Coral reef resilience to climate change in Guam in 2016

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*Project Co-Leaders
CITATION:


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Acknowledgments

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Executive Summary

Coral reef resilience to climate change in Guam in 2016

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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. 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.
**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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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 unidirectional 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 ± 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.**

<table>
<thead>
<tr>
<th>Variable name (unit)</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coral cover (%)</td>
<td>Average percent of points classified as coral on three 30-m point-intercept transects where points were classified at 50-cm intervals.</td>
</tr>
<tr>
<td>Coral diversity (unitless)</td>
<td>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 = \frac{(\text{sum of } n(n-1))/N(N-1))}{},) where (n = \text{total number of organisms of a particular species, and } N = \text{total number of organisms of all species observed.})</td>
</tr>
<tr>
<td>Coral recruitment (/m²)</td>
<td>Average density of corals with a geometric mean &lt; 5 cm from 12 replicate .25 m² quadrats; species that fissure and fragment frequently were excluded from this analysis.</td>
</tr>
<tr>
<td>Bleaching resistance (%)</td>
<td>Percent of the coral community made up of species considered to be resistant (rating ≤ 3 in Table A1)</td>
</tr>
<tr>
<td>Macroalgae cover (%)</td>
<td>Average percent of points classified as macroalgae (&gt; 1 cm in height) on three 30-m point-intercept transects where points were classified at 50-cm intervals.</td>
</tr>
<tr>
<td>Herbivorous fish biomass (g/m²)</td>
<td>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</td>
</tr>
</tbody>
</table>
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).

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**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 macoralgae 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%), Pugua 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.

<table>
<thead>
<tr>
<th>Site</th>
<th>Shallow</th>
<th>Deep</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coral</td>
<td>Macroalgae</td>
</tr>
<tr>
<td>Ague Point</td>
<td>43</td>
<td>13</td>
</tr>
<tr>
<td>Cocos Barrier Reef-E</td>
<td>26</td>
<td>18</td>
</tr>
<tr>
<td>Cocos Barrier Reef-W</td>
<td>12</td>
<td>24</td>
</tr>
<tr>
<td>Dadi Beach</td>
<td>23</td>
<td>21</td>
</tr>
<tr>
<td>Facpi Point</td>
<td>19</td>
<td>32</td>
</tr>
<tr>
<td>Fouha Bay</td>
<td>6</td>
<td>51</td>
</tr>
<tr>
<td>Ga’an Point</td>
<td>16</td>
<td>50</td>
</tr>
<tr>
<td>Hagatna Bay</td>
<td>33</td>
<td>12</td>
</tr>
<tr>
<td>Janom Point</td>
<td>19</td>
<td>25</td>
</tr>
<tr>
<td>Jinapsan Beach</td>
<td>32</td>
<td>26</td>
</tr>
<tr>
<td>Latte Point</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Luminao Reef</td>
<td>27</td>
<td>8</td>
</tr>
<tr>
<td>Manell Channel</td>
<td>19</td>
<td>26</td>
</tr>
<tr>
<td>Mangilao Golf Course</td>
<td>32</td>
<td>11</td>
</tr>
<tr>
<td>Orote Point</td>
<td>29</td>
<td>8</td>
</tr>
<tr>
<td>Pati Point</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Pugua Patch Reef</td>
<td>34</td>
<td>14</td>
</tr>
<tr>
<td>Tagua Point</td>
<td>28</td>
<td>16</td>
</tr>
<tr>
<td>Tepungan Bay</td>
<td>27</td>
<td>16</td>
</tr>
<tr>
<td>Tumon Bay</td>
<td>23</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>34</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>51</td>
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<tr>
<td></td>
<td>8</td>
<td>51</td>
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<td>11</td>
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<td></td>
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<td>61</td>
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<td>67</td>
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<td>52</td>
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<td>16</td>
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<td></td>
<td>17</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>44</td>
<td>19</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Local Name</th>
<th>Shallow Rank [Deep]</th>
<th>Resilience score</th>
<th>Raw resilience score</th>
<th>CC</th>
<th>CR</th>
<th>CD</th>
<th>BR</th>
<th>MA</th>
<th>HB</th>
<th>TV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tagua Point</td>
<td>1 [4]</td>
<td>1.00</td>
<td>0.77</td>
<td>0.65</td>
<td>0.40</td>
<td>0.92</td>
<td>0.67</td>
<td>0.91</td>
<td>1.00</td>
<td>0.85</td>
</tr>
<tr>
<td>Ague Point</td>
<td>2 [2]</td>
<td>0.99</td>
<td>0.76</td>
<td>1.00</td>
<td>0.67</td>
<td>0.96</td>
<td>0.80</td>
<td>0.94</td>
<td>0.97</td>
<td>0.89</td>
</tr>
<tr>
<td>Pugua Patch Reef</td>
<td>3 [1]</td>
<td>0.96</td>
<td>0.74</td>
<td>0.79</td>
<td>0.66</td>
<td>1.00</td>
<td>0.78</td>
<td>0.93</td>
<td>0.08</td>
<td>0.93</td>
</tr>
<tr>
<td>Orote Point</td>
<td>4 [7]</td>
<td>0.94</td>
<td>0.73</td>
<td>0.66</td>
<td>0.75</td>
<td>0.93</td>
<td>0.75</td>
<td>1.00</td>
<td>0.15</td>
<td>0.83</td>
</tr>
<tr>
<td>Hagatna Bay</td>
<td>5 [6]</td>
<td>0.93</td>
<td>0.72</td>
<td>0.78</td>
<td>0.43</td>
<td>0.92</td>
<td>0.89</td>
<td>0.96</td>
<td>0.18</td>
<td>0.89</td>
</tr>
<tr>
<td>Luminao Reef</td>
<td>6 [3]</td>
<td>0.91</td>
<td>0.71</td>
<td>0.62</td>
<td>1.00</td>
<td>0.72</td>
<td>0.66</td>
<td>0.99</td>
<td>0.08</td>
<td>0.86</td>
</tr>
<tr>
<td>Tepungan Bay</td>
<td>7 [10]</td>
<td>0.88</td>
<td>0.68</td>
<td>0.64</td>
<td>0.28</td>
<td>0.96</td>
<td>0.92</td>
<td>0.91</td>
<td>0.17</td>
<td>0.87</td>
</tr>
<tr>
<td>Jinapsan Beach</td>
<td>8 [9]</td>
<td>0.84</td>
<td>0.65</td>
<td>0.75</td>
<td>0.48</td>
<td>0.97</td>
<td>0.43</td>
<td>0.81</td>
<td>0.08</td>
<td>1.00</td>
</tr>
<tr>
<td>Tumon Bay</td>
<td>9 [5]</td>
<td>0.84</td>
<td>0.64</td>
<td>0.55</td>
<td>0.44</td>
<td>0.92</td>
<td>0.69</td>
<td>0.85</td>
<td>0.12</td>
<td>0.95</td>
</tr>
<tr>
<td>Dadi Beach</td>
<td>10 [12]</td>
<td>0.82</td>
<td>0.63</td>
<td>0.53</td>
<td>0.42</td>
<td>0.77</td>
<td>1.00</td>
<td>0.86</td>
<td>0.08</td>
<td>0.77</td>
</tr>
<tr>
<td>Manell Channel</td>
<td>11 [16]</td>
<td>0.81</td>
<td>0.63</td>
<td>0.45</td>
<td>0.41</td>
<td>0.98</td>
<td>0.91</td>
<td>0.80</td>
<td>0.07</td>
<td>0.77</td>
</tr>
<tr>
<td>Janom Point</td>
<td>12 [13]</td>
<td>0.80</td>
<td>0.61</td>
<td>0.45</td>
<td>0.53</td>
<td>0.91</td>
<td>0.63</td>
<td>0.81</td>
<td>0.05</td>
<td>0.91</td>
</tr>
<tr>
<td>Mangilao Golf Course</td>
<td>13 [11]</td>
<td>0.78</td>
<td>0.60</td>
<td>0.74</td>
<td>0.12</td>
<td>0.95</td>
<td>0.48</td>
<td>0.97</td>
<td>0.08</td>
<td>0.88</td>
</tr>
<tr>
<td>Cocos Barrier Reef-W</td>
<td>14 [14]</td>
<td>0.78</td>
<td>0.60</td>
<td>0.50</td>
<td>0.41</td>
<td>0.95</td>
<td>0.83</td>
<td>0.83</td>
<td>0.07</td>
<td>0.84</td>
</tr>
<tr>
<td>Cocos Barrier Reef-E</td>
<td>15 [20]</td>
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<td>0.60</td>
<td>0.60</td>
<td>0.19</td>
<td>0.99</td>
<td>0.67</td>
<td>0.89</td>
<td>0.07</td>
<td>0.78</td>
</tr>
<tr>
<td>Facpi Point</td>
<td>16 [19]</td>
<td>0.77</td>
<td>0.59</td>
<td>0.44</td>
<td>0.30</td>
<td>0.94</td>
<td>0.88</td>
<td>0.73</td>
<td>0.04</td>
<td>0.82</td>
</tr>
<tr>
<td>Ga’an Point</td>
<td>17 [17]</td>
<td>0.72</td>
<td>0.56</td>
<td>0.36</td>
<td>0.23</td>
<td>0.95</td>
<td>0.96</td>
<td>0.54</td>
<td>0.08</td>
<td>0.77</td>
</tr>
<tr>
<td>Fouha Bay</td>
<td>18 [18]</td>
<td>0.62</td>
<td>0.48</td>
<td>0.14</td>
<td>0.13</td>
<td>0.74</td>
<td>0.94</td>
<td>0.54</td>
<td>0.04</td>
<td>0.82</td>
</tr>
</tbody>
</table>

*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.

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

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.
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

Resilience rank
1 Tagua Point [4] 11 Manell Channel [16]
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 3. Relative classifications for coral recruitment. Normalized values for this and the other indicators are presented with Tables 1 and 2.
Figure 4. Relative classifications for coral diversity. Normalized values for this and the other indicators are presented with Tables 1 and 2.
Bleaching Resistance

Resilience rank
1 Tagua Point [4] 11 Manell Channel [16]
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 5. Relative classifications for bleaching resistance. Normalized values for this and the other indicators are presented with Tables 1 and 2.
Figure 6. Relative classifications for macroalgae cover. Normalized values for this and the other indicators are presented with Tables 1 and 2.
Figure 7. Relative classifications for herbivore biomass. Normalized values for this and the other indicators are presented with Tables 1 and 2.
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](image.png)

**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 ($\delta^2$) 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 ($\delta^2$) 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.
References


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).

<table>
<thead>
<tr>
<th>Coral Species</th>
<th>Growth Morphology</th>
<th>Bleaching Susceptibility</th>
<th>Habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acanthastrea brevis</td>
<td>Encrusting</td>
<td>2</td>
<td>P, Sg</td>
</tr>
<tr>
<td>Acanthastrea echinata</td>
<td>Encrusting</td>
<td>2</td>
<td>Lf, P, Rf, Sg</td>
</tr>
<tr>
<td>Acanthastrea hillae</td>
<td>Encrusting</td>
<td>2</td>
<td>P, Sg</td>
</tr>
<tr>
<td>Acanthastrea c.f. regularis</td>
<td>Encrusting</td>
<td>2</td>
<td>Lf</td>
</tr>
<tr>
<td>Acropora abrotanoides</td>
<td>Arborescent</td>
<td>3</td>
<td>Lf, P, Sg</td>
</tr>
<tr>
<td>Acropora aspera</td>
<td>Staghorn</td>
<td>5</td>
<td>P, Rf</td>
</tr>
<tr>
<td>Acropora azurea</td>
<td>Dgitate/corymbose</td>
<td>4</td>
<td>Lf, Sg</td>
</tr>
<tr>
<td>Acropora cerealis</td>
<td>Dgitate/corymbose</td>
<td>4</td>
<td>Lf, Sg</td>
</tr>
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<td>Lf</td>
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<td>Arborescent</td>
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<td>P</td>
</tr>
<tr>
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<td>3</td>
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<td>3</td>
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<td>Dgitate/corymbose</td>
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<td>Rf</td>
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<td>Sg</td>
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<td>Lf, P, Sg</td>
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<td>Growth Morphology</td>
<td>Bleaching Susceptibility</td>
<td>Habitat</td>
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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.
The Point is a significant archaeological site; some of the earliest settlements of people in the Marianas Islands were here.

**RELATIVE RESILIENCE**

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<th>Rank</th>
<th>Resilience Score</th>
<th>Coral Cover</th>
<th>Coral Diversity</th>
<th>Coral Recruitment</th>
<th>Bleaching Resistance</th>
<th>Macroalgae Cover</th>
<th>Herbivorous Fish Biomass</th>
<th>Temperature Variability</th>
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<td>0.65</td>
<td>0.40</td>
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<td>Deep</td>
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<td>0.95</td>
<td>0.76</td>
<td>0.78</td>
<td>1.00</td>
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- **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**

- Coral
- Macroalgae
- Coralline algae
- Other

**DEEP**

**FISH SPECIES**

**SHALLOW**

- Acanthurus blochii
- Acanthurus lineatus
- Acanthurus nigricans
- Acanthurus nigricauda
- Acanthurus nigrofuscus
- Acanthurus triostegus
- Acanthurus xanthopterus
- Aphaerus furca
- Calotomus carolinus
- Caranx melampygus
- Cephalopholis argus
- Chlorurus sordidus

**DEEP**

- Acanthurus nigricans
- Acanthurus nigricauda
- Acanthurus nigrofuscus
- Acanthurus xanthopterus
- Astreopsis furca
- Calotomus carolinus
- Caranx melampygus
- Cephalopholis argus
- Chlorurus sordidus

**TAGUA POINT**

1 – Shallow, 4 – Deep
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

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<th>Depth</th>
<th>Rank</th>
<th>Resilience Score</th>
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<th>Coral Diversity</th>
<th>Coral Recruitment</th>
<th>Bleaching Resistance</th>
<th>Macrolegumae Cover</th>
<th>Herbivorous Fish Biomass</th>
<th>Temperature Variability</th>
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<td>2/18</td>
<td>0.99</td>
<td>1.00</td>
<td>0.67</td>
<td>0.96</td>
<td>0.80</td>
<td>0.94</td>
<td>0.07</td>
<td>0.89</td>
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<tr>
<td>Deep</td>
<td>2/20</td>
<td>0.95</td>
<td>0.66</td>
<td>0.62</td>
<td>0.96</td>
<td>0.84</td>
<td>1.00</td>
<td>0.20</td>
<td>0.89</td>
</tr>
</tbody>
</table>

BENTHIC COMMUNITY

SHALLOW

DEEP

CORAL SPECIES

SHALLOW

Acanthastrea echinata
Acropora abroltoides
Acropora digitifera
Acropora gregicpes
Acopora surculosa
Acropora verweyi
Astrea curta
Cyphastrea chalcidicum
C. microphthalma
Dipsastrea danai
Dipsastrea favus
Dipsastrea matthaii
Dipsastrea pallida
Favites colemani
Favites valenciennesi
Galaxea fasciolaris
Goniastrea retiformis
Hydophora microconos
Leptastrea purpurea
Leptoria phrygia
Millepora dichotoma
Millepora platyphylla
Montipora c.f. studeri
Montipora caliculata
Montipora grisea
Montipora hoffmeisteri
Montipora monasteria
Montipora nodosa
Montipora tuberculosa
Pavona c.f. meandrina
Pavona varians
Pocillopora meandrina
Pocillopora verrucosa
Porites australiensis
Porites horizontalata
Porites lutea

DEEP

Acanthastrea brevis
Astreopora listeria
Astreopora myriophithalmus
Astreopora ocellata
Cyphastrea serailia
Dipsastrea danai
Dipsastrea favus
Dipsastrea maritima
Dipsastrea matthaii
Favites colemani
Favites valenciennesi
Goniastrea edwardsi
Leptastrea purpurea
Montipora caliculata
Montipora tuberculosa
Montipora verrucosa
Paragoniastrea russelli
Pavona duerdeni
Pavona varians
Platygyra pini
Pocillopora damicornis
Pocillopora verrucosa
Porites australiensis
Porites lichen
Porites lobate
Porites lutea
Porites rus
Psammocora haimana
Stylocoeniella armata

FISH SPECIES

SHALLOW

Acanthurus lineatus
Acanthurus nigricans
Acanthurus nigrofuscus
Acanthurus pyrofeus
Aphareus furca
Chlorurus sordidus
Gynosarda unicolor
Naso unicornis
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Nas...
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

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

BENTHIC COMMUNITY

SHALLOW

DEEP

CORAL SPECIES

SHALLOW

Acanthastrea brevis
Acanthastrea echinata
Acropora digitifera
Cyphastrea chalcidicum
C. microphthalma
Cyphastrea serailia
Dipsastrea favus
Dipsastrea maritima
Dipsastrea mathaii
Dipsastrea pallida, Dipsastrea speciosa
Favites coelemani
Favites valenciennesi
Galaxea fascicularis
Goniastrea edwardsi
Goniastrea reitmanni
Goniastrea stelligera
Leptoria phygia
Leptoseris mycterooides
Montipora hoffmeisteri
Montipora tuberculosa
Montipora venosa
Paragoniastrea russelli
Pavona chiquiensis
Pavona clavus
Pavona duredeni
Pavona varians
Pterygyra pini
Pocillopora verrucosa
Porites australiensis
Porites deformis
Porites lichen
Porites lobata
Porites lutea
Porites rus
Porites vaughani
Psammocora contigua
Psammocora niesrza
Stylocoeniella armata

DEEP

Acropora globiceps
Astreopora gracilis
Astreopora myriophthalma
Astreopora randalli
Cyphastrea chalcidicum
Cyphastrea microphthalma
Cyphastrea serailia
Dipsastrea favus
Dipsastrea maritima
Dipsastrea mathaii
Dipsastrea stelligera
Favites coelemani
Favites valenciennesi
Goniastrea pectinata
Goniastrea purpurea
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 harrisoni
Psammocora niesrza
Stylocoeniella armata

FISH SPECIES

SHALLOW

Acanthurus nigricans
Acanthurus nigrofuscus
Aphareus furca
Chlorurus sordidus
Ctenochaetus striatus
Naso lituratus
Scarus pusillus

DEEP

Acanthus nigricans
Acanthus nigrofuscus
Aphareus furca
Cephalopholis argus
Chlorurus microhinos
Chlorurus sordidus
Ctenochaetus striatus
Naso lituratus
Scarus forsteni
Scarus globiceps
Scarus paletus
Scarus schlegeli
Zebrazora 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

<table>
<thead>
<tr>
<th>Depth</th>
<th>Rank</th>
<th>Resilience Score</th>
<th>Coral Cover</th>
<th>Coral Diversity</th>
<th>Coral Recruitment</th>
<th>Bleaching Resistance</th>
<th>Macroalgae Cover</th>
<th>Herbivorous Fish Biomass</th>
<th>Temperature Variability</th>
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</thead>
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<td>0.94</td>
<td>0.66</td>
<td>0.75</td>
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<td>0.75</td>
<td>1.00</td>
<td>0.15</td>
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<tr>
<td>Deep</td>
<td>7/20</td>
<td>0.86</td>
<td>0.27</td>
<td>0.64</td>
<td>0.88</td>
<td>0.85</td>
<td>0.89</td>
<td>0.36</td>
<td>0.83</td>
</tr>
</tbody>
</table>

- **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**
- Coral
- Macroalgae
- Coralline algae
- Other

**DEEP**
- Coral
- Macroalgae
- Coralline algae
- Other

### Coral Species

**SHALLOW**
- Acanthastrea brevis
- Acropora palmerae
- Acropora surculosa
- Astrea curta
- Cyphastrea microphthalmal
- Dipsastrea matthaii
- Favites colemani
- Favites valenciennesi
- Goniastrea edwardsi
- Goniastrea stelligera
- Hydathophora microconos
- Leptastrea purpurea
- Leptoria phrygia
- Montipora efflorescens

**DEEP**
- Acanthastrea brevis
- Acropora gemmifera
- Acropora globiceps
- Alveopora listeri
- Astreopora myrophthalma
- Astreopora serattata
- Cyphastrea roliei
- Dipsastrea helianthoides
- Dipsastrea maritima
- Dipsastrea matthaii
- Favites colemani
- Favites valenciennesi
- Galaxea fascicularis
- Goniastrea edwardsi

**FISH SPECIES**

**SHALLOW**
- Acanthus lineatus
- Acanthus nigricans
- Acanthus nigrofuscus
- Acanthus olivaceus
- Acanthus triestegus
- Acanthurus furca
- Acanthurus nigricauda
- Acanthurus nigrofuscus
- Acanthurus olivaceus
- Acanthurus triestegus
- Acanthurus nigricans
- Acanthurus nigrofuscus
- Acanthurus olivaceus
- Acanthurus triestegus
- Acanthurus nigricauda
- Acanthurus nigrofuscus
- Acanthurus olivaceus
- Acanthurus triestegus
- Acanthurus nigricans
- Acanthurus nigrofuscus
- Acanthurus olivaceus
- Acanthurus triestegus

**DEEP**
- Calotomus carolinus
- Caranx melampygus
- Chlorurus sordidus
- Ctenocharax striatus
- Monotaxis grandoculis
- Naso brevirostris
- Naso lituratus
- Naso unicornis
- Naso vlamingii
- Naso lituratus
- Naso vlamingii
- Naso vlamingii

13.446° N, 144.618° E
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**

<table>
<thead>
<tr>
<th>Depth</th>
<th>Rank</th>
<th>Resilience Score</th>
<th>Coral Cover</th>
<th>Coral Diversity</th>
<th>Coral Recruitment</th>
<th>Bleaching Resistance</th>
<th>Macrolgae Cover</th>
<th>Herbivorous Fish Biomass</th>
<th>Temperature Variability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shallow</td>
<td>5/18</td>
<td>0.93</td>
<td>0.78</td>
<td>0.43</td>
<td>0.92</td>
<td>0.89</td>
<td>0.96</td>
<td>0.18</td>
<td>0.89</td>
</tr>
<tr>
<td>Deep</td>
<td>6/20</td>
<td>0.88</td>
<td>1.00</td>
<td>0.47</td>
<td>0.39</td>
<td>1.00</td>
<td>0.94</td>
<td>0.10</td>
<td>0.89</td>
</tr>
</tbody>
</table>

- **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**

- Coral
- Macroalgae
- Coralline algae
- Other

**DEEP**

- Coral
- Macroalgae
- Coralline algae
- Other

**Coral Species**

**SHALLOW**

- Acanthastrea echinata
- Astrea curta
- Astreopora myriophthalma
- Dipsastrea favus
- Dipsastrea maritima
- Dipsastrea pallida
- Favites colemani
- Favites valenciennesi
- Galaxea fascicularis
- Goniastrea retiformis
- Goniastrea stelligera
- Hydrophora microconos
- Leptastrea purpurea
- Leptoria phrygia

- Millepora platyphyllia
- Montipora aequituberculata
- Montipora calcitula
- Montipora danae
- Montipora ephelereens
- Montipora tuberculosa
- Montipora venosa
- Pavona clavus
- Pavona varias
- Pocillopora damicornis
- Porites deformis
- Porites lutea
- Porites rus
- Stylocoeniella armata

**DEEP**

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

**FISH SPECIES**

**SHALLOW**

- Acanthus nigricans
- Acanthus nigrofuscus
- Aphaeas furca
- Carangoides ferdau
- Chlorurus sordidus
- Ctenochaetus striatus
- Naso lituratus
- Naso unicornis
- Scarus psittacus
- Scomberoides lysan

**DEEP**

- Acanthus nigricans
- Acanthus nigrofuscus
- Aphaeas furca
- Carangoides ferdau
- Chlorurus sordidus
- Ctenochaetus striatus
- Lutjanus fulvus
- Monotaxis grandoculis
- Naso lituratus
- Naso unicornis
- Scarus psittacus
- Zebrasoma 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.

RELATIVE RESILIENCE

<table>
<thead>
<tr>
<th>Depth</th>
<th>Rank</th>
<th>Resilience Score</th>
<th>Coral Cover</th>
<th>Coral Diversity</th>
<th>Coral Recruitment</th>
<th>Bleaching Resistance</th>
<th>Macrolgae Cover</th>
<th>Herbivorous Fish Biomass</th>
<th>Temperature Variability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shallow</td>
<td>6/18</td>
<td>0.91</td>
<td>0.62</td>
<td>1.00</td>
<td>0.72</td>
<td>0.66</td>
<td>0.99</td>
<td>0.08</td>
<td>0.86</td>
</tr>
<tr>
<td>Deep</td>
<td>3/20</td>
<td>0.93</td>
<td>0.41</td>
<td>0.41</td>
<td>0.98</td>
<td>0.91</td>
<td>1.00</td>
<td>0.54</td>
<td>0.86</td>
</tr>
</tbody>
</table>

BENTHIC COMMUNITY

SHALLOW

DEEP

CORAL SPECIES

SHALLOW
Acanthastrea echinata
Acropora surculosa
Astrea curta
Cyphastrea microphthalma
Favia stelligera
Galaxea fascicularis
Goniastrea retiformis
Hydphora microconos
Leptastrea purpura
Leptoria phrygia
Montipora foveolata
Montipora grisea
Montipora tuberculosa
Montipora verrucosa
Pavona varians
Platygrya pini
Pocillopora elegans
Porites australiensis
Porites lobata

DEEP
Astreopora myriophthalma
Coscinaraea columna
Cycloseris vaughani
Cyphastrea chalcidicum
Dipsastrea danai
Dipsastrea favus
Dipsastrea maritima
Dipsastrea matthaii
Dipsastrea pallida
Favites coelemani
Favites valenciennesi
Goniastrea edwardsi
Goniastrea retiformis
Goniastrea stelligera
Herpolitha weberi
Leptastrea purpura
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

FISH SPECIES

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

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
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

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

BENTHIC COMMUNITY

SHALLOW

DEEP

CORAL SPECIES

SHALLOW

Acanthastrea brevis
Acanthastrea echinata
Acropora abrotanoides
Acropora surculosa
Astreopora listeria
Astreopora myriophthalma
Dipsastrea danai
Dipsastrea favus
Dipsastrea maritima
Dipsastrea Matthaii
Dipsastrea pallida
Favites valenciennesi
Galaxea fascicularis
Goniastrea retiformis
Goniastrea stelligera

Leptastrea purpurea
Leptoria phrygia
 Lobophyllia coromosa
Pavona chiquensis
Pavona varians
Platygyra pini
Pocillopora conicus
Pocillopora damicomis
Pocillopora verrucosa
Porites australiensis
Porites lobata
Porites lutea
Psammocora niesrzi
Stylocoeniella armata

DEEP

Acropora globiceps
Cyphastrea microphthalma
Dipsastrea danai
Dipsastrea favus
Dipsastrea maritima
Dipsastrea Matthaii
Dipsastrea pallida
Favites colemani
Favites valenciennesi
Galaxea fascicularis
Goniastrea edwardsi
Goniastrea pectinata
Goniastrea stelligera
Leptastrea purpurea

Lobactis scutaria
Paragoniastrea russelli
Pavona chiquensis
Pavona varians
Pocillopora conicus
Pocillopora verrucosa
Porites australiensis
Porites lobata
Porites lutea
Porites rus
Psammocora haimena
Stylocoeniella armata

FISH SPECIES

SHALLOW

Acanthurus lineatus
Acanthurus nigricans
Acanthurus nigrofuscus
Aphareus ferca
Calotomus carolinus
Carax melanopus
Chlorurus microhinos
Chlorurus sordidus
Ctenochaetus striatus
Kyphosus cinereus
Lutjanus rubus

Macolor macularis
Monotaxis grandoculis
Naso lituratus
Naso unicorns
Scarus altipinnis
Scarus forsteni
Scarus globiceps
Scarus psittacus
Scarus schlegeli
Zeburasoma veliferum

DEEP

Acanthurus nigricans
Acanthurus nigrofuscus
Acanthurus pyrofusus
Aphareus ferca
Calotomus carolinus
Carax melanopus
Chlorurus microhinos
Chlorurus sordidus
Ctenochaetus striatus
Hipposcarus longiceps
Lutjanus bohar
Macolor macularis
Monotaxis grandoculis
Naso lituratus
# JINAPSAN BEACH

8 – Shallow, 9 – Deep

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

## BENTHIC COMMUNITY

### SHALLOW

- Coral
- Macroalgae
- Coralline algae
- Other

### DEEP

- Coral
- Macroalgae
- Coralline algae
- Other

## CORAL SPECIES

### SHALLOW

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

### DEEP

- Acropora globiceps
- Acropora surculosa
- Astreopora mirophtalma
- Cyphastrea serailia
- Dipsastrea danai
- Dipsastrea favus
- Dipsastrea helioides
- Dipsastrea maritima
- Dipsastrea matthaii
- Dipsastrea pallida
- Dipsastrea speciosa
- Favites colemani
- Goniatrea edwardsi
- Leptastrea purpurea

## FISH SPECIES

### SHALLOW

- Acanthurus blochii
- Acanthurus lineatus
- Acanthurus nigricans
- Acanthurus nigrofuscus
- Acanthurus olivaceus
- Acanthurus pyroferus
- Aphaeus furca
- Calotomus carolinus
- Chlorotomus sordidus
- Ctenochaetus striatus
- Ctenochaetus striatus
- Leptastrea purpurea
- Montipora efflorescens
- Montipora floweri
- Montipora grisea
- Montipora hoffmeisteri
- Montipora monasteriata
- Montipora nodosa
- Pavona varians
- Platgyra pini
- Pocillopora verrucosa
- Porites australiensis
- Porites lutea
- Porites vaughani

### DEEP

- Acanthurus nigricans
- Acanthurus nigrofuscus
- Aphaeus furca
- Calotomus carolinus
- Chloroto nus sordidus
- Ctenochaetus birotatus
- Ctenochaetus striatus
- Lutjanus bohar
- Nasso nititatus
- Siganus argenteus
- Siganus vulpinus
**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**

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

- **Coral**
- **Macroalgae**
- **Coralline algae**
- **Other**

**BENTHIC COMMUNITY**

**SHALLOW**

**DEEP**

**FISH SPECIES**

**SHALLOW**

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

**DEEP**

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

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

**BENTHIC COMMUNITY**

SHALLOW

DEEP

**CORAL SPECIES**

SHALLOW

Dipsastrea danai
Dipsastrea maritima
Favites valenciennesi
Goniastrea edwardsi
Goniastrea pectinata
Goniastrea retiformis
Heliopora coerulea
Leptastrea purpura
Pavona chiquiensis
Pavona clavus
Pavona varians
Porites australiensis
Porites deformis
Porites horizontalata
Porites lichen

DEEP

Astreopora myriophthalma
Astreopora ocellata
Astreopora randalli
Cyphastrea microphthalma
Cyphastrea serailia
Dipsastrea danai
Dipsastrea favus
Dipsastrea maritima
Favites colemani
Favites valenciennesi
Galaxea fascicularis
Goniastrea edwardsi
Leptastrea purpura
Montipora nodosa
Montipora verrucosa

FISH SPECIES

**SHALLOW**

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

**DEEP**

Acanthurus nigrofuscus
Calotomus carolinus
Chlorurus sordidus
Monotaxis grandoculis
Naso lituratus
Naso unicornis
Naso vlamingii
Scarus forsteri
Scarus psittacus
Scarus schlegeli
**MANHELL CHANNEL**

11 – Shallow, 16 – Deep

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

### RELATIVE RESILIENCE

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

- **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**

- Coral
- Macroalgae
- Coralline algae
- Other

**DEEP**

- Coral
- Macroalgae
- Coralline algae
- Other

### CORAL SPECIES

**SHALLOW**

- *Acanthastrea brevis*
- *Acanthastrea echinata*
- *Acropora globiceps*
- *Astreopora myriophthalma*
- *Cyphastrea calicidum*
- *Cyphastrea serailia*
- *Diploastrea heliopora*
- *Dipsastrea favus*
- *Dipsastrea maritima*
- *Dipsastrea matthaii*
- *Dipsastrea pallida*
- *Dipsastrea rotundata*
- *Favites colemani*
- *Favites valenciennesi*
- *Goniastrea edwardsi*
- *Goniastrea retiformis*
- *Goniopora fruticose*
- *Leptastrea purpurea*
- *Leptoria phylgia*
- *Montipora efflorescens*
- *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*
- *Dipsastrea danai*
- *Dipsastrea favus*
- *Dipsastrea maritima*
- *Dipsastrea matthaii*
- *Dipsastrea pallida*
- *Favites valenciennesi*
- *Galaxea fascicularis*
- *Goniastrea edwardsi*
- *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*
- *Scaphyphylla cylindrical*
- *Stylocoeniella armata*
- *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*
- *Scaphyphylla cylindrical*
- *Stylocoeniella armata*

### FISH SPECIES

**SHALLOW**

- *Acanthurus nigricans*
- *Acanthurus nigricauda*
- *Acanthurus nigrofuscus*
- *Acanthurus olivaceus*
- *Calotomus carolinus*
- *Caranx melampygus*
- *Chlorurus microrhinos*
- *Chlorurus sordidus*
- *Ctenochaetus striatus*

**DEEP**

- *Naso lituratus*
- *Scarus psittacus*
- *Scarus schlegeli*
- *Siganus spinus*

**SHALLOW**

- *Acanthastrea brevis*
- *Astreopora myriophthalma*
- *Acanthastrea echinata*
- *Astreopora ocellata*
- *Dipsastrea favus*
- *Dipsastrea maritima*
- *Dipsastrea matthaii*
- *Dipsastrea pallida*
- *Favites valenciennesi*
- *Galaxea fascicularis*
- *Goniastrea edwardsi*
- *Goniastrea retiformis*
**JANOM POINT**

12 – Shallow, 13 – Deep

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

**SHALLOW**

**DEEP**

**RELATIVE RESILIENCE**

<table>
<thead>
<tr>
<th>Depth</th>
<th>Rank</th>
<th>Resilience Score</th>
<th>Coral Cover</th>
<th>Coral Diversity</th>
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<td>0.45</td>
<td>0.53</td>
<td>0.91</td>
<td>0.63</td>
<td>0.81</td>
<td>0.05</td>
<td>0.91</td>
</tr>
<tr>
<td>Deep</td>
<td>13/20</td>
<td>0.76</td>
<td>0.26</td>
<td>0.63</td>
<td>0.97</td>
<td>0.68</td>
<td>0.66</td>
<td>0.06</td>
<td>0.91</td>
</tr>
</tbody>
</table>

- **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 SPECIES**

**SHALLOW**

- Acanthastrea brevis
- Acanthastrea echinata
- Acropora azurea
- Acropora cerealis
- Acropora monticulosa
- Acropora surculosa
- Astreopora myriophthalma
- Astrea curta
- Cyphastrea microphthalma
- Cyphastrea serailia
- Dipsastrea favus
- Dipsastrea maritima
- Galaxea fascicularis
- Goniastrea retiformis
- Goniastrea stelligera
- Leptastrea purpurea
- Leptoria phrygia
- Montipora grisea
- Montipora hoffmeisteri
- Montipora tuberculosa
- Paragoniastrea russellii
- Pavona varians
- Platygrya pini
- Pocillopora verrucosa
- Pocillopora meandrina
- Psammocora nierstrazi

**DEEP**

- Acanthastrea echinata
- Acropora cf. quelchi
- Acropora gemmifera
- Acropora globiceps
- Acropora tenuis
- Acropora verweyi
- Astreopora listeria
- Astreopora myriophthalma
- Cyphastrea chalcidicum
- Cyphastrea microporphyra
- Dipsastrea danai
- Dipsastrea favus
- Dipsastrea maritima
- Dipsastrea mathaii
- Dipsastrea pallida
- Favites coelemani

**FISH SPECIES**

**SHALLOW**

- Acanthurus blochii
- Acanthurus guttatus
- Acanthurus lineatus
- Acanthurus nigricans
- Acanthurus nigrofuscus
- Acanthus olivaceus
- Acanthus triostegus
- Acanthus xanthopterus
- Calotomus carolinus
- Chlorurus microchirinos

**DEEP**

- Acanthaster nigrofuscus
- Acanthaster olivaceus
- Acanthaster triostegus
- Acanthaster xanthopterus
- Chlorurus microchirinos
- Chlorurus sordidus
- Ctenochaetus binotatus
- Ctenochaetus striatus
- Paracanthurus hepatus

Janom Point, 12 – Shallow, 13 – Deep

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

- Depth
- Rank
- Resilience Score
- Coral Cover
- Coral Diversity
- Coral Recruitment
- Bleaching Resistance
- Macroalgae Cover
- Herbivorous Fish Biomass
- Temperature Variability

<table>
<thead>
<tr>
<th>JANOM POINT</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 – Shallow, 13 – Deep</td>
</tr>
</tbody>
</table>

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

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

- 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**

- Coral
- Macroalgae
- Coralline algae
- Other

**DEEP**

- Coral
- Macroalgae
- Coralline algae
- Other

**CORAL SPECIES**

**SHALLOW**

- Acanthastrea echinata
- Acropora azurea
- Acropora cf. paniculata
- Acropora gemmifera
- Acropora robusta
- Acropora surculosa
- Astrea curta
- Dipsastrea furvus
- Dipsastrea mathaii
- Dipsastrea pallida
- Favites colemani
- Galaxea fascicularis
- Goniatrea retiformis
- Goniatrea stelligera
- Leptoria phrygia

- Millepora platyphylla
- Montipora tuberculosa
- Paragoniastrea russelli
- Pavona varians
- Pocillopora meandrina

**DEEP**

- Acropora surculosa
- Astreopora myriophthalma
- Astreopora ocellata
- Cyphastrea microphthalma
- Cyphastrea serailia
- Dipsastrea furvus
- Dipsastrea maritima
- Dipsastrea mathaii
- Dipsastrea pallida
- Favites colemani
- Galaxea fascicularis
- Goniatrea edwardsi
- Goniatrea stelligera
- Gonioaster fruticose

- Leptastrea purpurea
- Montipora faveolata
- Paragoniastrea russelli
- Platygrya daedalea
- Pocillopora danae
- Porites australiensis
- Porites horizontalata
- Porites lichen
- Porites lobata
- Porites lutea
- Porites deformis
- Psammocora haimana
- Psammocora nesiotri"}

**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
- Naso lituratus
- Siganus psittacus
- Siganus spinus

**DEEP**

- Acanthurus nigricans
- Acanthurus nigrofuscus
- Acanthurus pyroferus
- Acanthurus triostegus
- Aphareus furca
- Calotomus carolinus
- Chlorurus microrhinos
- Chlorurus sordidus
- Ctenochaetus striatus
- Gymnocanus sp.
- Kyphosus cinerascens
- Lutjanus fulvus
- Lutjanus monostigma
- Macolor macularis
- Naso lituratus

13.456° N, 144.838° E
COCOS BARRIER REEF WEST

14 – Shallow, 14 – 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 Dano.

RELATIVE RESILIENCE

<table>
<thead>
<tr>
<th>Depth</th>
<th>Rank</th>
<th>Resilience Score</th>
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<th>Coral Diversity</th>
<th>Coral Recruitment</th>
<th>Bleaching Resistance</th>
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<th>Herbivorous Fish Biomass</th>
<th>Temperature Variability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shallow</td>
<td>14/18</td>
<td>0.78</td>
<td>0.30</td>
<td>0.41</td>
<td>0.95</td>
<td>0.83</td>
<td>0.83</td>
<td>0.07</td>
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<tr>
<td>Deep</td>
<td>14/20</td>
<td>0.74</td>
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<td>0.54</td>
<td>0.92</td>
<td>0.79</td>
<td>0.69</td>
<td>0.14</td>
<td>0.84</td>
</tr>
</tbody>
</table>

BENTHIC COMMUNITY

SHALLOW

DEEP

Coral
Macroalgae
Coralline algae
Other

FISH SPECIES

SHALLOW

Acanthurus lineatus
Acanthurus nigricans
Acanthurus nigrofuscus
Acanthurus olivaceus
Chlorurus sordidus
Ctenochaetus striatus
Naso lituratus
Scarus globiceps
Scarus schlegeli

DEEP

Acanthurus nigrofuscus
Aphareus furca
Calotomus carolinus
Carcharhinus melanopterus
Chlorurus sordidus
Ctenochaetus striatus
Gnathodentex aureolineatus
Lutjanus bohar
Monotaxis grandoculis
Naso lituratus
Naso unicomis
Naso vlamingii
Scarus psittacus
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 Dåno.

RELATIVE RESILIENCE

<table>
<thead>
<tr>
<th>Depth</th>
<th>Rank</th>
<th>Resilience Score</th>
<th>Coral Cover</th>
<th>Coral Diversity</th>
<th>Coral Recruitment</th>
<th>Bleaching Resistance</th>
<th>Macrolgae Cover</th>
<th>Herbivorous Fish Biomass</th>
<th>Temperature Variability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shallow</td>
<td>15/18</td>
<td>0.78</td>
<td>0.60</td>
<td>0.19</td>
<td>0.99</td>
<td>0.67</td>
<td>0.89</td>
<td>0.07</td>
<td>0.78</td>
</tr>
<tr>
<td>Deep</td>
<td>20/20</td>
<td>0.64</td>
<td>0.26</td>
<td>0.32</td>
<td>0.92</td>
<td>0.53</td>
<td>0.56</td>
<td>0.12</td>
<td>0.78</td>
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</tbody>
</table>

BENTHIC COMMUNITY

SHALLOW

DEEP

Coral
Macroalgae
Coralline algae
Other

Coral Species

SHALLOW

Acropora azurea
Acropora cerealis
Acropora cophodactyla
Acropora digitifera
Acropora surculosa
Acropora verweyi
Astrea curta
Cyphastrea chalcidicum
Dipsastrea favus
Dipsastrea maritima
Dipsastrea palidula
Favites colemani
Galaxea fascicularis
Goniastrea edwardsi
Goniastrea retiformis
Goniastrea stelligera
Goniopora fruticose
Heliopora coerulea
Leptoria phrygia
Leptoseris myctosseoides
Millepora platyphylla
Montipora hoffmeisteri
Montipora tuberculosa
Pocillopora ankelii
Pocillopora eydouxi
Porites australiensis
Porites delormis
Porites lichen
Porites lobata
Porites vaughani
Psammocora nieslazi

DEEP

Astreopora listeria
Astreopora myriophthalma
Astreopora randalli
Cyphastrea microphthalma
Cyphastrea serailia
Dipsastrea favus
Dipsastrea maritima
Dipsastrea mathaii
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 haimana
Stylocoeniella armata

FISH SPECIES

SHALLOW

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

DEEP

Acanthurus nigrofuscus
Acanthurus olivaceus
Chlorurus sordidus
Ctenochaetus binotatus
Ctenochaetus striatus
Ctenochaetus strigosus
Naso lituratus
Scarus fuscoaudalis
Scarus poitacaus
Scarus schlegeli
Siganus argenteus
Zebrasoma flavescens

COCOS BARRIER REEF EAST
13.232° N, 144.648° E
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

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

- **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

- Coral
- Macroalgae
- Coralline algae
- Other

DEEP

FISH SPECIES

SHALLOW

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

DEEP

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

Coral and Fish Species:

- Shallow Coral Species:
  - Acanthastrea brevis
  - Acropora cerealis
  - Astreopora listeria
  - Astreopora myriophthalma
  - Astreopora ocellata
  - Cyathastrea serailia
  - Dipsastrea favus
  - Dipsastrea marthaii
  - Favites colemani
  - Galaxea fascicularis
  - Leptastrea purpurea
  - Leptastrea transversa
  - Pavona varias
  - Porites australiensis

- Deep Coral Species:
  - Acropora globiceps
  - Acropora selago
  - Astreopora cf. gracilis
  - Astreopora listeria
  - Astreopora myriophthalma
  - Astreopora ocellata
  - Cyathastrea chalcidicum
  - Cyathastrea serailia
  - Dipsastrea favus
  - Dipsastrea marthaii
  - Dipsastrea palida
  - Favites valenciennesi
  - Goniopora minor

- Deep Fish Species:
  - Leptastrea purpurea
  - Pavona varias
  - Porites australiensis
  - Porites lobata
  - Porites lutea
  - Porites rus
  - Psammocora haimeana
  - Psammocora nierstrazi
**GA’AN POINT**

17 – Shallow, 17 – Deep

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

**RELATIVE RESILIENCE**

<table>
<thead>
<tr>
<th>Depth</th>
<th>Rank</th>
<th>Resilience Score</th>
<th>Coral Cover</th>
<th>Coral Diversity</th>
<th>Coral Recruitment</th>
<th>Bleaching Resistance</th>
<th>Macroalgae Cover</th>
<th>Herbivorous Fish Biomass</th>
<th>Temperature Variability</th>
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<tr>
<td>Shallow</td>
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<td>0.72</td>
<td>0.36</td>
<td>0.23</td>
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<td>0.96</td>
<td>0.54</td>
<td>0.08</td>
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<tr>
<td>Deep</td>
<td>16/20</td>
<td>0.72</td>
<td>0.24</td>
<td>0.31</td>
<td>0.89</td>
<td>0.94</td>
<td>0.71</td>
<td>0.09</td>
<td>0.77</td>
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</table>

**BENTHIC COMMUNITY**

**SHALLOW**

[Pie chart showing distribution of Coral, Macroalgae, Coralline algae, Other]

**DEEP**

[Pie chart showing distribution of Coral, Macroalgae, Coralline algae, Other]

**CORAL SPECIES**

**SHALLOW**

- Dipsastrea danae
- Dipsastrea favus
- Dipsastrea matthaii
- Echinopora pacificus
- Fungia fungites
- Galaxea fascicularis
- Goniatista retiformis
- Heliopora coerulea
- Leptastrea purpurea
- Leptoria phygia
- Pavona chiriquiensis
- Pavona maldensis
- 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
- Dipsastrea favus
- Dipsastrea maritima
- Dipsastrea 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

**FISH SPECIES**

**SHALLOW**

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

**DEEP**

- Acanthurus nigrofuscus
- Acanthus olivaceus
- Apherus furca
- Calotomus carolinus
- Chlorurus sordidus
- Ctenochaetus striatus
- Naso lituratus
- Naso unicorns
- Scarus schlegeli

---

13.388° N, 144.653° E
**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

<table>
<thead>
<tr>
<th>Depth</th>
<th>Rank</th>
<th>Resilience Score</th>
<th>Coral Cover</th>
<th>Coral Diversity</th>
<th>Coral Recruitment</th>
<th>Bleaching Resistance</th>
<th>Macroalgae Cover</th>
<th>Herbivorous Fish Biomass</th>
<th>Temperature Variability</th>
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<tbody>
<tr>
<td>Shallow</td>
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<td>0.62</td>
<td>0.14</td>
<td>0.13</td>
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<td>0.54</td>
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<td>0.82</td>
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<tr>
<td>Deep</td>
<td>18/20</td>
<td>0.67</td>
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<td>0.15</td>
<td>0.96</td>
<td>0.87</td>
<td>0.60</td>
<td>0.04</td>
<td>0.82</td>
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</tbody>
</table>

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

### BENTHIC COMMUNITY

#### SHALLOW

- Coral
- Macroalgae
- Coralline algae
- Other

#### DEEP

- Coral
- Macroalgae
- Coralline algae
- Other

### CORAL SPECIES

#### SHALLOW

- Acropora humilis
- Astreopora myriophthalma
- Dipsastrea 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
- Dipsastrea favus
- Dipsastrea maritima
- Dipsastrea matthaii
- Dipsastrea speciose
- Favites valenciennesi
- Goniastrea edwardsi
- Goniastrea pectinata
- Goniopora fruticose
- Goniopora minor
- Leptastrea purpurea
- Montipora foveolata
- Montipora verrucosa
- Pavona varians
- Porites lichen
- Porites lichena
- Porites lutea
- Porites rus
- Stylocoeniella armata

### FISH SPECIES

#### SHALLOW

- Acanthurus nigricauda
- Acanthurus nigrofuscus
- Aphareus furca
- Calotomus carolinus
- Chlorurus sordidus
- Ctenochaetus striatus
- Monotaxis grandoculis
- Naso annulatus
- Naso unicornis
- Scarus forsteni

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

**Benthic Community**

**SHALLOW**

- Coral
- Macroalgae
- Coralline algae
- Other

**DEEP**

- Coral
- Macroalgae
- Coralline algae
- Other

**Coral Species**

**SHALLOW**

Not applicable

**DEEP**

- Acropora cerealis
- Astrea curta
- Astreopora myriophthalma
- Astreopora ocellata
- Cyphastrea chalcidicum
- Cyphastrea serailia
- Dipsastrea favus
- Dipsastrea matthaii
- Dipsastrea pallida
- Favites valenciennesi
- Galaxea fascicularis
- Goniatrea edwardsi
- Goniatrea stelligera

- Leptastrea purpurea
- Montipora caliculata
- Montipora hoffmeisteri
- Montipora nodosa
- Montipora tuberculosa
- Montipora verrucosa
- Pavona clavus
- Pavona varians
- Pavona venosa
- Platygrya pini
- Pocillopora elegans
- Porites lichen
- Porites lobata
- Porites lutea
- Porites rus

**DEEP**

- Acanthus nigricans
- Acanthus nigricauda
- Acanthus nigrofuscus
- Acanthus olivaceus
- Acanthus triostegus
- Acanthus xanthopterus
- Aethaloperca rogaa
- Apherhus 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 rubroviridis
- 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

<table>
<thead>
<tr>
<th>Depth</th>
<th>Rank</th>
<th>Resilience Score</th>
<th>Coral Cover</th>
<th>Coral Diversity</th>
<th>Coral Recruitment</th>
<th>Bleaching Resistance</th>
<th>Macroalgae Cover</th>
<th>Herbivorous Fish Biomass</th>
<th>Temperature Variability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shallow</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Deep</td>
<td>17/20</td>
<td>0.74</td>
<td>0.23</td>
<td>0.34</td>
<td>0.96</td>
<td>0.59</td>
<td>0.86</td>
<td>0.21</td>
<td>0.85</td>
</tr>
</tbody>
</table>

SHALLOW
- Coral
- Macroalgae
- Coralline algae
- Other

DEEP
- Coral
- Macroalgae
- Coralline algae
- Other

FISH SPECIES

SHALLOW
- Not applicable

DEEP
- Astreopora myriophthalma
- Astreopora ocellata
- Cyphastrea serailia
- Dipsastrea maritima
- Dipsastrea matthaii
- Dipsastrea pallida
- Favites valenciennesi
- Goniastrea retiformis
- Goniastrea stelligera
- Heliopora coerula
- Leptastrea purpurea
- Lobophyllia hemprichii
- Montipora caliculata
- Montipora hoffmeisteri
- Montipora tuberculosa
- Pavona clavus
- Pavona varians
- Pocillopora elegans
- Pocillopora eydouxii
- Pocillopora verrucosa
- Porites australiensis
- Porites lichen
- Porites lutea
- Porites vaughani
- Stylocoeniella armata
- Stylophora pistillata
- Acanthurus blochii
- Acanthurus nigricans
- Acanthurus nigrofuscus
- Acanthurus olivaceus
- Aethaloperca rogaa
- Apherus furca
- Calotomus carolinus
- Chlorurus microrhinos
- Chlorurus sordidus
- Ctenochaetus striatus
- Gymnosarda unicolor
- Lutjanus bohar
- Macolor macularis
- Naso lituratus
- Naso unicornis
- Naso vlamingii
- Scarus psittacus
- Scarus rubroviolaceus
- Siganus argenteus