Proceedings of the 11th International Coral Reef Symposium, Ft. Lauderdale, Florida, 7–11 July 2008
Session number 7

CORAL HEALTH AND DISEASE ASSESSMENT IN THE U.S. PACIFIC TERRITORIES AND AFFILIATED STATES

Bernardo Vargas-Ángel[1], Benjamin Wheeler [2]

[1] Joint Institute for Marine and Atmospheric Research, University of Hawaii, NOAA-PIFSC, Honolulu, HI
[2] Department of Oceanography, University of Hawaii, Honolulu, HI

Abstract. Quantitative coral disease assessments were conducted at 40 different U.S. Pacific coral islands, banks, and atolls, spanning more than 5000 km apart and over a 40° latitudinal gradient Distribution and abundance of disease were determined based on 2, 25-m belt transects (2–6 wide) at 326 sites, and ten broad diseases were identified, affecting 25 scleractinian genera. Pacific-wide, the most geographically and taxonomically widespread diseases were bleaching and skeletal growth anomalies, detected at >65% islands/atolls and on 19 and 11 genera, respectively. Band diseases (black band and banded fungal disease) were rare (<0.1% prevalence), with only two cases enumerated on *Porites* and *Coscinaraea*. Although Pacific-wide mean prevalence was low, site-specific hotspots occurred at Johnston, Kure, and Rose Atolls, French Frigate Shoals, and Guam. Prevalence patterns also varied among coral taxa, with only a few families being disproportionately affected by disease: Poritidae, Acroporidae, and Faviidae. Of potential concern is the presence of white syndrome at Johnston Atoll and French Frigate Shoals which can result in severe and rapid tissue loss, particularly on the tabular *Acropora cytherea*.

Key words: Coral disease, prevalence, U.S.-affiliated Pacific Territories

Introduction

Disease is defined as any impairment that interferes with or modifies the performance of normal physiological functions, including responses to environmental factors, toxicants, and climate; infectious agents; inherent or congenital defects; or a combination of these factors (Wobeser 2006). Pacific-wide, there is growing concern pertaining to the threat of increased prevalence, geographic distribution, and host range of coral diseases, particularly in the Great Barrier Reef (GBR), the Marshall Islands, the Red Sea, the Philippines, East Africa, and the Hawaiian Archipelago (Willis et al. 2004; Aeby 2006; Harvell et al. 2007). NOAA's Coral Reef Ecosystem Division (CRED) has embarked on a long-term, broad-scale coral disease assessment and monitoring program aimed at documenting the distribution and prevalence of coral diseases on U.S. Pacific reefs and investigating the factors that may be contributing to the occurrence of disease. Within this framework, between 2006 and 2007, a total of 326 coral disease surveys were conducted at 5 major regions, including: main Hawaiian Islands, Northwestern Hawaiian Islands, American Samoa, the Pacific Remote Island Areas (PRIA), Guam, and the Commonwealth of the Northern Mariana Islands (CNMI). These surveys are a coordinated effort within NOAA's interdisciplinary, Pacific Reef Assessment and Monitoring Program (RAMP).

Materials and Methods

Disease assessments were conducted along two, haphazardly placed 25-m belt (2–6 m width) transects laid end to end, separated by approximately 5 m. The smaller survey area was implemented at disease-rich sites or where surge, currents, or sea conditions precluded expanded surveys. Within belt transects, all diseased coral colonies were enumerated, identified to genus level, measured in two planar dimensions, and assigned to 1 of 10 lesion categories including: skeletal growth anomalies (SGA), acute tissue loss (hereafter white syndrome; WSY), subacute tissue loss (hereafter tissue loss; TLS), pigmentation response (PRS), trematodiasis (TRE), endolithic fungal infection (EFI), banded fungal infection (BFI), black band disease (BBD), and 'other' (OTH), including algal and cyanophyte infections, and syndromes of unknown etiology (see NOAA 2009 for lesion characterization and description). Colonies exhibiting full, partial or spotty bleaching (BLE) were also tallied and thus, hereafter, bleaching is treated as a disease state. Case counts were complemented with digital photography, as well as tissue collections for future histological examination and verification. A second diver performed community structure surveys by counting and identifying, to the genus level, all colonies within 50–100 cm on both sides of each transect line. Alternatively, at 37 sites in the CNMI, colony counts were conducted using 15–16,

haphazardly placed 0.25 m^2 quadrats. All the above data allowed for the computation of prevalence per genus/disease state, as follows: P = [(total no. cases of a specific disease for the genus × 100) ÷ (colony density of that specific genus per site × total area surveyed for presence of disease)].

Results

A total of 1744 cases of disease were recorded at 67% (220) of the sites surveyed. Farallon de Pajaros in the northern CNMI was the only island where no disease was recorded. A summary of prevalence of disease for each island group and genera are presented in Table 1.

The assessments conducted in American Samoa revealed the highest archipelago-wide mean prevalence (4.3% SE 1.3). Island-specific mean prevalence was the greatest at Rose Atoll (11.7% SE 5.7) and the lowest at Swains Island (1.3% SE 0.8). Of the 62 sites visited, 38 (61%) contained disease, and 7 disease states were enumerated: BLE, SGA, WSY, BBD, PRS, EFI, and OTH. Archipelago-wide, diseases were observed on corals belonging to 14 genera, with *Montastrea*, *Favia*, and *Montipora* exhibiting the greatest percent of cases (30.7%, 34.4%, and 14.8%, respectively), and *Favia*, *Porites*, and *Coscinaraea* showing the greatest mean prevalence values (1.5%, 0.5%, and 0.5%, respectively). Other lesions (OTH), particularly algal/cyanophyte infections were the most numerous disease state, representing 75.3% of cases and notably abundant on 2 west-northwestern forereef sites at Rose Atoll, in the vicinity of a major shipwreck impact site (Schroeder et al. 2008). Island-wide mean prevalence of OTH at Rose amounted to 9.5 (SE 0.5) and affected corals in the genera *Favia*, *Montastrea*, *Porites*, and *Montipora*. In addition, BLE although present at all islands was sporadic and mild, with the highest prevalence values observed at Ofu-Olosega (8.5%); archipelago-wide, however, mean prevalence of BLE amounted only to 0.6% (SE 0.2). BLE occurred mostly on *Porites*, *Montastrea*, and *Montipora*. Lesions involving SGA were occasional, representing 9.4% cases and occurring predominantly around Tutuila and Ofu-Olosega on *Acropora* and *Astreopora*, respectively; archipelago-wide mean prevalence of SGA was 0.8% (SE 0.4). PRS and EFI were also sporadic (6.0% and 7% of cases, respectively), with the greatest island-specific mean prevalence values for Rose Atoll and Tau (1.9% and 3.4%, respectively). Finally, cases of WSY and BBD were rare, representing only 1.7% and 0.2% of total, respectively; archipelago-wide mean prevalence for these two disease states was also low, amounting to 0.06% (SE 0.03) and 0.01% (SE 0.01) respectively.

Of the 64 sites surveyed in the Northwestern Hawaiian Is., 81% contained disease, and 8 different types of lesions were identified: BLE, WSY, TLS, SGA, PRS, TRE, EFI, and OTH; with a region-wide mean prevalence of 3.1 (SE 0.6). Diseases were observed on the 4 main reef-building coral genera (*Porite*s, *Montipora*, *Acropora*, and *Pocillopora*), of which nearly 70% of cases occurred on *Porites*. The greatest number of disease states was recorded at French Frigate Shoals and the lowest at Laysan Island (8 and 2, respectively; Table 1). Mean disease prevalence was greatest at Kure Atoll (7.3% SE 3.7), while Necker Island exhibited the lowest (2.0% SE 1.8). Three disease states, PRS, BLE, and TRE, were the most widespread and abundant. Although BLE was quite common at Laysan and Lisianski, prevalence values were relatively low (1–5%); BLE was moderate and focal and mostly affected on corals of the genera *Porites* and *Montipora*. Lesions involving PRS were ubiquitous but also occurred at low levels of prevalence, not exceeding 3% at any of the sites visited. In addition, the parasitic *Porites* TRE occurred at moderate levels at most sites, except for 2 western backreef sites at Kure Atoll, where prevalence values reached 23–27%. This was the result of reduced numerical abundance of colonies of the host genus at the sites where cases of TRE were enumerated. Together with TRE, lesions involving TLS, BLE, and PRS were present at 7 of the 8 islands/atolls. The 2006 surveys encountered TLS lesions exclusively on colonies of the genus *Porites* and low island-wide mean prevalence values (< 0.5%). Finally, of potential concern are WSY conditions detected on the tabular *Acropora cytherea* only at French Frigate Shoals. Although prevalence values only amounted to 4% for any one site, French Frigate Shoals harbors the largest population of *A. cytherea* in the Hawaiian Archipelago.

For Guam and the CNMI, mean disease prevalence region-wide was relatively low (2.9% SE 0.4), but as in the other archipelagos, exhibited considerable spatial variability. Sixty-six sites at 12 different islands were surveyed in this region and a total of 8 disease states were recorded: BLE, SGA, WSY, TLS, PRS, EFI, BFI, and OTH. The highest island-wide prevalence occurred at Guam (7.3% SE 1.9) and the lowest at Pagan (0.1% SE 0.1). Disease affected the greatest number of scleractinian genera (19) in the Guam-CNMI region: *Porites*, *Astreopora*, and *Cyphastrea* accounted for more than 75% of all cases and exhibited the greatest prevalence. In addition, the 3 main disease states, BLE, EFI, and PRS (in order of prevalence) accounted for more than 65% of cases. Cases of BLE were common particularly around the inhabited Guam, Saipan, Tinian, and Rota and also at uninhabited Alamagan.

Site-specific prevalence of BLE was as high as 12% around Guam. However, mean archipelago-wide prevalence was only 1.3% (SE 0.4). For the most part, BLE was mild to moderate and affected primarily corals in the genus *Astreopora*. EFI cases were widespread and numerous, predominantly around Saipan on the genus *Cyphastrea*, where site-specific prevalence values were as high as 20%; archipelago-wide mean prevalence only reached 0.9% (SE 0.4). Lesions involving PRS on *Porites* occurred mainly at Guam and Tinian, where mean prevalence values amounted to 2.0% and 1.0%, respectively; archipelago-wide, mean prevalence was 0.5% (SE 0.2). Cases of WSY, BFI, TLS, and SGA were sporadic and occurred in low, region-wide mean prevalence (0.1–0.2%).

The 80 sites surveyed in the PRIA revealed a region-wide mean prevalence of 2.8% (SE 0.7), and 6 lesion types (SGA, WSY, TLS, BLE, PRS, OTH) were identified affecting 12 different scleractinian genera, with *Acropora*, *Montipora*, and *Porites* accounting for 92% of cases. Diseases occurred at 43 (54%) of sites surveyed, with SGA being the most geographically and taxonomically widespread disease, detected at nearly 40% of sites. SGA were particularly abundant at Johnston Atoll, where site-specific prevalence was as high as 25.3%. WSY, which was hosted by 4 scleractinian genera, including *Acropora*, *Montipora*, *Goniastrea*, and *Platygyra*, was the second most prevalent disease region-wide (mean prevalence = 0.9%, SE ± 0.1%) with nearly 90% cases occurring at Johnston Atoll. Additionally, PRS and OTH, particularly algal algal/cyanophyte infections and tube-worm infestations, were infrequent and occurred in low prevalences region-wide (range: 0.1 and 0.4%, respectively). Overall, mean prevalence of all diseases was the highest at Johnston Atoll (8.5% SE 2.5) and lowest at Baker Island (0.1% SE 0.1) and patterns of prevalence varied considerably among coral genera with *Acropora*, *Montipora*, and *Porites* being disproportionately affected by SGA and WSY. Of potential concern is WSY, which results in severe and rapid tissue loss, particularly on the tabular *Acropora cytherea* at Johnston Atoll.

Mean, region-wide prevalence amounted to 1.1% (SE 0.3) for the main Hawaiian Islands, where 54 sites were surveyed and 7 disease states enumerated: BLE, SGA, TLS, TRE, EFI, PRS, and OTH. Disease affected 6 coral genera, with *Porites* accounting for more than 90% of the total number of cases (316). Four lesion types, SGA, TLS, EFI, and PRS, were the most widespread and abundant; however, except for limited small areas of higher abundance, disease-specific mean prevalence amounted to less than 2%; All 7 diseases were recorded on corals around the inhabited islands of Hawaii and Maui; Kauai followed with 6 disease states. Limited insight is available for Oahu, as only 1 representative survey was completed in 2006. Kauai exhibited the greatest mean prevalence (3.7% SE 1.8) and, on surrounding reefs, EFI, SGA, and TRE were the most common lesions. The island with the second highest mean prevalence was Lanai (1.5% SE 1.3). This was a result of bleaching occurrence on a few colonies of *Leptastrea*; this genus exhibited overall low numerical abundance at the sites where bleached colonies were encountered. The more remote islands of Niihau and Lehua exhibited both the lowest number of disease states (2) as well as lowest mean prevalences (0.5% SE 0.3 and 0.2% SE 0.1, respectively).

Discussion

This study represents perhaps the most extensive quantitative survey of coral disease across the U.S. Pacific reefs. Surveys detected disease at 67% of sites, and patterns of distribution and abundance varied considerably within and among islands, regions, and coral genera, with only a few taxa being disproportionately targeted by disease. The Northwestern Hawaiian Islands exhibited the greatest percent occurrence of disease with nearly twice as many cases (35%) as any other region; the PRIA exhibited the lowest (9.8%). Additionally, the most numerically abundant disease states Pacific-wide were PRS (20.5%) and BLE (16.1%); and the least abundant, BBD and BFI (0.05% each). However, relative to coral colony density, the most prevalent diseases were BLE and SGA (0.64% and 0.58%, respectively). Pacific-wide, mean prevalence was relatively low (2.8% SE 0.5), with the lowest mean value registered for the main Hawaiian Islands (1.1% SE 0.3) and the highest for American Samoa (4.3% SE 1.3). These archipelago-wide means are lower than those in disease-stricken regions of the Great Barrier Reef and the Caribbean (Puerto Rico, Mexico, and Jamaica; range 6.3–16.6%; Weil 2004; Willis et al. 2004). However, island-specific mean prevalences as high as 7.3%, 8.3%, and 11.7% for Guam, Johnston, and Rose Atoll, respectively, underpin the importance of continued coral disease monitoring to provide warning regarding the potential risk of specific coral populations.

Disease distribution also varied among island groups. For example, the parasitic TRE on *Porites* was only recorded in the Hawaiian Archipelago, while BBD and BFI were exclusive to American Samoa and the CNMI, respectively. The other disease states, BLE, PRS, SGA, WSY, TLS, EFI, and OTH, were more widely distributed among island groups. Additionally, different island groups exhibited differing levels of abundance and prevalence of

specific lesions. For example, BLE conditions were the most prevalent disease state in the Northwestern Hawaiian Islands and Guam-CNMI. Conversely, SGA and WSY were the most prevalent diseases in the PRIA, while OTH was in American Samoa. Factors including, but not limited to pathogen distribution and life history, environmental conditions and disturbances, host abundance, susceptibility, disease transmissibility and virulence may determine the occurrence and prevalence of disease (Wobeser 2006).

The 1744 cases tallied in this study occurred on 25 different coral genera, belonging to 10 scleractinian families. The Poritidae exhibited both the highest frequency of occurrence and mean prevalence in the main Hawaiian Islands (90.1% of cases, mean prevalence = 0.6%) and the Northwestern Hawaiian Islands (69.8% of cases, mean prevalence = 2.4%, respectively). Within the Poritidae, TRE and PRS were the most numerically abundant diseases (60% of cases, combined), while BFI and WSY were the only two syndromes not observed on this taxon. Comparatively, the Acroporidae was the taxon most susceptible to disease in the PRIA (65% of cases, mean prevalence = 1.3%) and the Faviidae in American Samoa (58.2% of cases, mean prevalence = 2.2%). Pacific-wide, SGA and WSY were the most numerically abundant and prevalent diseases on the Acroporidae (52% and 0.6%, respectively), while OTH (particularly algal/cyanophyte infections) were the most numerically abundant and prevalent lesions on the Faviidae (62% and 0.7%, respectively).

Overall, the three major families, Poritidae, Acroporidae, and Faviidae, hosted the greatest number of disease states (8, 6, and 6, respectively), as well as the greatest levels of mean prevalence (1.0%, 0.9%, and 0.7%, respectively). Pacific-wide, these three families are amongst the most numerically abundant and diverse taxa, representing a key community structural component. For example, these 3 families accounted for 70–80% of the live coral cover and 65–85% of colonies on the study reefs in American Samoa, the PRIA, and Guam-CNMI. Similarly, in the Hawaiian Archipelago, *Porites* alone represents more than 60% of the live coral cover and more than 47% of colonies (Vargas-Ángel and Kenyon unpubl. data). Recent studies indicate an escalating number of diseases and prevalence levels affecting a selected number of scleractinian taxa, whereby *Acropora*, *Montastraea*, and *Colpophyllia* appear highly susceptible to disease on Caribbean reefs, while *Porites*, *Acropora*, *Montipora* and *Pocillopora* are the chief disease-hosting genera on Indo-Pacific reefs (Weil 2004; Willis et al. 2004; Aeby 2006; Harvell et al. 2007). To what extent host susceptibility to disease is determined by numerical abundance and/or a life history trait is an important topic for further scientific investigation.

This study represents the first comprehensive attempt at assessing the distribution and abundance of coral diseases in the U.S.-affiliated Pacific States and Territories. Although archipelago-wide mean prevalences are relatively low (1.1–4.3%; Table 1), site-specific hotspots occur at Johnston, Kure, and Rose Atolls, French Frigate Shoals, and Guam. In addition, the scleractinian families Poritidae, Acroporidae, and Faviidae appear to be disproportionately affected by disease. Potential outbreaks of host-specific diseases can be a source of concern, given that these families are key contributors to reef building and structural dynamics in many U.S. Pacific reefs. Periodic regional monitoring, coupled with continued targeted research, will allow a better understanding of the natural coral disease dynamics and, therefore, help managers formulate informed decisions regarding the potential risk of specific coral populations.

Acknowledgements

NOAA Coral Reef Conservation Program for financial support. Institutional and logistic support provided by the NOAA-PIFSC-CRED, State of Hawaii Department of Land and Aquatic Resources, Papahanaumokuakea Marine National Monument, U.S. Fish and Wildlife Service, U.S. Air Force, American Samoa Department of Marine and Wildlife Resources, Fagatele Bay National Marine Sanctuary, U.S. National Park Service, Guam Department of Aquatic and Wildlife Resources, CNMI Department of Environmental Quality, and CNMI Coastal Resources Management Office. Officers and crew of the NOAA Ship *Hi`ialakai* are also gratefully acknowledged for support with small boat and dive operations. D Fenner, J Kenyon, J Maragos, and P Houk conducted colony counts; B DeJoseph assisted with the computation of coral generic densities; J Helyer and S Schopmeyer assisted with data collation, quality control, and preparation. The authors also want to thank M Nadon and J Kenyon, and two anonymous reviewers whose comments substantially improved this manuscript.

References

Aeby GS (2006) Baseline levels of coral disease in the Northwestern Hawaiian Islands. Atoll Res Bull 534: 471–488

Harvell DC, Jordán-Dahlgren E, Rosenberg E, Raymundo L, Smith G, Weil E, Willis B (2007) Coral disease, environmental drives and the balance between coral and microbial associates. Oceanogr 20:172–195

Schroeder RE, Green AL, DeMartini EE, Kenyon JC (2008) Long-term effects of a ship-grounding on coral reef fish assemblages at Rose Atoll, American Samoa. Bull Mar Sci 82: 345-364

NOAA (2009) Pacific Islands Fisheries Science Center. Coral health and disease assessment. Available from: http://www.pifsc.noaa.gov/cred/coraldiseases.php Accessed: 11 February, 2009

Weil E (2004) Coral reef diseases in the wider Caribbean. In: Rosenberg E and Loya Y (eds) Coral Health and Disease, Springer-Verlag, Berlin, pp35–68

Willis BL, Page C, Dinsdale E (2004) Coral diseases on the Great Barrier Reef. In: Rosenberg E and Loya Y (eds) Coral Health and Disease, Springer-Verlag, Berlin, pp69–104

Wobeser GA (2006) Essentials of disease in wild animals. Blackwell Publishing Professional, Ames, Iowa, USA, 243 p

Table 1. Mean prevalence (SE) of coral disease at 40 islands, banks, and atolls in the US-affiliated Pacific States and Territories. BLE: bleaching, SGA: skeletal growth anomalies, WSY: acute tissue loss or white syndrome, TLS: subacute tissue loss, TRE: trematodiasis; PRS: pigmentation response; EFI: endolithic fungal infections, BFI: banded fungal infections, BBD: black band disease, OTH: other syndromes including algal and cyanophyte infections, parasite infestations, and other lesions of unknown etiology, $\overline{X}$: island-wide mean prevalence computed based on all survey sites. Region: Main Hawaiian Islands (MHI), Northwestern Hawaiian Islands (NWHI), American Samoa (AMSA), the Pacific Remote Island Areas (PRIA), and Guam and the Commonwealth of the Northern Mariana Islands (CNMI). FFS = French Frigate Shoals; PHR = Pearl and Hermes Atoll. Taxa affected by disease are listed in order of decreasing prevalence.

Region	BLE	SGA	WSY	TLS	TRE	PRS	EFI	BFI	BBD	OTH	$\overline{X}$	Taxa affected
MHI												
Hawaii	0.0	0.1	0.0	0.1	0.0	0.4	0.0	0.0	0.0	0.0	0.7	
Maui	0.0	0.2	0.0	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.6	
Kauai	0.2	0.8	0.0	0.2	0.7	0.0	1.6	0.0	0.0	0.2	3.8	*Porites*, *Montipora*, *Pocillopora*, *Psammocora*, *Pavona*
Lanai	1.1	0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	1.5	
Molokai	0.0	0.1	0.0	0.1	0.0	0.3	0.1	0.0	0.0	0.0	0.6	
Niihau	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.1	0.5	
Lehua	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2	
Mean	**0.2**	**0.2**	**0.0**	**0.0**	**0.2**	**0.2**	**0.3**	**0.0**	**0.0**	**0.0**	**1.1% (SE 0.3)**	
NWHI												
Necker	1.0	0.0	0.0	0.1	0.4	0.5	0.0	0.0	0.0	0.2	2.0	
FFS	1.5	0.2	0.5	0.1	0.2	0.8	0.1	0.0	0.0	0.3	3.4	
Maro	1.2	0.0	0.0	0.1	0.2	0.8	0.0	0.0	0.0	0.0	2.3	
Laysan	2.9	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	3.3	*Porites*, *Montipora*, *Acropora*, *Pocillopora*
Lisianski	2.5	0.1	0.0	0.4	0.3	0.3	0.0	0.0	0.0	0.1	3.6	
PHR	0.1	0.0	0.0	0.1	0.3	0.4	0.0	0.0	0.0	0.7	1.0	
Midway	0.0	0.0	0.0	0.4	0.0	0.1	0.0	0.0	0.0	0.3	0.6	
Kure	0.0	0.0	0.0	0.1	7.0	0.0	0.2	0.0	0.0	0.1	7.3	
Mean	**1.0**	**0.0**	**0.1**	**0.2**	**1.2**	**0.4**	**0.1**	**0.0**	**0.0**	**0.3**	**3.1% (SE 0.6)**	
AMSA												
Tutuila	0.3	1.6	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.9	3.0	*Favia*, *Porites*, *Coscinaraea*,, *Acropora*, *Montastrea*, *Astreopora*, *Favites*, *Montipora*, *Leptoria*, *Platygyra*, *Fungia*, *Pavona*, *Pocillopora*, *Goniastrea*
Ofu-Olo	1.9	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	
Ta'u	0.3	0.4	0.0	0.0	0.0	0.0	3.4	0.0	0.0	0.0	4.1	
Swains	0.8	0.5	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	1.3	
Rose	0.1	0.0	0.1	0.0	0.0	1.9	0.0	0.0	0.0	9.6	11.7	
Mean	**0.6**	**0.8**	**0.1**	**0.0**	**0.0**	**0.0**	**0.5**	**0.0**	**0.1**	**2.2**	**4.3% (SE 1.3)**	
PRIA												
Wake	0.2	3.2	0.0	0.3	0.0	0.1	0.0	0.0	0.0	0.0	3.9	
Johnston	0.0	3.4	3.6	0.0	0.0	1.4	0.0	0.0	0.0	0.1	8.5	*Acropora*, *Porites*, *Pocillopora*, *Montipora*, *Gardineroseris*, *Astreopora*, *Platygyra*, *Favites*, *Goniastrea*, *Hydnophora*, *Leptastrea*, *Favia*
Baker	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	
Howland	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	
Jarvis	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.3	
Palmyra	1.0	0.3	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	1.4	
Kingman	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	
Mean	**0.2**	**1.4**	**0.9**	**0.0**	**0.0**	**0.4**	**0.0**	**0.0**	**0.0**	**0.1**	**2.8% (SE 0.7)**	
Guam-CNMI												
Guam	4.2	0.1	0.2	0.5	0.0	2.0	0.2	0.1	0.0	0.0	7.3	
Rota	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	
Tinian	0.4	0.1	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	1.3	
Saipan	0.8	0.0	0.0	0.0	0.0	0.8	2.6	0.0	0.0	0.1	4.4	*Porites*, *Astreopora*, *Cyphastrea*, *Platygyra*, *Gardineroseris*, *Montipora*, *Echinopora*, *Goniastrea*, *Coscinaraea*, *Acropora*, *Favia*, *Psammocora*, *Plesiastrea*, *Hydnophora*, *Pavona*, *Goniopora*, *Pocillopora*, *Turbinaria*
Sarigan	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.3	0.4	
Guguan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	
Alamagan	4.3	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.4	5.0	
Pagan	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.1	
Agrijan	0.1	0.0	2.2	0.0	0.0	0.0	0.0	1.4	0.0	0.0	3.8	
Aguijan	0.0	0.0	11.1	0.0	0.0	0.0	0.0	0.0	0.0	5.6	16.7	
Asuncion	0.0	0.3	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.7	
Maug	0.5	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.7	
Farallon de Pajaros	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Mean	**1.3**	**0.2**	**0.2**	**0.1**	**0.0**	**0.5**	**0.4**	**0.1**	**0.0**	**0.2**	**2.9% (SE 0.4)**	