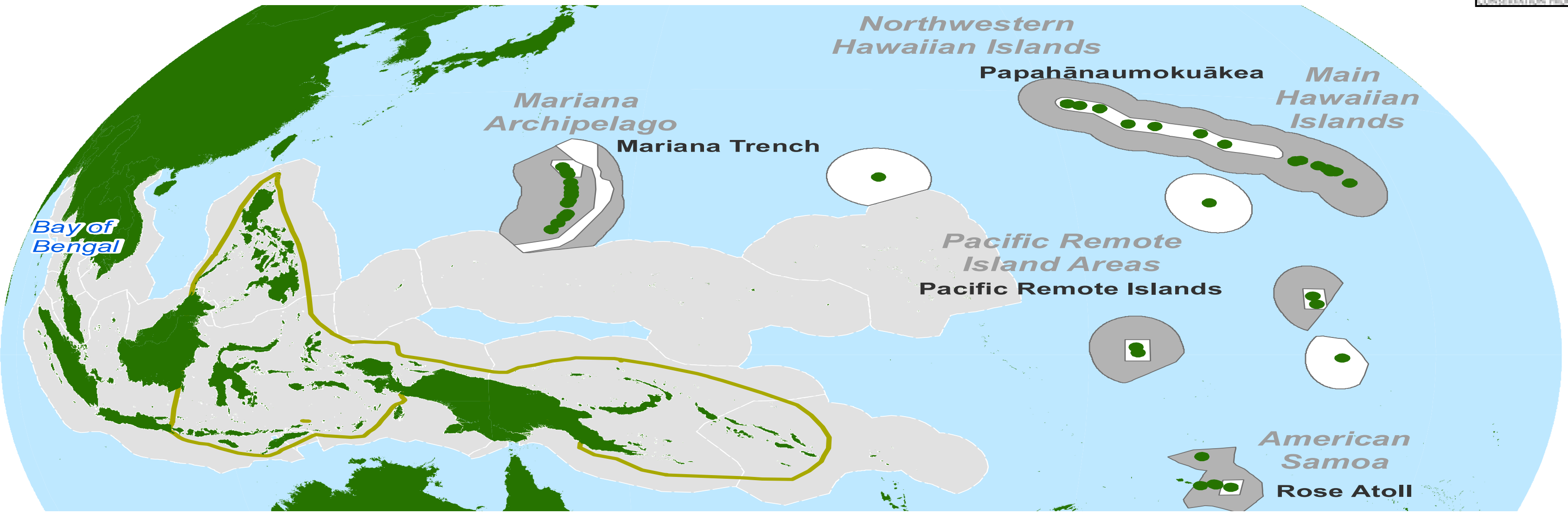
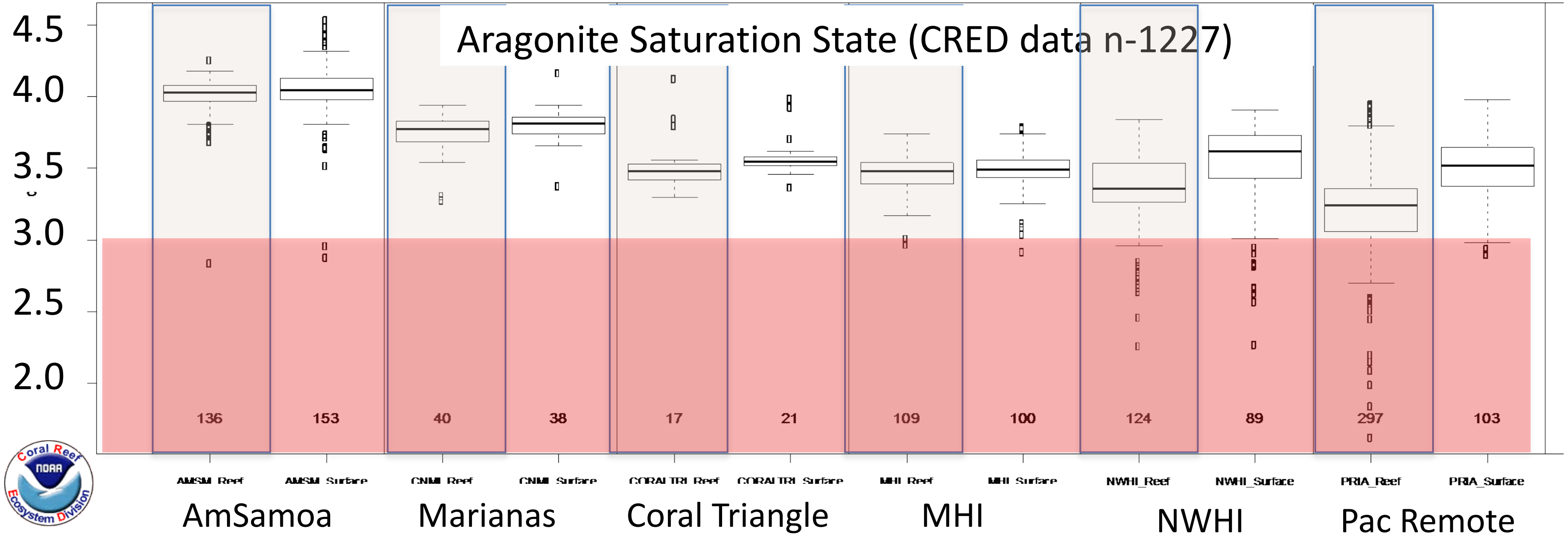


Fig. 1. Steady-state iron uptake rates in cultures of (A) T. weissflogii, (B) T. oceanica, (D) E. huxleyi, and (E) P. tricornutum as a function of total iron concentration (Fe_T) in EDTA-buffered culture medium over a range of pH/P_{CO_2}. Circles indicate T. weissflogii: red, pH 7.7/P_{CO_2} 950 ppm; green, pH 8.15/P_{CO_2} 320 ppm; and blue, pH 8.6/P_{CO_2} 90 ppm. Squares indicate T. oceanica: red, pH 7.85/P_{CO_2} 680 ppm; green, pH 8.2/P_{CO_2} 290 ppm; and blue, pH 8.6/P_{CO_2} 100 ppm. Triangles indicate E. huxleyi: red, pH 7.8/P_{CO_2} 770 ppm; green, pH 8.1/P_{CO_2} 370 ppm; and blue, pH 8.5/P_{CO_2} 130 ppm. Diamonds indicate P. tricornutum: red, pH 7.7/P_{CO_2} 950 ppm; green, pH 8.1/P_{CO_2} 360 ppm; and blue, pH 8.5/P_{CO_2} 130 ppm. (C) and (F) When plotted as a function of the unchelated iron concentration, Fe′, uptake rates coalesce for each organism following a one-to-one line. The red dashed line in (C) is identical to the one shown in (F). Results of each organism are from a single experiment. Additional experiments yielded results that follow the same lines shown in (C) and (F).

CRED Carbonate Chemistry

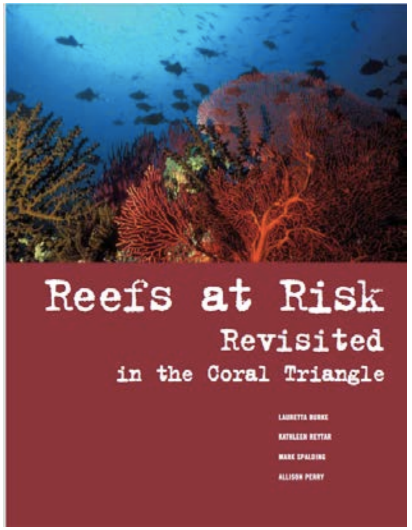
Ocean Acidification





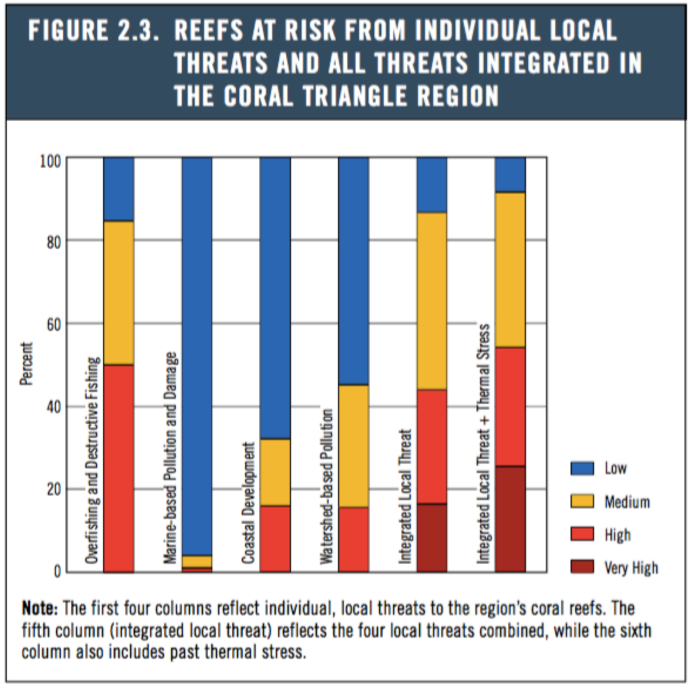
Source: Brainard, 2015

Anthropogenic Challenge to Coral Reefs in The Coral Triangle Region

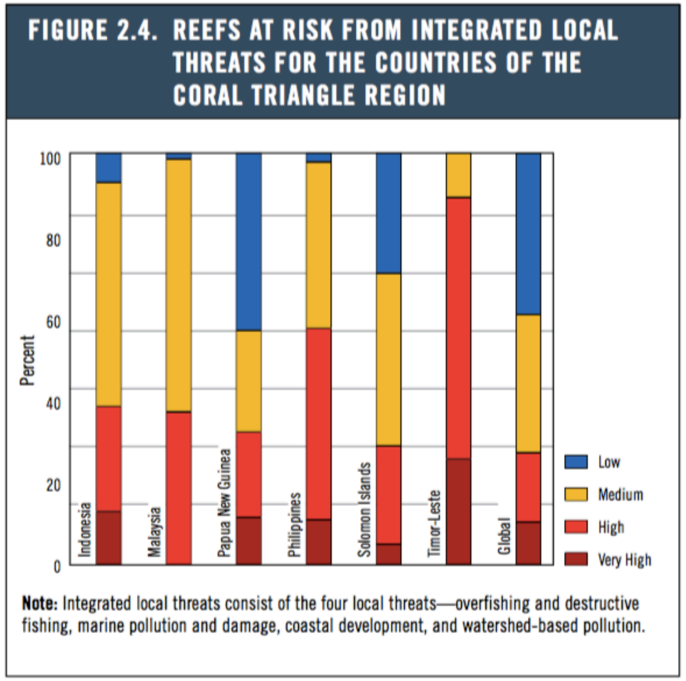


Integrated Local Threat:

- Overfishing
- Marine Based Pollution
- Coastal Development
- Watershed Based Pollution



Overfishing contributes +50% of reef risk on high level



+92% of reef effected by Integrated Local Threat in Coral Triangle Region

Burke, L., Reytar, K., Spalding, M., Perry, A., 2012, *Reefs at Risk Revisited in the Coral Triangle*, Washington DC., USA

Pressures → Conservation → Increased Resilience

B

CTI-CFF and conservation investment

Global Change Biology

Global Change Biology (2011) 17, 1798–1808, doi: 10.1111/j.1365-2486.2010.02364.x

Ocean acidification and warming will lower coral reef resilience

KENNETH R. N. ANTHONY*, JEFFREY A. MAYNARD†, GUILLERMO DIAZ-PULIDO‡, PETER J. MUMBY*, PAUL A. MARSHALL§, LONG CAO¶ and OVE HOEGH-GULDBERG*

*Global Change Institute, and ARC Centre of Excellence for Coral Reef Studies, The University of Queensland, St Lucia, QLD 4072, Australia, †Australian Centre of Excellence for Risk Analysis, School of Botany, University of Melbourne, Parkville, VIC 3010, Australia, ‡Griffith School of Environment and Australian Rivers Institute – Coasts & Estuaries, Nathan Campus, Griffith University, 170 Kessels Road, Nathan, QLD 4111, Australia, §Great Barrier Reef Marine Park Authority, Townsville QLD 4810, Australia, ¶Department of Global Ecology, Carnegie Institution, Stanford, CA 94305, USA

Abstract

Ocean warming and acidification from increasing levels of atmospheric CO_2 represent major global threats to coral reefs, and are in many regions exacerbated by local-scale disturbances such as overfishing and nutrient enrichment. Our understanding of global threats and local-scale disturbances on reefs is growing, but their relative contribution to reef resilience and vulnerability in the future is unclear. Here, we analyse quantitatively how different combinations of CO_2 and fishing pressure on herbivores will affect the ecological resilience of a simplified benthic reef community, as defined by its capacity to maintain and recover to coral-dominated states. We use a dynamic community model integrated with the growth and mortality responses for branching corals (*Acropora*) and fleshy macroalgae (*Lobophora*). We operationalize the resilience framework by parameterizing the response function for coral growth (calcification) by ocean acidification and warming, coral bleaching and mortality by warming, macroalgal mortality by herbivore grazing and macroalgal growth via nutrient loading. The model was run for changes in sea surface temperature and water chemistry predicted by the rise in atmospheric CO_2 projected from the IPCC's fossil-fuel intensive A1FI scenario during this century. Results demonstrated that severe acidification and warming alone can lower reef resilience (via impairment of coral growth and increased coral mortality) even under high grazing intensity and low nutrients. Further, the threshold at which herbivore overfishing (reduced grazing) leads to a coral–algal phase shift was lowered by acidification and warming. These analyses support two important conclusions: Firstly, reefs already subjected to herbivore overfishing and nutrification are likely to be more vulnerable to increasing CO_2. Secondly, under CO_2 regimes above 450–500 ppm, management of local-scale disturbances will become critical to keeping reefs within an *Acropora*-rich domain.

Keywords: climate change, coral reefs, herbivory, ocean acidification, resilience

Received 16 March 2010; revised version received 27 October 2010 and accepted 29 October 2010

Introduction

A fundamental question in ecology is to what extent local vs. global processes drive ecosystem dynamics (Davis *et al.*, 1998; Karlson & Cornell, 1998; Walther *et al.*, 2002). Coral reefs, which are highly diverse and valuable ecosystems, are under increasing threat from both global climate change and local-scale stressors (Wilkinson, 2004; Hoegh-Guldberg *et al.*, 2007). At the global scale, ocean warming is predicted to lead to an increasing frequency and intensity of coral bleaching events (Hoegh-Guldberg, 1999) and associated mortality (Anthony *et al.*, 2007). Also, ocean acidification due to the uptake of CO_2 (Sabine *et al.*, 2004) is predicted to lead to reduced rates of calcification for most marine calcifying organisms including corals (Kleypas & Langdon, 2006). By reducing the growth potential and survivorship of corals, ocean warming and acidification are likely to change the competitive hierarchy of corals and macroalgae – at least indirectly by reducing the ability of corals to maintain or rapidly colonize available space following disturbances (Carilli *et al.*, 2009). Generally, differential changes in the growth rates of species competing for a limited resource, such as space, influence the equilibrium abundances of the competing species (e.g. Jensen, 1987). At the local scale, overfishing

Correspondence: Kenneth R. N. Anthony, tel. + 61 427 177 290, fax + 61 733 654 755, e-mail: k.anthony@uq.edu.au

OPEN ACCESS Freely available online

PLoS one

Marine Reserves Enhance the Recovery of Corals on Caribbean Reefs

Peter J. Mumby*, Alastair R. Harborne

Marine Spatial Ecology Lab, School of BioSciences, Hatherly Laboratory, University of Exeter, Exeter, United Kingdom

Abstract

The fisheries and biodiversity benefits of marine reserves are widely recognised but there is mounting interest in exploiting the importance of herbivorous fishes as a tool to help ecosystems recover from climate change impacts. This approach might be particularly suitable for coral reefs, which are acutely threatened by climate change, yet the trophic cascades generated by reserves are strong enough that they might theoretically enhance the rate of coral recovery after disturbance. However, evidence for reserves facilitating coral recovery has been lacking. Here we investigate whether reductions in macroalgal cover, caused by recovery of herbivorous parrotfishes within a reserve, have resulted in a faster rate of coral recovery than in areas subject to fishing. Surveys of ten sites inside and outside a Bahamian marine reserve over a 2.5-year period demonstrated that increases in coral cover, including adjustments for the initial size-distribution of corals, were significantly higher at reserve sites than those in non-reserve sites. Furthermore, macroalgal cover was significantly negatively correlated with the change in total coral cover over time. Recovery rates of individual species were generally consistent with small-scale manipulations on coral-macroalgal interactions, but also revealed differences that demonstrate the difficulties of translating experiments across spatial scales. Size-frequency data indicated that species which were particularly affected by high abundances of macroalgae outside the reserve had a population bottleneck restricting the supply of smaller corals to larger size classes. Importantly, because coral cover increased from a heavily degraded state, and recovery from such states has not previously been described, similar or better outcomes should be expected for many reefs in the region. Reducing herbivore exploitation as part of an ecosystem-based management strategy for coral reefs appears to be justified.

Citation: Mumby PJ, Harborne AR (2010) Marine Reserves Enhance the Recovery of Corals on Caribbean Reefs. PLoS ONE 5(1): e8657. doi:10.1371/journal.pone.0008657

Editor: Brian Gratwicke, Smithsonian's National Zoological Park, United States of America

Received October 23, 2009; **Accepted** December 15, 2009; **Published** January 11, 2010

Funding: Funding for this study was provided by the Khalid bin Sultan Living Oceans Foundation (http://www.livingoceansfoundation.org/); the National Science Foundation (NSF - http://www.nsf.gov/); the Environmental Protection Agency (EPA - http://www.epa.gov/); the Natural Environment Research Council (NERC - http://www.nerc.ac.uk/); the Undersea Research Program of the National Oceanic and Atmospheric Administration (NURP - http://www.nurp.noaa.gov/). The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing Interests: The authors have declared that no competing interests exist.

* E-mail: P.J.Mumby@ex.ac.uk

These authors contributed equally to this work

Introduction

With increasing rates of global change, the need to conserve key ecosystem services, largely through conservation measures, is greater than ever [1]. In many cases, the implementation of conservation measures for dealing with global change involves a short-term economic cost to local stakeholders and adoption of conservation practices is most likely to be successful when the impacts of the conservation tool are demonstrably beneficial [2]. Frequently, however, the efficacy of conservation tools, such as reserves, is incompletely understood or controversial. This problem is amply demonstrated on coral reefs, where no-take marine reserves are the most widely-used conservation tool [3,4]. While the efficacy of reserves in promoting biodiversity and fish biomass by reducing local-scale stressors has been widely documented [5–7], there is an increasing desire to establish whether reserves can also build coral resilience and offset the effects of global climate change that elevate coral mortality and constrain coral calcification [8,9].

In Caribbean systems, protecting large herbivorous fishes from fishing can generate a trophic cascade that reduces the cover of macroalgae [10], which is a major competitor of corals [11,12]. In principle, such a shift in benthic community structure should facilitate the recovery of coral populations after bleaching events, or indeed other disturbance events such as hurricanes, that cause sudden and extensive coral mortality [13,14]. Thus, reserves in Caribbean systems have the potential to increase the resilience of coral to climate change [15], and thereby enhance the long-term services provided by these systems, such as coastal defence, tourism, and fisheries [16]. However, reserves have not yet been demonstrated to enhance coral recovery [17].

There are several explanations for the lack of data demonstrating the effects of entire reserves on coral recovery. Small-scale experimental manipulations have demonstrated that drastic reductions in fish grazing can cause harmful macroalgal blooms and reduce recovery of corals following bleaching-induced mortality [18]. While these results imply that the conservation of herbivores inside marine reserves should benefit coral recovery, extrapolating small-scale experiments to the spatial scale at which management occurs can be problematic. For example, experimental manipulations that use cages to exclude most fish do not necessarily represent conservation interventions, where relatively

Global Change Biology

Global Change Biology (2010) 16, 1229–1246, doi: 10.1111/j.1365-2486.2009.02062.x

Conservation management approaches to protecting the capacity for corals to respond to climate change: a theoretical comparison

MARISSA L. BASKETT*[1], ROGER M. NISBET†, CARRIE V. KAPPEL*, PETER J. MUMBY‡ and STEVEN D. GAINES†

*National Center for Ecological Analysis and Synthesis, 735 State St., Ste. 300, Santa Barbara, CA 93101, USA, †Ecology, Evolution and Marine Biology, University of California, Santa Barbara, CA 93106-9610, USA, ‡Marine Spatial Ecology Lab, School of BioSciences, University of Exeter, Prince of Wales Rd, Exeter EX4 4PS, UK

Abstract

Multiple anthropogenic impacts, including bleaching from climate change-related thermal stress, threaten coral reefs. Protecting coral capacity to respond to the increase in future thermal stress expected with climate change can involve (1) protecting coral reefs with characteristics indicative of greater resistance and resilience to climate change, and (2) reducing other anthropogenic impacts that are more likely to reduce coral resistance and resilience to climate change. Here, we quantitatively compare possible priorities and existing recommendations for protecting coral response capacity to climate change. Specifically, we explore the relative importance of the relevant dynamics, processes, and parameters in a size-structured model of coral and zooxanthellae ecological and evolutionary dynamics given projected future thermal stress. Model results with varying initial conditions indicate that protecting diverse coral communities is critical, and protecting communities with higher abundances of more thermally tolerant coral species and symbiont types secondary, to the long-term maintenance of coral cover. A sensitivity analysis of the coral population size in each size class and the total coral cover with respect to all parameter values suggests greater relative importance of reducing additional anthropogenic impacts that affect coral–macroalgal competition, early coral life history stages, and coral survivorship (compared with reproduction, growth, and shrinkage). Finally, model results with temperature trajectories from different locations, with and without connectivity, indicate that protection of, and connectivity to, low-thermal-stress locations may enhance the capacity for corals to respond to climate change.

Keywords: coral bleaching, coral reefs, global climate change, quantitative genetic model, size-structured matrix model

Received 25 March 2009; revised version received 30 July 2009 and accepted 5 August 2009

Introduction

Given the substantial impact of climate change on ecological communities (Walther *et al.*, 2002), accounting for how climate change affects population persistence, community structure, and the sustainable delivery of ecosystem services presents a major challenge for conservation biology and ecosystem management (McCarty, 2001). Accounting for the ecological impacts of climate change in management decisions requires an understanding of potential ecological and evolutionary dynamical responses to climate change (e.g., movement, acclimatization, and genetic adaptation) and how they depend on interactions between climate change and additional anthropogenic impacts (McCarty, 2001; Parmesan, 2006). Through this understanding, local management may alleviate the impact of global climate change (Heller & Zavaleta, 2009). Specifically, management may focus protection on populations and communities with a greater capacity to respond to climate change, i.e., those with biological and environmental characteristics that may lead to

Correspondence: Marissa L. Baskett, tel. + 1 530 752-1579, fax + 1 530 752 3350, e-mail: mlbaskett@ucdavis.edu

[1]Present address: Department of Environmental Science and Policy, University of California, Davis, One Shields Ave, Davis, CA 95616, USA.

CTI-CFF: a leading regional initiative

Coral Triangle Initiative on Coral Reefs, Fisheries, and Food Security

(a multilateral partnership): 2009 - 2020

Coral Reef Conservation
Sustainable Fisheries
Food Security

CTI-CFF Member States, Partners and Cooperation Arrangement

	INDONESIA	MALAYSIA	PAPUA NEW GUINEA	PHILIPPINES	SOLOMON ISLANDS	TIMOR-LESTE
Member States						
National Coordinating Committee (NCC)	KEMENTERIAN KOORDINATOR BIDANG KEMARITIMAN Ministry of Marine Affairs and Fisheries	MOSTI KEMENTERIAN SAINS, TEKNOLOGI DAN INOVASI MINISTRY OF SCIENCE, TECHNOLOGY AND INNOVATION Ministry of Science Technology and Innovation	CEPA Conservation and Environment Protection Authority	Department of Environment and Natural Resources	Ministry of Environment, Climate, Disaster Management and Meteorology	MINISTÉRIO DA AGRICULTURA E PESCAS Minister of Agriculture and Fisheries

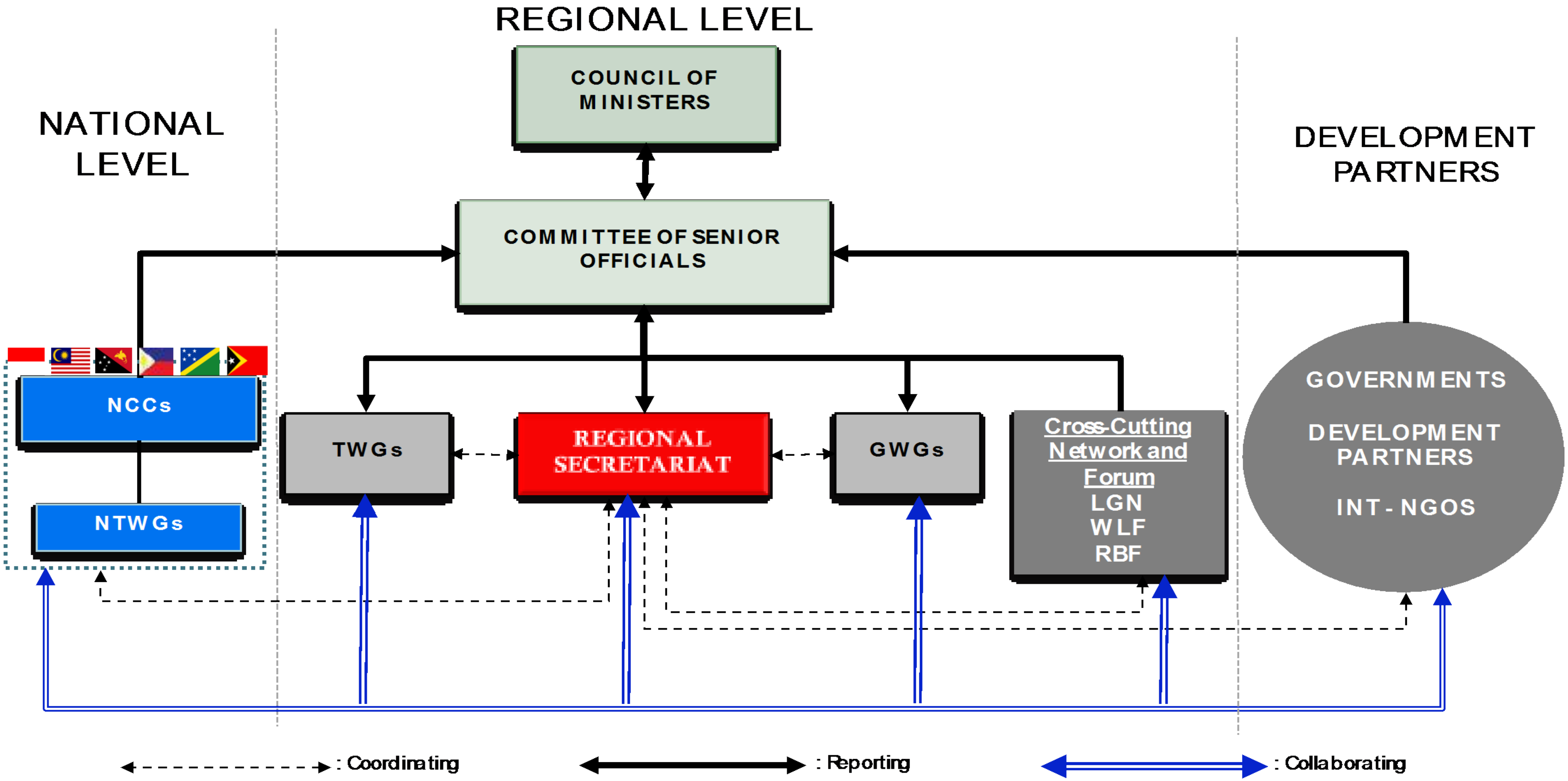
Development Partners

USAID FROM THE AMERICAN PEOPLE · Australian Government · ADB · gef · WWF · The Nature Conservancy – Protecting nature. Preserving life. · CONSERVATION INTERNATIONAL · CORAL TRIANGLE CENTER – Ensuring Coral Reefs for Life

Cooperation Arrangement with Regional Secretariat (i.e. MoU)

SEAFDEC · SPREP – Secretariat of the Pacific Regional Environment Programme · giz – Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH · The University of Queensland Australia · Institut Pertanian Bogor · Universitas Sam Ratulangi Manado · Universiti Malaysia Terengganu UMT · James Cook University Australia

CTI-CFF: Institutional Arrangement and Decision Making Process



Guiding Principles for Cooperation

9 Principles

1. people-centered biodiversity conservation, sustainable development, poverty reduction and equitable benefit sharing.

2. based on solid science

3. centered on quantitative goals and timetables adopted by governments at the highest political levels

4. use existing and future forums to promote implementation

5. aligned with international and regional commitments

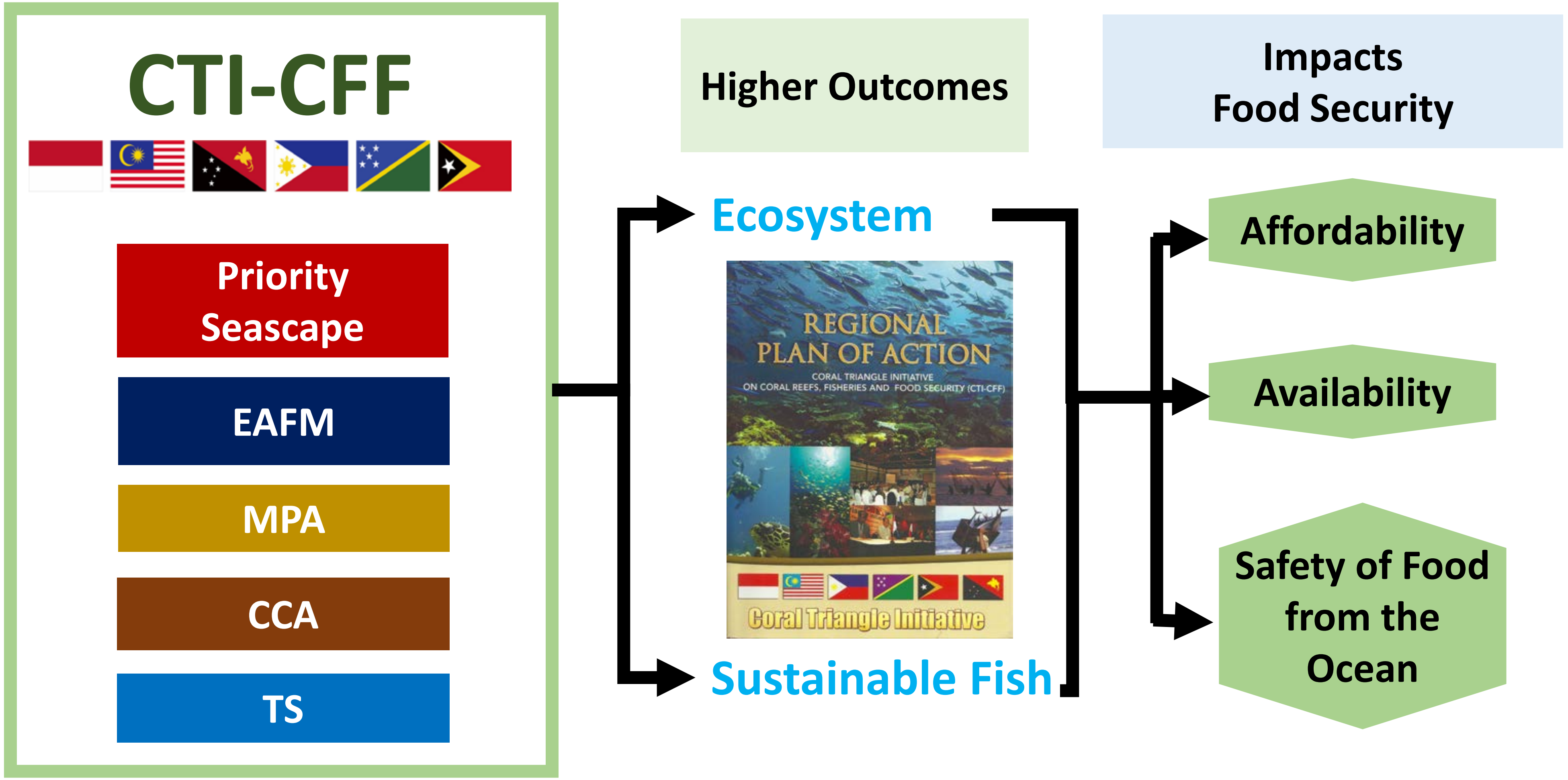
6. recognize the transboundary nature of some important marine natural resources

7. emphasize priority geographies

8. be inclusive and engage multiple stakeholders

9. recognize the uniqueness, fragility and vulnerability of island ecosystems

CTI-CFF: Goals, Outcomes and Long-term Impacts



RPOA → National Plan of Action

Annual Senior Official’s Meeting (SOM)

SOM-11 (Manado, Nov 2015)	SOM-12 (Port Moresby, Nov 2016)	SOM-13 (Manila, Nov 2017)
• Report of progress • Recommendation • Next Agenda of activities	• Report of progress • Recommendation • Next Agenda of Activities	• Report of progress • Recommendation • Next Agenda of Activities

CTI Annual Thematic Regional Exchange - Knowledge Management – Best Practices

MPA Regional Exchange (REX): 12-16 September 2016,Dumagute, Philippines

CCA REX: 26-27 September 2016, Kota Kinabalu, Sabah, Malaysia

TS REX: Putrajaya, Malaysia – March/April 2017

Seascape REX: Honiara, Solomon Island, 15 – 19 May 2017

CTI-CFF Regional Secretariat

The Pivotal Roles of CTI-CFF Regional Secretariat:

1. Coordinating activities in Coral Triangle areas with Member States, partners, and collaborators
2. Aligning National Plan of Action and as well as strengthening National Coordinating Committee (NCC) to ensure the delivery of the 5 Goals of CTI-TFF
3. Main liaison for CTI-CFF official functions (i.e. Ministerial Meeting and Senior Official Meetings)
4. Organization development, outreach and communication, regional coordination and mechanisms, technical and thematic working groups, the development of key regional reports and capacity development
5. Making potential partners and donors, aware of how the Regional Secretariat works, as it is not an NGO but an intergovernmental organization

Headquarters of CTI-CFF Regional Secretariat
Manado, Indonesia

C

CTI measures and steps towards the impact

Measures

CTI-CFF

- Priority Seascape
- EAFM
- MPA
- CCA
- TS

Higher Level outcome 1: Coral reef ecosystem integrity and services stabilized / maintained

Indicators	Measures
Condition of coral reef	• Change in percent live coral cover compared to baseline in CTMPAS sites • Threat reduction based on Reefs at Risk
Area of mangroves and seagrass	• Area of mangroves (hectares) based on satellite • Area of seagrass (hectares)
Fish biomass	• Change in reef fish biomass per 500 sq. meters compared to baseline in CTMPAS sites (inside and outside no take zones)
Extent of coral reef and associated habitats in full protected area	• Already covered in MPA indicator 3.1.3

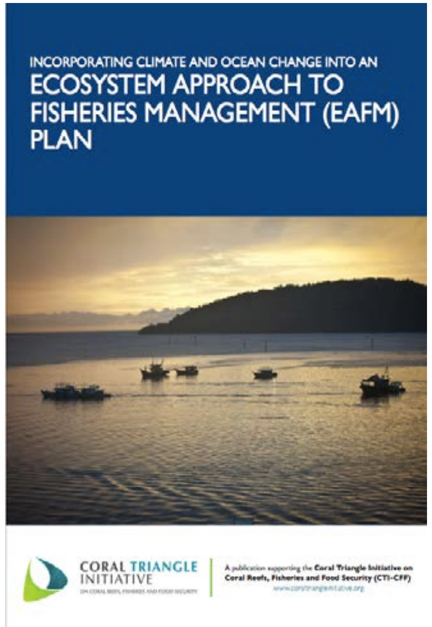
IMPACT

Indicators	Measures
Availability: food sufficiency of fishing household; food consumption of coastal communities	• Availability: Fish consumption per capita • Availability: Fish production –capture fisheries only
Quality and safety: contribution of fish to protein requirement, health of fishing communities	• Protein intake (g) from fish per capita per year
Affordability: income of fishers, price of fish	• Income of fishers • Price Index of Fish

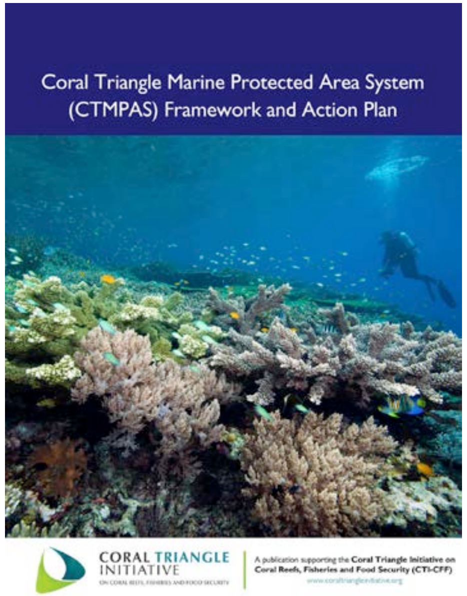
Improve resilience of the ecosystem: approaches to address the challenges in resource management

Seascape Model

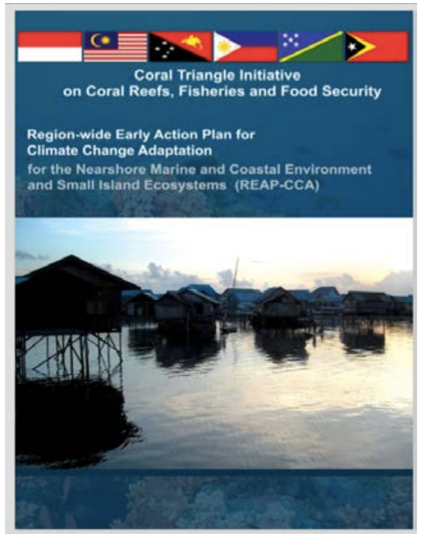
EAFM PLAN

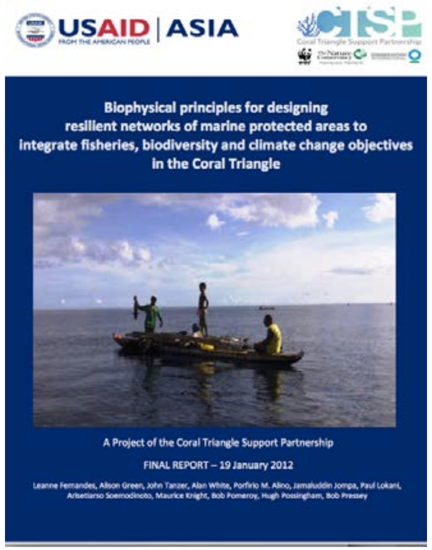


MPA Framework and Action Plan



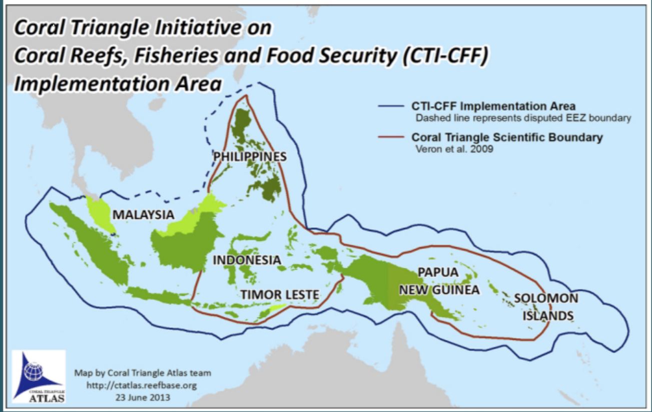
Region-wide Early Action Plan for Climate Change Adaptation





Threatened Species Management

CTI MPA 208,152 Km² [a]



Km²

1. Indonesia

82%
170,841

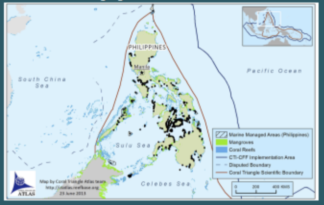
2. Malaysia

7%
13,653

3. Papua New Guinea

2%
4,558

4. Philippines

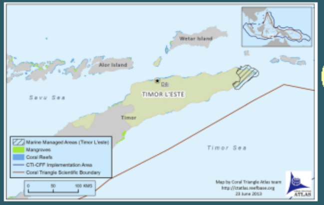


8%
17,164

5. Solomon Islands

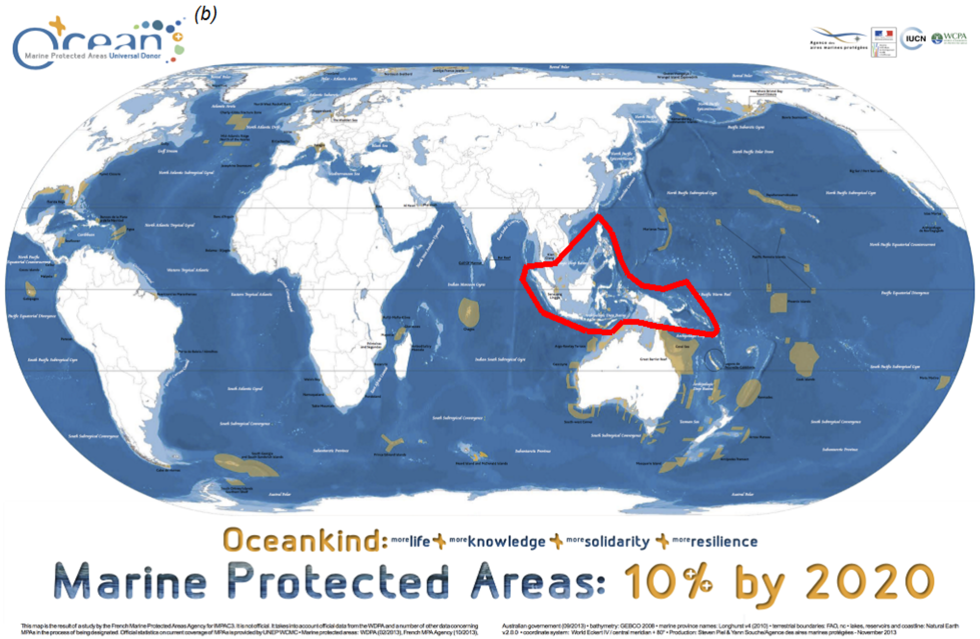
1%
1,325

6. Timor-Leste



0.3%
557

SDG Goal 14
Conserve and Sustainably Use The Oceans, Seas and Marine Resources for Sustainable Development



World Ocean Area = 1,471.5 million Km²
SDG MPA Targets 10 % 2020 = 147.1 million Km² of Total World's Ocean Area [c]

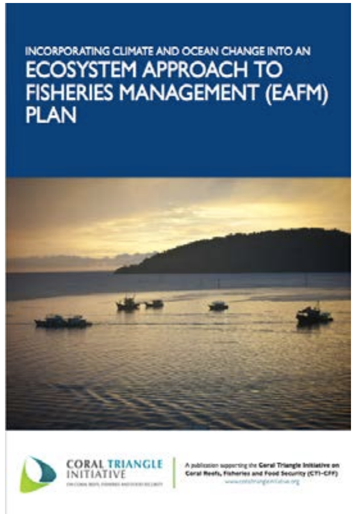
0.14%

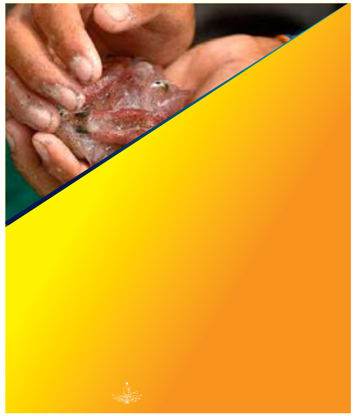
Coral Triangle Region is small, but it is "the global centre of marine diversity" (Veron et al., 2009)[d]

CORAL TRIANGLE INITIATIVE ON CORAL REEFS, FISHERIES AND FOOD SECURITY

Source:
[a] Coral Triangle Support Partnership, 2013, Coral Triangle Marine Protected Area System (CTMPAS) Framework and Action Plan
[b] Modified from 3rd International Marine Protected Areas Congress, 2013, Executive Summary Focusing Action, Picking Up The Pace for Ocean Conservation
[c] www.sustainabledevelopment.un.org, 2017
[d] Veron, 2009, Delineating the Coral Triangle, Journal of Coral Reef Studies 11: 91-100

Ecosystem Approach to Fisheries Management EAFM





ADB, 2014

https://www.adb.org/sites/default/files/publication/42411/economics-fisheries-aquaculture-coral-triangle.pdf

Table 49 Fisheries Management Tools and Strategies Implemented by CT6 Countries

Management Tool	Indonesia	Malaysia	Papua New Guinea	Philippines	Solomon Islands	Timor-Leste
Input Controls (Effort)						
Ban on some gears	✓	✓	✓	✓	✓	
Compressor ban			✓	Local	✓	
Cyanide use ban	✓	✓	✓	✓	✓	✓
Dynamite use ban	✓	✓	✓	✓	✓	✓
Limits on number of fishing vessels or boats		✓	✓		✓	
Limit on hours or days for fishing			✓		✓	
Technology limits (e.g., prohibition on use of fish finder, high-powered lights, etc.)			✓	✓	✓	
Boat size limits	✓	✓	✓	✓		
Engine horsepower limits		✓				
Limit on the number of fishers		✓		Some areas		
Licenses or permits	✓	✓	✓	✓	✓	
Surveillance efforts on fishing activities	✓	✓	✓	✓	✓	
Ban on use of multiple gears per boat	✓					
Protection of critical fish habitats	✓	✓	✓	✓	✓	✓
No fishing in spawning aggregation areas	✓	✓	✓	✓	✓	
Zoning or allocation of fishing areas	✓	✓	✓	✓	✓	
Output Controls (Catch)						
Catch quotas or total allowable catch			✓		✓	
Fish size limits			✓	Local/species	✓	
Limiting bycatch and discards	Turtle		Tuna, turtle	Tuna, turtle, dolphins	Tuna, turtle	
Conservation Measures						
Seasonal closures and/ or fishing bans related to reproduction of fishes or migration runs	✓	✓	✓	✓	✓	

continued on next page

Input controls (**EFFORT**) > output ones (**CATCH**: quota and size control)

Conservation Measures (dynamic MPA)

- Seasonal closure
- Fish habitat restoration
- Stock enhancement and restocking
- Ban on species (e.g. Wrasse)

Table 49 *continued*

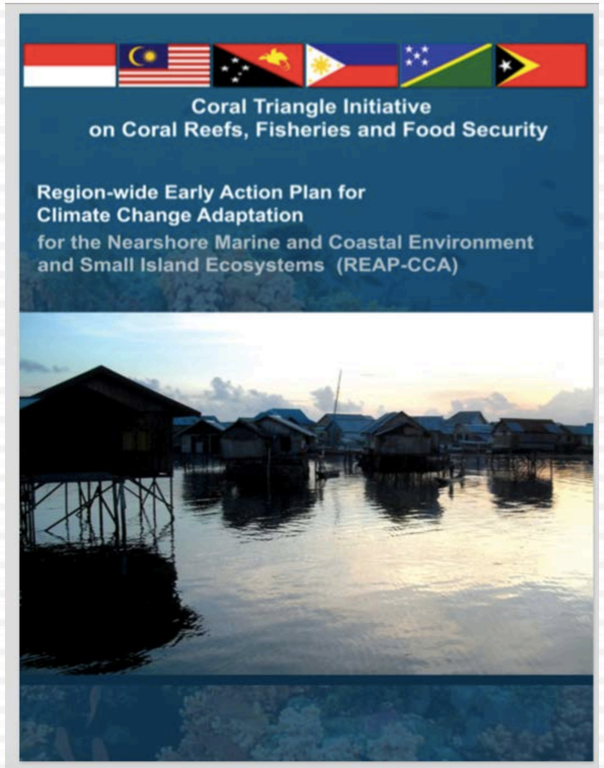
Management Tool	Indonesia	Malaysia	Papua New Guinea	Philippines	Solomon Islands	Timor-Leste
Fish habitat restoration	✓	✓	✓	✓	✓	
Stock enhancement and restocking	✓	✓	✓	✓	✓	
Ban on species (e.g., napoleon wrasses, turtles)	✓	✓	✓	✓	✓	
Subsidies	✓	✓				
Financial subsidies provided by governments (e.g., free gears or boats, discounted gas prices, tax cuts, etc.)						
Gear buy-back		✓				
Traditional fisheries management (e.g., sacred areas)	✓	✓	✓	✓	✓	

Source: Based on a survey conducted under the ADB technical assistance, Regional Cooperation on Knowledge Management, Policy, and Institutional Support to the Coral Triangle Initiative Project.

Other approaches:

- Livelihood approach to fisheries management
- Social marketing for conservation and sustainable use of the resources
- Conservation and Rehabilitation
- Ocean Governance

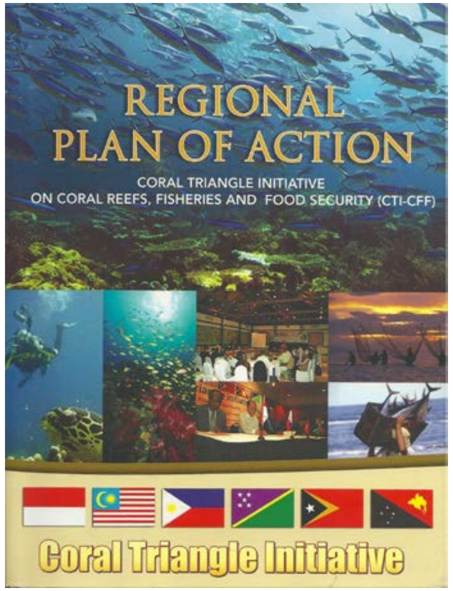
Steps towards the Impact



Region-wide Early Action Plan (REAP) for Climate Change Adaptation

CORAL TRIANGLE INITIATIVE ON CORAL REEFS, FISHERIES AND FOOD SECURITY

CCA Based on RPOA



Goal 4. CCA

Target 4.1 Region-wide Early Action Plan for Climate Change Adaption for the near-shore marine and coastal environment and small islands ecosystems developed and implemented

Regional Action

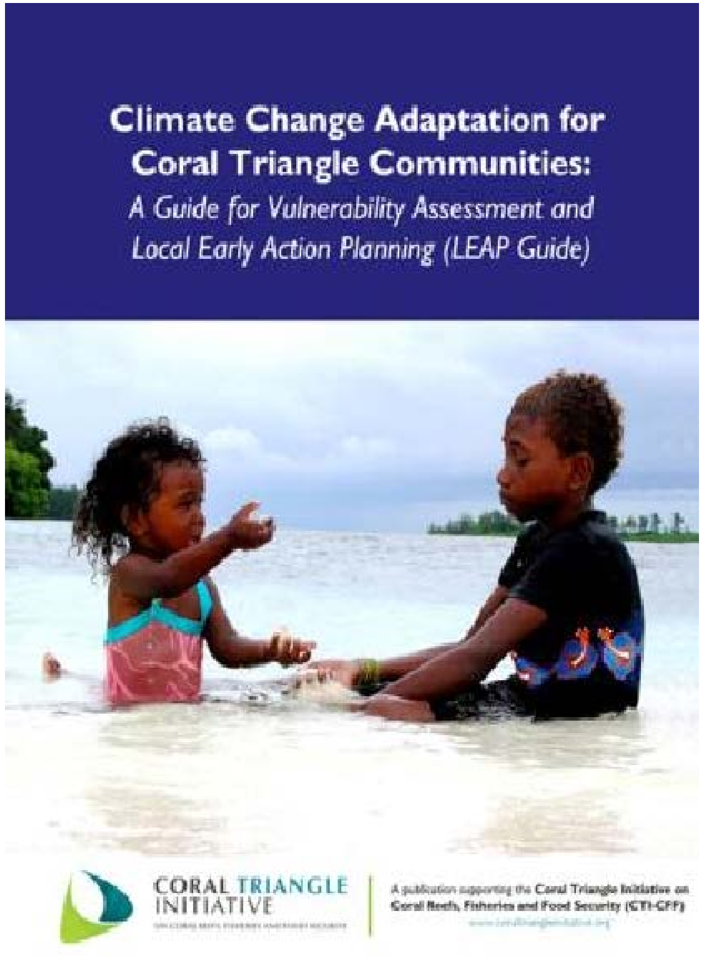
- **4.1.1 Identify the most important and immediate adaptation measures that should be taken across all Coral Triangle countries, based primarily on analyses using existing models**
- **4.1.2 Identify the most important and immediate adaptation measures that could be taken in each CT country**
- **4.1.3 Complete and implement a Region-wide Early Action Plan for Climate Change Adaptation**
- **4.1.4 Conduct capacity needs assessments and develop capacity building programs on climate change adaptation measures**
- **4.1.5 Mobilize financial resources to implement Region-wide Early Action Plan for Climate Change Adaptation**

Target 4.2 Networked National Centers of Excellence on Climate Change Adaptation for marine and coastal environments are established and in full operation

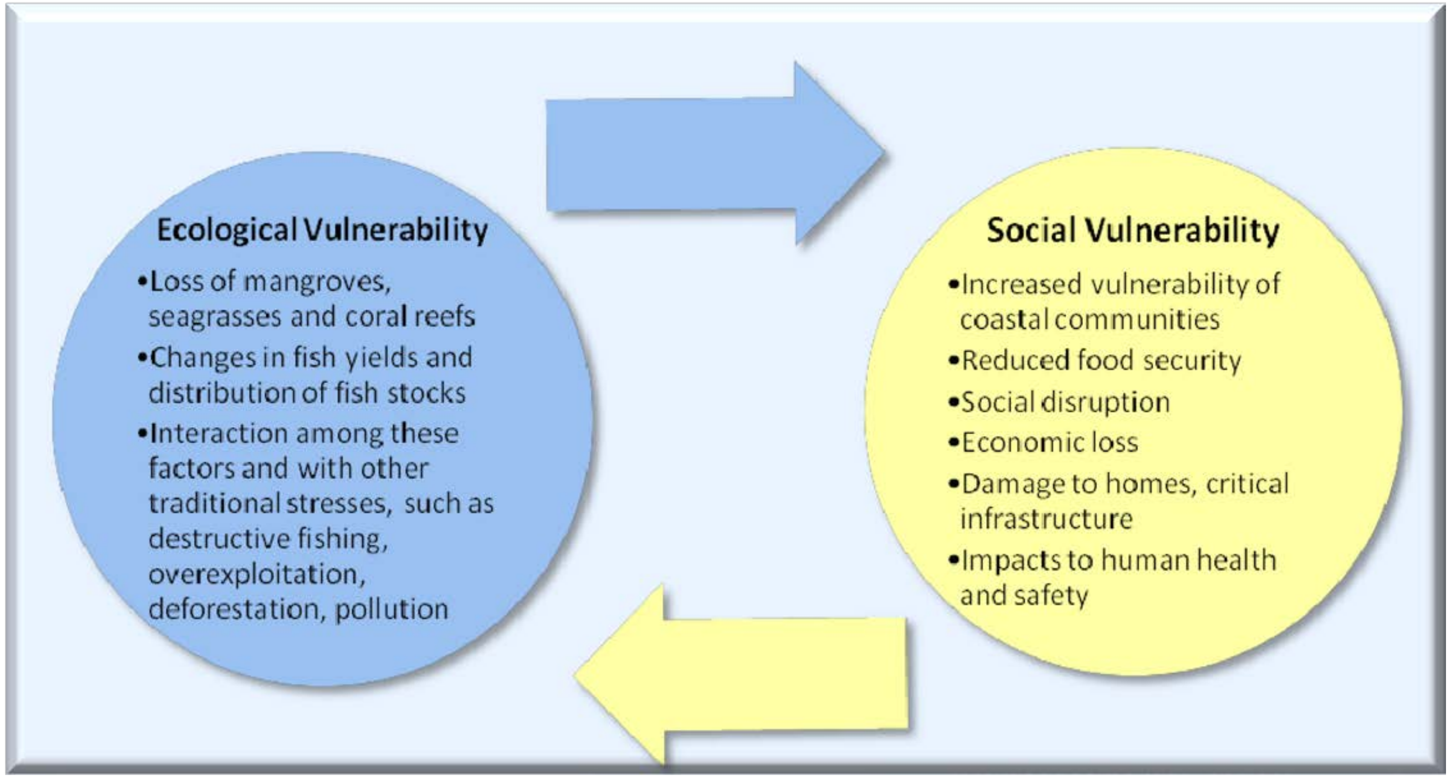
Regional Action

- **4.2.1 Collaborate around the design and implementation of a Pilot Phase for *National Centers of Excellence***

KEY CLIMATE CHANGE VULNERABILITIES IN THE CORAL TRIANGLE
Local Early Action Planning (LEAP)



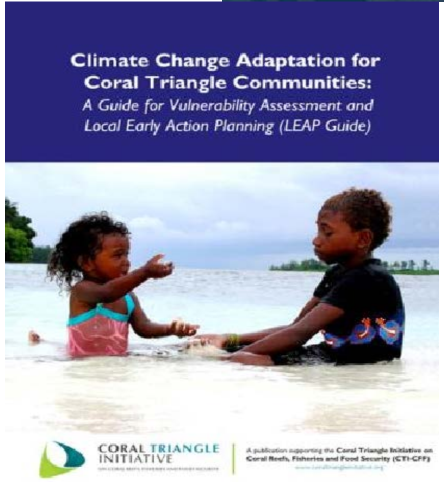
Member countries undertook Vulnerability Assessment



CCA INDICATORS

As per report on SOM-11 & SOM-12

Indicator 4.1.1: Number of regional agreements/frameworks/strategies/plans (e.g. REAP) developed	
2011: Joint Communiqué on Climate Change *(Submitted during UNFCCC COP19, Copenhagen. Denmark)* **2012:** Region-wide Early Action Plan on Climate Change Adaptation (REAP) **2013:** Local Early Action Planning (LEAP) Guide CCA Regional Priorities Development of Adaptation Marketplace	
2014	Statements on Climate Change in World Parks Congress 2014
2015	Side event during UNFCCC "Pathways to Climate Change: Financing for Small Islands Developing States" 3 Dec 2015

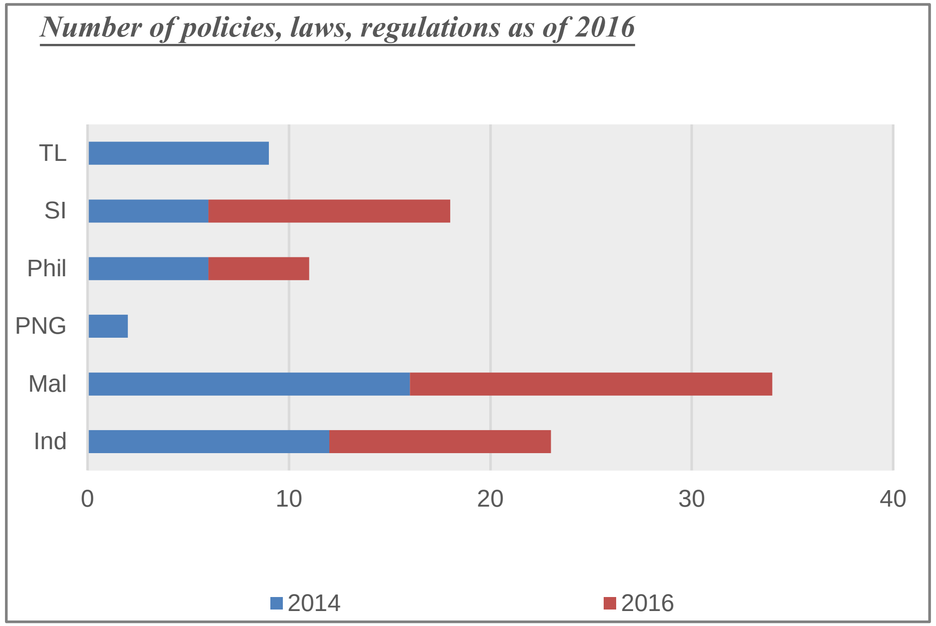


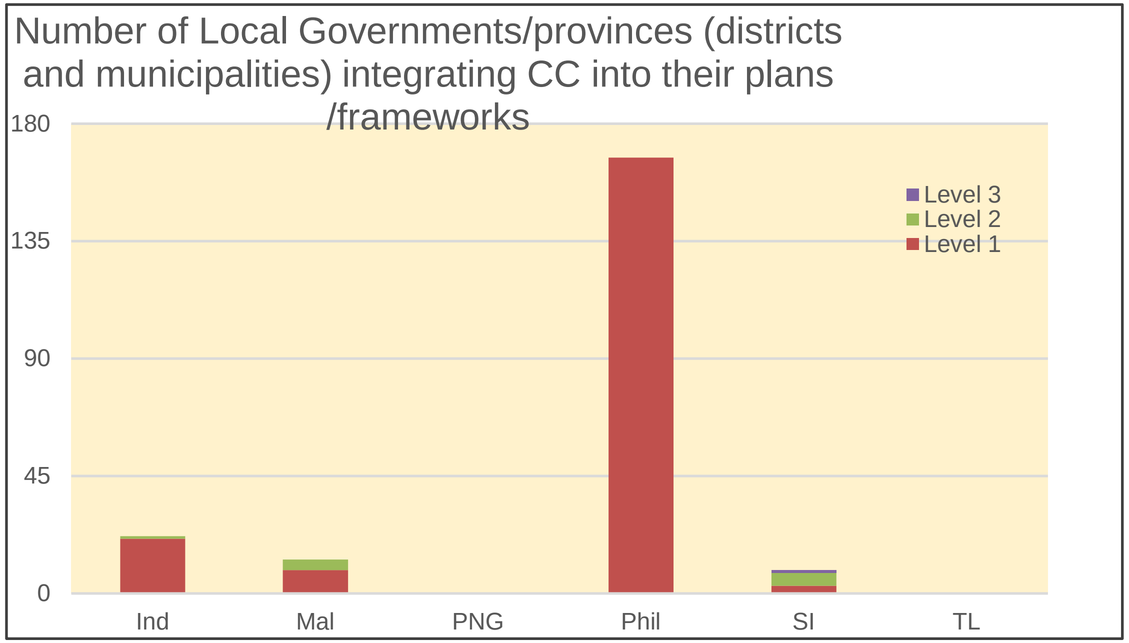
CORAL TRIANGLE INITIATIVE ON CORAL REEFS, FISHERIES AND FOOD SECURITY

CORAL TRIANGLE INITIATIVE ON CORAL REEFS, FISHERIES AND FOOD SECURITY

CCA INDICATORS (Cont')
As per report on SOM-11 & SOM-12

- **Indicator 4.1.2: Number of national policies (including national CCA plans and frameworks), laws and regulations on climate change adaptation proposed and adopted**
  - 2010- 2014 = 57
  - 2014 – 2015 = 15
  - 2015 - 2016 = >40 related plans, frameworks
- **Indicator 4.1.3: Percentage of local governments that have integrated climate adaptation into local governance (plans and actions)**
  - Up tp 2014 = 6%
  - 2014 - 2015 = 39 % (acceleration in countries) > Most have reached targets set, data to be further analysed.
- **Indicator 4.1.4: Area of Mangroves (hectares)**
- **Indicator 4.2.1: A national institution within CT6 designated and networked to address climate change adaptation coordinated with national government support**
  - (Target – to be determined after Center of Excellence framework defined)





CORAL TRIANGLE INITIATIVE ON CORAL REEFS, FISHERIES AND FOOD SECURITY

Activities/Initiatives on CCA in by Country: INDONESIA

- Act No. 32/2009: Obligations related to climate change adaptation
- National Action Plan of Climate Change Adaptation (RAN API)
- Early Warning System: Established in Malang, Morotai and Mentawai
- Indonesia Coastal Education (Sekolah Pantai Indonesia): Curiculum material on CCA
- Coastal Resilient Village (PDPT): 66 villages in 22 regencies/municipalities
- Blue carbon initiative

Activities/Initiatives on CCA in by Country: MALAYSIA

- National Scientific Research Expedition 2016
- National Coastal Erosion Study 2016
- Coastal Vulnerability Index / Coastal Vulnerability Assessment Toolkit
- Preliminary stage in establishing CCA Centre of Excellence
- To review and revise Integrated Coastal Management Plan (ICZM)
- Develop permanent monitoring stations for physical water quality

Activities/Initiatives on CCA in by Country: PAPUA NEW GUINEA

- Ridge to Reef Planning completed planning in West New Britain (UNDP) and East New Britain
- Building community resilience across 30% of Manus
- Mangrove rehabilitation program in country
- Identifying and working with different socio-economic groups

Activities/Initiatives on CCA in by Country: PHILIPPINES

- Establishment of Climate Change Academy
- Establishment of National Panel of Technical Experts (NPTE)
- "National Disaster Risk Reduction and Management Plan"
- Expansion and climate-smarting of the MPA network
- Community-based adaptation measures in terrestrial, coastal and marine regions
- Biophysical and Socio-Economic Vulnerability Assessments in selected coastal communities and national marine protected areas
- Climate-smart rice varieties
- Capacity Building for various sectors on CCA and disaster preparedness
- Grey-Green Infrastructure
- Income diversification of vulnerable coastal communities
- Build capacities on disaster risk reduction and climate change adaptation in small island communities
- Conduct Participatory Capacities and Vulnerabilities Assessments
- Availability of 1 billion pesos People's Survival Fund (PSF) from National Government to finance adaptation measures at the local community level
- Mobilization of financial and technical resources to support the national center of excellence

Activities/Initiatives on CCA in by Country: SOLOMON ISLANDS

- Chair – CCA TWG (Conference calls, COE Regional Exchange)
- CCA trainings/workshops and awareness raising
- Development of National V& A database
- Use of LEAP and REAP for CCA implementation at community/provincial level projects e.g. Temotu (OceanWatch), Western Province (SICCP)
- Progress for establishment of CCA Coordination mechanisms at Provincial Government levels

Activities/Initiatives on CCA in by Country: TIMOR LESTE

- **Adopt coral reef resilient to climate change principles in the MPA zoning/network design**
- **Develop and implement early warning and response plan to climate adaptation**
- **Coastal rehabilitation program to anticipate climate change impacts**
- **Start to strictly implementing commitment to UNFCCC**
- **Establish a Research Center on Climate Change**
- **Develop and operate national information network on climate change early warning and response**
- **Finalize studies on social resilient / vulnerability to Climate Change impacts**
- **Development and implementation of community awareness on early warning system**

Another Challenges

UNFCCC COP21 Side Event Overview

Regional Ocean Challenges:
Pathways to Climate Finance for Small Island Developing States

On 3rd December 2015, The Nature Conservancy and GLISPA (the Global Island Partnership) co-hosted a high-level side event at the UNFCCC COP 21, "Regional Ocean Challenges: Pathways to Climate Finance for Small Island Developing States". The event was held in the Climate Generations Area at the formal Paris COP Venue at Le Bourget, and was attended by around 100 participants representing a range of government, private sector and civil society groups.

Charlotte Vick of the Sylvia Earle Alliance/Mission Blue moderated the event, which focused on profiling pathways though which Small Island Developing States (SIDS) can secure climate finance. The event showcased the Micronesia Challenge, the Coral Triangle Initiative, the Caribbean Challenge Initiative and the Western Indian Ocean Coastal Challenge as effective frameworks for oceans governance; a high level speaker representing each region outlined the progress and successes achieved to date under each of the Challenges. In addition, the event highlighted the role that regional sustainable finance mechanisms (that either have been or are currently being established to support these frameworks) may play in disbursing climate finance flows. Given that the Paris Agreement endorsed by nearly 200 countries on 12th December includes a requirement for developed countries to provide at least $100 billion USD in climate finance per year by 2020, discussions on how to ensure this funding is able to be responsibly and swiftly channeled are timely.

Representing Solomon Islands, Dr. Melchior Mataki, Permanent Secretary of the Ministry of Environment, Climate Change, Disaster Management and Meteorology (MECDM), spoke on behalf of the CTI. Dr. Mataki strongly emphasized the role that Regional Challenges like the CTI are already playing in supporting effective climate change adaptation and resilience building, by supporting the sustainable management of natural systems - "Natural Resource Management is essentially adaptation to climate change and mitigation of climate change. This is an important point which I would like to drive home". Like Minister Hunt, Dr. Mataki underlined the value of the CTI and outlined a range of programs and projects made possible through the framework, including the Women Leaders' Forum. He also highlighted the strong alignment between the goals of the CTI and Solomon Islands own national climate change policies, as well as role that it has played in incentivizing the allocation of domestic resources to natural resource management, suggesting that "without the CTI, the Ministry would have great trouble making a case for the mobilisation of domestic resources". Dr. Mataki underscored the importance of identifying and where necessary building finance mechanisms that can support the disbursement of large-scale climate finance, noting that historically there has been a gap between donor requirements and absorptive capacity in SIDS, meaning that funding has not always been straightforward to access, "much to the detriment of Solomon Islands". He also noted that there are already working examples within the Solomon Islands, such as the Arnavons Community Marine Conservation Trust Fund, upon which to build. Dr. Mataki welcomed an increased focus on transparency within climate finance instruments such as the GCF, as well as the intention by the GEF to further explore blue bonds.

UNFCCC COP21 Side Event: Regional Ocean Challenges, 3rd December 2015

- The dynamics of CC/anthropogenic challenges in conserving the biodiversity is far beyond cumulative countries capacity (human resources and financial)
- Climate-related financial instruments and mechanisms are also another challenge for CTI member countries to get access due to a gap to fulfill the high requirements

Conclusion

- CT region is one of world reserves of biodiversity that will support the sustainability of world marine resources from pressures of increasing extraction efforts for food and economic development.
- However, it undoubtedly experiences the effects of climate change (ocean warming and acidification), and even couple-effects from various anthropogenic pressures,
- The CTI-CFF is one of environmental, regional investments, which tries to harmonize and coordinate countries-conservation efforts in order to address the aforementioned challenges for the future of marine biodiversity,
- Targets are regionally developed, and countries puts effort to provide measures and steps,
- This investment needs international support and commitment to optimize its existing collective efforts to address the challenges and pressures.

TERIMA KASIH – MARAMING SALAMAT – TERIMA KASIH
TAGIO TUMAS – OBRIGADO – TANK IU

CORAL TRIANGLE INITIATIVE ON CORAL REEFS, FISHERIES AND FOOD SECURITY

Headquarter:
CTI-CFF Secretariat Building
Jl. A.A. Maramis Kayuwatu, Kairagi II
Manado, North Sulawesi
95254, Indonesia

Website: www.coraltriangleinitiative.org
: cticff
: cticff
Email: regional.secretariat@cticff.org