



Coral reef resilience to climate change in Guam in 2016

Jeffrey Maynard*, Steven M. Johnson*, David R. Burdick*, Andrew Jarrett, Jordan Gault, Jacques Idechong, Roxanna M. Miller, Gareth J. Williams, Scott F. Heron, Laurie Raymundo

*Project Co-Leaders



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National Ocean Service

Dr. Russell Callender
Assistant Administrator

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Jeffrey Maynard^{1,2*}, Steven Johnson^{3*}, David Burdick^{4*}, Andrew Jarrett⁴, Jordan Gault⁴, Jacques Idechong⁴, Roxanna Miller⁴, Gareth J. Williams⁵, Scott F. Heron^{6,7}, Laurie Raymundo⁴

***Project Co-leaders**

1 – SymbioSeas and the Marine Applied Research Center, Wilmington NC, 28411, USA, 2 – Laboratoire d'Excellence «CORAIL» USR 3278 CNRS – EPHE, CRIOBE, Papetoai, Moorea, Polynésie Française, 3 – College of Earth, Ocean and Atmospheric Sciences, Oregon State University, Corvallis, OR 97331, USA, 4 – University of Guam Marine Laboratory, University of Guam, Mangilao GU 96923, USA, 5- School of Ocean Sciences, Bangor University, Menai Bridge, Anglesey LL59 5AB, UK, 5 – NOAA Coral Reef Watch, NESDIS Center for Satellite Applications and Research, 5830 University Research Ct., E/RA3, College Park, MD 20740, USA, 6 – Marine Geophysical Laboratory, Physics Department, College of Science, Technology and Engineering, James Cook University, Townsville, Qld 4814, Australia

E-mail addresses for Project Co-Leaders: Jeffrey Maynard (maynardmarine@gmail.com), Steven Johnson (stevenjohnson670@gmail.com), David Burdick (burdickd@triton.uog.edu)

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Executive Summary

Coral reef resilience to climate change in Guam in 2016

Jeffrey Maynard*, Steven Johnson*, David Burdick*, Andrew Jarrett, Jordan Gault, Jacques Idechong, Roxanna Miller, Laurie Raymundo

Introduction – Coral reef resilience is the capacity of a reef to resist or recover from degradation and maintain provision of ecosystem goods and services. Resilience-based management (RBM) has been developed to overcome the challenges of supporting ecosystem resilience in this era of rapid change. RBM involves the application of resilience theory and tools to deliver ecosystem-based management outcomes into the future. RBM of coral reefs can include assessing spatial variation in resilience potential and then targeting and tailoring appropriate actions to preserve or restore the resilience of reefs. Resilience assessments involve measuring or assessing resilience indicators (e.g., coral disease, coral recruitment and herbivorous fish biomass) and producing an aggregate score that expresses resilience potential for all sites as relative to the site with the highest (assessed) resilience potential.

The Marine Fisheries Management Plan of Guam explains that understanding the resilience of reef fisheries and the coral reefs upon which they depend is needed for future assessments of yield. This project was designed to meet this need.

Objectives – Obj. 1. Benthic Cover – Assess the percentage cover of major benthic groups, including corals, macroalgae, coralline algae, and ‘other’ (i.e., turf algae and unconsolidated substrate).

Obj. 2. Relative Resilience – Assess the relative resilience potential of coral reefs at two depths and compare resilience potential among survey sites.

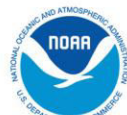
Obj. 3. Resilience Drivers – Determine the drivers of differences in resilience potential between sites.

Results – *Obj. 1* - Coral cover was higher on average in the shallow (25%) survey areas than the deep areas (19%). Differences between the shallow and deep survey sites in coral cover are driven by differences in macroalgae cover as coralline algae (12% shallow and 10% deep) and other cover (41% both depths) are very similar between the depths. Average macroalgae cover was 22% in the shallow and 30% in the deep.

Obj. 2 – For the shallow sites, normalized resilience scores ranged from 0.62 to 1.00. Three sites were assessed as having high resilience, five medium-high, nine medium-low, and two low. The three sites with high relative resilience are Tagua Point, Ague Point, and Pugua Patch Reef; these sites are in northern Guam. The two sites with low relative resilience are Ga’an Point and Fouha Bay, which are in southwestern Guam. There is a strong pattern that the relative resilience classes for survey sites are higher in the northern half of Guam and lower in the southern half and this was true for both depths (see figure below). For both depths and with very few exceptions, scores were medium-high or high for resilience indicators in northern Guam and medium-low or low in southern Guam.

For the deep sites, normalized resilience scores ranged from 0.64 to 1.00. Five sites were assessed as having high resilience, five medium-high, seven medium-low, and three low. The five sites with high relative resilience are Pugua Patch Reef, Ague Point, Luminao Reef, Tagua Point, and Tumon Bay; these sites are in northern Guam. The three sites with low relative resilience are Fouha Bay, Facpi Point and Cocos Barrier Reef-E, which are in southern Guam.

Coral reef resilience to climate change in Guam in 2016



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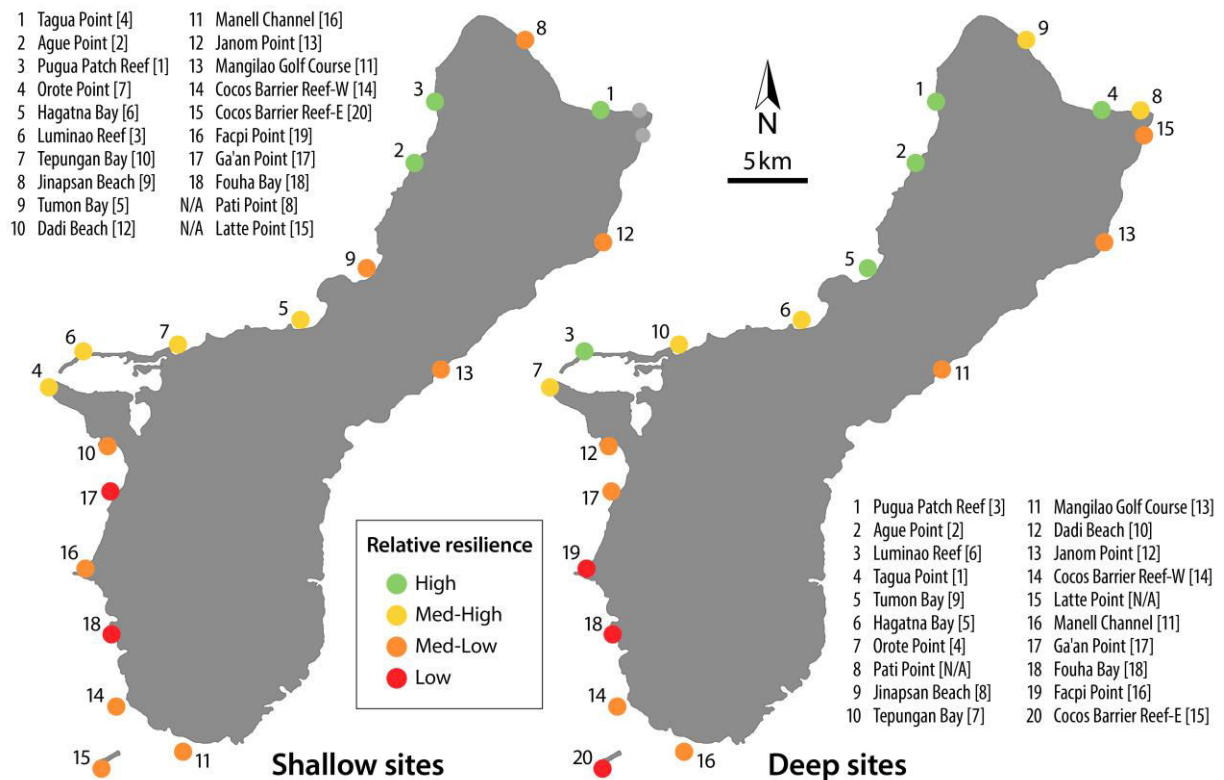


Figure – Spatial variation in relative resilience for both depths. Sites are ranked from highest to lowest relative resilience.

Obj. 3 - Across the shallow reef sites of Guam, higher resilience potential correlated most strongly with high coral cover and high coral recruitment and low resilience potential sites were negatively correlated with these same two indicators. Across the deep reef sites of Guam, higher resilience potential correlated most strongly with high coral recruitment, low macroalgae, high herbivore biomass and high coral cover.

Next Steps - Continued resilience monitoring can help managers identify the reefs that recover the fastest from recent bleaching events in Guam; these may be conservation priority areas. Combining the results of the Guam study with the CNMI study can help provide the groundwork for a regional planning and response. The data and results will be built into a Pacific-wide assessment of coral reef fisheries vulnerability to climate change being led by members of this project team from 2017-2019.

Site summaries – This report concludes with Site Summaries. These are 1-page summaries for each survey site that present the site name origin, and, for each site depth: coordinates, photographs, resilience ranks, resilience indicator scores, benthic community pie charts, and coral and fish species lists.

Acknowledgments - Financial support for this applied research was provided by a grant from the NOAA National Marine Fisheries Service Saltonstall-Kennedy Program. Resources were also provided in support of the fieldwork and project staff from the University of Guam Marine Laboratory. The contents of this report are solely the opinions of the authors and do not constitute a statement of policy, decision, or position on behalf of NOAA or the U.S. Government.

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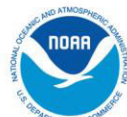
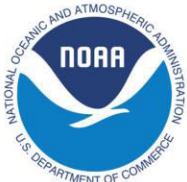


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Introduction

Coral reef resilience is the capacity of a reef to resist or recover from degradation and maintain provision of ecosystem goods and services (Mumby et al. 2007). Resilience-based management (RBM) has been developed to overcome the challenges of supporting ecosystem resilience in this era of rapid change (Bestelmeyer and Briske 2012). RBM involves the application of resilience theory and tools to deliver ecosystem-based management outcomes into the future (Chapin et al. 2009). RBM of coral reefs can include assessing spatial variation in resilience potential and then targeting and tailoring appropriate actions to preserve or restore the resilience of reefs. Such assessments have been strongly recommended by coral reef ecology experts and leading conservation organizations (Maynard et al. 2015; Anthony et al. 2015; McClanahan et al. 2012; Graham et al. 2013). The assessments involve measuring or assessing resilience indicators (e.g. coral disease, coral recruitment and herbivorous fish biomass) and producing an aggregate score that expresses resilience potential for all sites as relative to the site with the highest (assessed) resilience potential (see Maynard et al. 2015 for guidance). Examples are just emerging of assessments of resilience potential that explicitly guide managers in making targeted decisions (Maynard et al., 2015; Weeks & Jupiter, 2013).

The resilience assessment presented here for Guam builds on similar work undertaken in CNMI in collaboration with natural resource managers based in Saipan (Maynard et al. 2015). The CNMI assessment was the first field-based implementation of the framework recommended within *A Guide to Assessing Coral Reef Resilience for Decision Support* (Maynard et al. 2017).

Studies conducted in the late 1990's in Guam showed declines in rates of coral replenishment over the preceding decades and made the case these declines were due to both sedimentation and herbivore overfishing (Birkeland 1997). Those studies are reviewed on page 74 of the Marianas Fishery Management Plan (MFMP). Sedimentation and herbivore overfishing, which can inhibit ecosystem recovery, pose even greater threats to Guam's reefs today given recent coral bleaching events have resulted in substantial coral mortality (Reynolds et al. 2014). In addition to the compromised recovery capacity of Guam's reef systems, the recovery period following the major bleaching event in 2013 was brief, with additional bleaching-associated mortality occurring again in 2014 and 2016. The alarming trend of annual or near-annual bleaching events continues. At time of writing of this report, members of this team were again surveying the reefs in Guam as another severe bleaching event affected the island's reefs between July and October, 2017, with preliminary results suggesting coral mortality rates will be similar to those observed in 2013. The MFMP of Guam makes the case that understanding the resilience of reef fisheries and the coral reefs upon which they depend will be critically important in future assessments of yield. This project will result in managers and fishing community members better understanding spatial variation in the relative resilience of herbivorous fish communities and coral reefs in Guam.

Study Objectives

Obj. 1. Benthic Cover – Assess the percentage cover of major benthic groups, including corals, macroalgae, coralline algae, and 'other' (i.e., turf algae and unconsolidated substrate).

Obj. 2. Relative Resilience – Assess the relative resilience potential of coral reefs at two depths and compare resilience potential among survey sites.

Obj. 3. Resilience Drivers – Determine the primary drivers of differences in resilience potential between sites.

Methods

Field surveys were conducted at shallow (5 m) and deep (12 m) sites at 20 survey areas in the reef slope habitat of Guam from July – September of 2016. The sites surveyed by our 5-diver team represent the vast majority of the ecological and physical conditions around Guam. Some easterly sites we had hoped to include were not surveyed due to weather and logistical restrictions. Methods used to meet the three study objectives are described below.

Obj. 1. Benthic Cover – Benthic cover data was collected using a line-point intercept (LPI) methodology. Each site consists of three replicated 30 m transects. Data points were collected at 0.5 m intervals along the length of each transect. The observer would identify the benthos directly under the transect to the highest taxonomic resolution possible. Point data was then aggregated into the following categories: corals, macroalgae, coralline algae and other substrate (e.g., sand, turf algae or bare rock).

Obj. 2. Relative Resilience – The resilience indicators included were coral cover, coral diversity, coral recruitment, bleaching resistance, macroalgae cover, herbivorous fish biomass, and temperature variability. These indicators were selected from among those reviewed for perceived importance and scientific evidence within McClanahan et al. (2012) and six of these seven (exception: coral cover) were used within a similar resilience assessment conducted in CNMI (Maynard et al. 2015). Methods for assessment or measurement of each of the resilience indicators are described in Table 1.

The resilience assessment compared within rather than among depths; i.e., data for the two depths were not aggregated and shallow was not compared to deep or vice versa. Once data were collected and compiled for each indicator, values for each variable were normalized to a uni-directional scale of 0-1 by dividing by the maximum value for the variable among all 20 sites (i.e. this was done for each depth). To ensure that high scores always infer higher relative resilience, normalized scores were inverted for macroalgae cover. All indicators were equally weighted.

Resilience scores were calculated by averaging the normalized indicator scores for each site and then those site averages were normalized. This expresses resilience of all sites as relative to the site with the highest score. The final resilience scores range from 0-1 and represent decimal percentages of the site with the highest score (1.00). Relative classifications for resilience scores are as follows: high (final scores that are greater than 1 standard deviation (sd) above average), medium-high (<avg+1sd and >avg), medium-low (<avg and >avg-1sd), and low (<avg-1sd).

Resilience rankings and relative classifications, as well as scores for each resilience indicator and relative classifications for these, are all shown within tables and maps in the Results.

Obj. 3. Resilience Drivers – Understanding which variables most influence differences in resilience potential is another valuable product of resilience assessments. This is because the indicators most influencing rankings are: 1) the most important to include in monitoring programs, and 2) may reveal the types of management actions that would benefit the greatest number of sites. Indicators with the greatest variability most drive differences in the resilience rankings. We plotted the average \pm 1 standard deviation and maximum and minimum values for the final resilience scores and for the normalized values for the resilience indicators for both depths. We compare the range of values among the indicators for each depth and identify which indicators have highest and lowest range and variability.

We also used a canonical analysis of principal coordinates (CAP) (Anderson and Willis 2003) to examine which indicators were driving differences in resilience potential across the four relative classifications (low, med-low, med-high, and high) at each depth. The CAP was based on a Euclidean distance matrix. Variables that might be responsible for group differences are investigated by calculating the multiple correlations of canonical ordination axes with the original indicator variables (Anderson 2008).

Table 1. Field survey methods for resilience indicators.

Variable name (unit)	Methods
Coral cover (%)	Average percent of points classified as coral on three 30-m point-intercept transects where points were classified at 50-cm intervals.
Coral diversity (unitless)	The inverse of Simpson's index of diversity, which measures the probability that two species taken at random from the dataset are the same species. The resulting values range from 0-1, with higher values equating to higher diversity. The formula for Simpson's index is: $D = ((\text{sum of } n(n-1))/N(N-1))$, where n = total number of organisms of a particular species, and N = total number of organisms of all species observed.
Coral recruitment (#/m²)	Average density of corals with a geometric mean < 5 cm from 12 replicate .25 m ² quadrats; species that fissure and fragment frequently were excluded from this analysis.
Bleaching resistance (%)	Percent of the coral community made up of species considered to be resistant (rating \leq 3 in Table A1)
Macroalgae cover (%)	Average percent of points classified as macroalgae (> 1 cm in height) on three 30-m point-intercept transects where points were classified at 50-cm intervals.
Herbivorous fish biomass (g/m²)	Six replicate stationary point counts (SPC) were conducted. Observers counted all fishes that occurred in a 7.5-m radius cylinder. All fishes were identified to species and their total length estimated (TL). Biomass values were calculated using standard

Variable name (unit)	Methods
	length-weight regressions. Coefficients were sourced from FishBase and NOAA's Coral Reef Ecosystem Program (Weijerman et al. 2013). Species were classified as herbivores based on NOAA CREP functional group classifications.
Temperature variability	Standard deviation of the warm season (3 months centered on the warmest month – 1985-2016) temperatures (from Heron et al. 2016).

Results

Obj. 1. Benthic Cover

Coral cover was higher on average in the shallow (25%) survey areas than the deep (19%, this difference is not significant). Differences between the shallow and deep survey sites in coral cover are driven by differences in macroalgae cover as coralline algae (12% shallow and 10% deep) and other cover (41% both depths) are very similar between the depths. Spatial patterns in coral and macroalgae cover around Guam are shown in Figures 2 and 6 within the resilience indicator summaries section below. Average macroalgae cover was 22% in the shallow and 30% in the deep. The three shallow sites with the highest average coral cover were Ague Point (43%), Pugu Patch Reef (34%), and Hagatna Bay (33%). The three deep sites with the highest average coral cover were Hagatna Bay (52%), Tumon Bay (44%), and Ague Point (34%). The three shallow sites with the highest average macroalgae cover were Fouha Bay (51%), Ga'an Point (50%), and Facpi Point (32%). The three deep sites with the highest average macroalgae cover were Facpi Point (61%), Cocos Barrier Reef-E (51%) and Fouha Bay (47%).

Table 1. Percent cover of four major benthic groups for the shallow (left) and deep (right) survey sites. Sites are listed in alphabetical order. Data were collected using the line-intercept methodology, with three 30-m transects surveyed at each site.

	Shallow				Deep			
	Coral	Macroalgae	Coralline Algae	Other	Coral	Macroalgae	Coralline Algae	Other
Ague Point	43	13	7	37	34	11	8	47
Cocos Barrier Reef-E	26	18	11	45	13	51	7	29
Cocos Barrier Reef-W	12	24	13	51	8	39	5	48
Dadi Beach	23	21	8	48	11	28	33	28
Facpi Point	19	32	7	42	11	61	4	24
Fouha Bay	6	51	6	37	13	47	9	31
Ga'an Point	16	50	7	27	12	37	6	45
Hagatna Bay	33	12	25	30	52	16	14	18
Janom Point	19	25	8	48	13	41	3	43
Jinapsan Beach	32	26	7	35	18	21	1	60
Latte Point	NA	NA	NA	NA	12	24	12	52
Luminao Reef	27	8	16	49	21	11	21	47
Manell Channel	19	26	5	50	14	42	11	33
Mangilao Golf Course	32	11	12	45	24	34	8	34
Orote Point	29	8	14	49	14	21	4	61
Pati Point	NA	NA	NA	NA	20	16	13	51
Pugua Patch Reef	34	14	21	31	22	16	11	51
Tagua Point	28	16	9	47	16	31	3	50
Tepungan Bay	27	16	21	36	17	37	7	39
Tumon Bay	23	22	20	35	44	19	11	26

Obj. 2. Relative Resilience

Shallow – Normalized resilience scores ranged from 0.62 to 1.00. Three sites were assessed as having high resilience, four medium-high, nine medium-low, and two low. The three sites with high relative resilience are Tagua Point, Ague Point, and Pugua Patch Reef; these sites are in northern Guam. The two sites with low relative resilience are Ga’an Point and Fouha Bay, which are in southwestern Guam. There is a strong pattern that the relative resilience classes for survey sites are higher in the northern half of Guam and lower in the southern half. For both depths and with very few exceptions, scores were medium-high or high for resilience indicators in northern Guam and medium-low or low in southern Guam. Raw and normalized resilience scores, as well as normalized scores for all resilience indicators are presented within Table 2. Spatial patterns in relative resilience are shown for both depths in Figure 1.

Table 2. Resilience scores and relative classes for the shallow survey sites. Sites have been ordered from highest to lowest resilience score for this depth; deep rankings are shown in square [] brackets next to the shallow rankings. Relative classifications are as follows: high [green] (final scores that are greater than 1 standard deviation (sd) above average), medium-high [yellow] (<avg+1sd and >avg), medium-low [orange] (<avg and >avg-1sd), and low [red] (<avg-1sd). Indicator codes are as follows: CC – coral cover, CR – coral recruitment, CD – coral diversity, BR – bleaching resistance, MA – macroalgae cover, HB – herbivore biomass, TV – temperature variability.

Local Name	Shallow Rank [Deep]	Resilience score	Raw resilience score	CC	CR	CD	BR	MA	HB	TV
Tagua Point	1 [4]	1.00	0.77	0.65	0.40	0.92	0.67	0.91	1.00	0.85
Ague Point	2 [2]	0.99	0.76	1.00	0.67	0.96	0.80	0.94	0.07	0.89
Pugua Patch Reef	3 [1]	0.96	0.74	0.79	0.66	1.00	0.78	0.93	0.08	0.93
Orote Point	4 [7]	0.94	0.73	0.66	0.75	0.93	0.75	1.00	0.15	0.83
Hagatna Bay	5 [6]	0.93	0.72	0.78	0.43	0.92	0.89	0.96	0.18	0.89
Luminao Reef	6 [3]	0.91	0.71	0.62	1.00	0.72	0.66	0.99	0.08	0.86
Tepungan Bay	7 [10]	0.88	0.68	0.64	0.28	0.96	0.92	0.91	0.17	0.87
Jinapsan Beach	8 [9]	0.84	0.65	0.75	0.48	0.97	0.43	0.81	0.08	1.00
Tumon Bay	9 [5]	0.84	0.64	0.55	0.44	0.92	0.69	0.85	0.12	0.95
Dadi Beach	10 [12]	0.82	0.63	0.53	0.42	0.77	1.00	0.86	0.08	0.77
Manell Channel	11 [16]	0.81	0.63	0.45	0.41	0.98	0.91	0.80	0.07	0.77
Janom Point	12 [13]	0.80	0.61	0.45	0.53	0.91	0.63	0.81	0.05	0.91
Mangilao Golf Course	13 [11]	0.78	0.60	0.74	0.12	0.95	0.48	0.97	0.08	0.88
Cocos Barrier Reef-W	14 [14]	0.78	0.60	0.30	0.41	0.95	0.83	0.83	0.07	0.84
Cocos Barrier Reef-E	15 [20]	0.78	0.60	0.60	0.19	0.99	0.67	0.89	0.07	0.78
Facpi Point	16 [19]	0.77	0.59	0.44	0.30	0.94	0.88	0.73	0.04	0.82
Ga'an Point	17 [17]	0.72	0.56	0.36	0.23	0.95	0.96	0.54	0.08	0.77
Fouha Bay	18 [18]	0.62	0.48	0.14	0.13	0.74	0.94	0.54	0.04	0.82

Deep – Normalized resilience scores ranged from 0.64 to 1.00. Five sites were assessed as having high resilience, five medium-high, seven medium-low, and three low. The five sites with high relative resilience are Pugua Patch Reef, Ague Point, Luminao Reef, Tagua Point, and Tumon Bay; all of these sites are in northern Guam. The three sites with low relative resilience are Fouha Bay, Facpi Point and Cocos Barrier Reef-E, all of which are in southern Guam. As was the case for the shallow reef sites, there is a strong pattern that the relative resilience classes for deep survey sites are higher in the northern half of Guam and lower in the southern half. Raw and normalized resilience scores, as well as normalized scores for all resilience indicators are presented within Table 3. Spatial patterns in relative resilience are shown for both depths in Figure 1.

Table 3. Resilience scores and relative classes for the deep survey sites. Sites have been ordered from highest to lowest resilience score for this depth; shallow rankings are shown in square [] brackets next to the deep rankings. Relative classifications are as follows: high [green] (final scores that are greater than 1 standard deviation (sd) above average), medium-high [yellow] (<avg+1sd and >avg), medium-low [orange] (<avg and >avg-1sd), and low [red] (<avg-1sd). Indicator codes are as follows: CC – coral cover, CR – coral recruitment, CD – coral diversity, BR – bleaching resistance, MA – macroalgae cover, HB – herbivore biomass, TV – temperature variability.

Local Name	Deep Rank [Shallow]	Resilience score	Raw resilience score	CC	CR	CD	BR	MA	HB	TV
Pugua Patch Reef	1 [3]	1.00	0.78	0.43	1.00	0.95	0.89	0.94	0.32	0.93
Ague Point	2 [2]	0.95	0.74	0.66	0.62	0.96	0.84	1.00	0.20	0.89
Luminao Reef	3 [6]	0.93	0.73	0.41	0.41	0.98	0.91	1.00	0.54	0.86
Tagua Point	4 [1]	0.93	0.72	0.30	0.42	0.95	0.76	0.78	1.00	0.85
Tumon Bay	5 [9]	0.93	0.72	0.86	0.51	0.68	0.97	0.91	0.18	0.95
Hagatna Bay	6 [5]	0.88	0.69	1.00	0.47	0.39	1.00	0.94	0.10	0.89
Orote Point	7 [4]	0.86	0.67	0.27	0.64	0.88	0.85	0.89	0.36	0.83
Pati Point	8 [NA]	0.84	0.66	0.38	0.41	0.98	0.69	0.94	0.33	0.85
Jinapsan Beach	9 [8]	0.82	0.64	0.34	0.40	0.95	0.75	0.89	0.18	1.00
Tepungan Bay	10 [7]	0.81	0.63	0.33	0.37	0.98	0.91	0.71	0.27	0.87
Mangilao Golf Course	11 [13]	0.79	0.62	0.46	0.21	0.99	0.79	0.74	0.24	0.88
Dadi Beach	12 [10]	0.76	0.60	0.20	0.61	0.94	0.68	0.81	0.16	0.77
Janom Point	13 [12]	0.76	0.60	0.26	0.63	0.97	0.68	0.66	0.06	0.91
Cocos Barrier Reef-W	14 [14]	0.74	0.58	0.15	0.54	0.92	0.79	0.69	0.14	0.84
Latte Point	15 [NA]	0.74	0.58	0.23	0.34	0.96	0.59	0.86	0.21	0.85
Manell Channel	16 [11]	0.74	0.57	0.28	0.30	1.00	0.70	0.66	0.31	0.77
Ga'an Point	17 [17]	0.72	0.56	0.24	0.31	0.89	0.94	0.71	0.09	0.77
Fouha Bay	18 [18]	0.67	0.53	0.25	0.15	0.96	0.87	0.60	0.04	0.82
Facpi Point	19 [16]	0.66	0.52	0.20	0.19	0.97	0.88	0.44	0.13	0.82
Cocos Barrier Reef-E	20 [15]	0.64	0.50	0.26	0.32	0.92	0.53	0.56	0.12	0.78

Spatial patterns for the resilience indicators are presented within Figures 2-8. With very few exceptions, values for the resilience indicators were higher in northern Guam than southern and especially southwestern Guam.

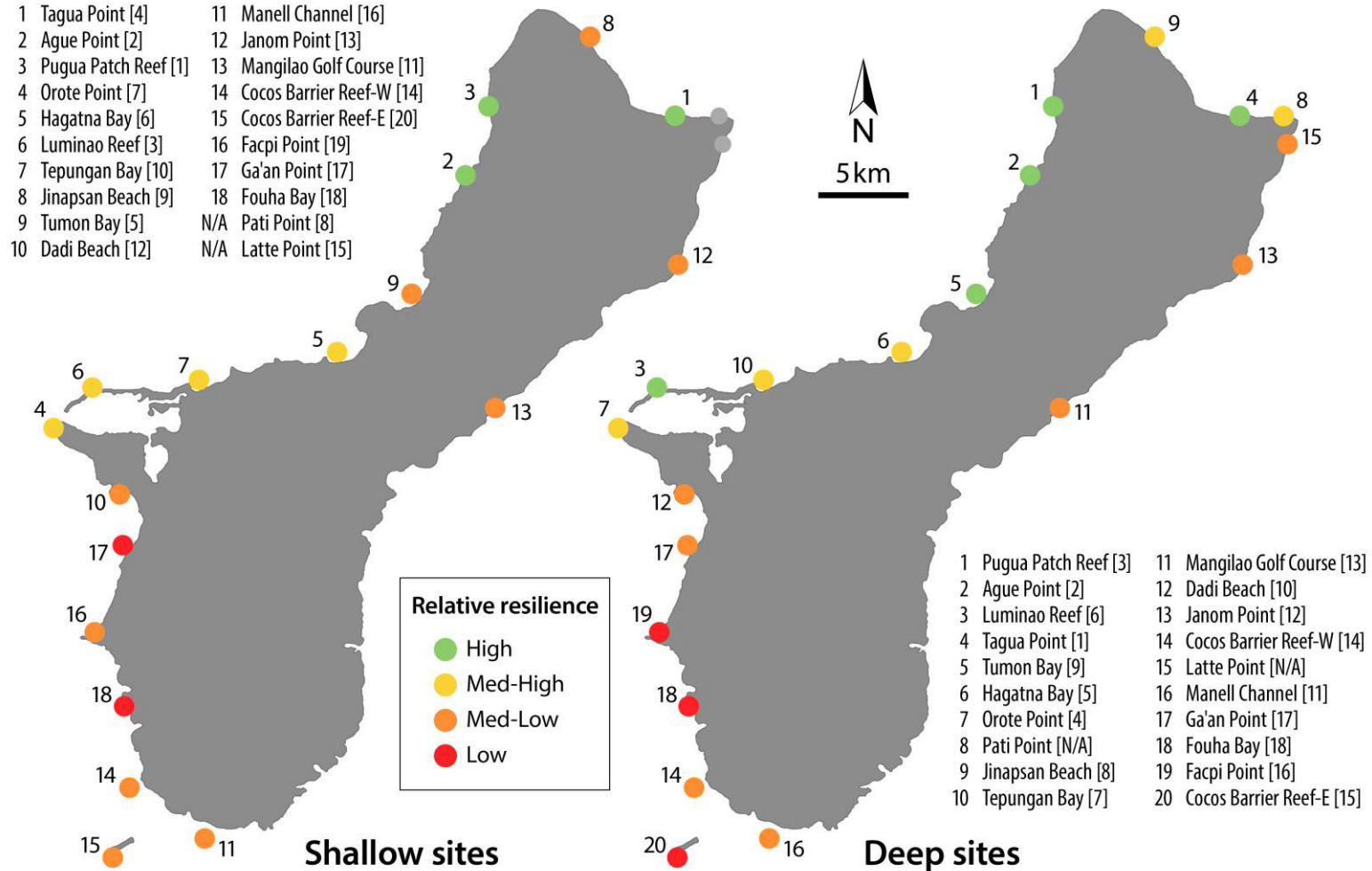


Figure 1. Relative resilience of coral reefs in Guam. Sites are ordered from highest to lowest ranking for the shallow in the top left and deep in the bottom right. Raw and normalized resilience scores are shown for each site within Tables 1 and 2. Relative resilience is an aggregate score for 7 resilience indicators: coral cover, coral recruitment, coral diversity, bleaching resistance, macroalgae cover, herbivore biomass, and temperature variability. Spatial patterns are shown for each resilience indicator within Figures 2-8, in the upcoming pages.

Coral Cover

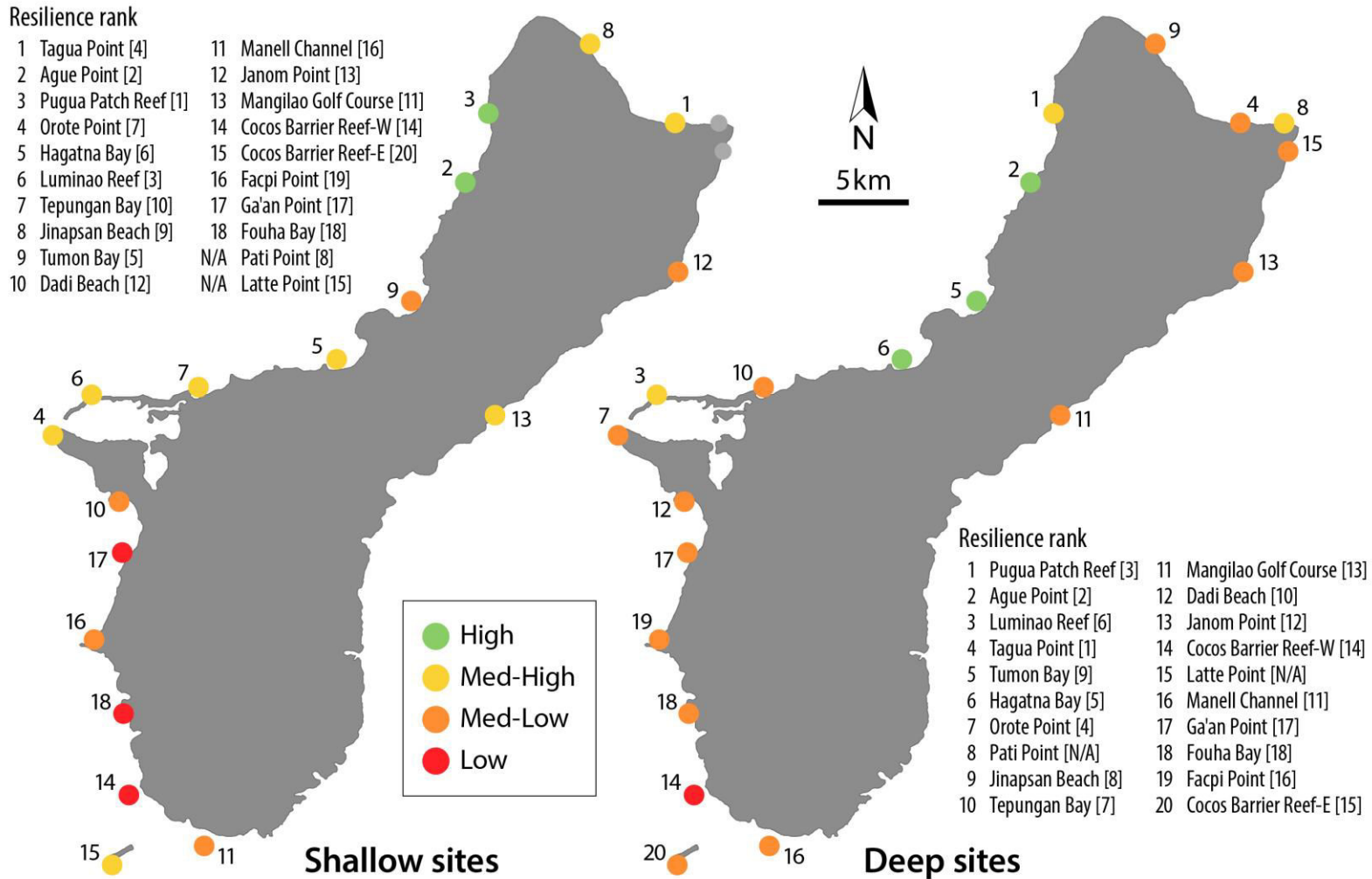


Figure 2. Relative classifications for coral cover. Normalized values for this and the other indicators are presented with Tables 1 and 2. On the shallow side, resilience rankings for deep are in [] brackets, and on the deep side, resilience rankings for shallow are in [] brackets. This also applies to Figures 3-8.

Coral Recruitment

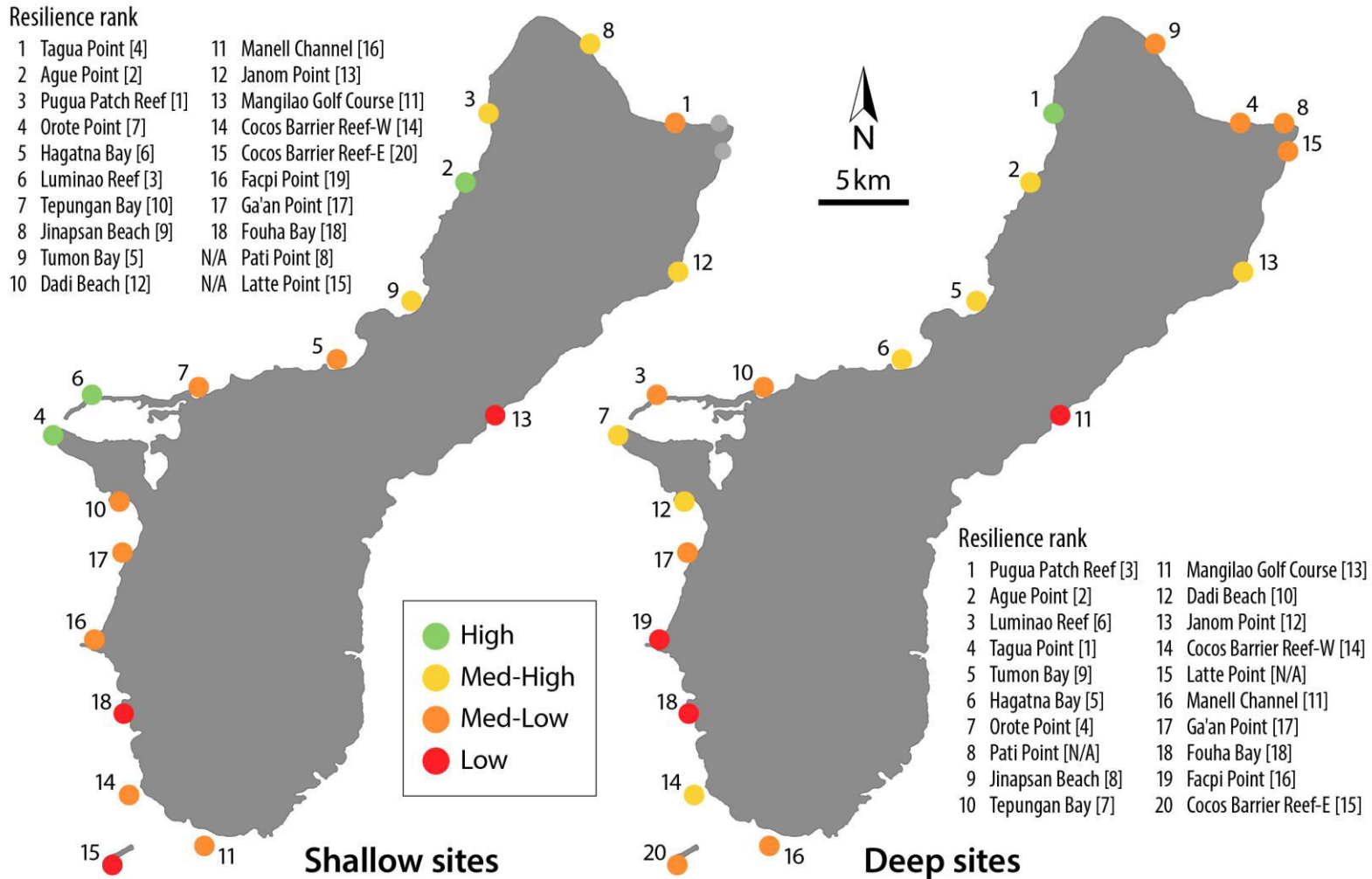


Figure 3. Relative classifications for coral recruitment. Normalized values for this and the other indicators are presented with Tables 1 and 2.

Coral Diversity

Resilience rank

- | | |
|------------------------|------------------------------|
| 1 Tagua Point [4] | 11 Manell Channel [16] |
| 2 Ague Point [2] | 12 Janom Point [13] |
| 3 Pugua Patch Reef [1] | 13 Mangilao Golf Course [11] |
| 4 Orote Point [7] | 14 Cocos Barrier Reef-W [14] |
| 5 Hagatna Bay [6] | 15 Cocos Barrier Reef-E [20] |
| 6 Luminao Reef [3] | 16 Facpi Point [19] |
| 7 Tepungan Bay [10] | 17 Ga'an Point [17] |
| 8 Jinapsan Beach [9] | 18 Fouha Bay [18] |
| 9 Tumon Bay [5] | N/A Pati Point [8] |
| 10 Dadi Beach [12] | N/A Latte Point [15] |

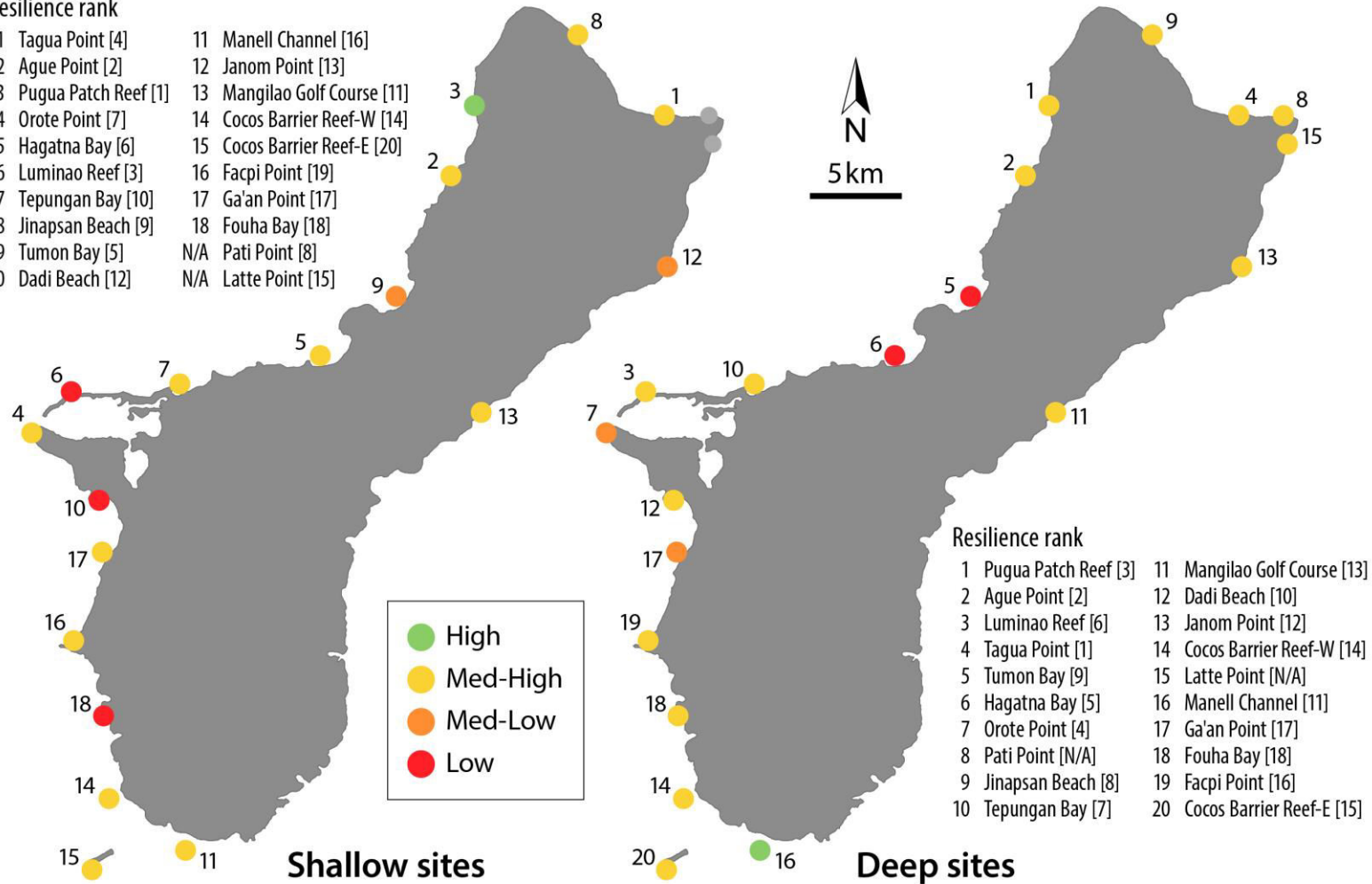


Figure 4. Relative classifications for coral diversity. Normalized values for this and the other indicators are presented with Tables 1 and 2.

Bleaching Resistance

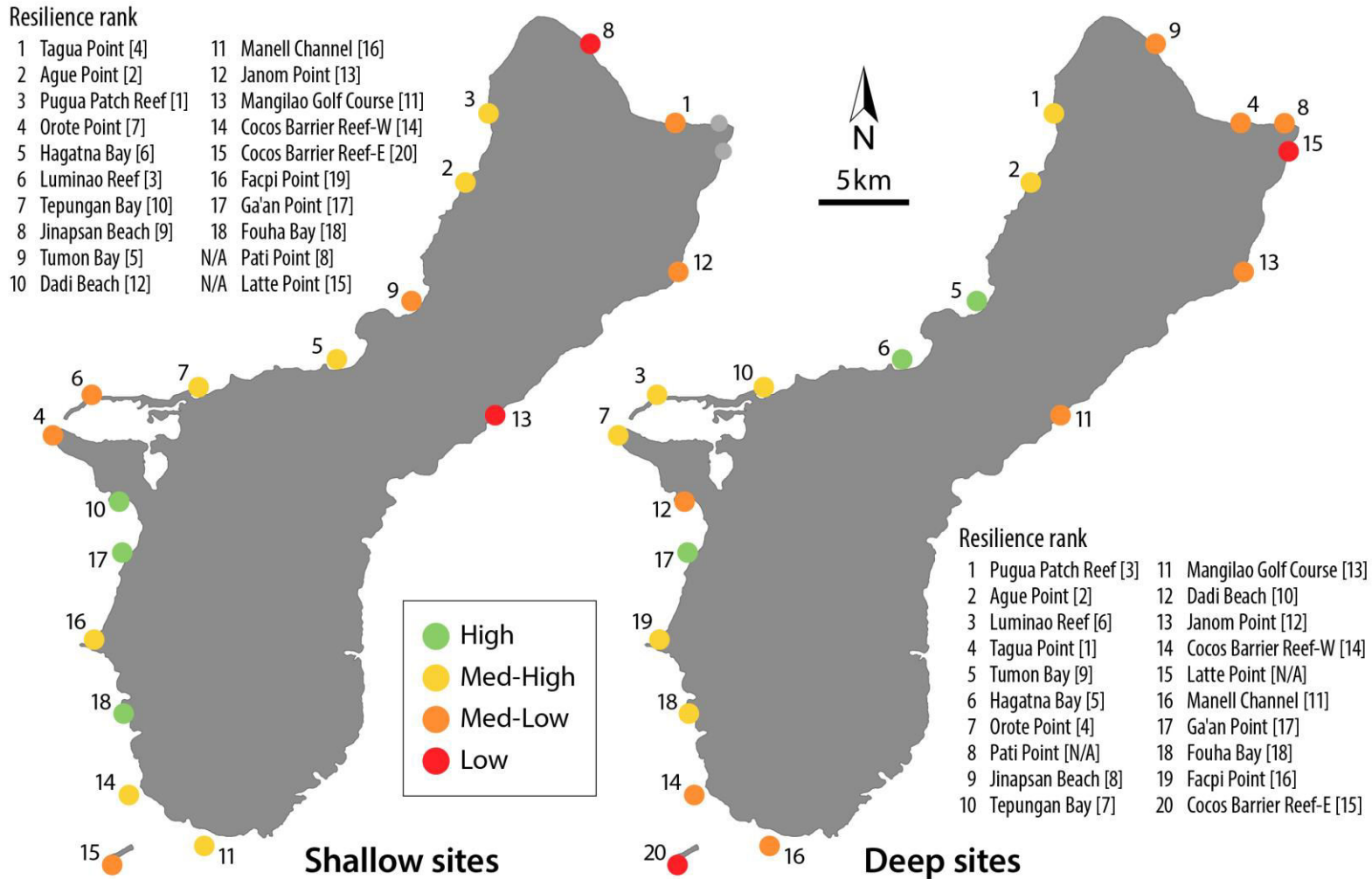


Figure 5. Relative classifications for bleaching resistance. Normalized values for this and the other indicators are presented with Tables 1 and 2.

Macroalgae Cover

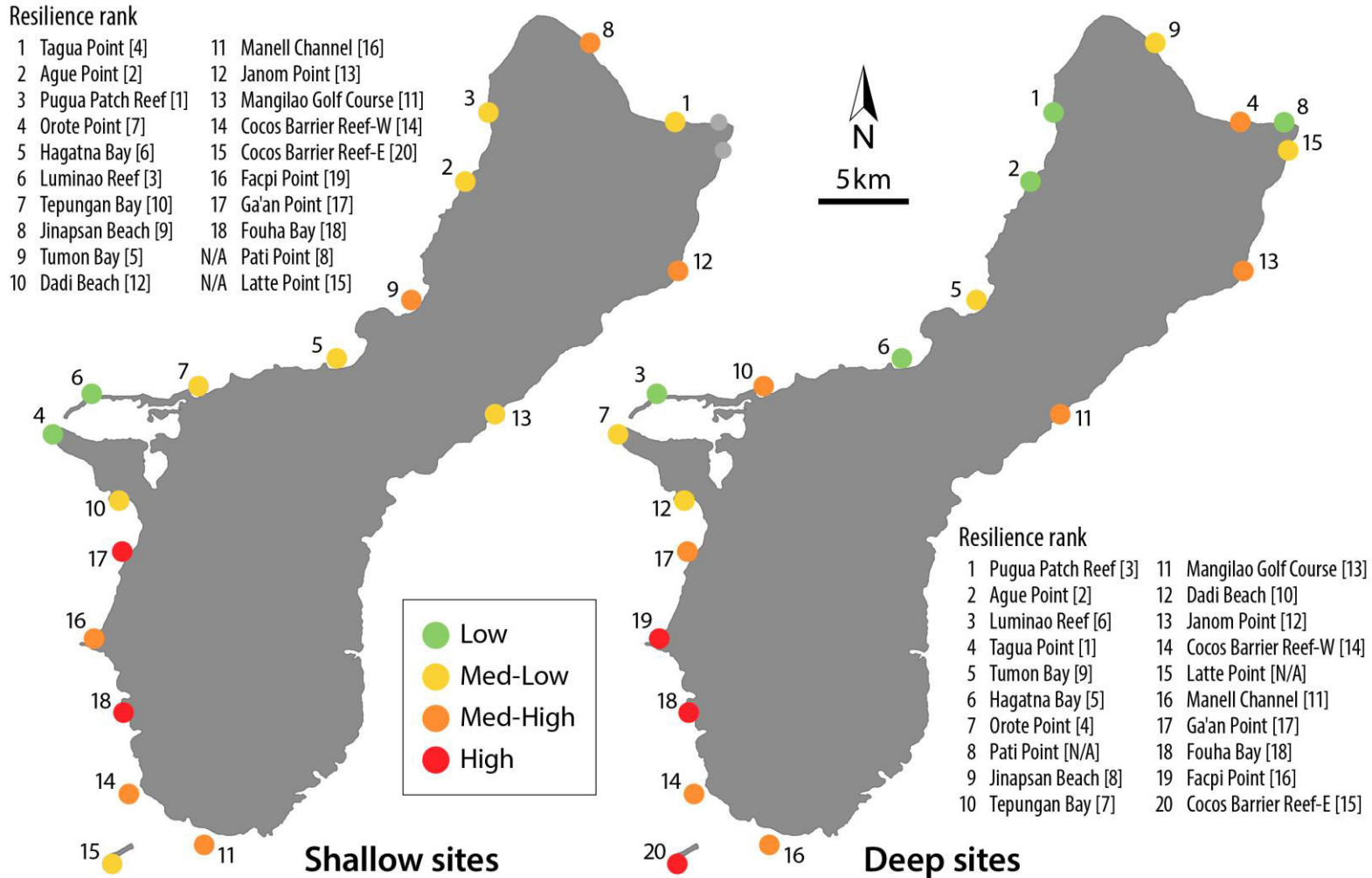


Figure 6. Relative classifications for macroalgae cover. Normalized values for this and the other indicators are presented with Tables 1 and 2.

Herbivore Biomass

Resilience rank

- | | |
|------------------------|------------------------------|
| 1 Tagua Point [4] | 11 Manell Channel [16] |
| 2 Ague Point [2] | 12 Janom Point [13] |
| 3 Pugua Patch Reef [1] | 13 Mangilao Golf Course [11] |
| 4 Orote Point [7] | 14 Cocos Barrier Reef-W [14] |
| 5 Hagatna Bay [6] | 15 Cocos Barrier Reef-E [20] |
| 6 Luminao Reef [3] | 16 Facpi Point [19] |
| 7 Tepungan Bay [10] | 17 Ga'an Point [17] |
| 8 Jinapsan Beach [9] | 18 Fouha Bay [18] |
| 9 Tumon Bay [5] | N/A Pati Point [8] |
| 10 Dadi Beach [12] | N/A Latte Point [15] |

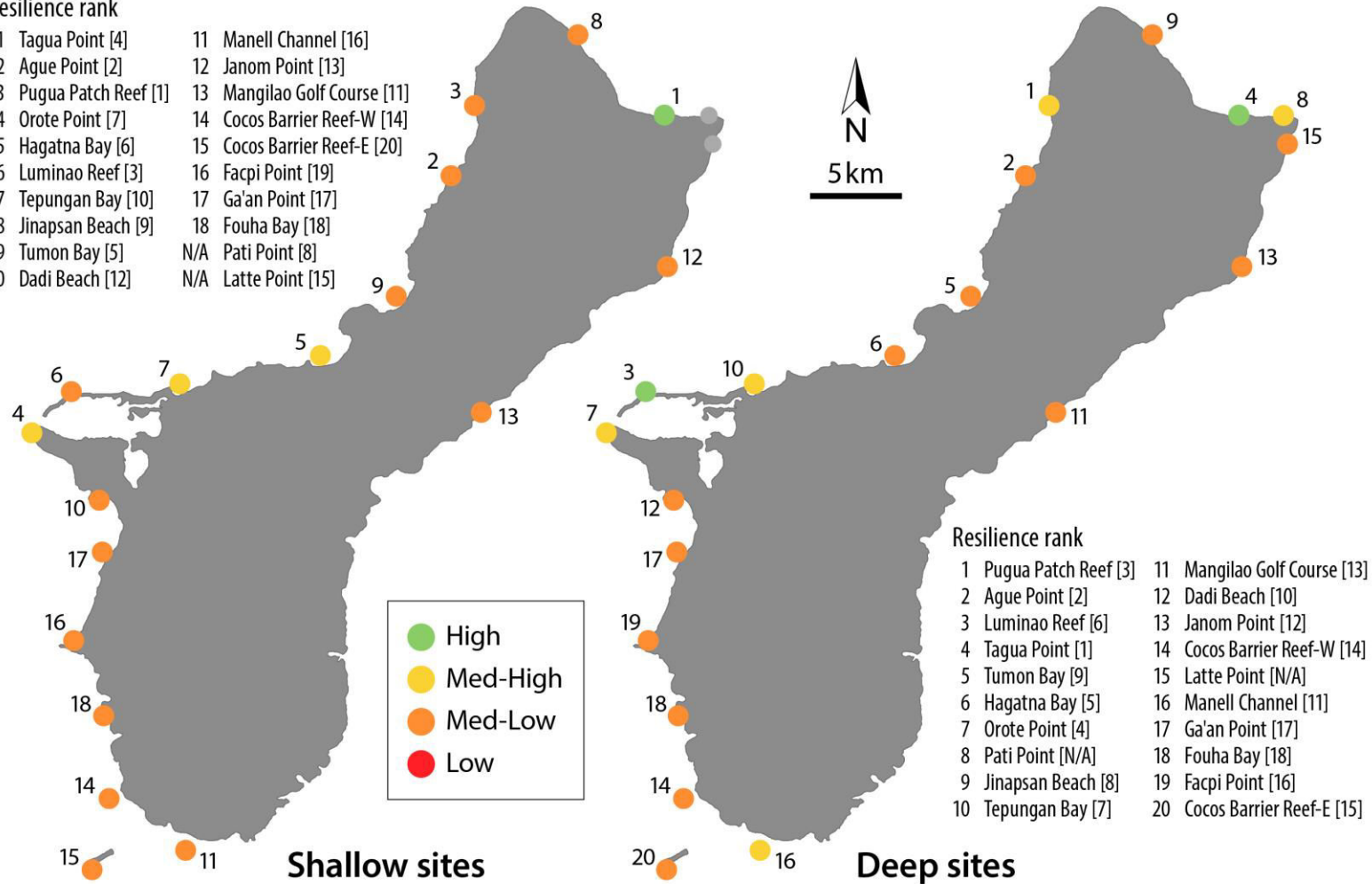


Figure 7. Relative classifications for herbivore biomass. Normalized values for this and the other indicators are presented with Tables 1 and 2.

Temperature Variability

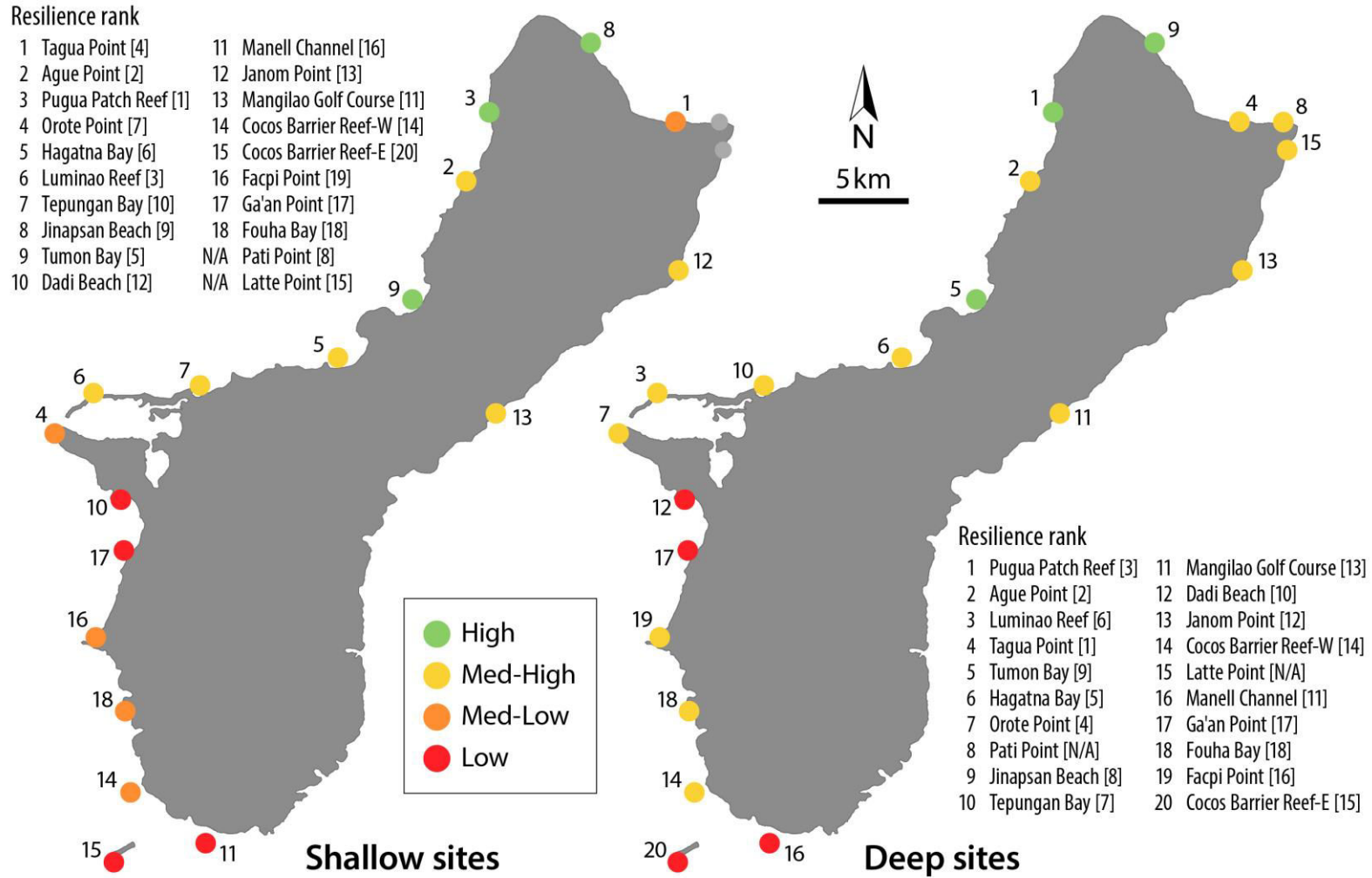


Figure 8. Relative classifications for temperature variability. Normalized values for this and the other indicators are presented with Tables 1 and 2.

Obj. 3. Resilience Drivers

It was possible that high resilience sites could have this classification as a result of having high scores for different indicators and low resilience sites could have low scores for different indicators. We examined whether high scores for some indicators are consistently associated with high resilience (and low scores for some indicators with low resilience) using a CAP analysis.

Across the shallow reef sites of Guam, higher resilience potential correlated most strongly with high coral cover and high coral recruitment (along CAP axis 1), and high herbivore biomass at a single high resilience site (Tagua Point) along CAP axis 2 (Fig. 9). In contrast, low resilience potential sites were negatively correlated with these same three indicators, but were positively associated with increased bleaching resistance (along CAP axis 1) (Fig. 9).

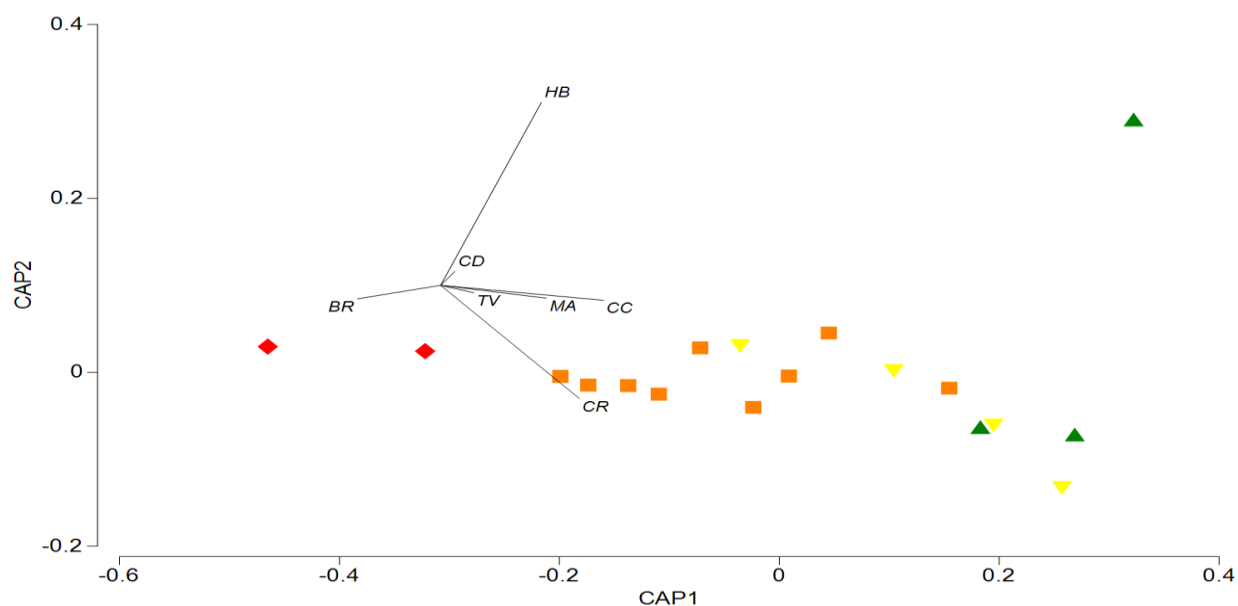


Figure 9. Canonical analysis of principal coordinates showing the relative contribution of the seven resilience indicators (overlaid as vectors) to the overall resilience (High – *green*, Medium-High – *yellow*, Medium-Low – *orange*, Low – *red*) of shallow reef sites at Guam. CC, coral cover; CR, coral recruitment; CD, coral diversity; BR, bleaching resistance; MA, macroalgae cover; HB, herbivore biomass; TV, temperature variability. Squared canonical correlation value (δ^2) of the first and second ordination axes equal 0.778 and 0.122, respectively.

Across the deep reef sites of Guam, higher resilience potential correlated most strongly with high coral recruitment and low macroalgae cover along CAP axis 1 and with higher herbivore biomass and coral cover along CAP axis 2 (Fig. 2). Coral diversity was also positively associated with higher resilience potential along CAP axis 2 and is driving the higher relative resilience at Tagua Point (Fig. 10).

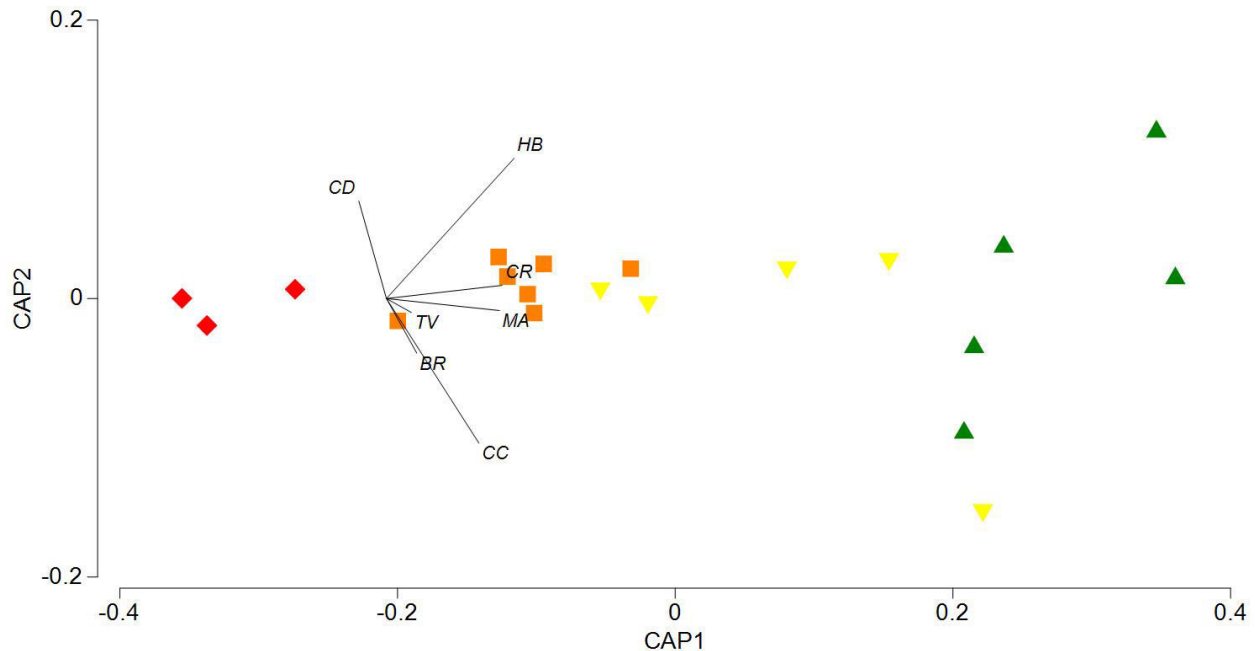


Figure 10. Canonical analysis of principal coordinates showing the relative contribution of the seven resilience indicators (overlaid as vectors) to the overall resilience (High – green, Medium-High – yellow, Medium-Low – orange, Low – red) of deep reef sites at Guam. CC, coral cover; CR, coral recruitment; CD, coral diversity; BR, bleaching resistance; MA, macroalgae cover; HB, herbivore biomass – sum of the grazers, reef builders and browsers; TV, temperature variability. Squared canonical correlation value (δ^2) of the first and second ordination axes equal 0.895 and 0.054, respectively.

Next Steps

The following list includes timely research projects and communication and reporting activities that can build on the research and work presented within this report.

- Reef resilience work can be integrated with ongoing bleaching response planning. Data from the resilience study can help guide managers to the places that are most likely to bleach in the future based upon exposure. At time of report publication, such work was underway. Members of this project team led bleaching response surveys in Guam in October of 2017 to document impacts from recurrent bleaching (reefs in Guam also bleached in 2014 and 2016).
- Continued resilience monitoring can help managers identify the reefs that recover the fastest. These reefs would be likely candidates for stronger management actions (e.g., protected area, gear restrictions) that support continued resilience.
- Results from the resilience assessment can help managers target and tailor management actions. A varied management approach across sites can also help manage the various social needs of the island community.

- Combining the results of the Guam study with the CNMI study can help provide the groundwork for a regional planning and response strategy. While the two jurisdictions face different social, economic, and political futures, they both have to deal with climate change. Pooling resources and taking an archipelago-wide approach to management and planning can only give coral reefs in the Marianas a better chance of coping with climate change.
- The results of subsequent assessments of condition and resiliency at the survey sites can be used to assess the predictive power of this first assessment. Such studies could lead to revisions of the assessment methods used and the guidance we have provided to others (Maynard et al. 2017) that want to replicate or adapt our approach.
- The data and results will be built into a Pacific-wide assessment of coral reef fisheries vulnerability to climate change being led by members of this project team from 2017-2019.
- The resilience assessment data and data collected during ongoing (at time of writing) bleaching characterization/post-bleaching recovery assessments can inform studies on population genetics and connectivity. Results of such studies could add important context to the existing resilience and bleaching data, informing both future assessment methods and management activities.

Outreach

Near this project's conclusion, our team led a workshop in Guam to share the resilience assessment results and describe state-of-art information on projected climate change impacts to the reefs of Guam. About 40 people attended including coral reef and fisheries managers, scientists, educators, policy specialists and managers with the Guam EPA, fishers, staff from conservation organizations and public service non-profits, and students. Two quotes from attendees appear below, with a photo of the workshop group.

“This team has developed so much good information on climate impacts and resilience that I can use to inform how I focus my team’s efforts.” –Jim Richardson (Director of the National Parks Service for Guam and CNMI).

“We now have a far better understanding of how to talk about climate change and explain expected climate change impacts on coastal ecosystems in Guam.” - Joe Quinata (Humatak Foundation)



Workshop attendees, Guam 2017.

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Appendix 1 – Bleaching susceptibility ratings for coral species

Table A1. Most common morphology, bleaching susceptibility rating, and known habitats for all coral species observed during the 2016 surveys. Bleaching susceptibility ratings range from 1-5 (from least to most susceptible). Susceptibility ratings are based on the team’s personal observations during past bleaching events in Guam and CNMI as well as from a literature review. Habitat classifications are as follows, and refer to the types of habitat(s) the species is known to occur in CNMI: Lf = loose framework reef, P = patch reef, Rf = reef flat, SG = spur and groove reef. Lists of coral species observed at each of the 20 survey sites are within the Site Summary Guide – See Appendix 2).

CORAL SPECIES	GROWTH MORPHOLOGY	BLEACHING SUSCEPTIBILITY	HABITAT
<i>Acanthastrea brevis</i>	Encrusting	2	P, Sg
<i>Acanthastrea echinata</i>	Encrusting	2	Lf, P, Rf, Sg
<i>Acanthastrea hillae</i>	Encrusting	2	P, Sg
<i>Acanthastrea c.f. regularis</i>	Encrusting	2	Lf
<i>Acropora abrotanoides</i>	Arborescent	3	Lf, P, Sg
<i>Acropora aspera</i>	Staghorn	5	P, Rf
<i>Acropora azurea</i>	Digitate/corymbose	4	Lf, Sg
<i>Acropora cerealis</i>	Digitate/corymbose	4	Lf, Sg
<i>Acropora cophydactyla</i>	Digitate/corymbose	3	Lf
<i>Acropora cuneata</i>	Arborescent	2	P
<i>Acropora digitifera</i>	Digitate/corymbose	3	Lf, P, Sg
<i>Acropora gemmifera</i>	Digitate/corymbose	3	Lf, Sg
<i>Acropora granulosa</i>	Digitate/corymbose	3	Lf, Sg
<i>Acropora humilis</i>	Digitate/corymbose	3	Lf, Sg
<i>Acropora juv.</i>	Branching	3	Lf, P, Sg
<i>Acropora latistella</i>	Digitate/corymbose	4	Lf, P, Sg
<i>Acropora monticulosa</i>	Arborescent	3	Lf, Rf, Sg
<i>Acropora muricata</i>	Staghorn	5	P
<i>Acropora nana</i>	Digitate/corymbose	5	Sg
<i>Acropora nasuta</i>	Digitate/corymbose	5	Lf, Sg
<i>Acropora pulchra</i>	Staghorn	5	Rf
<i>Acropora robusta</i>	Arborescent	4	Lf, Sg
<i>Acropora secale</i>	Digitate/corymbose	3	Lf, P, Sg
<i>Acropora surculosa</i>	Digitate/corymbose	3	Lf, P, Sg
<i>Acropora c.f. striata</i>	Digitate/corymbose	4	Sg
<i>Acropora tenuis</i>	Digitate/corymbose	5	Lf, P, Rf, Sg
<i>Acropora teres</i>	Staghorn	5	P, Rf
<i>Acropora vaughani</i>	Digitate/corymbose	4	Lf, Rf, Sg
<i>Acropora verweyi</i>	Digitate/corymbose	4	Lf, P, Sg

Coral reef resilience to climate change in Guam in 2016

CORAL SPECIES	GROWTH MORPHOLOGY	BLEACHING SUSCEPTIBILITY	HABITAT
<i>Alveopora fenestrata</i>	Massive	3	Lf
<i>Astreopora gracilis</i>	Massive	4	Lf
<i>Astreopora listeri</i>	Massive	4	Lf, P, Sg
<i>Astreopora myriophthalma</i>	Massive	4	Lf, P, Sg
<i>Astreopora randalli</i>	Massive	4	Lf, Sg
<i>Cyphastrea agassizi</i>	Massive	3	Lf, Sg
<i>Cyphastrea chalcidicum</i>	Massive	3	Lf, P, Sg
<i>Cyphastrea c.f. japonica</i>	Massive	3	Sg
<i>Cyphastrea ocellina</i>	Massive	3	Lf, Sg
<i>Cyphastrea seraila</i>	Massive	3	Lf, Sg
<i>Diploastrea heliopora</i>	Massive	1	Lf
<i>Echinophyllia aspera</i>	Encrusting	2	P
<i>Echinopora lamellosa</i>	Plate	2	Lf, P, Sg
<i>Favia danae</i>	Massive	3	Lf, R
<i>Favia fавus</i>	Massive	3	Lf, P, Sg
<i>Favia helianthoides</i>	Massive	3	Lf, Sg
<i>Favia mathaii</i>	Massive	3	Lf, P, Sg
<i>Favia pallida</i>	Massive	3	Lf, Sg
<i>Favia rotumana</i>	Massive	3	P
<i>Favia speciosa</i>	Massive	3	Lf, P, Sg
<i>Favia stelligera</i>	Massive	4	Lf, Sg
<i>Favites abdita</i>	Massive	2	Lf, P, Sg
<i>Favites flexuosa</i>	Massive	2	Lf, P
<i>Favites russelli</i>	Massive	1	Lf, P, Rf, Sg
<i>Fungia sp.</i>	Free-living	2	Lf
<i>Fungia fungites</i>	Free-living	2	Lf
<i>Fungia paumotensis</i>	Free-living	2	Lf
<i>Fungia repanda</i>	Free-living	2	Lf
<i>Fungia scutaria</i>	Free-living	2	Lf, P, Sg
<i>Galaxea fascicularis</i>	Encrusting	3	Lf, P, Sg
<i>Gardineroseris planulata</i>	Massive	3	Lf, Sg
<i>Goniastrea aspera</i>	Massive	4	P
<i>Goniastrea edwardsi</i>	Massive	4	Lf, P, Rf, Sg
<i>Goniastrea pectinata</i>	Massive	3	Lf, P, Sg
<i>Goniastrea retiformis</i>	Massive	4	Lf, P, Rf, Sg
<i>Goniopora djiboutiensis</i>	Massive	1	Lf
<i>Goniopora fruticosa</i>	Encrusting	1	Lf, Sg
<i>Goniopora minor</i>	Massive	1	P
<i>Heliopora coerulea</i>	Branching	1	Lf, P, Rf
<i>Hydnophora microconos</i>	Massive	4	Lf, P, Rf, Sg
<i>Isopora palifera</i>	Arborescent	2	Lf, P, Sg
<i>Leptastrea bottae</i>	Encrusting	2	Lf, P, Sg

CORAL SPECIES	GROWTH MORPHOLOGY	BLEACHING SUSCEPTIBILITY	HABITAT
<i>Leptastrea purpurea</i>	Encrusting	2	Lf, P, Sg
<i>Leptastrea transversa</i>	Encrusting	2	Lf, Sg
<i>Leptoria phrygia</i>	Massive	3	Lf, P, Rf, Sg
<i>Lobophyllia corymbosa</i>	Massive	3	Lf, Sg
<i>Lobophyllia hemprichii</i>	Massive	3	Sg
<i>Millepora dichotoma</i>	Branching	1	Sg
<i>Millepora platyphylla</i>	Massive	1	Lf
<i>Millepora tuberosa</i>	Encrusting	1	Lf, P, Sg
<i>Montastrea curta</i>	Massive	3	Lf, P, Sg
<i>Montastrea valenciennesi</i>	Massive	3	Lf, Sg
<i>Montipora</i> sp.	Encrusting	4	Lf, P, Rf, Sg
<i>Montipora aequituberculata</i>	Encrusting	4	Lf, Sg
<i>Montipora caliculata</i>	Encrusting	4	Lf, P, Sg
<i>Montipora danae</i>	Encrusting	4	P, Sg
<i>Montipora efflorescens</i>	Encrusting	4	Lf, P, Sg
<i>Montipora floweri</i>	Encrusting	4	Lf, Sg
<i>Montipora foveolata</i>	Encrusting	4	Lf, Sg
<i>Montipora grisea</i>	Encrusting	4	Lf, Sg
<i>Montipora hoffmeisteri</i>	Encrusting	4	Sg
<i>Montipora lobulata</i>	Encrusting	4	P
<i>Montipora monasteriata</i>	Encrusting	4	Lf, P, Sg
<i>Montipora nodosa</i>	Encrusting	4	Lf, P, Rf, Sg
<i>Montipora tuberculosa</i>	Encrusting	4	Lf, P, Sg
<i>Montipora verrilli</i>	Encrusting	4	P, Sg
<i>Montipora verrucosa</i>	Encrusting	4	Lf, Sg
<i>Oulophyllia crispa</i>	Massive	3	Lf, Sg
<i>Pavona cactus</i>	Foliose	3	P
<i>Pavona divaricata</i>	Foliose	3	Lf, P, Rf, Sg
<i>Pavona duerdini</i>	Massive	4	Lf, P, Sg
<i>Pavona explanulata</i>	Cryptic	3	Lf
<i>Pavona frondifera</i>	Cryptic	3	Lf
<i>Pavona maldiviensis</i>	Cryptic	3	Lf, Sg
<i>Pavona minuta</i>	Encrusting	3	Lf
<i>Pavona varians</i>	Encrusting	1	Lf, P, Sg
<i>Pavona venosa</i>	Encrusting	2	Lf, Sg
<i>Platygyra daedalea</i>	Massive	3	P, Sg
<i>Platygyra pini</i>	Massive	3	Lf, P, Sg
<i>Plesiastrea versipora</i>	Massive	1	Lf, Sg
<i>Pocillopora</i> sp.	Digitate/corymbose	4	Lf, P, Sg
<i>Pocillopora ankeli</i>	Digitate/corymbose	4	Lf, Sg
<i>Pocillopora damicornis</i>	Digitate/corymbose	2	Lf, P, Rf, Sg

Coral reef resilience to climate change in Guam in 2016

CORAL SPECIES	GROWTH MORPHOLOGY	BLEACHING SUSCEPTIBILITY	HABITAT
<i>Pocillopora danae</i>	Digitate/corymbose	3	Lf, Sg
<i>Pocillopora elegans</i>	Digitate/corymbose	4	Lf, P, Sg
<i>Pocillopora eydouxi</i>	Digitate/corymbose	4	Sg
<i>Pocillopora meandrina</i>	Digitate/corymbose	4	Lf, Sg
<i>Pocillopora verrucosa</i>	Digitate/corymbose	4	Lf, Sg
<i>Pocillopora woodjonesi</i>	Digitate/corymbose	4	Sg
<i>Porites</i> sp.	Massive	1	Lf, P, Rf, Sg
<i>Porites annae</i>	Massive	2	Lf
<i>Porites australiensis</i>	Massive	1	Lf, Sg
<i>Porites cylindrica</i>	Branching	2	Lf, Rf, Sg
<i>Porites deformis</i>	Columnar	2	Lf
<i>Porites densa</i>	Massive	1	Lf
<i>Porites lichen</i>	Encrusting	1	Lf, P, Sg
<i>Porites lobata</i>	Massive	1	Lf, P, Sg
<i>Porites lutea</i>	Massive	1	Lf, P, Rf, Sg
<i>Porites "massive"</i> (<i>lobata/lutea/australiensis</i>)	Massive	1	Lf, P, Rf, Sg
<i>Porites rus</i>	Columnar	1	Lf, P, Sg
<i>Porites vauhani</i>	Encrusting	1	Lf, P, Sg
<i>Psammocora</i> sp.	Encrusting	1	Lf, P, Rf, Sg
<i>Psammocora digitata</i>	Columnar	2	Lf, Rf
<i>Psammocora haimeana</i>	Cryptic	1	Lf, Sg
<i>Psammocora nierstrazi</i>	Encrusting	1	Lf, P, Sg
<i>Psammocora stellata</i>	Cryptic	1	Rf
<i>Scolymia australis</i>	Encrusting	1	P
<i>Stylocoeniella armata</i>	Encrusting	1	Lf, P, Rf, Sg
<i>Stylocoeniella guentheri</i>	Encrusting	1	Lf
<i>Stylophora mordax</i>	Branching	5	Lf, P, Rf, Sg
<i>Turbinaria reniformis</i>	Plate	3	Lf, Sg
<i>Turbinaria stellulata</i>	Encrusting	2	Lf, Sg

Appendix 2 - Site Summary Guide

The first one-page summary is shown in the graphic below. Each part of the summary is enclosed within a box that has a letter label. Descriptions are provided below for each of these parts of the summary, next to the relevant letter label. The 20 one-page summaries are in the upcoming pages.

A – Site name and resilience rankings for the shallow and deep reef areas.

B – Site name origin and map showing the location of the survey site in Guam.

C – Representative site photos for each depth with site coordinates.

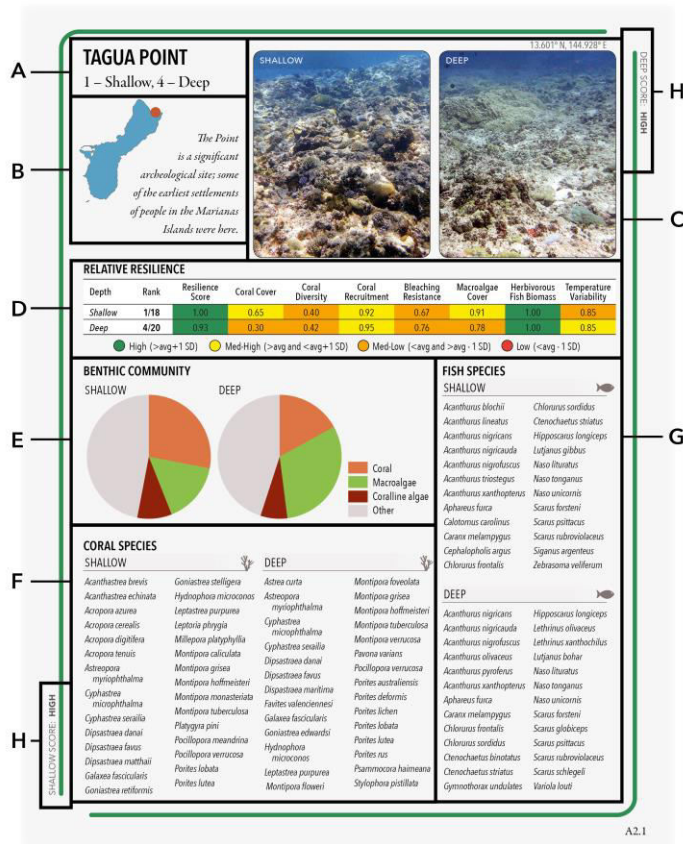
D – Resilience and resilience indicator scores with colors signifying relative classes.

E – Benthic community pie charts showing percent cover of the four major benthic groups for the shallow and deep reef areas. ‘Other’ refers mostly to turfing algae and, to a lesser degree, unconsolidated substrate.

F – Lists of coral species observed.

G – Lists of fish species observed

H – Relative class for the resilience scores for the shallow (left and top) and deep (right and bottom) reef areas.

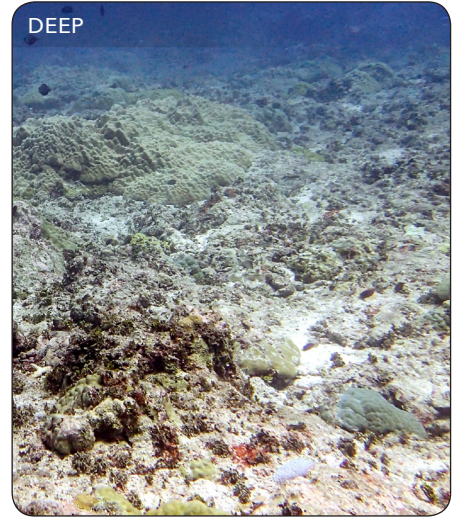


TAGUA POINT

1 – Shallow, 4 – Deep



The Point is a significant archeological site; some of the earliest settlements of people in the Marianas Islands were here.



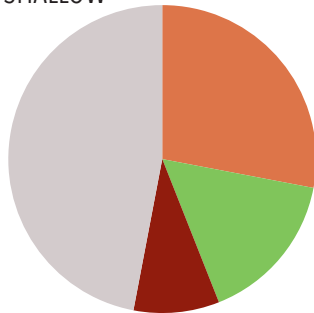
RELATIVE RESILIENCE

Depth	Rank	Resilience Score	Coral Cover	Coral Diversity	Coral Recruitment	Bleaching Resistance	Macroalgae Cover	Herbivorous Fish Biomass	Temperature Variability
Shallow	1/18	1.00	0.65	0.40	0.92	0.67	0.91	1.00	0.85
Deep	4/20	0.93	0.30	0.42	0.95	0.76	0.78	1.00	0.85

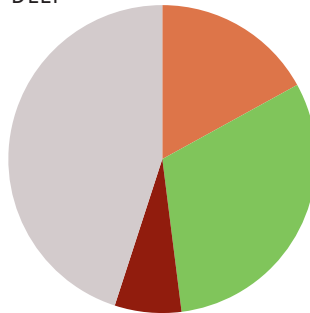
● High (>avg+1 SD) ● Med-High (>avg and <avg+1 SD) ● Med-Low (<avg and >avg - 1 SD) ● Low (<avg - 1 SD)

BENTHIC COMMUNITY

SHALLOW



DEEP



● Coral
● Macroalgae
● Coralline algae
● Other

FISH SPECIES

SHALLOW

- Acanthurus blochii*
- Acanthurus lineatus*
- Acanthurus nigricans*
- Acanthurus nigricauda*
- Acanthurus nigrofuscus*
- Acanthurus triostegus*
- Acanthurus xanopterus*
- Aphareus furca*
- Calotomus carolinus*
- Caranx melampygus*
- Cephalopholis argus*
- Chlorurus frontalis*
- Chlorurus sordidus*
- Ctenochaetus striatus*
- Hipposcarus longiceps*
- Lutjanus gibbus*
- Naso lituratus*
- Naso tonganus*
- Naso unicornis*
- Scarus forsteni*
- Scarus psittacus*
- Scarus rubroviolaceus*
- Siganus argenteus*
- Zebрасoma veliferum*

CORAL SPECIES

SHALLOW

- Acanthastrea brevis*
- Acanthastrea echinata*
- Acropora azurea*
- Acropora cerealis*
- Acropora digitifera*
- Acropora tenuis*
- Astreopora myriophthalma*
- Cyphastrea microphthalma*
- Cyphastrea serailia*
- Dipsastraea danai*
- Dipsastraea favus*
- Dipsastraea matthaii*
- Galaxea fascicularis*
- Goniastrea retiformis*

- Goniastrea stelligera*
- Hydnophora microconos*
- Leptastrea purpurea*
- Leptoria phrygia*
- Millepora platyphyllia*
- Montipora caliculata*
- Montipora grisea*
- Montipora hoffmeisteri*
- Montipora monasteriata*
- Montipora tuberculosa*
- Platygyra pini*
- Pocillopora meandrina*
- Pocillopora verrucosa*
- Porites lobata*
- Porites lutea*

DEEP

- Astrea curta*
- Astreopora myriophthalma*
- Cyphastrea microphthalma*
- Cyphastrea serailia*
- Dipsastraea danai*
- Dipsastraea favus*
- Dispastraea maritima*
- Favites valenciennesi*
- Galaxea fascicularis*
- Goniastrea edwardsi*
- Hydnophora microconos*
- Leptastrea purpurea*
- Montipora floweri*

- Montipora foveolata*
- Montipora grisea*
- Montipora hoffmeisteri*
- Montipora tuberculosa*
- Montipora verrucosa*
- Pavona varians*
- Pocillopora verrucosa*
- Porites australiensis*
- Porites deformis*
- Porites lichen*
- Porites lobata*
- Porites lutea*
- Porites rus*
- Psammocora haimeana*
- Stylophora pistillata*

DEEP

- Acanthurus nigricans*
- Acanthurus nigricauda*
- Acanthurus nigrofuscus*
- Acanthurus olivaceus*
- Acanthurus pyroferus*
- Acanthurus xanopterus*
- Aphareus furca*
- Caranx melampygus*
- Chlorurus frontalis*
- Chlorurus sordidus*
- Ctenochaetus binotatus*
- Ctenochaetus striatus*
- Gymnothorax undulates*
- Hipposcarus longiceps*
- Lethrinus olivaceus*
- Lethrinus xanthochilus*
- Lutjanus bohar*
- Naso lituratus*
- Naso tonganus*
- Naso unicornis*
- Scarus forsteni*
- Scarus globiceps*
- Scarus psittacus*
- Scarus rubroviolaceus*
- Scarus schlegeli*
- Variola louti*

AGUE POINT

2 – Shallow, 2 – Deep



Ague Cove, located near the Point, is a popular hiking and swimming destination as the cove creates a natural swimming pool.



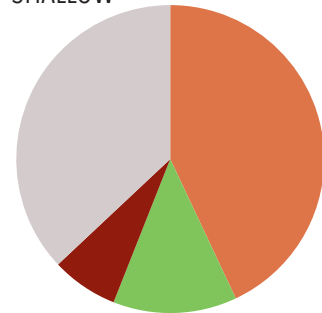
RELATIVE RESILIENCE

Depth	Rank	Resilience Score	Coral Cover	Coral Diversity	Coral Recruitment	Bleaching Resistance	Macroalgae Cover	Herbivorous Fish Biomass	Temperature Variability
Shallow	2/18	0.99	1.00	0.67	0.96	0.80	0.94	0.07	0.89
Deep	2/20	0.95	0.66	0.62	0.96	0.84	1.00	0.20	0.89

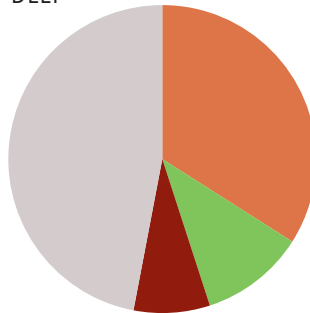
● High (>avg+1 SD) ● Med-High (>avg and <avg+1 SD) ● Med-Low (<avg and >avg - 1 SD) ● Low (<avg - 1 SD)

BENTHIC COMMUNITY

SHALLOW



DEEP



● Coral
● Macroalgae
● Coralline algae
● Other

FISH SPECIES

SHALLOW

- Acanthurus lineatus*
- Acanthurus nigricans*
- Acanthurus nigrofuscus*
- Acanthurus pyroferus*
- Aphareus furca*
- Chlorurus sordidus*
- Ctenochaetus binotatus*
- Ctenochaetus striatus*
- Naso lituratus*
- Naso unicornis*
- Scarus psittacus*

CORAL SPECIES

SHALLOW

- Acanthastrea echinata*
- Acropora abrotenoides*
- Acropora digitifera*
- Acropora globiceps*
- Acropora surculosa*
- Acropora verweyi*
- Astrea curta*
- Cyphastrea chalcidicum*
- C. microphthalmum*
- Dipsastraea danai*
- Dipsastraea favus*
- Dipsastraea maritima*
- Dipsastraea matthaii*
- Dipsastraea pallida*
- Favites colemani*
- Favites valenciennesi*
- Galaxea fascicularis*
- Goniastrea retiformis*
- Hydnophora microconus*

- Leptastrea purpurea*
- Leptoria phrygia*
- Millepora dichotoma*
- Millepora platyphyllia*
- Montipora c.f. studeri*
- Montipora caliculata*
- Montipora grisea*
- Montipora hoffmeisteri*
- Montipora monasteriata*
- Montipora nodosa*
- Montipora tuberculosa*
- Pavona c.f. meandrina*
- Pavona chriquiensis*
- Pavona varians*
- Pocillopora meandrina*
- Pocillopora verrucosa*
- Porites australiensis*
- Porites horizontalata*
- Porites lutea*

DEEP

- Acanthastrea brevis*
- Astreopora listeria*
- Astreopora myriophthalma*
- Astreopora ocellata*
- Cyphastrea serailia*
- Dipsastraea danai*
- Dipsastraea favus*
- Dipsastraea maritima*
- Dipsastraea matthaii*
- Favites colemani*
- Favites valenciennesi*
- Goniastrea edwardsi*
- Leptastrea purpurea*
- Montipora caliculata*
- Montipora tuberculosa*

DEEP

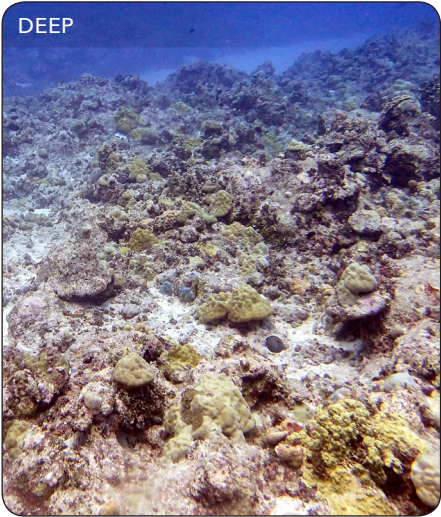
- Acanthurus nigricans*
- Acanthurus nigricauda*
- Acanthurus nigrofuscus*
- Acanthurus pyroferus*
- Aphareus furca*
- Chlorurus sordidus*
- Ctenochaetus binotatus*
- Ctenochaetus striatus*
- Gymnosarda unicolor*
- Naso lituratus*
- Naso vlamingii*
- Scarus globiceps*
- Scarus psittacus*
- Scarus schlegeli*

PUGUA PATCH REEF

3 – Shallow, 1 – Deep



Also known as Double Reef, this is a pair of two patch reefs, which house some of the highest biodiversity seen during these surveys.



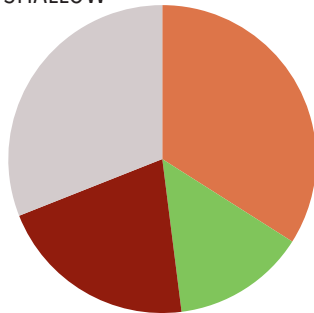
RELATIVE RESILIENCE

Depth	Rank	Resilience Score	Coral Cover	Coral Diversity	Coral Recruitment	Bleaching Resistance	Macroalgae Cover	Herbivorous Fish Biomass	Temperature Variability
Shallow	3/18	0.96	0.79	0.66	1.00	0.78	0.93	0.08	0.93
Deep	1/20	1.00	0.43	1.00	0.95	0.89	0.94	0.32	0.93

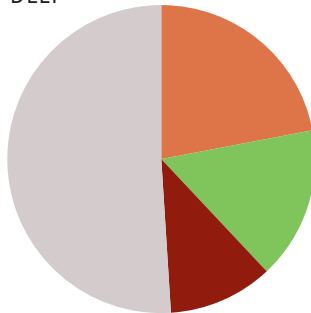
● High (>avg+1 SD) ● Med-High (>avg and <avg+1 SD) ● Med-Low (<avg and >avg - 1 SD) ● Low (<avg - 1 SD)

BENTHIC COMMUNITY

SHALLOW



DEEP



● Coral
● Macroalgae
● Coralline algae
● Other

FISH SPECIES

SHALLOW



- Acanthurus nigricans*
- Acanthurus nigrofuscus*
- Aphareus furca*
- Chlorurus sordidus*
- Ctenochaetus striatus*
- Naso lituratus*
- Scarus psittacus*

CORAL SPECIES

SHALLOW



- Acanthastrea brevis*
- Acanthastrea echinata*
- Acropora digitifera*
- Cyphastrea chalcidicum*
- C. microphthalma*
- Cyphastrea serailia*
- Dipsastraea favus*
- Dipsastraea maritima*
- Dipsastraea matthaii*
- Dipsastraea pallida*
- Dipsastraea speciosa*
- Favites colemani*
- Favites valenciennesi*
- Galaxea fascicularis*
- Goniastrea edwardsi*
- Goniastrea retiformis*
- Goniastrea stelligera*
- Leptoria phrygia*
- Leptoseris mycetoseroides*

- Montipora hoffmeisteri*
- Montipora tuberculosa*
- Montipora venosa*
- Paragoniastrea russelli*
- Pavona chriquiensis*
- Pavona clavus*
- Pavona duerdeni*
- Pavona varians*
- Platygyra pini*
- Pocillopora verrucosa*
- Porites australiensis*
- Porites deformis*
- Porites lichen*
- Porites lobata*
- Porites lutea*
- Porites rus*
- Porites vaughani*
- Psammocora contigua*
- Psammocora nierstrazi*
- Stylocoeniella armata*

DEEP



- Acropora globiceps*
- Astreopora gracilis*
- Astreopora myriophthalma*
- Astreopora randalli*
- Cyphastrea chalcidicum*
- Cyphastrea microphthalma*
- Cyphastrea serailia*
- Dipsastraea favus*
- Dipsastraea maritima*
- Dipsastraea matthaii*
- Dipsastraea stelligera*
- Favites colemani*
- Favites valenciennesi*
- Goniastrea edwardsi*

- Goniastrea pectinata*
- Leptastrea purpurea*
- Leptastrea transversa*
- Montipora hoffmeisteri*
- Montipora venosa*
- Paragoniastrea russelli*
- Pavona c.f. meandrina*
- Pavona varians*
- Porites australiensis*
- Porites lichen*
- Porites lobata*
- Porites lutea*
- Porites rus*
- Psammocora haimeana*
- Psammocora nierstrazi*
- Stylocoeniella armata*

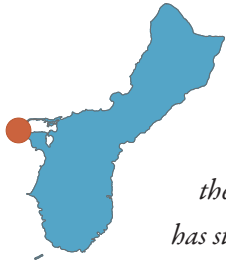
DEEP



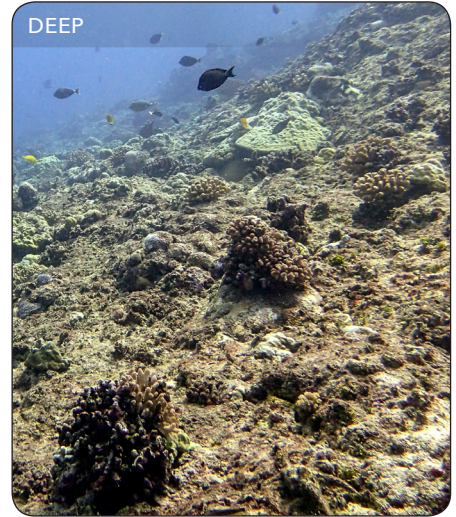
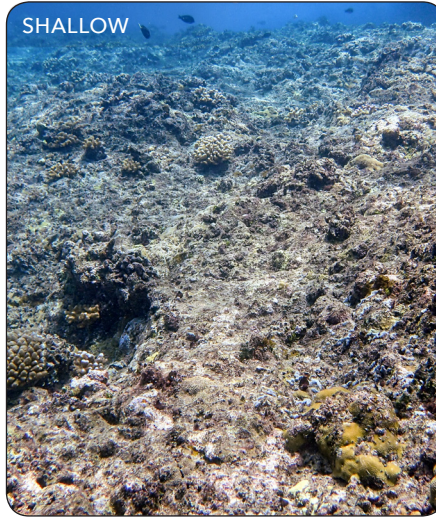
- Acanthurus nigricans*
- Acanthurus nigrofuscus*
- Aphareus furca*
- Cephalopholis argus*
- Chlorurus microrhinos*
- Chlorurus sordidus*
- Ctenochaetus striatus*
- Naso lituratus*
- Scarus forsteni*
- Scarus globiceps*
- Scarus psittacus*
- Scarus schlegeli*
- Zebrosoma flavescens*

OROTE POINT

4 – Shallow, 7 – Deep



Surrounding Apra Harbor, the Orote Peninsula has steep drop-offs that plunge from shallow reefs to 50 m depths.



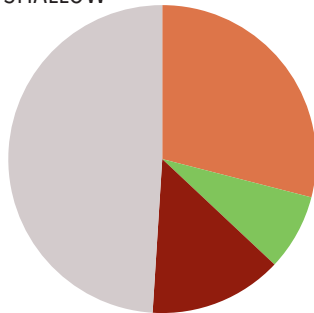
RELATIVE RESILIENCE

Depth	Rank	Resilience Score	Coral Cover	Coral Diversity	Coral Recruitment	Bleaching Resistance	Macroalgae Cover	Herbivorous Fish Biomass	Temperature Variability
Shallow	4/18	0.94	0.66	0.75	0.93	0.75	1.00	0.15	0.83
Deep	7/20	0.86	0.27	0.64	0.88	0.85	0.89	0.36	0.83

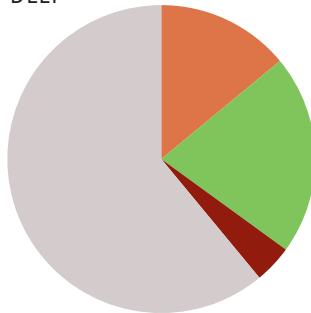
● High (>avg+1 SD) ● Med-High (>avg and <avg+1 SD) ● Med-Low (<avg and >avg - 1 SD) ● Low (<avg - 1 SD)

BENTHIC COMMUNITY

SHALLOW



DEEP



● Coral
● Macroalgae
● Coralline algae
● Other

FISH SPECIES

SHALLOW

- Acanthurus lineatus*
- Acanthurus nigricans*
- Acanthurus nigrofuscus*
- Acanthurus olivaceus*
- Acanthurus triostegus*
- Aphareus furca*
- Chlorurus sordidus*
- Ctenochaetus striatus*
- Monotaxis grandoculis*
- Naso lituratus*
- Naso vlamingii*
- Scarus psittacus*
- Scarus schlegeli*
- Zebbrasoma flavescens*
- Zebbrasoma veliferum*

CORAL SPECIES

SHALLOW

- Acanthastrea brevis*
- Acropora palmerae*
- Acropora surculosa*
- Astrea curta*
- Cyphastrea microphthalma*
- Dipsastraea matthaii*
- Favites colemani*
- Favites valenciennesi*
- Goniastrea edwardsi*
- Goniastrea stelligera*
- Hydnophora microconos*
- Leptastrea purpurea*
- Leptoria phrygia*
- Montipora efflorescens*
- Montipora grisea*
- Montipora hoffmeisteri*
- Montipora tuberculosa*
- Pavona varians*
- Platygyra pini*
- Pocillopora ankeli*
- Pocillopora elegans*
- Pocillopora eydouxi*
- Pocillopora verrucosa*
- Porites lobata*
- Porites lutea*
- Psammocora haimeana*

DEEP

- Acanthastrea brevis*
- Acropora gemmifera*
- Acropora globiceps*
- Astreopora listeri*
- Astreopora myriophthalma*
- Astreopora ocellata*
- Cyphastrea serialia*
- Dipsastraea helianthoides*
- Dipsastraea maritima*
- Dipsastraea matthaii*
- Favites colemani*
- Favites valenciennesi*
- Galaxea fascicularis*
- Goniastrea edwardsi*
- Leptastrea purpurea*
- Montipora grisea*
- Montipora nodosa*
- Montipora verrucosa*
- Pavona meandrina*
- Pavona varians*
- Pocillopora verrucosa*
- Porites australiensis*
- Porites lutea*
- Psammocora haimeana*
- Scapophyllia cylindrica*

DEEP

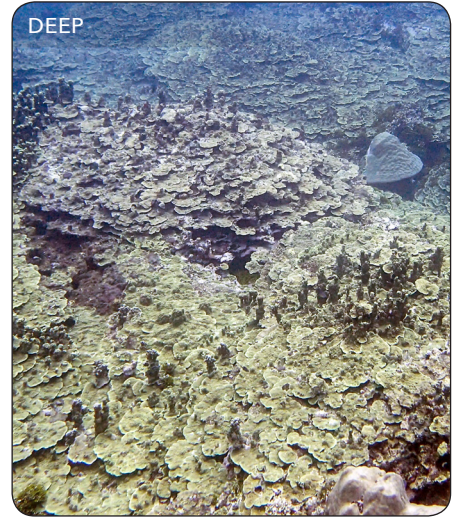
- Acanthurus nigricans*
- Acanthurus nigricauda*
- Acanthurus nigrofuscus*
- Acanthurus olivaceus*
- Acanthurus triostegus*
- Aphareus furca*
- Calotomus carolinus*
- Caranx melampygus*
- Chlorurus sordidus*
- Ctenochaetus striatus*
- Monotaxis grandoculis*
- Naso brevirostris*
- Naso lituratus*
- Naso unicornis*
- Naso vlamingii*
- Scarus forsteni*
- Scarus psittacus*
- Scarus schlegeli*
- Zebbrasoma flavescens*

HAGÁTÑA BAY

5 – Shallow, 6 – Deep



The capital of Guam, Hagåtña is derived from the Chamorro word *haga*, which means blood and is thought to represent the bloodlines of the families that established the village.



RELATIVE RESILIENCE

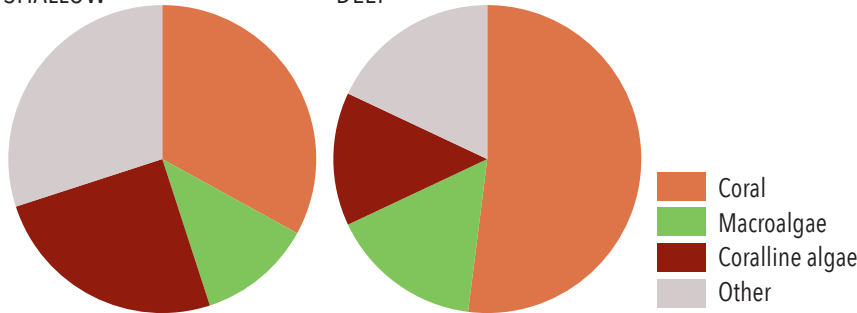
Depth	Rank	Resilience Score	Coral Cover	Coral Diversity	Coral Recruitment	Bleaching Resistance	Macroalgae Cover	Herbivorous Fish Biomass	Temperature Variability
Shallow	5/18	0.93	0.78	0.43	0.92	0.89	0.96	0.18	0.89
Deep	6/20	0.88	1.00	0.47	0.39	1.00	0.94	0.10	0.89

● High (>avg+1 SD) ● Med-High (>avg and <avg+1 SD) ● Med-Low (<avg and >avg - 1 SD) ● Low (<avg - 1 SD)

BENTHIC COMMUNITY

SHALLOW

DEEP



FISH SPECIES

SHALLOW

- Acanthurus nigricans*
- Acanthurus nigrofuscus*
- Aphareus furca*
- Carangoides ferdau*
- Chlorurus sordidus*
- Ctenochaetus striatus*
- Naso lituratus*
- Naso unicornis*
- Scarus psittacus*
- Scomberoides lysan*

CORAL SPECIES

SHALLOW

DEEP

- Acanthastrea echinata*
- Astrea curta*
- Astreopora myriophthalma*
- Dipsastraea favus*
- Dipsastraea maritima*
- Dipsastraea pallida*
- Favites colemani*
- Favites valenciennesi*
- Galaxea fascicularis*
- Goniastrea retiformis*
- Goniastrea stelligera*
- Hydnophora microconos*
- Leptastrea purpurea*
- Leptoria phrygia*
- Millepora platyphyllia*
- Montipora aequituberculata*
- Montipora caliculata*
- Montipora danae*
- Montipora efflorescens*
- Montipora tuberculosa*
- Montipora venosa*
- Pavona clavus*
- Pavona varians*
- Pocillopora damicornis*
- Porites deformis*
- Porites lutea*
- Porites rus*
- Stylocoeniella armata*

DEEP

- Galaxea fascicularis*
- Pocillopora verrucosa*
- Porites monticulosa*
- Porites rus*
- Porites vaughani*
- Psammocora profundacella*

DEEP

- Acanthurus nigricans*
- Acanthurus nigrofuscus*
- Aphareus furca*
- Chlorurus microrhinos*
- Chlorurus sordidus*
- Ctenochaetus striatus*
- Lutjanus fulvus*
- Monotaxis grandoculis*
- Naso lituratus*
- Naso unicornis*
- Scarus psittacus*
- Zebrosoma flavescens*

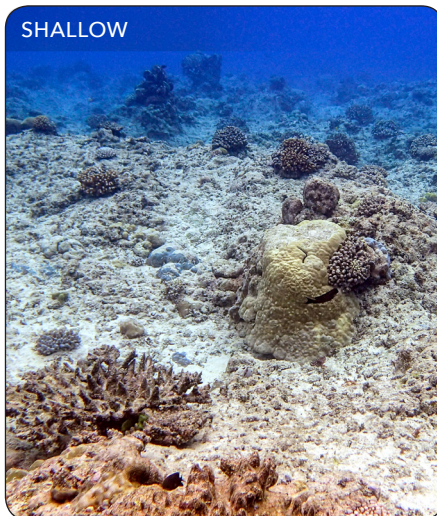
LUMINAO REEF

6 – Shallow, 3 – Deep



Enclosing Apra Harbor, Luminao Reef has the Glass Breakwater built atop it. Luminao is Chamorro for earthquake, named for the sound the waves make while breaking.

13.466° N, 144.638° E



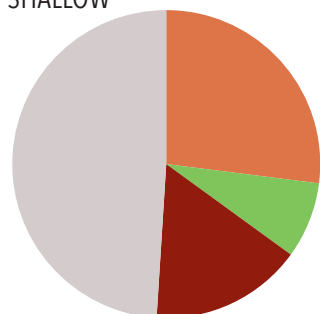
RELATIVE RESILIENCE

Depth	Rank	Resilience Score	Coral Cover	Coral Diversity	Coral Recruitment	Bleaching Resistance	Macroalgae Cover	Herbivorous Fish Biomass	Temperature Variability
Shallow	6/18	0.91	0.62	1.00	0.72	0.66	0.99	0.08	0.86
Deep	3/20	0.93	0.41	0.41	0.98	0.91	1.00	0.54	0.86

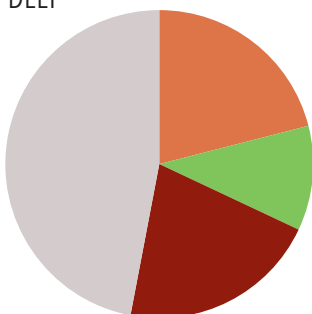
● High (>avg+1 SD) ● Med-High (>avg and <avg+1 SD) ● Med-Low (<avg and >avg - 1 SD) ● Low (<avg - 1 SD)

BENTHIC COMMUNITY

SHALLOW



DEEP



● Coral
● Macroalgae
● Coralline algae
● Other

FISH SPECIES

SHALLOW



- Acanthurus nigrofuscus*
- Chlorurus microrhinos*
- Chlorurus sordidus*
- Ctenochaetus striatus*
- Naso lituratus*
- Scarus psittacus*
- Zebrasoma veliferum*

CORAL SPECIES

SHALLOW



- Acanthastrea echinata*
- Acropora surculosa*
- Astrea curta*
- Cyphastrea micropthalma*
- Favia stelligera*
- Galaxea fascicularis*
- Goniastrea retiformis*
- Hydnophora microconos*
- Leptastrea purpurea*
- Leptoria phrygia*
- Montipora foveolata*
- Montipora grisea*
- Montipora tuberculosa*
- Montipora verrucosa*
- Pavona varians*
- Platygyra pini*
- Pocillopora elegans*
- Porites australiensis*
- Porites lobata*

DEEP



- Astreopora myriophthalma*
- Coscinaraea columna*
- Cycloseris vaughani*
- Cyphastrea chalcidicum*
- Dipsastraea danai*
- Dipsastraea favus*
- Dipsastraea maritima*
- Dipsastraea matthaii*
- Dipsastraea pallida*
- Favites colemani*
- Favites valenciennesi*
- Goniastrea edwardsi*
- Goniastrea retiformis*
- Goniastrea stelligera*
- Herpolitha weberi*
- Leptastrea purpurea*
- Leptoria phrygia*
- Lobophyllia hemprichii*
- Montipora tuberculosa*
- Paragoniastrea russelli*
- Pavona clavus*
- Pavona varians*
- Porites australiensis*
- Porites lobata*
- Porites lutea*
- Porites rus*
- Porites vaughani*
- Psammocora haimeana*
- Psammocora nierstrazi*
- Stylocoeniella armata*

DEEP



- Acanthurus nigricans*
- Acanthurus nigricauda*
- Acanthurus nigrofuscus*
- Acanthurus olivaceus*
- Aphareus furca*
- Calotomus carolinus*
- Cetoscarus bicolor*
- Chlorurus microrhinos*
- Chlorurus sordidus*
- Ctenochaetus striatus*
- Lutjanus fulvus*
- Naso lituratus*
- Naso vlamingii*
- Scarus globiceps*
- Scarus psittacus*
- Scarus schlegeli*
- Zebrasoma flavescens*

SHALLOW SCORE: MED-HIGH

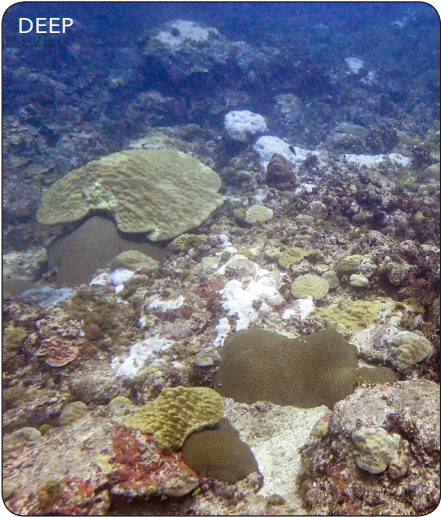
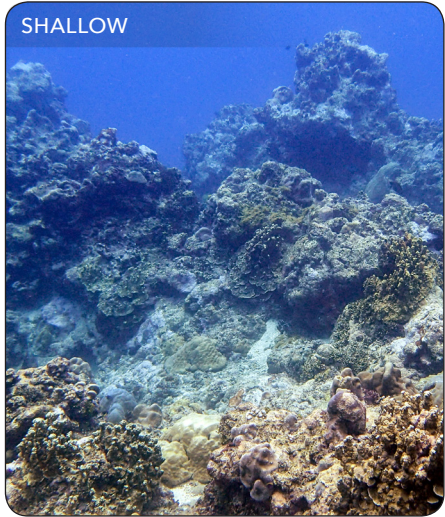
DEEP SCORE: HIGH

TEPUNGAN BAY

7 – Shallow, 10 – Deep



Also known as Piti Bay, this is one of Guam's marine protected areas and the location of The Fish Eye Observatory.



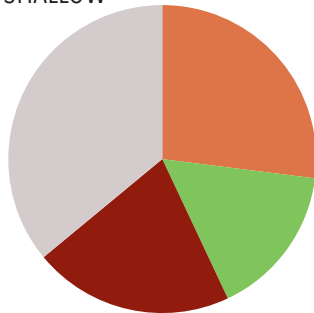
RELATIVE RESILIENCE

Depth	Rank	Resilience Score	Coral Cover	Coral Diversity	Coral Recruitment	Bleaching Resistance	Macroalgae Cover	Herbivorous Fish Biomass	Temperature Variability
Shallow	7/18	0.88	0.64	0.28	0.96	0.92	0.91	0.17	0.87
Deep	10/20	0.81	0.33	0.37	0.98	0.91	0.71	0.27	0.87

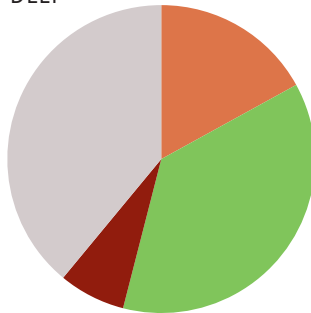
● High (>avg+1 SD) ● Med-High (>avg and <avg+1 SD) ● Med-Low (<avg and >avg - 1 SD) ● Low (<avg - 1 SD)

BENTHIC COMMUNITY

SHALLOW



DEEP



● Coral
● Macroalgae
● Coralline algae
● Other

FISH SPECIES

SHALLOW

- Acanthurus lineatus*
- Acanthurus nigricans*
- Acanthurus nigrofuscus*
- Aphareus furca*
- Calotomus carolinus*
- Caranx melampygus*
- Chlorurus microrhinos*
- Chlorurus sordidus*
- Ctenochaetus striatus*
- Kyphosus cinerascens*
- Lutjanus fulvus*
- Macolor macularis*
- Monotaxis grandoculis*
- Naso lituratus*
- Naso unicornis*
- Scarus altipinnis*
- Scarus forsteni*
- Scarus globiceps*
- Scarus psittacus*
- Scarus schlegeli*
- Zebbrasoma veliferum*

CORAL SPECIES

SHALLOW

- Acanthastrea brevis*
- Acanthastrea echinata*
- Acropora abrotenoides*
- Acropora surculosa*
- Astreopora listeria*
- Astreopora myriophthalma*
- Dipsastraea danai*
- Dipsastraea favus*
- Dipsastraea maritima*
- Dipsastraea matthaii*
- Dipsastraea pallida*
- Favites valenciennesi*
- Galaxea fascicularis*
- Goniastrea retiformis*
- Goniastrea stelligera*
- Leptastrea purpurea*
- Leptoria phrygia*
- Lobophyllia corymbosa*
- Pavona chriquiensis*
- Pavona varians*
- Platygyra pini*
- Pocillopora coniculus*
- Pocillopora damicornis*
- Pocillopora verrucosa*
- Porites australiensis*
- Porites horizontalata*
- Porites lobata*
- Porites lutea*
- Psammocora nierstrazi*
- Stylocoeniella armata*

DEEP

- Acropora globiceps*
- Cyphastrea microphthalma*
- Dipsastraea danai*
- Dipsastraea favus*
- Dipsastraea maritima*
- Dipsastraea matthaii*
- Dipsastraea pallida*
- Favites colemani*
- Favites valenciennesi*
- Galaxea fascicularis*
- Goniastrea edwardsi*
- Goniastrea pectinata*
- Goniastrea stelligera*
- Leptastrea purpurea*
- Lobactis scutaria*
- Paragoniastrea russelli*
- Pavona chriquiensis*
- Pavona varians*
- Pocillopora coniculus*
- Pocillopora verrucosa*
- Porites australiensis*
- Porites lobata*
- Porites lutea*
- Porites rus*
- Psammocora haimeana*
- Stylocoeniella armata*

DEEP

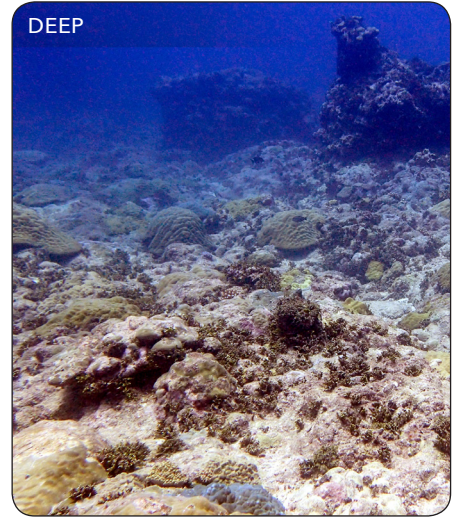
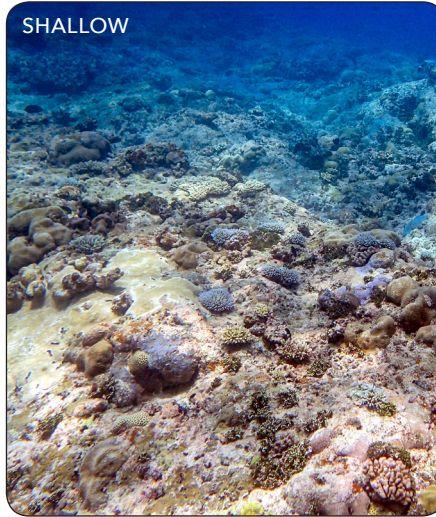
- Acanthurus nigricans*
- Acanthurus nigrofuscus*
- Acanthurus pyroferus*
- Aphareus furca*
- Calotomus carolinus*
- Chlorurus microrhinos*
- Chlorurus sordidus*
- Ctenochaetus striatus*
- Hipposcarus longiceps*
- Lutjanus bohar*
- Macolor macularis*
- Monotaxis grandoculis*
- Naso lituratus*
- Plectropomus laevis*
- Scarus altipinnis*
- Scarus fuscicaudalis*
- Scarus psittacus*
- Scarus schlegeli*
- Zebbrasoma flavescens*
- Zebbrasoma scopas*

JINAPSAN BEACH

8 – Shallow, 9 – Deep



Located on the Anderson Air Force Base, this is one of Guam's well known turtle nesting beaches



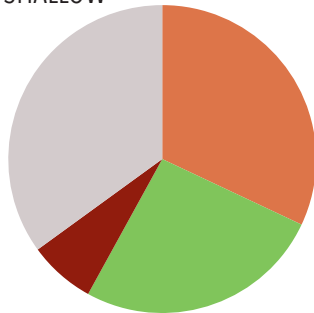
RELATIVE RESILIENCE

Depth	Rank	Resilience Score	Coral Cover	Coral Diversity	Coral Recruitment	Bleaching Resistance	Macroalgae Cover	Herbivorous Fish Biomass	Temperature Variability
Shallow	8/18	0.84	0.75	0.48	0.97	0.43	0.81	0.08	1.00
Deep	9/20	0.82	0.34	0.40	0.95	0.75	0.89	0.18	1.00

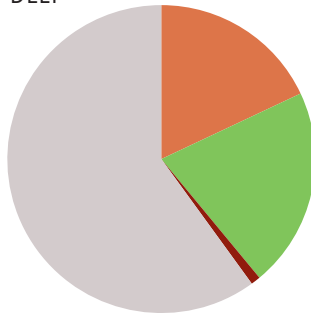
● High (>avg+1 SD) ● Med-High (>avg and <avg+1 SD) ● Med-Low (<avg and >avg - 1 SD) ● Low (<avg - 1 SD)

BENTHIC COMMUNITY

SHALLOW



DEEP



● Coral
● Macroalgae
● Coralline algae
● Other

FISH SPECIES

SHALLOW

- Acanthurus blochii*
- Acanthurus lineatus*
- Acanthurus nigricans*
- Acanthurus nigrofuscus*
- Acanthurus olivaceus*
- Acanthurus pyroferus*
- Aphareus furca*
- Calotomus carolinus*
- Chlorurus sordidus*
- Ctenochaetus striatus*
- Naso lituratus*
- Naso unicornis*
- Scarus forsteni*

CORAL SPECIES

SHALLOW

- Acanthastrea echinata*
- Acropora cerealis*
- Acropora globiceps*
- Acropora vaughani*
- Astrea curta*
- Astreopora myriophthalma*
- Cyphastrea microphthalma*
- Dipsastraea favus*
- Dipsastraea matthaii*
- Dipsastraea pallida*
- Echinophyllia echinata*
- Favites colemani*
- Favites valenciennesi*
- Goniastrea edwardsi*
- Isopora cuneate*
- Leptastrea purpurea*
- Montipora efflorescens*
- Montipora floweri*
- Montipora grisea*
- Montipora hoffmeisteri*
- Montipora monasteriata*
- Montipora nodosa*
- Montipora tuberculosa*
- Pavona varians*
- Platygyra pini*
- Pocillopora meandrina*
- Pocillopora verrucosa*
- Porites australiensis*
- Porites lutea*
- Porites vaughani*

DEEP

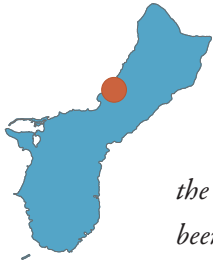
- Acropora globiceps*
- Acropora surculosa*
- Astreopora myriophthalma*
- Cyphastrea serailia*
- Dipsastraea danai*
- Dipsastraea favus*
- Dipsastraea heliathoides*
- Dipsastraea maritima*
- Dipsastraea matthaii*
- Dipsastraea pallida*
- Dipsastraea speciosa*
- Favites colemani*
- Goniastrea edwardsi*
- Leptastrea purpurea*
- Montipora grisea*
- Montipora hoffmeisteri*
- Montipora nodosa*
- Montipora venosa*
- Paragoniastrea russelli*
- Pavona varians*
- Platygyra pini*
- Pocillopora verrucosa*
- Porites australiensis*
- Porites lichen*
- Porites lutea*
- Stylophora pistillata*

DEEP

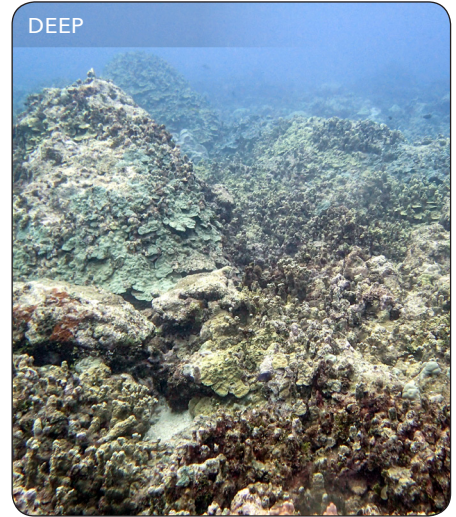
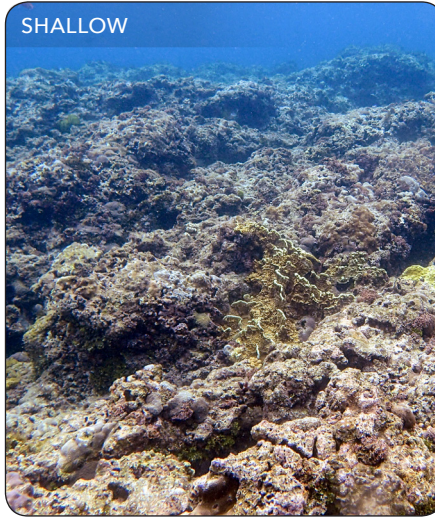
- Acanthurus nigricans*
- Acanthurus nigrofuscus*
- Aphareus furca*
- Calotomus carolinus*
- Chlorurus sordidus*
- Ctenochaetus binotatus*
- Ctenochaetus striatus*
- Lutjanus bohar*
- Naso lituratus*
- Scarus globiceps*
- Scarus psittacus*
- Siganus argenteus*

TUMON BAY

9 – Shallow, 5 – Deep



The original meaning of the word **Tumon** has been lost; the Tumon area is Guam's primary tourism district.



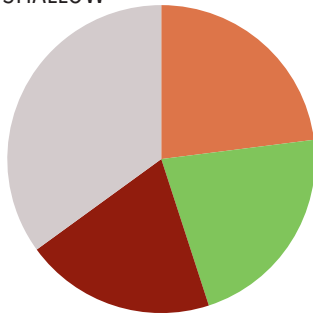
RELATIVE RESILIENCE

Depth	Rank	Resilience Score	Coral Cover	Coral Diversity	Coral Recruitment	Bleaching Resistance	Macroalgae Cover	Herbivorous Fish Biomass	Temperature Variability
Shallow	9/18	0.84	0.55	0.44	0.92	0.69	0.85	0.12	0.95
Deep	5/20	0.93	0.86	0.51	0.68	0.97	0.91	0.18	0.95

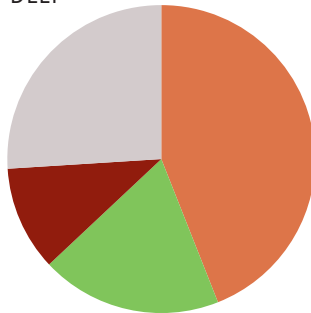
● High (>avg+1 SD) ● Med-High (>avg and <avg+1 SD) ● Med-Low (<avg and >avg - 1 SD) ● Low (<avg - 1 SD)

BENTHIC COMMUNITY

SHALLOW



DEEP



● Coral
● Macroalgae
● Coralline algae
● Other

FISH SPECIES

SHALLOW

- Acanthurus lineatus*
- Acanthurus nigricans*
- Acanthurus nigrofuscus*
- Aphareus furca*
- Calotomus carolinus*
- Chlorurus sordidus*
- Ctenochaetus striatus*
- Naso lituratus*
- Scarus globiceps*
- Scarus psittacus*
- Scomberoides lysan*

CORAL SPECIES

SHALLOW

- Acanthastrea echinata*
- Acropora digitifera*
- Acropora surculosa*
- Dipsastraea matthaii*
- Galaxea fascicularis*
- Goniastrea retiformis*
- Goniastrea stelligera*
- Goniopora fruticose*
- Leptastrea purpurea*
- Leptastrea transversa*
- Leptoria phrygia*
- Pavona varians*
- Platygyra pini*
- Pocillopora damicornis*
- Pocillopora setchelli*

DEEP

- Cyphastrea serailia*
- Dipsastraea speciosa*
- Favites colemani*
- Goniastrea edwardsi*
- Goniastrea retiformis*
- Goniopora minor*
- Leptastrea purpurea*
- Merulina ampliata*
- Millepora dichotoma*
- Millepora platyphyllia*
- Paragoniastrea russelli*
- Pavona varians*
- Pocillopora verrucosa*
- Porites australiensis*
- Porites horizontalata*

DEEP

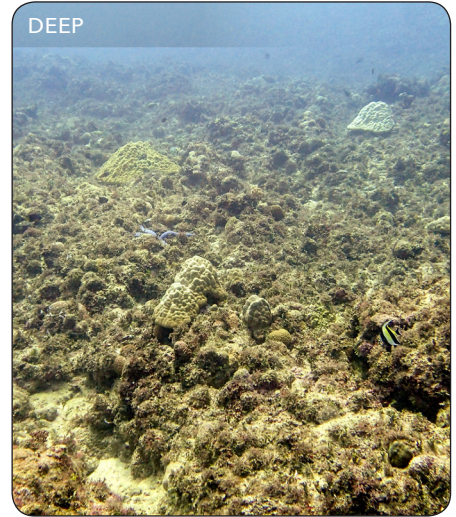
- Acanthurus nigricans*
- Acanthurus nigrofuscus*
- Aphareus furca*
- Cephalopholis argus*
- Chlorurus sordidus*
- Ctenochaetus striatus*
- Elagatis bipinnulata*
- Lutjanus fulvus*
- Macolor niger*
- Monotaxis grandoculis*
- Naso lituratus*
- Scarus forsteni*
- Zebrosoma flavescens*

DADI BEACH

10 – Shallow, 12 – Deep



This is the site of the Orote Village, which persisted well into the 17th century and is now located on the Naval Base of Guam.



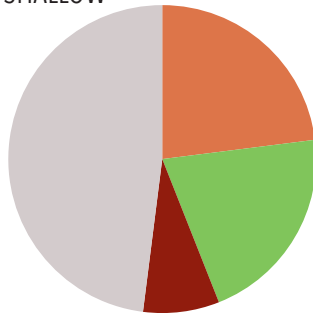
RELATIVE RESILIENCE

Depth	Rank	Resilience Score	Coral Cover	Coral Diversity	Coral Recruitment	Bleaching Resistance	Macroalgae Cover	Herbivorous Fish Biomass	Temperature Variability
Shallow	10/18	0.82	0.53	0.42	0.77	1.00	0.86	0.08	0.77
Deep	12/20	0.76	0.20	0.61	0.94	0.68	0.81	0.16	0.77

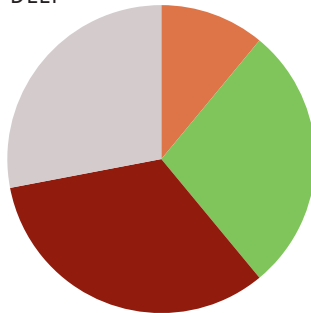
● High (>avg+1 SD) ● Med-High (>avg and <avg+1 SD) ● Med-Low (<avg and >avg - 1 SD) ● Low (<avg - 1 SD)

BENTHIC COMMUNITY

SHALLOW



DEEP



● Coral
● Macroalgae
● Coralline algae
● Other

FISH SPECIES

SHALLOW



- Acanthurus nigricans*
- Acanthurus nigrofuscus*
- Calotomus carolinus*
- Chlorurus sordidus*
- Ctenochaetus striatus*
- Naso lituratus*
- Naso unicornis*
- Scarus psittacus*

CORAL SPECIES

SHALLOW



- Dipsastraea danai*
- Dipsastraea maritima*
- Favites valenciennesi*
- Goniastrea edwardsi*
- Goniastrea pectinate*
- Goniastrea retiformis*
- Heliopora coerulea*
- Leptastrea purpurea*
- Pavona chriquiensis*
- Pavona clavus*
- Pavona varians*
- Porites australiensis*
- Porites deformis*
- Porites horizontalata*
- Porites lichen*
- Porites lobata*
- Porites lutea*
- Porites rus*
- Porites vaughani*
- Stylocoeniella armata*
- Stylophora pistillata*

DEEP



- Astreopora myriophthalma*
- Astreopora ocellata*
- Astreopora randalli*
- Cyphastrea micropthalma*
- Cyphastrea serailia*
- Dipsastraea danai*
- Dipsastraea favus*
- Dipsastraea maritima*
- Favites colemani*
- Favites valenciennesi*
- Galaxea fascicularis*
- Goniastrea edwardsi*
- Leptastrea purpurea*
- Montipora nodosa*
- Montipora verrucosa*
- Pavona varians*
- Pocillopora damicornis*
- Pocillopora danae*
- Pocillopora eydouxi*
- Pocillopora setchelli*
- Pocillopora verrucosa*
- Porites australiensis*
- Porites deformis*
- Porites lichen*
- Porites lobata*
- Porites lutea*
- Porites rus*
- Psammocora haimeana*
- Psammocora nierstrazi*
- Stylocoeniella armata*
- Stylocoeniella guentheri*

DEEP



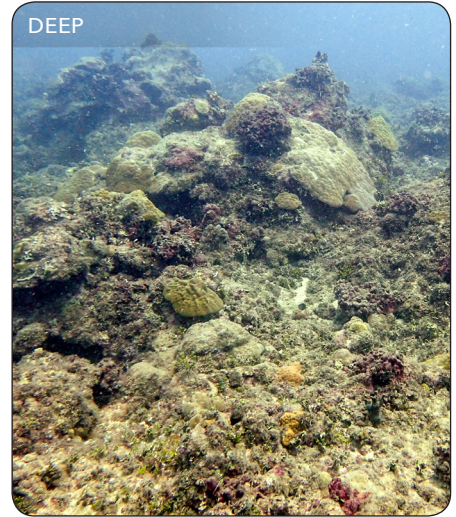
- Acanthurus nigrofuscus*
- Calotomus carolinus*
- Chlorurus sordidus*
- Monotaxis grandoculis*
- Naso lituratus*
- Naso unicornis*
- Naso vlamingii*
- Scarus forsteni*
- Scarus psittacus*
- Scarus schlegeli*

MANELL CHANNEL

11 – Shallow, 16 – Deep



The channel provides access to Guam's southern reefs via a small boat ramp.



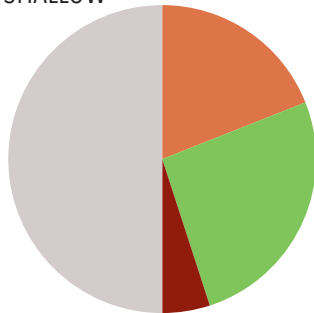
RELATIVE RESILIENCE

Depth	Rank	Resilience Score	Coral Cover	Coral Diversity	Coral Recruitment	Bleaching Resistance	Macroalgae Cover	Herbivorous Fish Biomass	Temperature Variability
Shallow	11/18	0.81	0.45	0.41	0.98	0.91	0.80	0.07	0.77
Deep	16/20	0.74	0.28	0.30	1.00	0.70	0.66	0.31	0.77

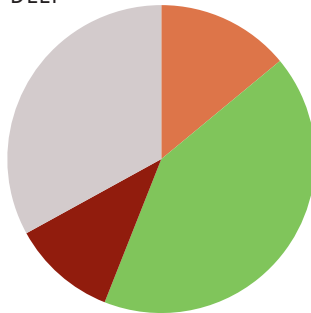
● High (>avg+1 SD) ● Med-High (>avg and <avg+1 SD) ● Med-Low (<avg and >avg - 1 SD) ● Low (<avg - 1 SD)

BENTHIC COMMUNITY

SHALLOW



DEEP



● Coral
● Macroalgae
● Coralline algae
● Other

FISH SPECIES

SHALLOW

- Acanthurus nigricans*
- Acanthurus nigricauda*
- Acanthurus nigrofuscus*
- Acanthurus olivaceus*
- Calotomus carolinus*
- Caranx melampygus*
- Chlorurus microrhinos*
- Chlorurus sordidus*
- Ctenochaetus striatus*
- Naso lituratus*
- Scarus psittacus*
- Scarus schlegeli*
- Siganus spinus*

CORAL SPECIES

SHALLOW

- Acanthastrea brevis*
- Acanthastrea echinata*
- Acropora globiceps*
- Astreopora myriophthalma*
- Cyphastrea chalcidicum*
- Cyphastrea serailia*
- Diploastrea heliopora*
- Dipsastraea favus*
- Dipsastraea maritima*
- Dipsastraea matthaii*
- Dipsastraea pallida*
- Dipsastraea rotundata*
- Favites colemani*
- Favites valenciennesi*
- Goniastrea edwardsi*
- Goniastrea retiformis*
- Goniopora fruticose*
- Leptastrea purpurea*
- Leptoria phrygia*
- Montipora efflorescen*
- Pavona varians*
- Pocillopora damicornis*
- Porites australiensis*
- Porites lichen*
- Porites lutea*
- Porites rus*
- Stylocoeniella armata*
- Stylophora pistillata*

DEEP

- Acanthastrea brevis*
- Acanthastrea echinata*
- Astreopora myriophthalma*
- Astreopora ocellata*
- Astreopora randalli*
- Dipsastraea danai*
- Dipsastraea favus*
- Dipsastraea maritima*
- Dipsastraea matthaii*
- Dipsastraea pallida*
- Favites valenciennesi*
- Galaxea fascicularis*
- Goniastrea edwardsi*
- Goniastrea pectinate*
- Goniastrea retiformis*
- Goniopora fruticose*
- Leptastrea purpurea*
- Montipora verrucosa*
- Paragoniastrea russelli*
- Pavona varians*
- Pocillopora damicornis*
- Pocillopora meandrina*
- Pocillopora verrucosa*
- Porites australiensis*
- Porites lichen*
- Porites lobata*
- Porites lutea*
- Porites vaughani*
- Psammocora haimeana*
- Scapophyllia cylindrical*
- Stylocoeniella armata*

DEEP

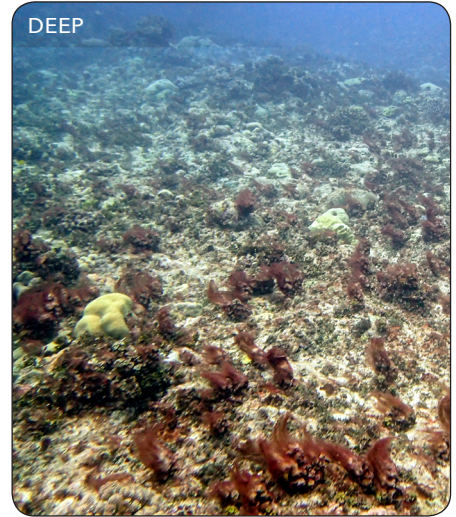
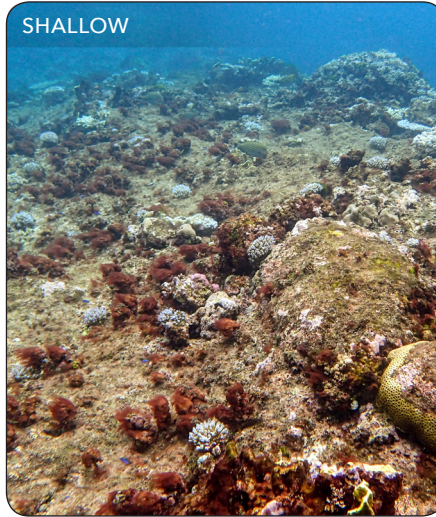
- Acanthurus nigrofuscus*
- Acanthurus olivaceus*
- Aphareus furca*
- Chlorurus microrhinos*
- Chlorurus sordidus*
- Ctenochaetus binotatus*
- Ctenochaetus striatus*
- Macolor macularis*
- Monotaxis grandoculis*
- Naso lituratus*
- Plectropomus laevis*
- Scarus psittacus*
- Scarus schlegeli*
- Siganus argenteus*
- Siganus spinus*
- Zebbrasoma scopas*

JANOM POINT

12 – Shallow, 13 – Deep



Janom is the Chamorro word for water; this area has significant freshwater springs.



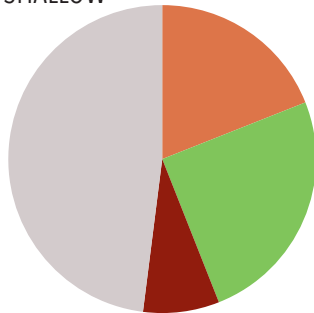
RELATIVE RESILIENCE

Depth	Rank	Resilience Score	Coral Cover	Coral Diversity	Coral Recruitment	Bleaching Resistance	Macroalgae Cover	Herbivorous Fish Biomass	Temperature Variability
Shallow	12/18	0.80	0.45	0.53	0.91	0.63	0.81	0.05	0.91
Deep	13/20	0.76	0.26	0.63	0.97	0.68	0.66	0.06	0.91

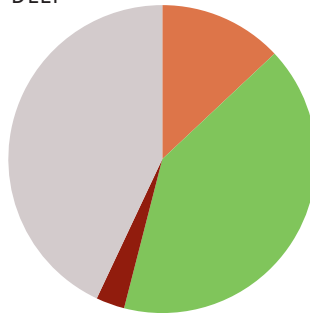
● High (>avg+1 SD) ● Med-High (>avg and <avg+1 SD) ● Med-Low (<avg and >avg - 1 SD) ● Low (<avg - 1 SD)

BENTHIC COMMUNITY

SHALLOW



DEEP



● Coral
● Macroalgae
● Coralline algae
● Other

FISH SPECIES

SHALLOW

- Acanthurus blochii*
- Acanthurus guttatus*
- Acanthurus lineatus*
- Acanthurus nigricans*
- Acanthurus nigrofuscus*
- Acanthurus olivaceus*
- Acanthurus triostegus*
- Aphareus furca*
- Calotomus carolinus*
- Chlorurus microrhinos*
- Chlorurus sordidus*
- Ctenochaetus striatus*
- Naso lituratus*
- Scarus globiceps*
- Scarus psittacus*

CORAL SPECIES

SHALLOW

- Acanthastrea brevis*
- Acanthastrea echinata*
- Acropora azurea*
- Acropora cerealis*
- Acropora monticulosa*
- Acropora surculosa*
- Astreopora myriophthalma*
- Astrea curta*
- Cyphastrea microphthalma*
- Cyphastrea serailia*
- Dipsastraea favus*
- Dipsastraea maritima*
- Galaxea fascicularis*
- Goniastrea retiformis*
- Goniastrea stelligera*
- Leptastrea purpurea*
- Leptoria phrygia*
- Montipora grisea*
- Montipora hoffmeisteri*
- Montipora tuberculosa*
- Paragoniastrea russelli*
- Pavona varians*
- Platygyra pini*
- Pocillopora verrucosa*
- Porites lutea*
- Psammocora nierstrazi*

DEEP

- Acanthastrea echinata*
- Acropora cf. quelchi*
- Acropora gemmifera*
- Acropora globiceps*
- Acropora tenuis*
- Acropora verweyi*
- Astreopora listeria*
- Astreopora myriophthalma*
- Cyphastrea chalcidicum*
- Cyphastrea microphthalma*
- Dipsastraea danai*
- Dipsastraea favus*
- Dipsastraea maritima*
- Dipsastraea matthaii*
- Dipsastraea pallida*
- Favites colemani*
- Favites valenciennesi*
- Goniastrea edwardsi*
- Goniastrea stelligera*
- Leptastrea purpurea*
- Montipora grisea*
- Montipora hoffmeisteri*
- Montipora nodosa*
- Montipora tuberculosa*
- Pavona varians*
- Pocillopora meandrina*
- Pocillopora verrucosa*
- Porites australiensis*
- Porites lichen*
- Porites lobata*
- Porites lutea*
- Porites vaughani*
- Stylocoeniella armata*
- Stylophora pistillata*

DEEP

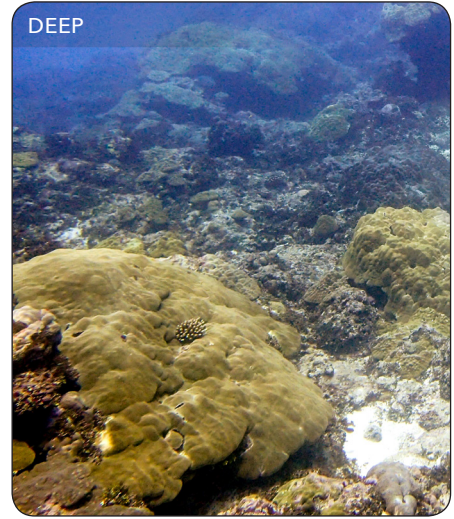
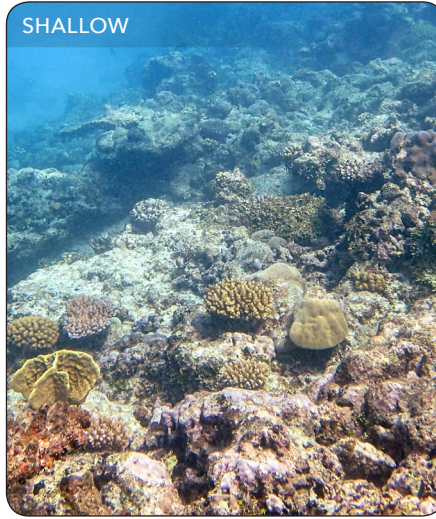
- Acanthurus nigrofuscus*
- Acanthurus olivaceus*
- Acanthurus triostegus*
- Acanthurus xanthopterus*
- Chlorurus microrhinos*
- Chlorurus sordidus*
- Ctenochaetus binotatus*
- Ctenochaetus striatus*
- Paracanthurus hepatus*

MANGILAO GOLF COURSE

13 – Shallow, 11 – Deep



Located just off the Mangilao Golf Course, this reef bench provides an optimal place for reef growth despite the harsh environmental conditions on the windward coast.



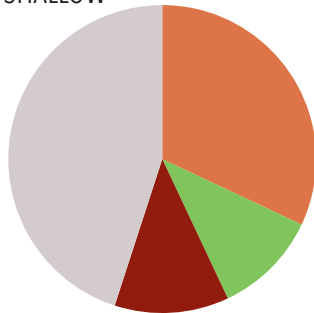
RELATIVE RESILIENCE

Depth	Rank	Resilience Score	Coral Cover	Coral Diversity	Coral Recruitment	Bleaching Resistance	Macroalgae Cover	Herbivorous Fish Biomass	Temperature Variability
Shallow	13/18	0.78	0.74	0.12	0.95	0.48	0.97	0.08	0.88
Deep	11/20	0.79	0.46	0.21	0.99	0.79	0.74	0.24	0.88

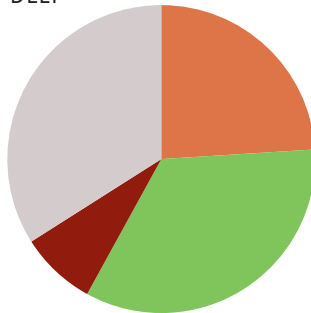
● High (>avg+1 SD) ● Med-High (>avg and <avg+1 SD) ● Med-Low (<avg and >avg - 1 SD) ● Low (<avg - 1 SD)

BENTHIC COMMUNITY

SHALLOW



DEEP



● Coral
● Macroalgae
● Coralline algae
● Other

FISH SPECIES

SHALLOW

- Acanthurus blochii*
- Acanthurus guttatus*
- Acanthurus lineatus*
- Acanthurus nigricans*
- Acanthurus nigrofuscus*
- Acanthurus triostegus*
- Aprion virescens*
- Calotomus carolinus*
- Chlorurus frontalis*
- Chlorurus sordidus*
- Ctenochaetus striatus*
- Lethrinus harak*
- Naso lituratus*
- Scarus psittacus*
- Siganus spinus*

CORAL SPECIES

SHALLOW

- Acanthastrea echinata*
- Acropora azurea*
- Acropora cf. paniculata*
- Acropora gemmifera*
- Acropora robusta*
- Acropora surculosa*
- Astrea curta*
- Dipsastraea favus*
- Dipsastraea matthaii*
- Dipsastraea pallida*
- Favites colemani*
- Galaxea fascicularis*
- Goniastrea retiformis*
- Goniastrea stelligera*
- Leptoria phrygia*

DEEP

- Acropora surculosa*
- Astreopora myriophthalma*
- Astreopora ocellata*
- Cyphastrea microphthalma*
- Cyphastrea serailia*
- Dipsastraea favus*
- Dipsastraea maritima*
- Dipsastraea matthaii*
- Dipsastraea pallida*
- Favites colemani*
- Galaxea fascicularis*
- Goniastrea edwardsi*
- Goniastrea stelligera*
- Goniopora fruticose*

DEEP

- Acanthurus nigricans*
- Acanthurus nigrofuscus*
- Acanthurus pyroferus*
- Acanthurus triostegus*
- Aphareus furca*
- Calotomus carolinus*
- Chlorurus microrhinos*
- Chlorurus sordidus*
- Ctenochaetus striatus*
- Gymnocranius sp.*
- Kyphosus cinerascens*
- Lutjanus fulvus*
- Lutjanus monostigma*
- Macolor macularis*
- Naso lituratus*
- Plectorhinchus vittatus*
- Scarus forsteni*
- Scarus globiceps*
- Scarus psittacus*
- Scarus schlegeli*
- Siganus argenteus*

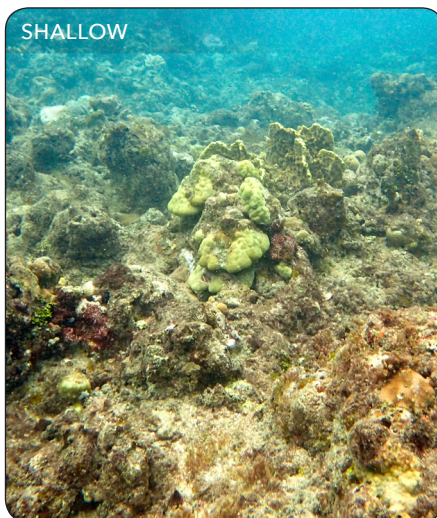
COCOS BARRIER REEF WEST

14 – Shallow, 14 – Deep

13.267° N, 144.656° E



Named after the island it surrounds, Cocos receives its name from the coconut trees that cover the tiny island. The original Chamorro name for the island is *Islan Dãno*.



RELATIVE RESILIENCE

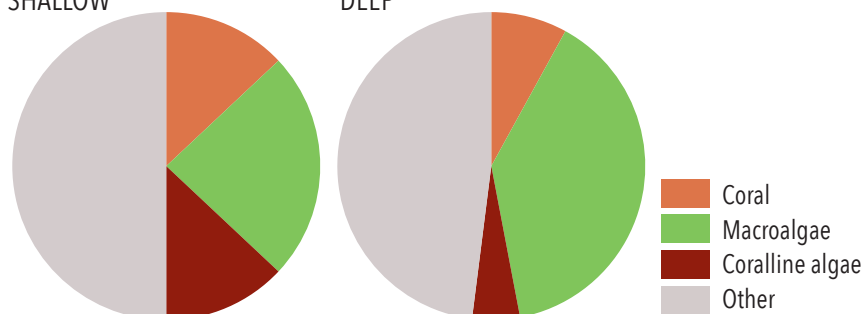
Depth	Rank	Resilience Score	Coral Cover	Coral Diversity	Coral Recruitment	Bleaching Resistance	Macroalgae Cover	Herbivorous Fish Biomass	Temperature Variability
Shallow	14/18	0.78	0.30	0.41	0.95	0.83	0.83	0.07	0.84
Deep	14/20	0.74	0.15	0.54	0.92	0.79	0.69	0.14	0.84

● High (>avg+1 SD) ● Med-High (>avg and <avg+1 SD) ● Med-Low (<avg and >avg - 1 SD) ● Low (<avg - 1 SD)

BENTHIC COMMUNITY

SHALLOW

DEEP



FISH SPECIES

SHALLOW

- Acanthurus lineatus*
- Acanthurus nigricans*
- Acanthurus nigrofuscus*
- Acanthurus olivaceus*
- Chlorurus sordidus*
- Ctenochaetus striatus*
- Naso lituratus*
- Scarus globiceps*
- Scarus schlegeli*
- Siganus argenteus*
- Siganus spinus*

CORAL SPECIES

SHALLOW

DEEP

DEEP

- | | | | | | |
|------------------------------|-------------------------------|---------------------------------|--------------------------------|-----------------------------------|-----------------------------|
| <i>Acanthastrea echinata</i> | <i>Millepora platyphyllia</i> | <i>Acanthastrea echinata</i> | <i>Paragoniastrea russelli</i> | <i>Acanthurus nigrofuscus</i> | <i>Scarus schlegeli</i> |
| <i>Acropora globiceps</i> | <i>Pavona meandrina</i> | <i>Astreopora listeria</i> | <i>Pavona varians</i> | <i>Aphareus furca</i> | <i>Zebrasoma flavescens</i> |
| <i>Acropora verweyi</i> | <i>Pavona varians</i> | <i>Astreopora myriophthalma</i> | <i>Porites australiensis</i> | <i>Calotomus carolinus</i> | |
| <i>Cyphastrea serailia</i> | <i>Porites australiensis</i> | <i>Astreopora ocellata</i> | <i>Porites lobata</i> | <i>Carcharhinus melanopterus</i> | |
| <i>Dipsastraea favus</i> | <i>Porites horizontalata</i> | <i>Cyphastrea serailia</i> | <i>Porites lutea</i> | <i>Chlorurus sordidus</i> | |
| <i>Dipsastraea maritima</i> | <i>Porites lichen</i> | <i>Dipsastraea favus</i> | <i>Psammocora haimeana</i> | <i>Ctenochaetus striatus</i> | |
| <i>Dipsastraea matthaii</i> | <i>Porites lutea</i> | <i>Dipsastraea maritima</i> | <i>Stylocoeniella armata</i> | <i>Gnathodentex aureolineatus</i> | |
| <i>Favites valenciennesi</i> | <i>Porites rus</i> | <i>Dipsastraea matthaii</i> | | <i>Lutjanus bohar</i> | |
| <i>Galaxea fascicularis</i> | <i>Stylocoeniella armata</i> | <i>Favites colemani</i> | | <i>Monotaxis grandoculis</i> | |
| <i>Goniastrea edwardsi</i> | | <i>Favites valenciennesi</i> | | <i>Naso lituratus</i> | |
| <i>Goniastrea retiformis</i> | | <i>Goniastrea edwardsi</i> | | <i>Naso unicornis</i> | |
| <i>Goniastrea stelligera</i> | | <i>Goniastrea pectinate</i> | | <i>Naso vlamingii</i> | |
| <i>Hydnophora microconos</i> | | <i>Goniastrea retiformis</i> | | <i>Scarus psittacus</i> | |
| <i>Leptastrea purpurea</i> | | <i>Leptastrea purpurea</i> | | | |
| <i>Leptoria phrygia</i> | | | | | |

SHALLOW SCORE: MED-LOW

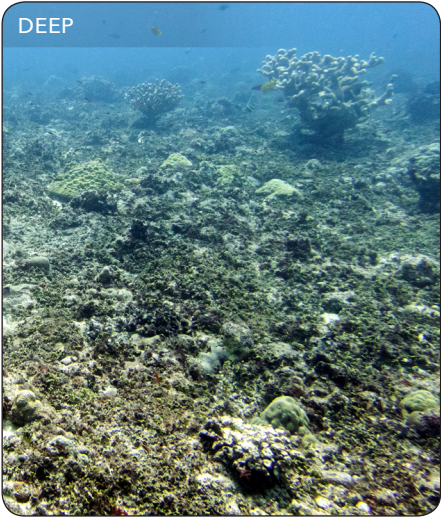
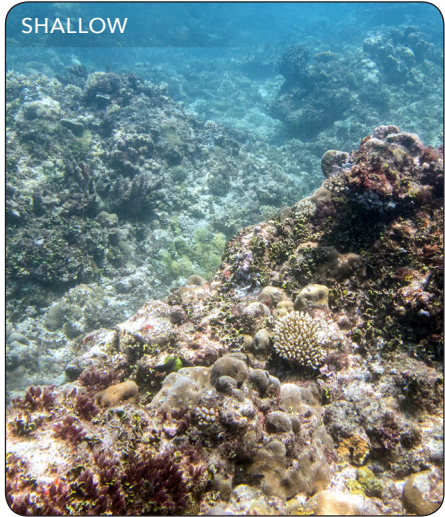
DEEP SCORE: MED-LOW

COCOS BARRIER REEF EAST

15 – Shallow, 20 – Deep



Named after the island it surrounds, Cocos receives its name from the coconut trees that cover the tiny island. The original Chamorro name for the island is *Islan Dãno*.



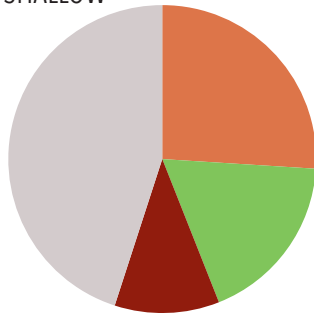
RELATIVE RESILIENCE

Depth	Rank	Resilience Score	Coral Cover	Coral Diversity	Coral Recruitment	Bleaching Resistance	Macroalgae Cover	Herbivorous Fish Biomass	Temperature Variability
Shallow	15/18	0.78	0.60	0.19	0.99	0.67	0.89	0.07	0.78
Deep	20/20	0.64	0.26	0.32	0.92	0.53	0.56	0.12	0.78

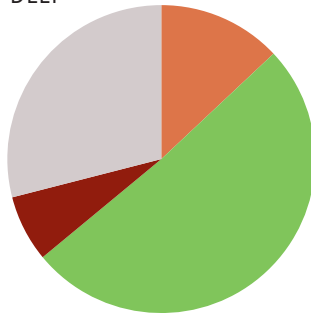
● High (>avg+1 SD) ● Med-High (>avg and <avg+1 SD) ● Med-Low (<avg and >avg - 1 SD) ● Low (<avg - 1 SD)

BENTHIC COMMUNITY

SHALLOW



DEEP



● Coral
● Macroalgae
● Coralline algae
● Other

FISH SPECIES

SHALLOW

- Acanthurus nigricans*
- Acanthurus nigrofuscus*
- Calotomus carolinus*
- Chlorurus sordidus*
- Ctenochaetus striatus*
- Lutjanus bohar*
- Naso lituratus*
- Scarus psittacus*
- Scarus schlegeli*
- Siganus spinus*

CORAL SPECIES

SHALLOW

- Acropora azurea*
- Acropora cerealis*
- Acropora cophodactyla*
- Acropora digitifera*
- Acropora surculosa*
- Acropora verweyi*
- Astrea curta*
- Cyphastrea chalcidicum*
- Dipsastraea favus*
- Dipsastraea maritima*
- Dipsastraea pallida*
- Favites colemani*
- Galaxea fascicularis*
- Goniastrea edwardsi*
- Goniastrea retiformis*
- Goniastrea stelligera*



- Goniopora fruticose*
- Heliopora coerulea*
- Leptoria phrygia*
- Leptoseris mycetoseroides*
- Millepora platyphyllia*
- Montipora hoffmeisteri*
- Montipora tuberculosa*
- Pocillopora ankei*
- Pocillopora eydouxi*
- Porites australiensis*
- Porites deformis*
- Porites lichen*
- Porites lobata*
- Porites vaughani*
- Psammocora nierstrazi*

DEEP

- Astreopora listeria*
- Astreopora myriophthalma*
- Astreopora randalli*
- Cyphastrea microphthalma*
- Cyphastrea serailia*
- Dipsastraea favus*
- Dipsastraea maritima*
- Dipsastraea matthaii*
- Favites colemani*
- Galaxea fascicularis*
- Goniastrea edwardsi*
- Heliopora coerulea*
- Leptastrea purpurea*
- Leptoseris incrustans*



- Montipora nodosa*
- Montipora tuberculosa*
- Montipora verrucosa*
- Pavona varians*
- Platygyra daedalea*
- Platygyra pini*
- Pocillopora verrucosa*
- Porites australiensis*
- Porites lutea*
- Psammocora haimeana*
- Stylocoeniella armata*

DEEP

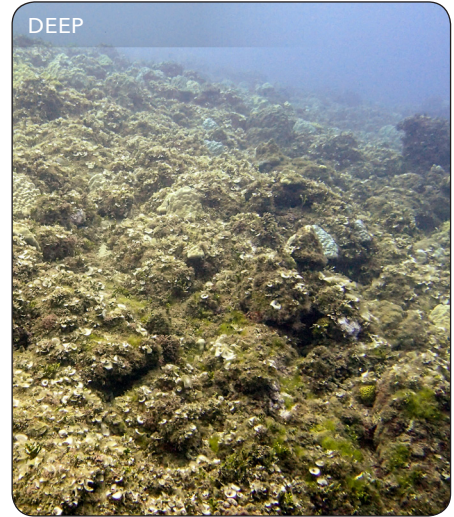
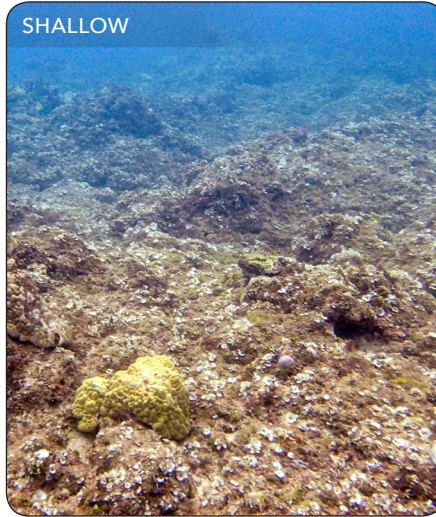
- Acanthurus nigrofuscus*
- Acanthurus olivaceus*
- Chlorurus sordidus*
- Ctenochaetus binotatus*
- Ctenochaetus striatus*
- Ctenochaetus strigosus*
- Naso lituratus*
- Scarus fuscocaudalis*
- Scarus psittacus*
- Scarus schlegeli*
- Siganus argenteus*
- Zebrasoma flavescens*

FACPI POINT

16 – Shallow, 19 – Deep



A prominent feature of southwestern Guam, the Point contains a massive stack of black coralline limestone, resulting from a volcanic eruption. *Facpi* is the Chamorro word for the Pacific frigate bird (*Fregata minor minor*).



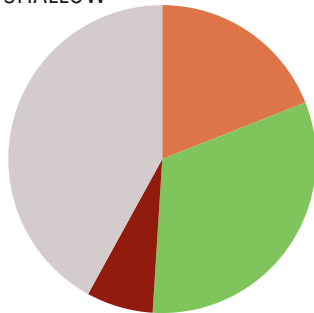
RELATIVE RESILIENCE

Depth	Rank	Resilience Score	Coral Cover	Coral Diversity	Coral Recruitment	Bleaching Resistance	Macroalgae Cover	Herbivorous Fish Biomass	Temperature Variability
Shallow	16/18	0.77	0.44	0.30	0.94	0.88	0.73	0.04	0.82
Deep	19/20	0.66	0.20	0.19	0.97	0.88	0.44	0.13	0.82

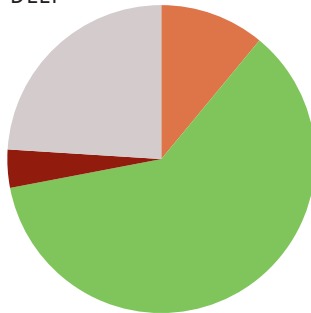
● High (>avg+1 SD) ● Med-High (>avg and <avg+1 SD) ● Med-Low (<avg and >avg - 1 SD) ● Low (<avg - 1 SD)

BENTHIC COMMUNITY

SHALLOW



DEEP



● Coral
● Macroalgae
● Coralline algae
● Other

FISH SPECIES

SHALLOW



- Acanthurus nigricauda*
- Acanthurus nigrofuscus*
- Acanthurus pyroferus*
- Calotomus carolinus*
- Chlorurus microrhinos*
- Chlorurus sordidus*
- Ctenochaetus striatus*
- Naso lituratus*
- Scarus psittacus*

CORAL SPECIES

SHALLOW



- Acanthastrea brevis*
- Acropora cerealis*
- Astreopora listeria*
- Astreopora myriophthalma*
- Astreopora ocellata*
- Cyphastrea serailia*
- Dipsastraea favus*
- Dipsastraea matthaii*
- Favites colemani*
- Galaxea fascicularis*
- Leptastrea purpurea*
- Leptastrea transversa*
- Pavona varians*
- Porites australiensis*
- Porites lichen*
- Porites lobata*
- Porites lutea*
- Porites rus*
- Psammocora haimeana*
- Stylocoeniella armata*

DEEP



- Acropora globiceps*
- Acropora selago*
- Astreopora cf. gracilis*
- Astreopora listeria*
- Astreopora myriophthalma*
- Astreopora ocellata*
- Cyphastrea chalcidicum*
- Cyphastrea serailia*
- Dipsastraea favus*
- Dipsastraea maritima*
- Dipsastraea matthaii*
- Dipsastraea pallida*
- Favites valenciennesi*
- Goniopora minor*
- Leptastrea purpurea*
- Pavona varians*
- Porites australiensis*
- Porites lobata*
- Porites lutea*
- Porites rus*
- Psammocora haimeana*
- Psammocora nierstrazi*

DEEP



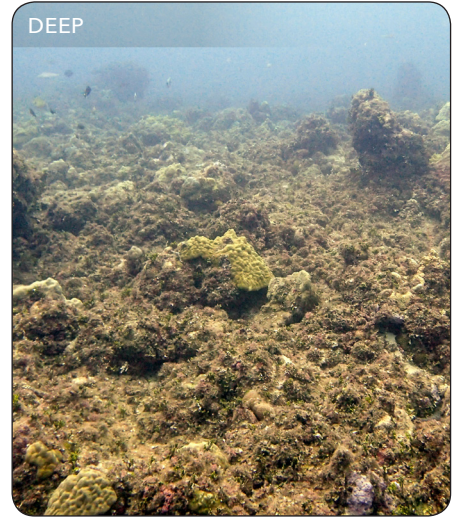
- Acanthurus nigrofuscus*
- Acanthurus olivaceus*
- Calotomus carolinus*
- Chlorurus sordidus*
- Ctenochaetus binotatus*
- Lutjanus bohar*
- Monotaxis grandoculis*
- Naso lituratus*
- Scarus schlegeli*
- Variola louti*
- Zebrasoma veliferum*

GA'AN POINT

17 – Shallow, 17 – Deep



Ga'an Point was the site of a battle during World War II.



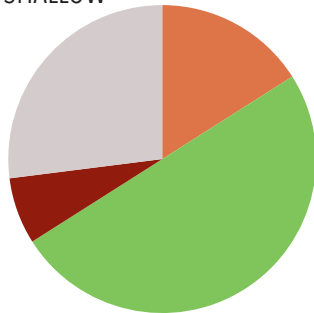
RELATIVE RESILIENCE

Depth	Rank	Resilience Score	Coral Cover	Coral Diversity	Coral Recruitment	Bleaching Resistance	Macroalgae Cover	Herbivorous Fish Biomass	Temperature Variability
Shallow	17/18	0.72	0.36	0.23	0.95	0.96	0.54	0.08	0.77
Deep	16/20	0.72	0.24	0.31	0.89	0.94	0.71	0.09	0.77

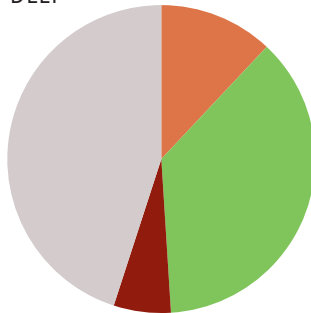
● High (>avg+1 SD) ● Med-High (>avg and <avg+1 SD) ● Med-Low (<avg and >avg - 1 SD) ● Low (<avg - 1 SD)

BENTHIC COMMUNITY

SHALLOW



DEEP



● Coral
● Macroalgae
● Coralline algae
● Other

FISH SPECIES

SHALLOW



- Acanthurus nigrofuscus*
- Calotomus carolinus*
- Chlorurus microrhinos*
- Chlorurus sordidus*
- Ctenochaetus striatus*
- Naso lituratus*
- Naso unicornis*
- Scarus globiceps*
- Scarus psittacus*
- Siganus spinus*
- Zebrasoma veliferum*

CORAL SPECIES

SHALLOW



- Dipsastraea danae*
- Dipsastraea favus*
- Dipsastraea matthaii*
- Echinopora pacificus*
- Fungia fungites*
- Galaxea fascicularis*
- Goniastrea retiformis*
- Heliopora coerulea*
- Leptastrea purpurea*
- Leptoria phrygia*
- Pavona chiriquiensis*
- Pavona maldivensis*
- Pavona sp. "albomarginata"*
- Pavona varians*
- Pocillopora damicornis*
- Pocillopora verrucosa*
- Porites lichen*
- Porites murrayensis*
- Porites rus*
- Porites vaughani*
- Psammocora contigua*
- Stylocoeniella armata*

DEEP



- Acanthastrea echinata*
- Acropora humilis*
- Astreopora myriophthalma*
- Astreopora randalli*
- Dipsastraea favus*
- Dipsastraea maritima*
- Dipsastraea pallida*
- Echinopora lamellosa*
- Favites valenciennesi*
- Galaxea fascicularis*
- Herpolitha limax*
- Leptastrea purpurea*
- Pavona varians*
- Pocillopora verrucosa*
- Porites deformis*
- Porites lichen*
- Porites lobata*
- Porites lutea*
- Porites rus*
- Stylocoeniella armata*

DEEP



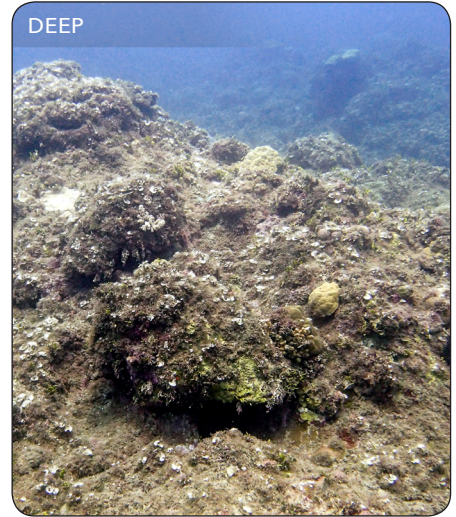
- Acanthurus nigrofuscus*
- Acanthurus olivaceus*
- Aphareus furca*
- Calotomus carolinus*
- Chlorurus sordidus*
- Ctenochaetus striatus*
- Naso lituratus*
- Naso unicornis*
- Scarus schlegeli*

FOUHA BAY

18 – Shallow, 18 – Deep



Fouha Bay is where the ancient Chamorro creation myth originates. The story says that the first humans emerged from Fouha Rock, which was formed by the creation gods Puntan and Fu'una.



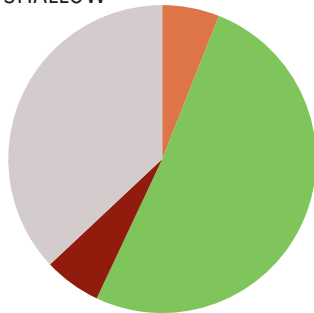
RELATIVE RESILIENCE

Depth	Rank	Resilience Score	Coral Cover	Coral Diversity	Coral Recruitment	Bleaching Resistance	Macroalgae Cover	Herbivorous Fish Biomass	Temperature Variability
Shallow	18/18	0.62	0.14	0.13	0.74	0.94	0.54	0.04	0.82
Deep	18/20	0.67	0.25	0.15	0.96	0.87	0.60	0.04	0.82

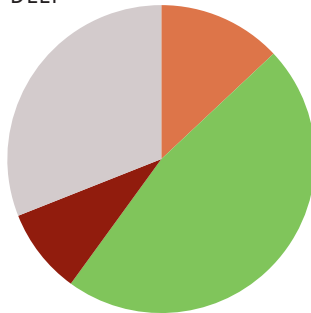
● High (>avg+1 SD) ● Med-High (>avg and <avg+1 SD) ● Med-Low (<avg and >avg - 1 SD) ● Low (<avg - 1 SD)

BENTHIC COMMUNITY

SHALLOW



DEEP



● Coral
● Macroalgae
● Coralline algae
● Other

FISH SPECIES

SHALLOW

- Acanthurus nigricauda*
- Acanthurus nigrofuscus*
- Aphareus furca*
- Calotomus carolinus*
- Chlorurus sordidus*
- Ctenochaetus striatus*
- Monotaxis grandoculis*
- Naso annulatus*
- Naso lituratus*
- Naso unicornis*
- Naso vlamingii*
- Scarus schlegeli*

CORAL SPECIES

SHALLOW

- Acropora humilis*
- Astreopora myriophthalma*
- Dipsastraea matthaii*
- Goniopora fruticosa*
- Leptastrea purpurea*
- Pavona bipartita*
- Porites lobata*
- Porites lutea*
- Psammocora haimeana*

DEEP

- Acanthastrea brevis*
- Astreopora myriophthalma*
- Astreopora randalli*
- Cyphastrea microphthalma*
- Cyphastrea serailia*
- Diploastrea heliopora*
- Dipsastraea favus*
- Dipsastraea maritima*
- Dipsastraea matthaii*
- Dipsastraea speciose*
- Favites valenciennesi*
- Goniastrea edwardsi*
- Goniastrea pectinata*
- Goniopora fruticosa*
- Goniopora minor*
- Leptastrea purpurea*
- Montipora foveolata*
- Montipora verrucosa*
- Pavona varians*
- Porites lichen*
- Porites lobata*
- Porites lutea*
- Porites rus*
- Stylocoeniella armata*

DEEP

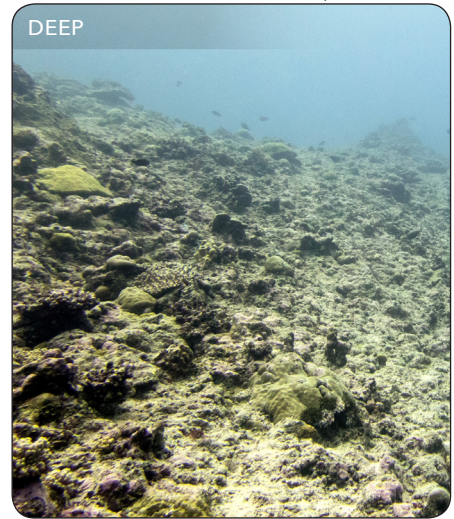
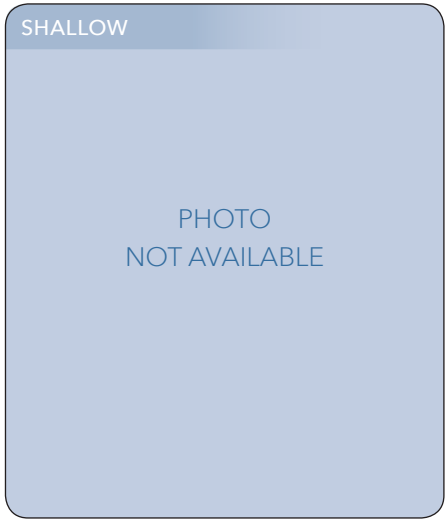
- Acanthurus nigricauda*
- Acanthurus nigrofuscus*
- Calotomus carolinus*
- Chlorurus sordidus*
- Ctenochaetus striatus*
- Epinephelus fasciatus*
- Epinephelus merra*
- Lutjanus fulvus*
- Monotaxis grandoculis*
- Naso lituratus*
- Naso unicornis*
- Scarus forsteni*

PATI POINT

N/A – Shallow, 8 – Deep



Guam's eastern most point, Pati Point is often inaccessible due to the near year-round presence of large waves.



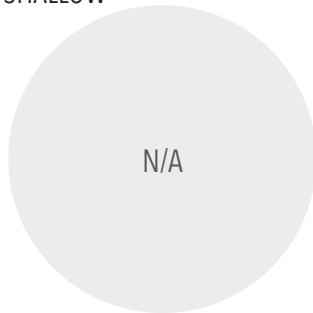
RELATIVE RESILIENCE

Depth	Rank	Resilience Score	Coral Cover	Coral Diversity	Coral Recruitment	Bleaching Resistance	Macroalgae Cover	Herbivorous Fish Biomass	Temperature Variability
Shallow	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Deep	7/20	0.84	0.38	0.41	0.98	0.69	0.94	0.33	0.85

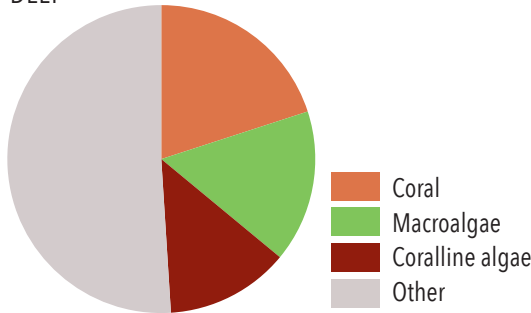
● High (>avg+1 SD) ● Med-High (>avg and <avg+1 SD) ● Med-Low (<avg and >avg - 1 SD) ● Low (<avg - 1 SD)

BENTHIC COMMUNITY

SHALLOW



DEEP



FISH SPECIES

SHALLOW

Not applicable

CORAL SPECIES

SHALLOW

Not applicable

DEEP

- Acropora cerealis*
- Astrea curta*
- Astreopora myriophthalma*
- Astreopora ocellata*
- Cyphastrea chalcidicum*
- Cyphastrea serailia*
- Dipsastraea favus*
- Dipsastraea maritima*
- Dipsastraea matthaii*
- Dipsastraea pallida*
- Favites valenciennesi*
- Galaxea fascicularis*
- Goniastrea edwardsi*
- Goniastrea stelligera*
- Leptastrea purpurea*
- Montipora caliculata*
- Montipora hoffmeisteri*
- Montipora nodosa*
- Montipora tuberculosa*
- Montipora verrucosa*
- Pavona clavus*
- Pavona varians*
- Pavona venosa*
- Platygyra pini*
- Pocillopora elegans*
- Porites lichen*
- Porites lobata*
- Porites lutea*
- Porites rus*

DEEP

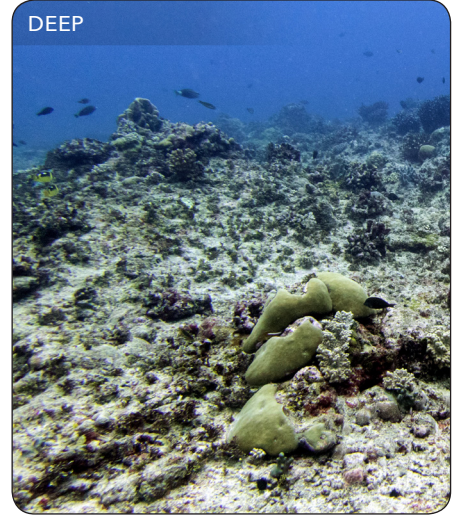
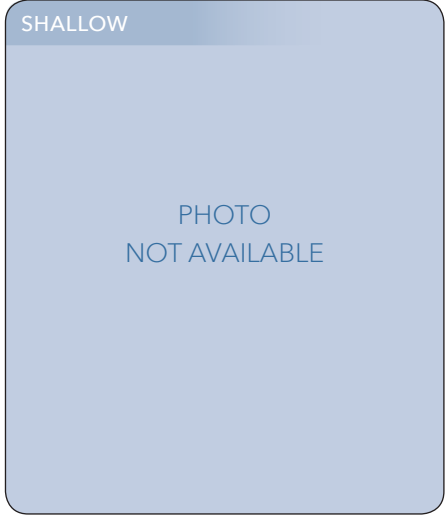
- Acanthurus nigricans*
- Acanthurus nigricauda*
- Acanthurus nigrofuscus*
- Acanthurus olivaceus*
- Acanthurus triostegus*
- Acanthurus xanthopterus*
- Aethaloperca rogaa*
- Aphareus furca*
- Aprion virescens*
- Calotomus carolinus*
- Caranx melampygus*
- Cheilinus undulates*
- Chlorurus sordidus*
- Ctenochaetus striatus*
- Gymnosarda unicolor*
- Hipposcarus longiceps*
- Lutjanus bohar*
- Lutjanus monostigma*
- Macolor macularis*
- Monotaxis grandoculis*
- Naso hexacanthus*
- Naso lituratus*
- Naso vlamingii*
- Scarus forsteni*
- Scarus fuscocaudalis*
- Scarus psittacus*
- Scarus rubroviolaceus*
- Variola louti*

LATTE POINT

N/A – Shallow, 15 – Deep



The latte is a symbol of Chamorro culture. The latte stones were architectural structures used to build ancient Chamorro homes.



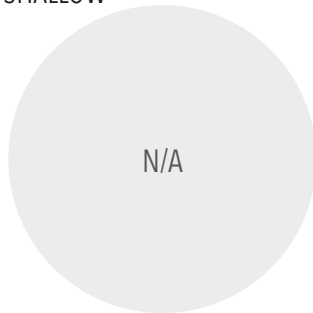
RELATIVE RESILIENCE

Depth	Rank	Resilience Score	Coral Cover	Coral Diversity	Coral Recruitment	Bleaching Resistance	Macroalgae Cover	Herbivorous Fish Biomass	Temperature Variability
Shallow	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Deep	17/20	0.74	0.23	0.34	0.96	0.59	0.86	0.21	0.85

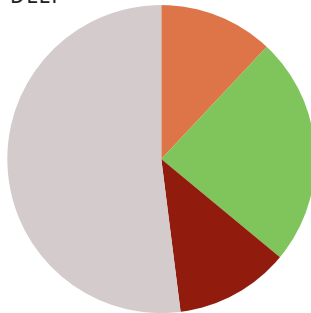
● High (>avg+1 SD) ● Med-High (>avg and <avg+1 SD) ● Med-Low (<avg and >avg - 1 SD) ● Low (<avg - 1 SD)

BENTHIC COMMUNITY

SHALLOW



DEEP



● Coral
● Macroalgae
● Coralline algae
● Other

FISH SPECIES

SHALLOW



Not applicable

CORAL SPECIES

SHALLOW

Not applicable



DEEP

Astreopora myriophthalma
Astreopora ocellata
Cyphastrea serailia
Dipsastraea maritima
Dipsastraea matthaii
Dipsastraea pallida
Favites valenciennesi
Goniastrea retiformis
Goniastrea stelligera
Heliopora coerulea
Leptastrea purpurea
Lobophyllia hemprichii
Montipora caliculata
Montipora cf. venosa



Montipora hoffmeisteri
Montipora tuberculosa
Pavona clavus
Pavona varians
Pocillopora elegans
Pocillopora eydouxi
Pocillopora verrucosa, *Porites australiensis*
Porites lichen
Porites lutea
Porites vaughani
Stylocoeniella armata
Stylophora pistillata

DEEP



Acanthurus blochii
Acanthurus nigricans
Acanthurus nigrofuscus
Acanthurus olivaceus
Aethaloperca rogaa
Aphareus furca
Calotomus carolinus
Chlorurus microrhinos
Chlorurus sordidus
Ctenochaetus striatus
Gymnosarda unicolor
Lutjanus bohar
Macolor macularis
Naso lituratus
Naso unicornis