

# The United States Virgin Islands

## TERRITORIAL CORAL REEF MONITORING PROGRAM



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**A collaboration between:**

**The Center for Marine and Environmental Studies, University of the Virgin Islands**



**The Division of Coastal Zone Management, USVI Department of Planning and Natural Resources**



**The Coral Reef Conservation Program, National Oceanic and Atmospheric Administration**



# INDEX

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# INDEX

|                                                                         |                   |
|-------------------------------------------------------------------------|-------------------|
| <b><u>INDEX OF TABLES</u></b>                                           | <b><u>XII</u></b> |
| <b><u>PREFACE</u></b>                                                   | <b><u>1</u></b>   |
| <b><u>MISSION</u></b>                                                   | <b><u>2</u></b>   |
| OUR VISION                                                              | 2                 |
| OBJECTIVES                                                              | 2                 |
| <b><u>EXECUTIVE SUMMARY</u></b>                                         | <b><u>3</u></b>   |
| CORAL REEFS OF THE VIRGIN ISLANDS: MANGEMENT ACTIONS NEEDED             | 3                 |
| CORAL REEFS OF THE VIRGIN ISLANDS: POSITIVE SIGNS                       | 5                 |
| <b><u>RESEARCH HIGHLIGHTS</u></b>                                       | <b><u>9</u></b>   |
| <b><u>THE IMPACT OF 2005 AND 2010 CORAL BLEACHING EVENTS</u></b>        | <b><u>11</u></b>  |
| RECOMMENDATIONS                                                         | 14                |
| <b><u>POPULATIONS OF COMMERCIALY IMPORTANT FISH SPECIES</u></b>         | <b><u>15</u></b>  |
| RECOMMENDATIONS                                                         | 16                |
| <b><u>IMPACTS OF LAND-BASED SOURCES OF POLLUTION ON CORAL REEFS</u></b> | <b><u>17</u></b>  |
| RECOMMENDATIONS                                                         | 18                |
| <b><u>INTRODUCTION</u></b>                                              | <b><u>21</u></b>  |
| OBJECTIVES FOR MONITORING CORAL REEFS                                   | 24                |
| <b><u>METHODS</u></b>                                                   | <b><u>26</u></b>  |
| BENTHIC ASSESSMENTS                                                     | 26                |
| FISH CENSUS                                                             | 32                |
| <b><u>TERRITORIAL CORAL REEF MONITORING SUMMARY</u></b>                 | <b><u>34</u></b>  |

# INDEX

|                                                         |                  |
|---------------------------------------------------------|------------------|
| <b>BENTHIC COMMUNITIES AND CORAL REEF HEALTH</b>        | <b>35</b>        |
| CORAL COVER                                             | 35               |
| EPILITHIC ALGAL COMMUNITY COVER                         | 37               |
| MACROALGAL COVER                                        | 39               |
| FILAMENTOUS CYANOBACTERIA                               | 41               |
| GORGONIAN AND ANTIPATHARIAN COVER                       | 43               |
| SPONGE COVER                                            | 45               |
| <b>FISH COMMUNITIES</b>                                 | <b>47</b>        |
| FISH ABUNDANCE                                          | 49               |
| FISH BIOMASS                                            | 51               |
| <b>BLACK SPINY SEA URCHIN <i>DIADEMA ANTILLARUM</i></b> | <b>53</b>        |
| <b><u>SITE SUMMARIES</u></b>                            | <b><u>55</u></b> |
| RATIONALE                                               | 55               |
| SITE SUMMMARY ELEMENTS                                  | 55               |
| <b><u>ST.CROIX</u></b>                                  | <b><u>59</u></b> |
| BUCK ISLAND, ST. CROIX                                  | 61               |
| CANE BAY                                                | 67               |
| CANE BAY DEEP                                           | 73               |
| CASTLE                                                  | 79               |
| EAGLE RAY                                               | 85               |
| GREAT POND                                              | 91               |
| JACKS BAY                                               | 97               |
| KINGS CORNER                                            | 103              |
| LANG BANK EAST END MARINE PARK                          | 109              |
| LANG BANK RED HIND FISH SPAWNING AGGREGATION            | 115              |
| MUTTON SNAPPER                                          | 121              |
| SALT RIVER WEST                                         | 127              |
| SALT RIVER DEEP                                         | 133              |

# INDEX

|                                |                   |
|--------------------------------|-------------------|
| SPRAT HOLE                     | 139               |
| <b><u>ST. JOHN</u></b>         | <b><u>145</u></b> |
| CORAL BAY                      | 147               |
| FISH BAY                       | 151               |
| MERI SHOAL                     | 155               |
| <b><u>ST. THOMAS</u></b>       | <b><u>159</u></b> |
| BLACK POINT                    | 161               |
| BOTANY BAY                     | 167               |
| BREWERS BAY                    | 171               |
| BUCK ISLAND, ST. THOMAS        | 177               |
| COCULUS ROCK                   | 181               |
| COLLEGE SHOAL                  | 185               |
| FLAT CAY                       | 191               |
| GINSBURGS FRINGE               | 197               |
| GRAMMANIK TIGER                | 201               |
| HIND BANK                      | 207               |
| LITTLE SAINT JAMES             | 213               |
| MAGENS BAY                     | 217               |
| SAVANA ISLAND                  | 221               |
| SEAHORSE COTTAGE SHOAL         | 225               |
| SOUTH CAPELLA                  | 231               |
| SOUTH WATER                    | 237               |
| <b><u>LITERATURE CITED</u></b> | <b><u>243</u></b> |

## Index of Figures

|                                                                                                                                                                                                  |    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| Figure 1. Bleached colonies of boulder star coral <i>Montastraea annularis</i> at Flat Cay, October 2005. ....                                                                                   | 11 |
| Figure 2. Stark white bleaching and white disease prevalence, and coral cover from 2004-2010 in (top) shallow reefs (n=18) and (bottom) mesophotic reefs (n=4). ....                             | 12 |
| Figure 3. Bleaching, outgrowth and recovery of the susceptible corals <i>Agaricia agaricites</i> and branching <i>Porites</i> in the USVI over years 2005, 2010, and 2012 .....                  | 13 |
| Figure 4. Frequency of encounters with commercially important species on TCRMP transects (2003-2009). ..                                                                                         | 15 |
| Figure 5. (above) A silt laden ghut flows to the ocean on St. Thomas. (left) Relationship between silt accumulation and coral health indicators for eight nearshore TCRMP monitoring sites.....  | 17 |
| Figure 6. Locations of Territorial Coral Reef Monitoring Sites in the US Virgin Islands, 2008-2010. Boundaries indicate federal and territorial marine protected areas. ....                     | 25 |
| Figure 7. A screen grab of benthic video used for the determination of percent cover of coral reef organisms and non-living substrate. ....                                                      | 28 |
| Figure 8. Coral cover ( $\pm$ SE) across TCRMP monitoring sites over time. ....                                                                                                                  | 36 |
| Figure 9. Epilithic Algal Community cover ( $\pm$ SE) across TCRMP monitoring sites over time.....                                                                                               | 38 |
| Figure 10. Macroalgae cover ( $\pm$ SE) across TCRMP monitoring sites over time.....                                                                                                             | 40 |
| Figure 11. Filamentous cyanobacteria cover ( $\pm$ SE) across TCRMP monitoring sites over time.....                                                                                              | 42 |
| Figure 12. Gorgonian and Antipatharian cover ( $\pm$ SE) across TCRMP monitoring sites over time.....                                                                                            | 44 |
| Figure 13. Sponge cover ( $\pm$ SE) across TCRMP monitoring sites over time.....                                                                                                                 | 46 |
| Figure 14. Fish abundance ( $\pm$ SE) across TCRMP monitoring sites over time. ....                                                                                                              | 50 |
| Figure 15. Mean fish biomass ( $\pm$ SE) across TCRMP monitoring sites over time.....                                                                                                            | 52 |
| Figure 16. Abundance of the black spiny sea urchin ( <i>Diadema antillarum</i> ) at TCRMP monitoring sites. Note the log scale. ....                                                             | 54 |
| Figure 17. The Buck Island, St. Croix. (top) Position in the Buck Island Reef National Monument. (right) A representative photo.....                                                             | 61 |
| Figure 18. Buck Island, St. Croix benthic temperatures (14 m depth). Data provided by the National Park Service (site BUIS_SFR).....                                                             | 62 |
| Figure 19. Buck Island, St. Croix. (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment. .... | 63 |
| Figure 20. Buck Island, St. Croix benthic cover and coral health through time (mean $\pm$ SE). ....                                                                                              | 64 |
| Figure 21. The Buck Island, St. Croix fish community by absolute and relative biomass. ....                                                                                                      | 66 |

# INDEX

|                                                                                                                                                                                        |    |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| Figure 22. Cane Bay. (top) Location. (right) A representative photo of the reef.....                                                                                                   | 67 |
| Figure 23. Cane Bay benthic temperatures (8 m depth).....                                                                                                                              | 68 |
| Figure 24. Cane Bay. (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.....      | 69 |
| Figure 25. Cane Bay benthic cover and coral health through time (mean $\pm$ SE).....                                                                                                   | 70 |
| Figure 26. The Cane Bay fish community by absolute and relative biomass.....                                                                                                           | 72 |
| Figure 27. Cane Bay Deep. (top) Location. (right) A representative photo of the reef during the 2005 bleaching event. Bleached colonies are 0.5 – 3 m wide.....                        | 73 |
| Figure 28. Cane Bay Deep temperature (39 m depth).....                                                                                                                                 | 74 |
| Figure 29. Cane Bay Deep. (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment..... | 75 |
| Figure 30. Cane Bay Deep benthic cover and coral health through time (mean $\pm$ SE).....                                                                                              | 76 |
| Figure 31. The Cane Bay Deep fish community by absolute and relative biomass.....                                                                                                      | 78 |
| Figure 32. Castle. (top) Location. (right) A representative photo of the reef.....                                                                                                     | 79 |
| Figure 33. Castle benthic temperatures (9 m depth). ....                                                                                                                               | 80 |
| Figure 34. Castle. (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.....        | 81 |
| Figure 35. Castle benthic cover and coral health through time (mean $\pm$ SE). ....                                                                                                    | 82 |
| Figure 36. The Castle fish community by absolute and relative biomass.....                                                                                                             | 84 |
| Figure 37. Eagle Ray. (top) Location. (right) A representative photo of the reef.....                                                                                                  | 85 |
| Figure 38. Eagle Ray benthic temperature at 9 m depth .....                                                                                                                            | 86 |
| Figure 39. Eagle Ray. (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.....     | 87 |
| Figure 40. Eagle Ray benthic cover and coral health through time (mean $\pm$ SE). ....                                                                                                 | 88 |
| Figure 41. The Eagle Ray fish community by absolute and relative biomass. ....                                                                                                         | 90 |
| Figure 42. Great Pond. (top) Location. (right) A representative photo of the reef.....                                                                                                 | 91 |
| Figure 43. Great Pond benthic temperature (5 m depth). ....                                                                                                                            | 92 |
| Figure 44. Great Pond (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.....     | 93 |
| Figure 45. Great Pond benthic cover and coral health through time (mean $\pm$ SE).....                                                                                                 | 94 |
| Figure 46. The Great Pond fish community by absolute and relative biomass.....                                                                                                         | 96 |
| Figure 47. Jacks Bay. (top) Location. (right) A representative photo of the reef.....                                                                                                  | 97 |
| Figure 48. Jacks Bay benthic temperature at 12 m depth.....                                                                                                                            | 98 |

# INDEX

|                                                                                                                                                                                                        |     |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| Figure 49. Jacks Bay (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.....                      | 99  |
| Figure 50. Jacks Bay benthic cover and coral health through time (mean $\pm$ SE).....                                                                                                                  | 100 |
| Figure 51. The Jacks Bay fish community by absolute and relative biomass.....                                                                                                                          | 102 |
| Figure 52. Kings Corner. (top) Location. (right) A representative photo of the reef with a school of lane snapper ( <i>Lutjaussynagris</i> ).....                                                      | 103 |
| Figure 53. Kings Corner benthic temperature (17 m depth).....                                                                                                                                          | 104 |
| Figure 54. Kings Corner (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.....                   | 105 |
| Figure 55. Kings Corner benthic cover and coral health through time (mean $\pm$ SE).....                                                                                                               | 106 |
| Figure 56. The Kings Corner fish community by absolute and relative biomass.....                                                                                                                       | 108 |
| Figure 57. Lang Bank EEMP. (top) Location. (right) A representative photo of the reef.....                                                                                                             | 109 |
| Figure 58. Lang Bank EEMP benthic temperature (28 m depth).....                                                                                                                                        | 110 |
| Figure 59. Lang Bank East End Marine Park (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment..... | 111 |
| Figure 60. Lang Bank EEMP benthic cover and coral health through time (mean $\pm$ SE).....                                                                                                             | 112 |
| Figure 61. The Lang Bank EEMP fish community by absolute and relative biomass.....                                                                                                                     | 114 |
| Figure 62. Lang Bank EEMP. (top) Location. (right) A representative photo of the reef.....                                                                                                             | 115 |
| Figure 63. Lang Bank Hind current speed (left) and benthic temperature (right; 33m depth).....                                                                                                         | 116 |
| Figure 64. Lang Bank Red Hind FSA (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment. ....        | 117 |
| Figure 65. Lang Bank Red HindFSA benthic cover and coral health through time (mean $\pm$ SE).....                                                                                                      | 118 |
| Figure 66. The Lang Bank Red Hind FSA fish community by absolute and relative biomass.....                                                                                                             | 120 |
| Figure 67. Mutton Snapper. (top) Location. (right) A representative photo of the reef.....                                                                                                             | 121 |
| Figure 68. Mutton Snapper benthic temperature record at 23 m (left) and 39 m depth (right).....                                                                                                        | 122 |
| Figure 69. Mutton Snapper (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.....                 | 123 |
| Figure 70. Mutton Snapper benthic cover and coral health through time (mean $\pm$ SE).....                                                                                                             | 124 |
| Figure 71. The Mutton Snapper fish community by absolute and relative biomass.....                                                                                                                     | 126 |
| Figure 73. Salt River. (top) Location. (right) A representative photo of the reef.....                                                                                                                 | 127 |
| Figure 74. Salt River West surface-benthic temperature record (1 and 5m depths). Data provided by the NOAA ICON monitoring network.....                                                                | 128 |

# INDEX

|                                                                                                                                                                                                     |            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <i>Figure 75. Salt River West (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.....</i>      | <i>129</i> |
| <i>Figure 76. Salt River West benthic cover and coral health through time (mean <math>\pm</math>SE). .....</i>                                                                                      | <i>130</i> |
| <i>Figure 77. The Salt River West fish community by absolute and relative biomass.....</i>                                                                                                          | <i>132</i> |
| <i>Figure 78. Salt River Deep. (top) Location. (right) A representative photo of the reef .....</i>                                                                                                 | <i>133</i> |
| <i>Figure 79. Salt River Deep benthic temperature at 30 m depth (left) and 40 m depth (right).....</i>                                                                                              | <i>134</i> |
| <i>Figure 80. Salt River Deep (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.....</i>      | <i>135</i> |
| <i>Figure 81. Salt River Deep benthic cover and coral health through time (mean <math>\pm</math>SE). .....</i>                                                                                      | <i>136</i> |
| <i>Figure 82. The Salt River Deep fish community by absolute and relative biomass. ....</i>                                                                                                         | <i>138</i> |
| <i>Figure 83. Sprat Hole. (top) Location. (right) A representative photo of the reef.....</i>                                                                                                       | <i>139</i> |
| <i>Figure 84. Sprat Hole benthic temperature (7 m depth).....</i>                                                                                                                                   | <i>140</i> |
| <i>Figure 85. Sprat Hole (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.....</i>           | <i>141</i> |
| <i>Figure 86. Sprat Hole benthic cover and coral health through time (mean <math>\pm</math>SE).....</i>                                                                                             | <i>142</i> |
| <i>Figure 87. The Sprat Hole fish community by absolute and relative biomass.....</i>                                                                                                               | <i>144</i> |
| <i>Figure 88. Coral Bay. (top) Location. (right) A representative photo of the reef.....</i>                                                                                                        | <i>147</i> |
| <i>Figure 89. Coral Bay benthic temperature (9 m depth).....</i>                                                                                                                                    | <i>148</i> |
| <i>Figure 90. Coral Bay (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.....</i>            | <i>149</i> |
| <i>Figure 91. Coral Bay benthic cover and coral health in 2011 (mean <math>\pm</math>SE). ....</i>                                                                                                  | <i>150</i> |
| <i>Figure 92. Coral Bay. (top) Location. (right) A representative photo of the reef.....</i>                                                                                                        | <i>151</i> |
| <i>Figure 93. Fish Bay benthic temperature record (6m depth). ....</i>                                                                                                                              | <i>152</i> |
| <i>Figure 94. Fish Bay (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.....</i>             | <i>153</i> |
| <i>Figure 95. Fish Bay benthic cover and coral health through time (mean <math>\pm</math>SE). ....</i>                                                                                              | <i>154</i> |
| <i>Figure 96. Meri Shoal. (top) Location. (right) A representative photo of the reef during the 2005 coral bleaching event (Oct. 6, 2005). The brain coral in the foreground is 1.8m wide. ....</i> | <i>155</i> |
| <i>Figure 97. Meri Shoal benthic temperature record (30m depth).....</i>                                                                                                                            | <i>156</i> |
| <i>Figure 98. Meri Shoal (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.....</i>           | <i>157</i> |
| <i>Figure 99. Meri Shoal benthic cover and coral health through time (mean <math>\pm</math>SE).....</i>                                                                                             | <i>158</i> |
| <i>Figure 100. Black Point. (top) Location. (right) A representative photo of the reef.....</i>                                                                                                     | <i>161</i> |

# INDEX

|                                                                                                                        |     |
|------------------------------------------------------------------------------------------------------------------------|-----|
| Figure 101. Black point current speed and benthic temperature record (8 m depth).....                                  | 162 |
| Figure 102. Black Point chlorophyll (left) and turbidity (right) record (16 m depth).....                              | 162 |
| Figure 103. Black Point. (left) Relative composition of the sessile epibenthic animal community. (right)               |     |
| Relative composition of the algal community and unconsolidated sediment.....                                           | 163 |
| Figure 104. Black Point benthic cover and coral health through time (mean $\pm$ SE).....                               | 164 |
| Figure 105. The Black Point fish community by absolute and relative biomass.....                                       | 166 |
| Figure 106. Botany Bay. (top) Location. (right) A representative photo of the reef.....                                | 167 |
| Figure 107. Botany Bay benthic temperature record (11 m depth).....                                                    | 168 |
| Figure 108. A large colony of pillar coral ( <i>Dendrogyra cylindricus</i> ) dislodge, toppled, and diseased after the |     |
| 2009 swell event (Botany Bay, June 25, 2009). ....                                                                     | 168 |
| Figure 109. Botany Bay. (left) Relative composition of the sessile epibenthic animal community. (right)                |     |
| Relative composition of the algal community and unconsolidated sediment.....                                           | 169 |
| Figure 110. Botany Bay benthic cover and coral health through time (mean $\pm$ SE). ....                               | 170 |
| Figure 111. Brewers Bay. (top) Location. (right) A representative photo of the reef. ....                              | 171 |
| Figure 112. Brewers Bay. (left) Relative composition of the sessile epibenthic animal community. (right)               |     |
| Relative composition of the algal community and unconsolidated sediment.....                                           | 173 |
| Figure 113. Brewers Bay benthic cover and coral health through time (mean $\pm$ SE).....                               | 174 |
| Figure 114. The Brewers Bay fish community by absolute and relative biomass.....                                       | 176 |
| Figure 115. Buck Island, St. Thomas. (top) Location. (right) A representative photo of the reef.....                   | 177 |
| Figure 116. Buck Island, St. Thomas benthic temperature record (12 m depth). ....                                      | 178 |
| Figure 117. Buck Island, St. Thomas. (left) Relative composition of the sessile epibenthic animal community.           |     |
| (right) Relative composition of the algal community and unconsolidated sediment. ....                                  | 179 |
| Figure 118. Buck Island, St. Thomas benthic cover and coral health through time (mean $\pm$ SE).....                   | 180 |
| Figure 119. Cocus Rock. (top) Location. (right) A representative photo of the reef showing the aggregation             |     |
| of yellowtail parrotfish. ....                                                                                         | 181 |
| Figure 120. Cocus Rock benthic temperature record (7m depth). ....                                                     | 182 |
| Figure 121. Cocus Rock. (left) Relative composition of the sessile epibenthic animal community. (right)                |     |
| Relative composition of the algal community and unconsolidated sediment.....                                           | 183 |
| Figure 122. Cocus Rock benthic cover and coral health through time (mean $\pm$ SE). ....                               | 184 |
| Figure 123. College Shoal. (top) Location. (right) A representative photo of the reef.....                             | 185 |
| Figure 124. College Shoal benthic temperature record (29m depth). ....                                                 | 186 |
| Figure 125. College Shoal (left) Relative composition of the sessile epibenthic animal community. (right)              |     |
| Relative composition of the algal community and unconsolidated sediment.....                                           | 187 |

# INDEX

|                                                                                                                                                                                               |     |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| Figure 126. College Shoal benthic cover and coral health through time (mean $\pm$ SE).....                                                                                                    | 188 |
| Figure 127. The College Shoal fish community by absolute and relative biomass.....                                                                                                            | 190 |
| Figure 128. Flat Cay. (top) Location. (right) A representative photo of the reef.....                                                                                                         | 191 |
| Figure 129. Flat Cay benthic current speed (left) and temperature record (right) (14m depth).....                                                                                             | 192 |
| Figure 130. Flat Cay (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.....             | 193 |
| Figure 131. Flat Cay benthic cover and coral health through time (mean $\pm$ SE).....                                                                                                         | 194 |
| Figure 132. The Flat Cay fish community by absolute and relative biomass.....                                                                                                                 | 196 |
| Figure 133. Ginsburgs Fringe. (top) Location. (right) A representative photo of the reef showing whorled lettuce coral colonies up to 7m in width.....                                        | 197 |
| Figure 134. Ginsburgs Fringe current speed (50m depth).....                                                                                                                                   | 198 |
| Figure 135. Ginsburgs Fringe. (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.....    | 199 |
| Figure 136. Ginsburgs Fringe benthic cover through time (mean $\pm$ SE).....                                                                                                                  | 200 |
| Figure 137. Grammanik Tiger (top) Location. (right) A representative photo of the reef.....                                                                                                   | 201 |
| Figure 138. Grammanik Tiger benthic currents speed and temperature record (38 m depth).....                                                                                                   | 202 |
| Figure 139. Grammanik Tiger FSA. (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment..... | 203 |
| Figure 140. Grammanik Tiger benthic cover and coral health through time (mean $\pm$ SE).....                                                                                                  | 204 |
| Figure 141. The Grammanik Tiger fish community by absolute and relative biomass.....                                                                                                          | 206 |
| Figure 142. Hind Bank (top) Location. (right) A representative photo of the reef.....                                                                                                         | 207 |
| Figure 143. Hind Bank benthic current speed (40m depth). Benthic temperature record at 20, 30, and 40 m depth.....                                                                            | 208 |
| Figure 144. Hind Bank. (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.....           | 209 |
| Figure 145. Hind Bank benthic cover and coral health through time (mean $\pm$ SE).....                                                                                                        | 210 |
| Figure 146. The Hind Bank East fish community by absolute and relative biomass.....                                                                                                           | 212 |
| Figure 147. Little St. James. (top) Location. (right) A representative photo of the reef.....                                                                                                 | 213 |
| Figure 148. Little St. James benthic temperature record (19m depth).....                                                                                                                      | 214 |
| Figure 149. Little St. James. (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.....    | 215 |
| Figure 150. Little St. James benthic cover and coral health through time (mean $\pm$ SE).....                                                                                                 | 216 |
| Figure 151. Magens Bay. (top) Location. (right) A representative photo of the reef.....                                                                                                       | 217 |

# INDEX

|                                                                                                                                                                                                      |     |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| Figure 152. Magens Bay current speed and benthic temperature record (9 m depth).....                                                                                                                 | 218 |
| Figure 153. Magens Bay chlorophyll (left) and turbidity (right) record (16 m depth).....                                                                                                             | 218 |
| Figure 154. Magens Bay. (left) Relative composition of the sessile epibenthic animal community. (right)<br>Relative composition of the algal community and unconsolidated sediment.....              | 219 |
| Figure 155. Magens Bay benthic cover and coral health through time (mean $\pm$ SE).....                                                                                                              | 220 |
| Figure 156. Savana. (top) Location. (right) A representative photo of the reef during the 2005 coral<br>bleaching event. The dog snapper <i>Lutjanus jocu</i> is approximately 50cm in length. ....  | 221 |
| Figure 157. Savana benthic temperature record (10m depth). ....                                                                                                                                      | 222 |
| Figure 158. Savana Island. (left) Relative composition of the sessile epibenthic animal community. (right)<br>Relative composition of the algal community and unconsolidated sediment.....           | 223 |
| Figure 159. Savana Island benthic cover and coral health through time (mean $\pm$ SE).....                                                                                                           | 224 |
| Figure 160. Seahorse Cottage Shoal. (top) Location. (right) A representative photo of the reef. ....                                                                                                 | 225 |
| Figure 161. Seahorse benthic temperature record (21m depth).....                                                                                                                                     | 226 |
| Figure 162. Seahorse Cottage Shoal. (left) Relative composition of the sessile epibenthic animal community.<br>(right) Relative composition of the algal community and unconsolidated sediment. .... | 227 |
| Figure 163. Seahorse Cottage Shoal benthic cover and coral health through time (mean $\pm$ SE). ....                                                                                                 | 228 |
| Figure 164. The Seahorse Cottage Shoal fish community by absolute and relative biomass. ....                                                                                                         | 230 |
| Figure 165. South Capella. (top) Location. (right) A representative photo of the reef.....                                                                                                           | 231 |
| Figure 166. South Capella benthic temperature record (24m depth).....                                                                                                                                | 232 |
| Figure 167. South Capella. (left) Relative composition of the sessile epibenthic animal community. (right)<br>Relative composition of the algal community and unconsolidated sediment.....           | 233 |
| Figure 168. South Capella benthic cover and coral health through time (mean $\pm$ SE).....                                                                                                           | 234 |
| Figure 169. The South Capella fish community by absolute and relative biomass.....                                                                                                                   | 236 |
| Figure 170. South Water. (top) Location. ....                                                                                                                                                        | 237 |
| Figure 171. South Water benthic temperature record (24m depth).....                                                                                                                                  | 238 |
| Figure 172. South Water. (left) Relative composition of the sessile epibenthic animal community. (right)<br>Relative composition of the algal community and unconsolidated sediment.....             | 239 |
| Figure 173. South Water benthic cover and coral health through time (mean $\pm$ SE). ....                                                                                                            | 240 |
| Figure 174. The South Water fish community by absolute and relative biomass. ....                                                                                                                    | 242 |

## Index of Tables

|                                                                                                                                                                                                      |           |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| <i>Table 1. TCRMP site reef complex type, location coordinates, and depths. FSA = Fish Spawning Aggregation. EEMP = East End Marine Park. ....</i>                                                   | <i>29</i> |
| <i>Table 2. TCRMP site date sampled (benthic/health) and type of sampling. ....</i>                                                                                                                  | <i>30</i> |
| <i>Table 3. Species richness across sites in belt transects and roving diver surveys (RDS). Sites are divided into nearshore, offshore and mesophotic sites as described in the text above. ....</i> | <i>48</i> |

## Preface

We are pleased to present a **new look and design** for the 2011 Territorial Coral Reef Monitoring Program (TCRMP) report. We hope the new features will make the report more readable and more useful for the public, reef managers, policy makers, students, and scientists. This redesign celebrates the *11<sup>th</sup> year of the program and a 75% increase* in the number of permanent monitoring sites presented. Many of these sites were previously funded under temporary programs and most have over seven years of associated data. Their inclusion will greatly add to the comprehensiveness of the TCRMP.

This report redesign incorporates the following sections:

- **Executive Summary.** This has now been expanded and made more relevant to managers and policy makers who may not have time to read the entire report.
- **Research Highlights.** This section will present new or updated annual highlights from focal areas of research that we feel are of particular interest. Examples include impacts of climate change, impacts of land-based sources of pollution, and impacts of fishing.
- **TCRMP Summary.** This section is the core of information provided in reports from previous years and it is maintained for easy comparison to the past. It also provides a useful overview of reef condition across our jurisdiction. Important new additions are water quality and sediment data.
- **Site Summaries.** The great volume of data from individual sites deserves greater attention. As such, multi-page portfolios for each site have been developed that include site-specific descriptions, maps, photos, benthic structure, coral health, fish community structure, benthic temperature, and, where recorded, currents. We hope this section will be a quick reference for those interested in specific geographic areas, reef types, and sites.
- **Appendices.** We have moved to an all-digital online format for appendices.

# MISSION

## Mission



## OUR VISION

To provide critical information on the status and threats to all Virgin Islands coral reef ecosystems in order to increase management effectiveness and improve basic and applied coral reef research

## OBJECTIVES

- Monitor the **status and trajectories** of coral reefs across a majority of habitats and threats, including land-based sources of pollution & thermal stress
- Link changes in coral reef health with specific stressors, indicating specific **management interventions** most effective for preserving reefs
- Integrate assessments of understudied **mesophotic coral reef ecosystems** and **threatened species** in the USVI
- Provide data, outputs, and advice to stakeholders and create a **nexus of information** for reef research

# EXECUTIVE SUMMARY

## Executive Summary

Coral reefs in the Caribbean are facing a dramatic decline and are at a crossroads. Management decisions made today will affect the goods and services that reefs provide for decades to come. The government of the United States Virgin Islands (USVI), in coordination with the NOAA Coral Reef Conservation Program and the University of the Virgin Islands, implemented the **Territorial Coral Reef Monitoring Program (TCRMP)**. The TCRMP has established baseline conditions and temporal trends of coral reefs and fish populations and has identified threats that will influence the future reef health and development.

*A major focus of the TCRMP is to provide information that can lead to more effective management strategies that balance the immediate needs of the Virgin Island's population with preservation and sustainability of coral reefs and the renewable goods and services they provide.*

The intent of this report is to distill monitoring data into actionable information that can guide management decisions and inform the public and policy-makers on areas that need further effort. This executive summary presents information on threats to USVI reefs that require management intervention/action as well as positive signs that can inform our understanding of sustainability.

### CORAL REEFS OF THE VIRGIN ISLANDS: MANAGEMENT ACTIONS NEEDED

The TCRMP data has identified threats to USVI coral reef ecosystems that need increased management attention if reef corals are to persist in a condition that is equal to or better than current conditions.

**Coral Reef Bleaching.** High thermal stress caused by climate change is currently the greatest threat to USVI coral reef ecosystems. The 2005 coral bleaching event caused the

# EXECUTIVE SUMMARY

largest loss of coral in the documented history of the USVI, with a 50% decline in coral cover in shallow waters less than 25m/85' deep. This event surpassed all known modern impacts from physical damage (storms and anchoring), ecosystem changes (fishing and disease), and pollution (terrestrial sediments and toxins). These



events are predicted to increase with a warming planet, troubling news for the USVI

While local management actions cannot mitigate impacts to reefs from global warming, reefs that are otherwise less stressed by land-based sources of pollution, fishing, and/or physical damage are known to recover more quickly from bleaching. Hence, local management actions that promote seascape-wide coral reef health offer the best strategy for sustainable reefs. We can also identify areas that are naturally more resistant to thermal stress and offer these areas further protection, since they offer insurance against the worst possible future outcomes for USVI reefs.

**Overfishing.** There are clear indications that reefs of the USVI are suffering the effects of overexploitation of reef resources, although there are also positive signs (see next section). The entire district of St. Croix has an extremely low abundance of commercially important grouper species, including the threatened Nassau grouper. In St. John and St. Thomas, many common species have completely or nearly disappeared from nearshore waters in the last 30 years. For example, a study conducted by Rogers et al. (1982) on the southwest coast of St. Thomas during the airport runway expansion (1979-1981) found a variety of species that are no longer encountered or are rare, including the black, Nassau, tiger, and yellowfin groupers, as well as the protected parrotfish species blue, midnight, and rainbow. A study by Randall (1963) also found high relative abundances of groupers

# EXECUTIVE SUMMARY

and threatened parrotfish on the south coast of St. John. Rebuilding these fish stock will require comprehensive life-history information for target species, a willingness to find strategies to rebuild stocks, and partnerships between commercial and recreational fishers, community stakeholders and managers.

**Land-Based Source of Pollution.** The steep hillsides of the USVI are natural conduits for run-off during heavy rain events and in many instances there is little interception of materials before they reach the sea and impact coral reefs. When tropical soils are naturally disturbed or through the actions of man, they can erode and release fine-grained silt and clay particles. In the USVI, these fine-grained particles are quickly transported to coral reefs where they can block sunlight, directly smother corals, or increase the growth organisms that compete with corals for space. There is evidence from the TCRMP that terrestrial sediments are having large negative impacts on nearshore coral reefs by increasing mortality of ecologically important corals.

## CORAL REEFS OF THE VIRGIN ISLANDS: POSITIVE SIGNS

Despite the incredible declines in reef health witnessed since the inception of the TCRMP in 2001, there are many positive signs for the USVI that should be highlighted. These successes offer lessons that can be applied to troubled reefs and may indicate refuge areas where we might “double-down” on current management strategies.

**Reef Refuges.** The USVI is blessed, perhaps uniquely for the Caribbean, with extensive areas of deep bank and slope reefs that are buffered from the direct impacts of climate change and local pressures. The mesophotic (pronounced: mizo-photik; meaning; “middle-light”) reefs of the USVI are the best developed in the Caribbean from what is currently known. Mesophotic Coral Ecosystem (MCE) bank reefs with high populations of boulder star corals (*Montastraea annularis* species complex), which have recently been proposed for listing as endangered on the United States Endangered Species List (NOAA 2012), form extensive tracts on the south shelf of St. John and St. Thomas, from the

## EXECUTIVE SUMMARY

British Virgin Islands to Vieques, Puerto Rico. Well-formed, but patchier mesophotic boulder coral reefs also form on the Lang Bank, St. Croix and the northern Puerto Rican Shelf. During the 2005 bleaching event, where shallow water reefs lost 50% of coral cover, MCE studied by the TCRMP hardly bleached and lost a more modest 20% coral cover. Thus, there is hope that these reefs will serve as refuges for corals during a time of increasing ocean temperatures.

In federal waters some of these areas are wholly or partly protected from fishing of ecologically important species that help maintain reef health. These include the Red Hind Marine Conservation District (est. 1999), the Grammanik Bank Seasonally Closed Area (est. 2005), and the Lang Bank Red Hind Seasonally Closed Area (est. 1993). However, extensively developed mesophotic reef in unprotected territorial waters also exist near the island of French Cap and Sail Rock, St. Thomas District. It is important that these areas are identified, their threats assessed, and they are incorporated into the territorial and federal management planning process.

**Rebounding Fisheries Species.** There are positive signs of recovery for certain fish species in some areas. At the Grammanik Bank grouper spawning aggregation site there have been increasing numbers of Nassau grouper present for annual spawning (Nemeth, unpub. data) and a red hind aggregation in the Red Hind Marine Conservation District (MCD) has dramatically rebounded (Nemeth 2005). Red hind caught in the fishery on the south side of St. Thomas are more numerous and larger (D. Olsen, pers. comm.). It is also the impression of the authors that stocks of grouper and snapper are increasing in the MCD, although TCRMP measurements are confounded to some degree by the rotating array of aggregating fishes. Other territorial and federal closed areas in St. Croix, St. John, and St. Thomas are more recently established and may not show effects for several years. However, in 2011 the TCRMP recorded the first ever sightings of two Nassau grouper in St. Croix, a positive sign. For species that are completely protected from fishing (Nassau

# EXECUTIVE SUMMARY

grouper and blue, midnight, and rainbow parrotfish), educational campaigns for recreational and commercial fisherman are critical, as awareness of regulations appears to be lacking (Authors, unpub. obs.).

**Land-based source of pollution.** While development of steep island slopes has continued despite current regulations intended to prevent sediments from entering nearshore waters, research has identified key targets for restoration and some effective habitat restoration best-management practices. Results from TCRMP research suggest that there are certain levels of silt-laden terrestrial run-off that are damaging to corals, providing a target for reductions of sediment in the marine environment. Unpaved road segments have been implicated as the worst culprits in the production of sediment-laden run-off (Ramos-Scharrón and MacDonald 2007b) and this provides a clear target for where management can be most effectively applied. Restoration of watersheds has shown that implementation of best-management practices and control structures can be effective in reducing sedimentation. For example, the American Recovery and Reinvestment Act project “USVI Coastal Habitat Restoration Through Watershed Stabilization” showed promising results (Virgin Islands Resource Conservation and Development Council; P.I. M. Taylor).

This report presents results of the 11<sup>th</sup> year of monitoring on reefs surrounding St. Croix, St. John, and St. Thomas (years 2001-2011). Monitoring sites were distributed across the insular platform in depths from 5 to 63 m (16 – 220') in an effort to capture the diversity of reef types present in the Virgin Islands. Digital video and diver surveys were used to quantify benthic cover and coral health at 14 permanent sites surrounding the island of St. Croix and 19 permanent sites on the Puerto Rican Shelf surrounding the island of St. John and St. Thomas. In addition, at 19 of these sites sea urchin density and fish community structure were evaluated. This report presents data from a major expansion of coral reef monitoring sites. Long-term data is now presented from 33 sites, an

## EXECUTIVE SUMMARY

increase of 14 sites, including the condition of 1 new reef location around St. Croix and 13 surrounding St. John-St. Thomas. While not exhaustive, with the expanded number of sites, the TCRMP is now more inclusive of the geographic areas and variety of reef types in the USVI.

## Research Highlights

# CORAL BLEACHING

### The Impact of 2005 and 2010 Coral Bleaching Events

Recent episodes of coral bleaching are the greatest modern threat to coral reefs of the USVI and, although global forces are the cause, there are local management actions that can limit degradation of vital reef resources. Unprecedented high seawater temperatures affected the USVI and the wider northeastern Antilles from August to October of 2005 (Eakin et al. 2010). Climate modeling suggests that human-induced global warming from the emission of greenhouse gases caused this event (Donner et al. 2007). The year 2010 started warmer than 2005 and experts predicted another mass bleaching event, however when Hurricane Earl passed the USVI sea surface temperatures dropped rapidly in an example of tropical storm cooling (Manzello et al. 2007) averting more significant bleaching and mortality.

Thermal bleaching is caused by exposure of corals to high temperatures and light. This initiates a breakdown of the microscopic brown algae (*Symbiodinium*) that live in coral tissue and a loss of the food they supply to the coral animal.

Eventually these symbiotic algae are expelled from the coral, turning the tissues pale to stark white (Fig. 1). Bleached corals are at increased risk of disease (Brandt and McManus 2009) and death (Baker et al. 2008).

**Figure 1.** Bleached colonies of boulder star coral *Montastraea annularis* at Flat Cay, October 2005.

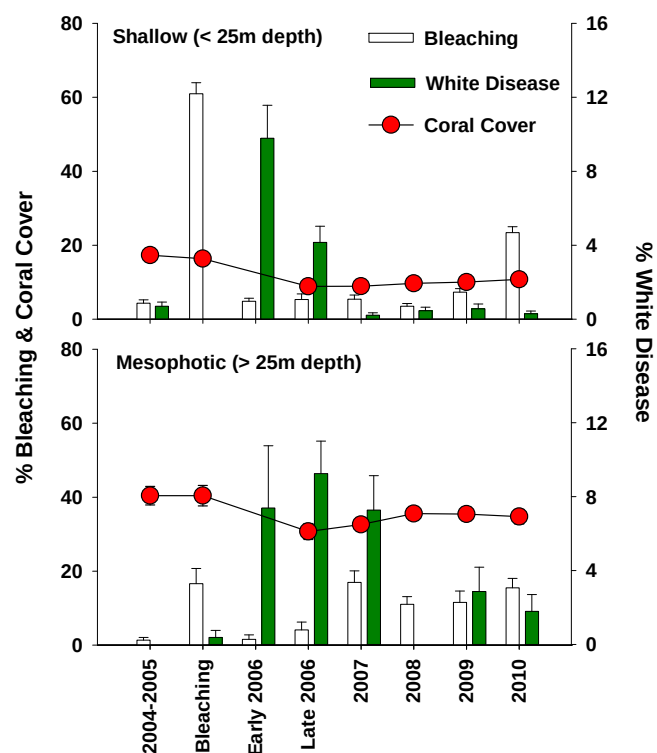


# CORAL BLEACHING

The 2005 coral bleaching event had major, negative impacts to coral communities in the USVI (Fig. 2). About 60% of shallow corals in water less than 25 m depth were approximately 60% bleached to stark white. This led to unprecedented levels of white disease and severely affected the foundational reef building boulder star coral (*Montastraea annularis* spp. complex), leading to an approximate 50% loss of coral cover. Boulder star corals are responsible for much of the habitat creation that supports USVI fisheries and other coral species. Deeper, mesophotic reefs in waters greater than 25m depth were less affected by bleaching, but subsequently experienced high and enduring levels of white disease that led to a loss of coral cover of about 20%.

There was high site-to-site variability in the mortality suffered following bleaching. Most monitored mesophotic sites fared better than shallow water sites. However, mesophotic wall environments showed extensive bleaching and, although cover was not monitored in 2005, they appear to have lost large amounts of cover. In general, low coral cover reefs showed less dramatic or no loss of coral cover. This may reflect a coral community composed of species that are more resistant to coral bleaching related mortality. Offshore shallow sites with higher abundance of boulder star coral showed higher losses of coral cover, which ranged from 22% (Flat Cay) to an extreme 87% (Mutton Snapper).

**Figure 2. Stark white bleaching and white disease prevalence, and coral cover from 2004-2010 in (top) shallow reefs (n=18) and (bottom) mesophotic reefs (n=4).**



## RESEARCH HIGHLIGHTS

The USVI shallow water coral communities' response suggests that Caribbean reefs under seawater warming conditions will shift to higher dominance of more resistant species. The boulder star corals and the giant brain coral (*Colpophyllia natans*) were shown to be very susceptible to disease after bleaching and this led to large losses of coral cover. On the other hand, moderate bleaching, no to low disease, and no to low cover loss was seen in the resistant small massive species *Diploria strigosa*, *Montastraea cavernosa*, *Porites astreoides*, and *Siderastrea siderea*. The species *Agaricia agaricites* and branching *Porites* were very susceptible to bleaching and mortality, but are showing signs of fast-regrowth and resilience (Fig. 3).

Reefs that saw losses of coral cover also may show differing capabilities for recovery. On many St. Croix reefs areas exposed due to losses in coral cover were colonized by an abundance of macroalgae and filamentous cyanobacteria, indicating that fishes and invertebrates that normally control algae were not present in sufficient numbers. St. John and St. Thomas, with more robust fish communities, were less likely to gain macroalgae and cyanobacteria. This might indicate that reefs with higher protection of critical ecological fish species, such as parrotfish, will rebound faster (Mumby and Harborne 2010). The specific mechanisms for this in the USVI need further research.



**Figure 3. Bleaching, outgrowth and recovery of the susceptible corals *Agaricia agaricites* and branching *Porites* in the USVI over years 2005, 2010, and 2012**

# CORAL BLEACHING

## RECOMMENDATIONS

There are local management actions that work to protect coral reefs in the face of a changing climate (Marshall and Schuttenberg 2006) and ensure they continue to provide economic and social benefits for the USVI. These strategies involve understanding how corals are responding across the seascape and applying best management practices to support reef health. Data from the TCRMP can help determine the most effective actions with the least direct and indirect costs to the USVI economy.

**Strategy #1.** Reduce local stressors, such as removal of ecologically important species (e.g., large-bodied parrotfish), land-based sources of pollution, and physical damage to reefs. Bleached reefs are most fragile during bleaching and the following year. Special restrictions might be considered during this period to reduce stress and disease.

**Strategy #2.** Identify reefs resistant to climate change. The TCRMP has identified deeper mesophotic reef systems as resistant to bleaching. Mesophotic reefs likely exceed shallow water reef area in the USVI and they may have the ability to reseed degraded shallow systems. Special management could be applied, including reducing fish traps that remove ecologically important fishes and damage coral, and restricting anchoring and cable laying. These reefs should be fully researched to understand their extent, their future persistence, and their ability to re-seed young corals to degraded shallow reefs.

**Strategy #3.** Identify reefs and species susceptible to climate change. A shift away from reef dominance by boulder star corals to small corals and algae would degrade the fisheries and tourist potential of USVI reefs, yet shallow boulder star coral reefs are the most susceptible to bleaching. These reefs should be fully catalogued and set aside as special areas. Many USVI protected areas with the power to assist coral reef recovery (e.g., no take reserves) are sited outside the densest areas of star corals. For example, the East End Marine Park's no-take area inside a barrier reef contains relatively little boulder coral, whereas the outer barrier reef has large populations of these important species.

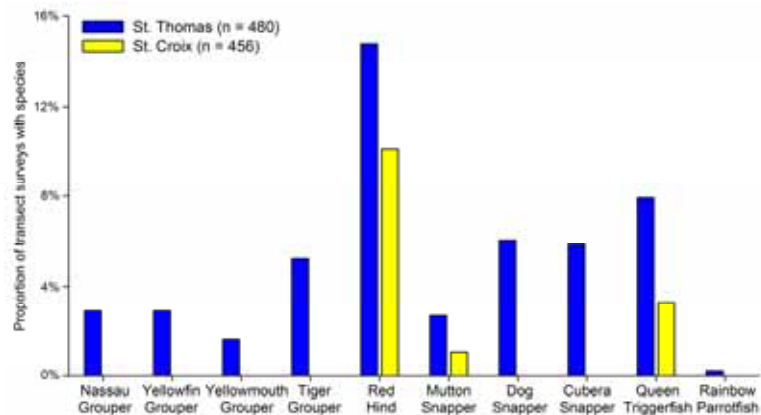
## Populations of Commercially Important Fish Species

Reef fishes serve important ecological roles that directly and indirectly affect the health of coral reefs. For example, large-bodied parrotfishes are grazers of macroalgae that displace juvenile corals and compete with adult corals for reef space (Mumby 2006), increasing coral disease and mortality (Smith et al. 2006). In addition, commercially important species are also important predators that create cascading effects with the potential to improve reef health (Sandin et al. 2008). Maintaining healthy populations of reef fishes is a worthy/valuable management target as a way to promote sustainable fisheries resources and overall reef health and function.

In the USVI, assessments of reef fish populations have been few and tended to focus on marine reserve effectiveness. The TCRMP has assessed populations of fishes across many sites (5 – 40m depth). Fish census data between 2003 and 2009 showed that many species that were relatively common on St. John-St. Thomas reefs were in low abundance on St. Croix reefs (Fig. 4). Fishing pressure as measured by the number of registered commercial fisherman versus shelf area (<65 m depth) was approximately four times greater per area on St. Croix than on St. Thomas-St. John, largely because the northern USVI has about three times as much deep shelf area (26-65m depth). Shallow St. Croix waters also allowed more intensive netting & spearing on SCUBA. In addition, many snapper species are avoided

south of St. John and St. Thomas due to Ciguatera Fish Poisoning.

**Figure 4. Frequency of encounters with commercially important species on TCRMP transects (2003-2009).**



# FISHERIES IMPACTS

These data suggest that some fish species on St. Croix are severely overfished and cannot perform their critical ecological roles as predators and grazers. In territorial and federal waters of the USVI insular shelf, many limited- or no-take marine protected areas and specially protected species regulations (e.g., no possession of Nassau grouper and blue, midnight, and rainbow parrotfish) are only a decade old or less. Therefore, regulations may not have had sufficient time to rebuild fish stocks. Yet, many of these restrictions are not enforced, therefore, the intended impact of protecting and restoring these vital fish populations may not be realized.

## RECOMMENDATIONS

**Strategy #1.** Maintain and enforce current fisheries regulations so that the intended benefits of protection can be realized. Examine the marine protected areas network to identify unprotected areas that might be important to rebuilding fisheries stocks or protected areas that are not performing a stock enhancement role. Also, pay attention to ecologically important areas, such as boulder star coral reefs recovering from bleaching mortality, where sustaining high fish abundance is important to enhancing reef recovery.

**Strategy #2.** Identify and protect fish spawning aggregations (FSA). All reproductive fish from an entire population can be concentrated in FSA where they are most vulnerable to overexploitation. Loss of entire local populations is possible if these FSA are allowed to be exploited.

**Strategy #3.** Research the ecological roles of fisheries species, such as parrotfish, to determine populations necessary to maintain reef health and incorporate results into management strategies.

**Strategy #4.** Promote the harvest of the invasive Indo-Pacific lionfish (*Pterois volitans*), which is a voracious consumer of young and small fishes.

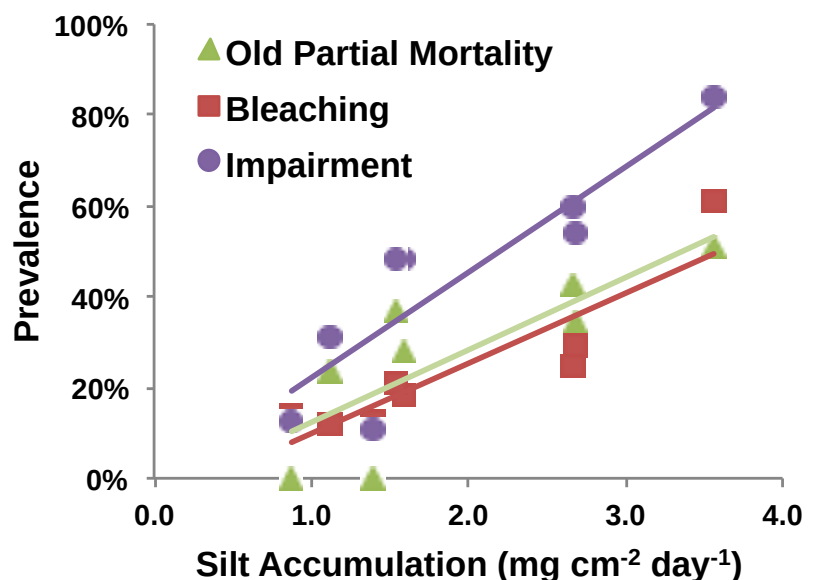
## RESEARCH HIGHLIGHTS

### Impacts of Land-Based Sources of Pollution on Coral Reefs

Land-Based Sources of Pollution are a significant threat to the integrity of nearshore coral ecosystems in the USVI. Rates of silt accumulation, often associated with terrestrial sediment-laden runoff, increase dramatically from offshore to nearshore waters of the USVI (Smith et al. 2008). Terrestrial silt and clay particles less than  $0.75\mu\text{m}$  diameter have strong negative effects on economically important stony corals, including bleaching, disease, and mortality (Weber et al. 2006). Data from the TCRMP (Fig. 5) shows that nearshore sites the highest levels of silt input are sicker than other reefs<sup>1</sup>. This indicates that USVI corals are suffering from sediment impacts that are degrading nearshore coral reef systems and limiting the benefits they provide to our community.



**Figure 5.** (above) A silt laden gully flows to the ocean on St. Thomas. (left) Relationship between silt accumulation and coral health indicators for eight nearshore TCRMP monitoring sites.



<sup>1</sup>(Old Partial Mortality:  $R^2=0.80$ ,  $F=10.6$ ,  $p<0.0175$ ; Bleaching:  $R^2=0.90$ ,  $F=25.3$ ,  $p<0.0024$ ; Overall Impairment:  $R^2=0.89$ ,  $F=17.3$ ,  $p<0.0031$ )

# LAND-BASED SOURCES OF POLLUTION

Less is known about other land-based sources of pollution and their impacts on coral reef ecosystems. These include toxins carried with run-off or leached from domestic and industrial activities, such as the central waste dumpsters that are often sited on roadways adjacent to ghuts. Nutrients carried or leached from sediments can also have indirect effects on corals by stimulating benthic macroalgae and nuisance algal blooms. Nutrients can also reduce water clarity and block light to corals through the stimulation of microscopic algae in the water column (phytoplankton).

The good news is that the effects of land-based sources of pollution are very amenable to management actions. Many problems can be tackled through simple solutions intended to keep sediments out of coastal waters, which do not require expensive restoration or inhibit economic development.

## RECOMMENDATIONS

**Strategy #1.** Implement standards, certifications, and educational programs for contractors and heavy machinery operators that offer guidance for earth moving. This guidance could include months where earth work is not advised due to the potential of soil loss through runoff, such as during tropical storm periods (Jul.-Nov.).

**Strategy #2.** Unpaved roads are the largest artificial producers of terrestrial sediment in the USVI (Ramos-Scharrón and MacDonald 2007b). Identify the worst roads and target these for publically supported restoration. Offer tax rebates to homeowners for road paving or implementation of sediment reduction techniques. Strengthen requirements for private and commercial road construction that reduce sediment production (e.g., slope restrictions, re-grading requirements, special restrictions near drainages).

**Strategy #3.** Protect salt ponds as they are very effective natural sediment retention structures. Restore salt ponds that have been compromised by berm opening or infilling and create artificial sediment retention ponds along problematic ghuts.

## RESEARCH HIGHLIGHTS

**Strategy #4.** Invest in research to understand how terrestrial sediment levels affect coral reefs, what thresholds of sediment most impact corals and what could be tolerated, and identify coastal areas where sediment mitigation is most likely to protect coral reefs, particularly those within marine protected areas.



# INTRODUCTION

## Introduction

The U.S. Virgin Islands consists of three large islands, St. Thomas, St. John and St. Croix, and numerous smaller islands surrounded by a diverse, tropical marine environment that includes coral reefs, seagrass beds, and mangrove forests (Fig. 6). The islands of St. Thomas and St John lie on the Puerto Rican Shelf, an extensive shallow water platform that connects them to Puerto Rico to the west and the British Virgin Islands to the east. Sixty-five kilometers to the south of St. Thomas and St. John and separated by the Anegada Passage and the Virgin Islands Trough (over 3,000 m deep), St. Croix lies on an isolated platform. This forms an effective barrier to the migration of coral reef fishes and invertebrates. The coral reefs of the Virgin Islands represent a wide range of characteristic coral reef habitats of the Caribbean, including patch reefs, fringing reefs, barrier reefs, shelf reefs, and extensive bank and slope mesophotic coral reef ecosystems.

Tourism drives the economy of the Virgin Islands, famous for white sand beaches that give way to clean, clear marine waters. The Virgin Islands are ideal for sailing because of the persistent trade winds and the numerous bays that provide protected anchorages. The diverse marine life of the coral reefs and other habitats attracts thousands of skin and scuba divers each year. Sportfishing on charter boats and private vessels also makes an important contribution to the economy.

In addition to their tourist appeal, the coral reefs and other habitats in the Virgin Islands are essential to the lives of hundreds of thousands of species including economically important queen conch, whelk, spiny lobster, snapper and grouper. Over three hundred full-time or part-time commercial fishermen fish in territorial and federal waters surrounding all three islands (Tobias 1997). Recreational and artisanal fishing is a frequent activity and is likely to have a significant impact on nearshore fish populations, but there exists very limited data on species composition and spatial distribution of annual catches (Authors, personal observation). In tough economic times and after

# INTRODUCTION

natural disasters, fishing is an important means of supplemental income or extra protein for many people.

Over the last few decades, major hurricanes, coral disease outbreaks and mass coral reef bleaching have caused extensive coral mortality to the coral reefs surrounding the Virgin Islands (Gladfelter 1982, Edmunds and Witman 1991, Rogers et al. 1991, Rothenberger et al. 2008, Woody et al. 2008, Miller et al. 2010). Recovery from these natural disturbances is hindered by a multitude of human impacts that affect coral reefs, such as overfishing of ecologically important species, physical damage to reef structure, and pollution (Hatcher 1984, Pastorok and Bilyard 1985, Rogers and Garrison 2001, Mumby 2006, Mumby et al. 2006, Mumby and Harborne 2010). Moreover, rapid development of steep island slopes has dramatically increased soil erosion and sedimentation into nearshore waters (Brooks et al. 2007, Gray et al. 2008, Smith et al. 2008), particularly below unpaved road surfaces (Anderson and Macdonald 1998, Ramos-Scharrón and MacDonald 2007a). Chronic sedimentation affects the abundance and diversity of corals and other reef organisms, increases coral stress and susceptibility to diseases and bleaching, and reduces the ability of corals and other reef organisms to recover and regenerate after natural disturbances such as hurricanes (Acevedo and Morelock 1988, Rogers 1990, Nemeth and Sladeck Nowlis 2001, Fabricius 2005). The first sightings of the invasive Indo-Pacific lionfish (*Pterois volitans*) occurred in the US Virgin Islands in 2009. This predator has the ability to dramatically alter coral reef fish community structure (Cote and Maljkovic 2010) and these alterations may have additional, indirect impacts on benthic communities (Albins and Hixon 2011).

High thermal stress and coral bleaching events affected the northeastern Caribbean in 2005 and 2010, but these events had contrasting signatures in the United States Virgin Islands. The year 2005 was the most severe high sea surface temperature (SST) event on record for the northeastern Caribbean (Eakin et al. 2010). In the Virgin Islands a peak of

# INTRODUCTION

10.25 Degree Heating Weeks (DHW) was registered from satellite SST records (NOAA 2012) and a period of approximately 59 days above the local bleaching threshold of 29.5°C (Aug. 20 – Oct. 18); a level of thermal stress accumulation associated with severe coral bleaching and some mortality. The warm season of 2010 started as warm or warmer than 2005, with the bleaching threshold surpassed for 21 days between August 12 and September 2. In a clear example of ameliorative storm cooling (Manzello et al. 2007), the passing of the storm center of Hurricane Earl on August 30<sup>th</sup>, approximately 100 km to the northeast of the St. Thomas-St. John, caused a rapid decline in SST's below the bleaching threshold to 29.3°C, and then from October 5 - 8, the passage of Hurricane Otto caused windy and cloudy weather that further reduced SST below 29.1°C. Total DHW accumulated in 2010 began to decrease after the beginning of October, when it had reached 5.1 DHW, a level associated with some bleaching and limited mortality.

Most research around the Virgin Islands has focused on fringing reefs (5 – 30 m depth) located along the shoreline of the three main islands, St. Thomas, St. John, and St. Croix. In contrast, very little information exists for offshore and deeper reef systems, which can be quite extensive. Surrounding St. Thomas and St. John, these other reef systems include mid-shelf reefs (5 – 30 m depth) located 2 to 10 km from the shore of the main islands and mesophotic reefs (>30 m depth) located from 0.5 to 15 km offshore along the edge of the insular platform (Armstrong et al. 2002, Herzlieb et al. 2005, Armstrong et al. 2006, Armstrong 2007, Menza et al. 2007, Menza et al. 2008, Nemeth et al. 2008, Smith et al. 2010b). Distance from shore may be a factor in the historical degeneration of coral reef systems in the Virgin Islands (Herzlieb et al. 2005, Calnan et al. 2008, Smith et al. 2008). A systematic approach to investigating these cross-shelf coral reef systems allows us to evaluate the variable impacts and synergistic effects of natural impacts and human-induced stress that influence the decline or recovery of Caribbean coral reef systems. The first two years of this project (2001 and 2002) concentrated on the fringing reefs surrounding St. Croix. In 2003, monitoring continued at St. Croix reefs and began at reef

# INTRODUCTION

systems distributed across the insular platform surrounding St. Thomas. In 2004, 2005 and 2006 monitoring continued at reefs surrounding both islands, with additional reefs surrounding St. Thomas added in 2004, 2005, and 2011. Mesophotic coral reef monitoring sites were added to St. Croix during the 2008 and 2009 monitoring, as well as an additional monitoring site in the St. Croix East End Marine Park. This report has also expanded to include sites established under separate funding that will be continued in the core TCRMP monitoring activities funded by USVI DPNR and NOAA CRCP.

## OBJECTIVES FOR MONITORING CORAL REEFS

Effective management is necessary to maintain the resources in the territorial and federal waters of the Virgin Islands in an ecologically and economically sustainable manner. Monitoring programs are essential for successful management because they provide managers with fundamental information with which to make and reinforce decisions. Standards for resource protection can be measured by comparison to baseline data established by monitoring. Monitoring also provides the means to assess the status and trends of ecological resources, allowing managers to determine the effectiveness of current management and to develop effective management plans for the future. The Territorial Coral Reef Monitoring Program monitors the condition of coral reefs throughout the U.S. Virgin Islands and provides key information to better manage these ecosystems. This report presents monitoring results from 2001-2011 in St. Croix and from 2003-2011 in St. Thomas. For both islands, temporal changes from year to year in the conditions of the reef communities are assessed.

# INTRODUCTION

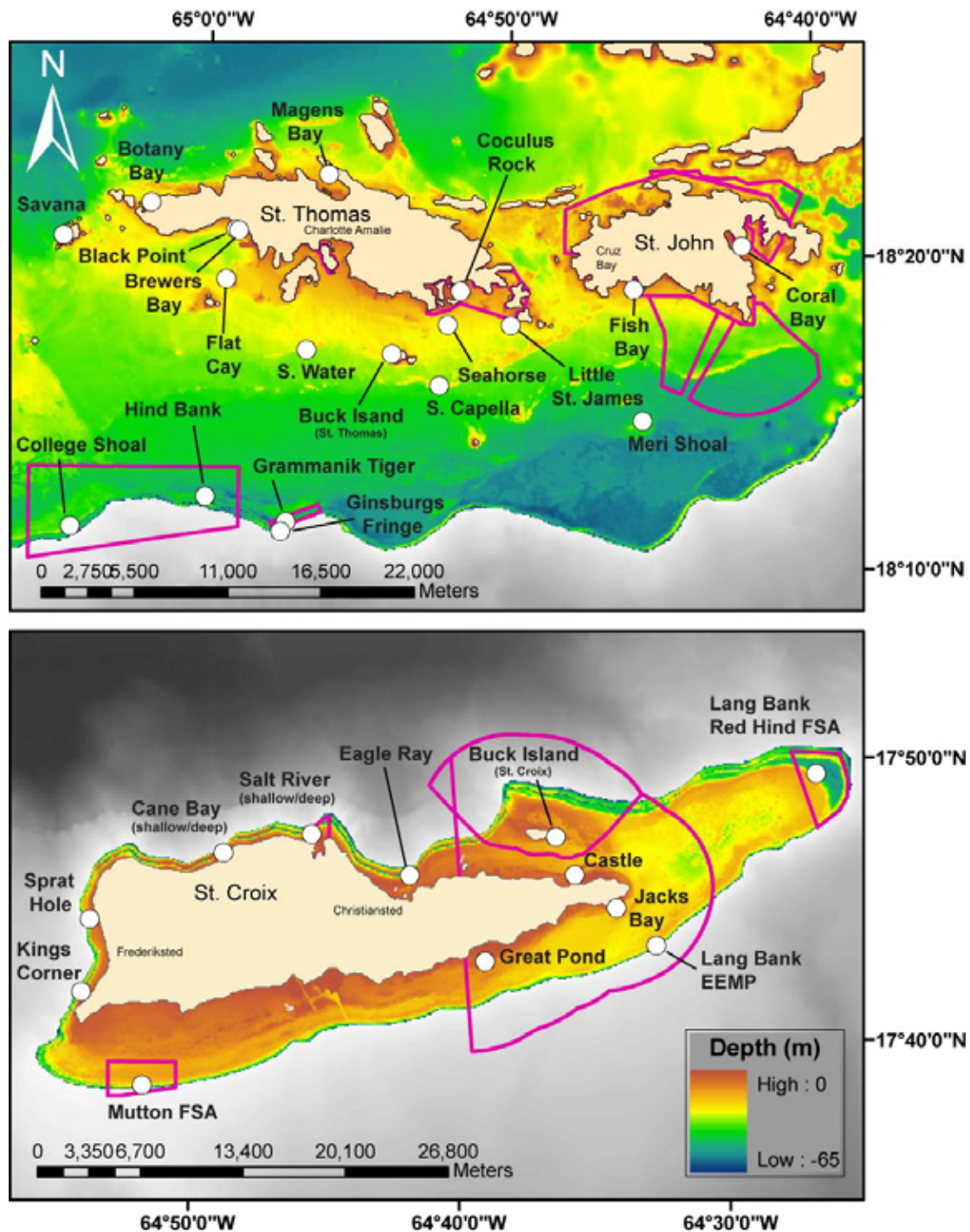


Figure 6. Locations of Territorial Coral Reef Monitoring Sites in the US Virgin Islands, 2008-2010. Boundaries indicate federal and territorial marine protected areas.



## Methods

### BENTHIC ASSESSMENTS

The University of the Virgin Islands determined the benthic composition at 33 long-term monitoring sites between 2001 and 2010 (Fig. 6). Around St. Croix the following 14 sites were assessed: Buck Island-St. Croix, Cane Bay, Cane Bay Deep, Castle, Eagle Ray, Great Pond, Jacks/Isaacs Bay, Kings Corner<sup>2</sup>, Lang Bank East End Marine Park (Lang EEMP), Lang Bank Red Hind Fish Spawning Aggregation (Lang Hind), Mutton Snapper, Salt River, Salt River Deep, and Sprat Hole. Four of these sites are within the St. Croix East End Marine Park boundary (Castle, Great Pond, Jacks Bay, Lang EEMP), three sites are within National Park Service boundaries (Buck Island-St. Croix, Salt River West, and Salt River Deep), two sites are within federal fisheries marine protected areas (Lang Hind, Mutton

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<sup>2</sup> Indicates a site newly incorporated into TCRMP funded by CZM/CRCP

# METHODS

Snapper), and four sites can be considered mesophotic coral reefs (Cane Bay Deep, Lang Bank EEMP, Lang Hind FSA, Salt River Deep; sensu Hinderstein et al. 2010). Salt River Deep transects 1-4 were moved from 40 m depth at the April 2009 sampling to 30 m in the January 2010 sampling due to low coral cover in the deeper transects.

Around St. John-St. Thomas the following 19 sites were assessed: Black Point\*, Botany Bay\*, Brewers Bay\*, Buck Island-St. Thomas\*, Cocus Rock\*, College Shoal East, Coral Bay\*, Fish Bay\*, Flat Cay\*, Ginsburg Fringe\*, Grammanik Bank Fish Spawning Aggregation (Grammanik Tiger), Red Hind Bank Fish Spawning Aggregation (Hind Bank), Little St. James\*, Magens Bay\*, Savana Island\*, Seahorse Cottage Shoal (Seahorse), Meri Shoal, South Capella, and South Water Island. One site is the within the St. Thomas East End Reserve (Cocus Rock), four sites are within federal fisheries marine protected areas (College Shoal, Ginsburg Fringe, Grammanik Tiger, Hind Bank), and five sites can be considered mesophotic coral reefs (College Shoal, Ginsburg Fringe, Grammanik Tiger, Hind Bank, Shaun Rise). Four sites are also part of the Ciguatera Fish Monitoring Program and have been surveyed monthly for benthic structure and coral health since 2010 (Black Point, Cocus Rock, Flat Cay, Seahorse).

**Benthic Cover.** At each site benthic cover and coral health surveys were conducted along six 10 m long permanent transect marked with steel or brass rods. Video sampling consisted of one diver traversing each transect videotaping the benthic cover using a high definition video cassette recorder (Sony FX-7 in Light and Motion Housing). The diver swam at a uniform speed, pointing the camera down and keeping the lens approximately 0.4 m above the substrate at all times. A guide wand or dropper weight attached to the camera housing was used to help the diver maintain the camera a constant distance above the reef. After taping, approximately 20 - 50 non-overlapping images per transect were captured and saved as JPEG files (Fig. 7). Captured images represented an area of reef approximately 0.31 m<sup>2</sup> (0.64 m x 0.48 m). Coral Point Count with Excel Extension

# METHODS

software (Kohler and Gil 2006) was used to superimpose ten randomly located dots on each image. The substrate type located under each of the dots was then identified to the most descriptive level possible and entered into a database. Where multiple benthic cover categories fell under a single point, for example macroalgae over bedrock, the upper benthic category was assessed. For each transect, the percent cover of coral, epilithic algae (formerly called dead coral with turf algae), macroalgae, sponges, gorgonians, and sand/sediment were calculated by dividing the number of random dots falling on that substrate type by the total number of dots for that transect. Epilithic algae (*sensu* Hatcher and Larkum 1983) are diminutive turfs and filamentous algae without thallus structure that cover all rock surfaces of coral reefs not occupied by larger epibenthic organisms. They can also be considered to be grazed surfaces are often an indicator of healthy grazing communities and high animal cover.



**Figure 7. A screen grab of benthic video used for the determination of percent cover of coral reef organisms and non-living substrate.**

# METHODS

**Table 1. TCRMP site reef complex type, location coordinates, and depths. FSA = Fish Spawning Aggregation. EEMP = East End Marine Park.**

| Island     | Site                   | Reef Complex      | Lat      | Long      | Depth (m) |
|------------|------------------------|-------------------|----------|-----------|-----------|
| St. Croix  | Buck Island-St. Croix  | Offshore-Shallow  | 17.78500 | -64.60917 | 15        |
|            | Cane Bay               | Nearshore         | 17.77388 | -64.81350 | 10        |
|            | Cane Bay Deep          | Offshore-MCE      | 17.77661 | -64.81522 | 38        |
|            | Castle                 | Offshore-Shallow  | 17.76278 | -64.59743 | 7         |
|            | Eagle Ray              | Offshore-Shallow  | 17.76150 | -64.69880 | 10        |
|            | Great Pond             | Nearshore         | 17.71097 | -64.65221 | 6         |
|            | Jacks Bay              | Nearshore         | 17.74337 | -64.57160 | 14        |
|            | Kings Corner           | Nearshore         | 17.69116 | -64.90008 | 17        |
|            | Lang Bank EEMP         | Offshore-MCE      | 17.72145 | -64.54706 | 27        |
|            | Lang Bank Red Hind FSA | Offshore-MCE      | 17.82372 | -64.44943 | 33        |
|            | Mutton Snapper FSA     | Offshore-Shallow  | 17.63660 | -64.86240 | 24        |
|            | Salt River Deep        | Offshore-MCE      | 17.78523 | -64.75917 | 30        |
|            | Salt River West        | Offshore-Shallow  | 17.78530 | -64.75940 | 11        |
|            | Sprat Hole             | Nearshore         | 17.73400 | -64.89540 | 8         |
| St. John   | Coral Bay              | Nearshore-Shallow | 18.33797 | -64.70402 | 9         |
|            | Fish Bay               | Nearshore         | 18.31417 | -64.76408 | 6         |
|            | Meri Shoal             | Offshore-MCE      | 18.24433 | -64.75832 | 30        |
| St. Thomas | Black Point            | Nearshore         | 18.34450 | -64.98595 | 9         |
|            | Botany Bay             | Nearshore         | 18.35845 | -65.03330 | 8         |
|            | Brewers Bay            | Nearshore         | 18.34403 | -64.98435 | 6         |
|            | Buck Island-St. Thomas | Offshore-Shallow  | 18.27883 | -64.89833 | 14        |
|            | Coculus Rock           | Nearshore         | 18.31257 | -64.86058 | 7         |
|            | College Shoal East     | Offshore-MCE      | 18.18568 | -65.07677 | 30        |
|            | Flat Cay               | Offshore-Shallow  | 18.31822 | -64.99104 | 12        |
|            | Ginsburgs Fringe       | Offshore-MCE      | 18.18770 | -64.95998 | 63        |
|            | Grammanik Tiger FSA    | Offshore-MCE      | 18.19113 | -64.95032 | 38        |
|            | Hind Bank East FSA     | Offshore-MCE      | 18.20217 | -65.00158 | 39        |
|            | Magens Bay             | Nearshore         | 18.37425 | -64.93438 | 7         |
|            | Savana                 | Offshore-Shallow  | 18.34064 | -65.08205 | 9         |
|            | Seahorse Cottage Shoal | Offshore-Shallow  | 18.29467 | -64.86750 | 20        |
|            | South Capella          | Offshore-Shallow  | 18.26267 | -64.87237 | 20        |
|            | South Water            | Offshore-Shallow  | 18.28068 | -64.94592 | 20        |
|            | St James               | Offshore-Shallow  | 18.29459 | -64.83238 | 15        |

# METHODS

**Table 2. TCRMP site date sampled (benthic/health) and type of sampling.**

| Island     | Site                   | Date Sampled | Benthic | Health | Fish/Urchin |
|------------|------------------------|--------------|---------|--------|-------------|
| St. Croix  | Buck Island STX        | 7/19/11      | x       | x      | x           |
|            | Cane Bay               | 7/20/11      | x       | x      | x           |
|            | Cane Bay Deep          | 7/20/11      | x       | x      | x           |
|            | Castle                 | 7/19/11      | x       | x      | x           |
|            | Eagle Ray              | 7/17/11      | x       | x      | x           |
|            | Great Pond             | 7/16/11      | x       | x      | x           |
|            | Jacks Bay              | 7/15/11      | x       | x      | x           |
|            | Kings Corner           | 7/18/11      | x       | x      | x           |
|            | Lang Bank EEMP         | 7/15/11      | x       | x      | x           |
|            | Lang Bank Red Hind FSA | 7/14/11      | x       | x      | x           |
|            | Mutton Snapper FSA     | 7/16/11      | x       | x      | x           |
|            | Salt River Deep        | 7/16/11      | x       | x      | x           |
|            | Salt River West        | 7/13/11      | x       | x      | x           |
|            | Sprat Hole             | 7/18/11      | x       | x      | x           |
| St. John   | Coral Bay              | 10/11/11     | x       | x      |             |
|            | Fish Bay               | 9/16/11      | x       | x      |             |
|            | Meri Shoal             | 11/18/11     | x       | x      |             |
| St. Thomas | Black Point            | 10/20/11     | x       | x      | x           |
|            | Botany Bay             | 10/27/11     | x       | x      |             |
|            | Brewers Bay            | 10/27/11     | x       | x      | x           |
|            | Buck Island STT        | 10/21/11     | x       | x      |             |
|            | Coculus Rock           | 10/18/11     | x       | x      | x           |
|            | College Shoal East     | 10/07/11     | x       | x      | x           |
|            | Flat Cay               | 10/20/11     | x       | x      | x           |
|            | Ginsburgs Fringe       | 4/19/11      | x       | x      |             |
|            | Grammanik Tiger FSA    | 10/5/11      | x       | x      | x           |
|            | Hind Bank East FSA     | 11/03/11     | x       | x      | x           |
|            | Magens Bay             | 10/06/11     | x       | x      |             |
|            | Savana                 | 10/06/11     | x       | x      |             |
|            | Seahorse Cottage Shoal | 10/18/11     | x       | x      | x           |
|            | South Capella          | 10/01/11     | x       | x      | x           |
|            | South Water            | 11/29/11     | x       | x      | x           |
|            | St James               | 10/11/11     | x       | x      |             |

# METHODS

**Coral Health.** Coral health assessments follow methodologies outlined in (Calnan et al. 2008) and (Smith et al. 2008) and are briefly described here. All coral colonies located directly under the transect lines were assessed in situ for signs of mortality and disease following a modified Atlantic and Gulf Rapid Reef Assessment protocol (Kramer et al. 2005). In contrast to previous years where only colonies greater than 10 cm in maximum linear dimension were assessed, starting in 2008 all colonies were assessed, regardless of size. Partial mortality of coral colonies was broken into two categories. Recent partial mortality was characterized visually as skeleton not eroded (fine corallite structure still intact) and bare or with a thin veneer of sheeting or filamentous algae. Recent partial mortality is typically visible for up to three months following tissue loss. Old partial mortality was characterized as skeleton eroded and covered with turf or macroalgae. Old partial mortality is a transition from recent mortality and typically lasts up to 1–6 years (Smith et al. 2008, also see <http://www.agrra.org/method/methodcor.html>).

Diseases were conservatively categorized into recognized Caribbean scleractinian diseases and syndromes that included bleaching, black band disease, dark spots disease, white plague, and yellow band (blotch) disease (following Bruckner 2007). Acroporid corals were extremely rare at the study sites; thus, their associated diseases (white band and white pox) are not presented. Bleaching was assessed as abnormal paling of the colony, and, when present, the severity of the bleaching (paling or total whitening) and the area of the colony affected were assessed. A major bleaching event occurred between September and December 2005, affecting all monitored sites, and a mild bleaching event occurred September and October 2010. On St. Croix, a subset of sites were assessed during the 2010 coral bleaching event, and included Cane Bay, Cane Bay Deep, and Jacks Bay.

For each transect, the prevalence of coral impairment categories was calculated as the number of colonies with partial mortality, disease, or bleaching divided by the number of

# METHODS

colonies assessed. Also, for affected colonies in each transect the average three-dimensional surface area (%) of the colony affected was also estimated for each impairment category.

## FISH CENSUS

Fish surveys have been conducted at 14 sites around St. Croix and 10 sites around St. Thomas (Table 2). In 2008, fish census methods across both islands were consistent with those used on St. Croix from 2003 through 2005. Ten replicate belt transects and three replicate roving dive surveys (RDS) were conducted at each site. Belt transects were 30m x 2m and were conducted in 15 min per replicate. RDS replicates were either 30 min (sites < 25 m depth) or 15 min (sites >25 m depth) (see Table 3). All fish encountered were recorded except blennies and gobies.

In 2009 to 2011 fish census methods were slightly modified from those used from 2003 through 2008. As in previous years, ten replicate belt transects and three replicate roving diver surveys were conducted at each site. Belt transects were changed to include an 8 min 25m x 4m survey during which all non-site attached fish were enumerated, followed by a 7 min return survey along the same transect line surveying site attached fish. Site attached fish included small (<5 mm) scarids and labrids, pomocentrids (excluding *Chromis spp*), fairy basslets (*Grammaloreto*) and sharpnose puffers (*Canthigas terrostrata*). This change in methodology maximized the capture of larger, more mobile fish, and increased the precision of enumeration of small and cryptic site attached fishes. As in previous years, all transects were begun at a random location on the site, and were swum in a random direction. In addition to relative abundance data, specific total length estimates were made for each large grouper, large snapper or hogfish (*Lachnolaimus maximus*) encountered. Data from all fish surveys were transcribed to Microsoft Excel and Access spreadsheets, and were analyzed for descriptive statistics of reef fish assemblage structure.

## METHODS

Divers also counted the number of *Diadema antillarum* sea urchins within 1 m on either side of transects. From 2001 – 2008 this occurred along the 6 – 10 m long benthic transects. Starting in 2009, urchins were assessed along 25x2m belt transects corresponding to the return of the 10 fish transects. The mean number of sea urchins per 100 m<sup>2</sup> was calculated for each site.

## Territorial Coral Reef Monitoring Summary

# TCRMP MONITORING SUMMARY

## BENTHIC COMMUNITIES AND CORAL REEF HEALTH

Benthic cover was monitored at 33 monitoring sites and coral health was monitored at 32 sites in 2011. Coral health was not monitored at the deep (63m) Ginsburgs Fringe. Benthic cover raw data is presented in electronic Appendix I. Coral health raw data is presented in electronic Appendix II.

### Coral Cover

The cover of hard corals decreased at most sites after the 2005 coral bleaching event, but showed little or no change as the results of the 2010 coral bleaching event. Shallow (<25 m depth), nearshore and offshore sites with greater than about 20% coral cover showed declines in cover, but there was extreme variability in the degree of cover change. For example the Mutton Snapper site on St. Croix lost 87% of its coral cover between 2004 and 2006. Sites that had low coral cover prior to 2005 lost far less relative cover as the result of bleaching. While part of this may be due to detectability at values nearer to 0, these sites tend to be dominated by small massive species that are more resistant to disease related mortality (Smith et al. unpub. manuscript).

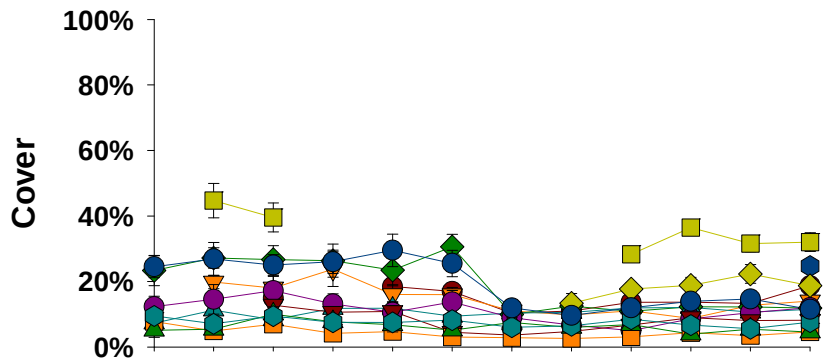
Mesophotic coral monitoring sites that were sampled before and after the 2005 coral bleaching event showed slight relative losses of coral cover. Losses ranged from 5.4% (Grammanik Tiger) to 36.0% (Meri Shoal).

Recovery since bleaching was marginal at most sites. The majority of sites had apparently level coral cover with recovery potentially inhibited by disease and increased interactions with other organisms. However, slow upward trajectories are notable at some sites.

# BENTHIC COVER & CORAL HEALTH

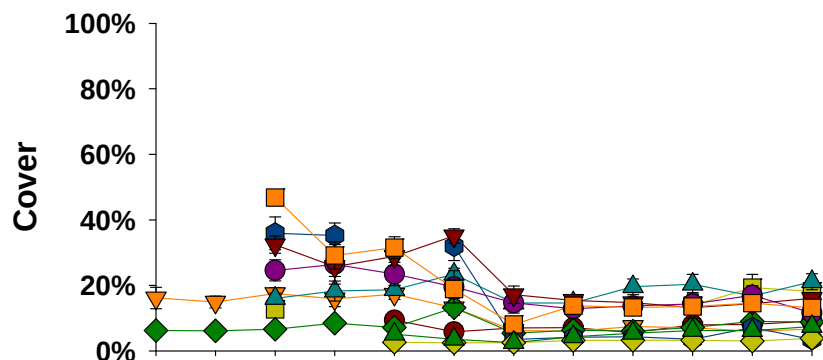
## Nearshore

- Black Point
- ▼ Botany Bay
- Brewers Bay
- ◆ Cane Bay
- ▲ Coculus Rock
- Coral Bay
- Fish Bay
- ▼ Great Pond
- Jacks Bay
- ◆ Kings Corner
- ▲ Magens Bay
- Salt River West
- Sprat Hole



## Offshore

- Buck Island STT
- ▼ Buck Island STX
- Castle
- ◆ Eagle Ray
- ▲ Flat Cay
- Mutton Snapper
- Savana Island
- ▼ Seahorse
- South Capella
- ◆ South Water
- ▲ St. James



## Mesophotic

- Cane Bay Deep
- ▼ College Shoal
- Ginsburgs Fringe
- ◆ Grammanik Tiger
- ▲ Hind Bank FSA
- Lang Bank EEMP
- Lang Bank FSA
- ▼ Meri Shoal
- Salt River Deep

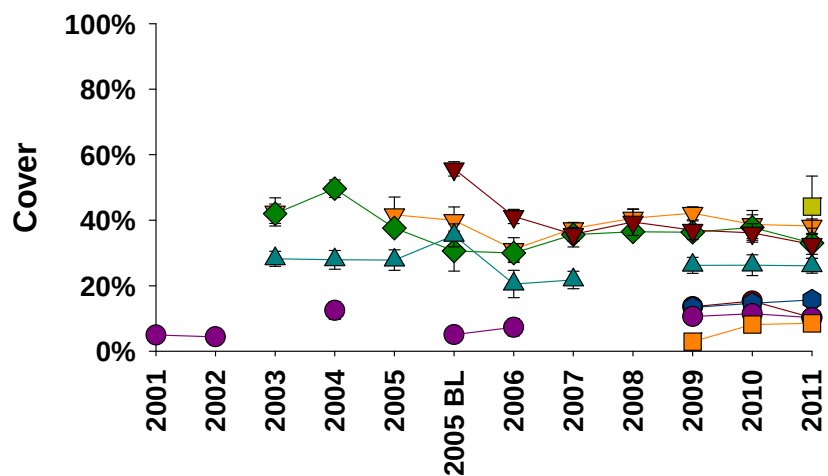


Figure 8. Coral cover ( $\pm$ SE) across TCRMP monitoring sites over time.

# TCRMP MONITORING SUMMARY

## **Epilithic Algal Community Cover**

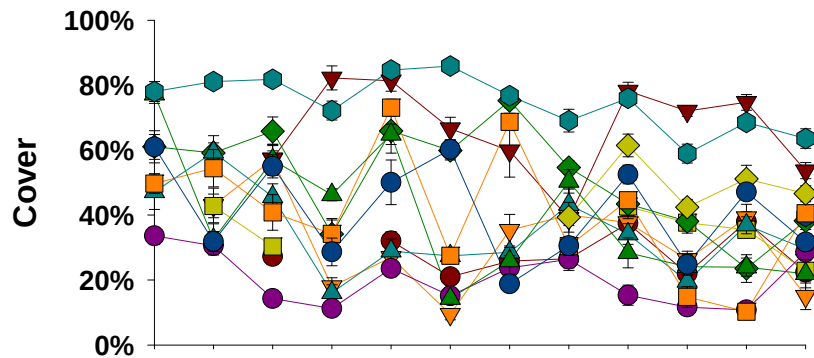
Algae show the highest inter-annual variability of any group of benthic organisms. This is largely due to highly variable seasonality. The cover of epilithic algae is no exception, since it tends to negatively covary with more ephemeral macroalgae. Epilithic Algae is important as it can indicate substrates grazed by herbivores and therefore open to the settlement of sessile epibenthic animals, including coral.

Nearshore and mesophotic sites showed little inter-annual trend in epilithic algal cover. Many offshore sites, such as Eagle Ray and Buck Island, St. Croix, appear to have a declining abundance of epilithic algae, indicating an increase in other benthic components, such as macroalgae and filamentous cyanobacteria, and possibly indicating declining grazing.

# BENTHIC COVER & CORAL HEALTH

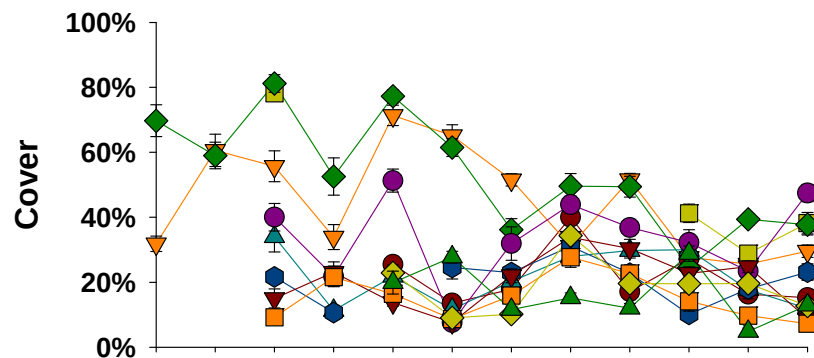
## Nearshore

- Black Point
- ▼ Botany Bay
- Brewers Bay
- ◆ Cane Bay
- ▲ Coculus Rock
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- Jacks Bay
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- ▲ Magens Bay
- Salt River West
- Sprat Hole



## Offshore

- Buck Island STT
- ▼ Buck Island STX
- Castle
- ◆ Eagle Ray
- ▲ Flat Cay
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- Savana Island
- ▼ Seahorse
- South Capella
- ◆ South Water
- ▲ St. James



## Mesophotic

- Cane Bay Deep
- ▼ College Shoal
- Ginsburgs Fringe
- ◆ Grammanik Tiger
- ▲ Hind Bank FSA
- Lang Bank EEMP
- Lang Bank FSA
- ▼ Meri Shoal
- Salt River Deep

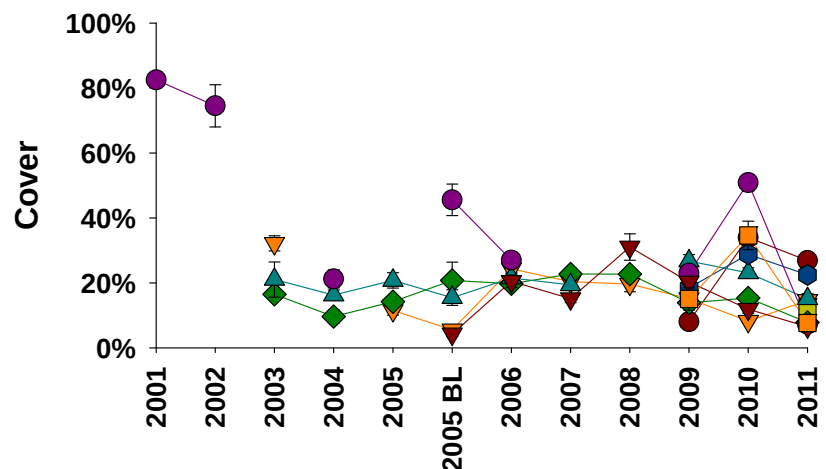


Figure 9. Epilithic Algal Community cover ( $\pm$ SE) across TCRMP monitoring sites over time.

# TCRMP MONITORING SUMMARY

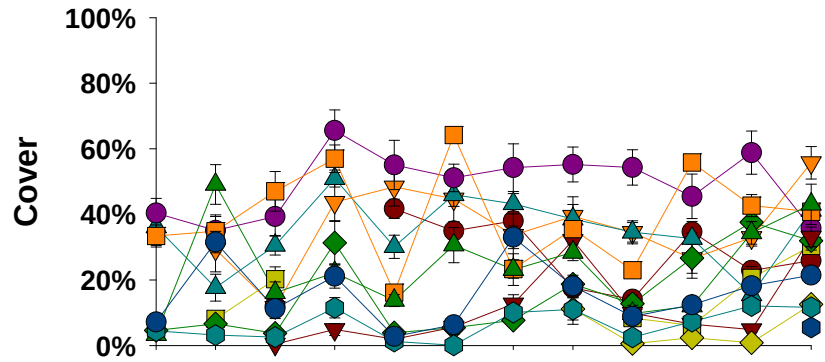
## Macroalgal Cover

Macroalgae have been increasing at many reefs, particularly after the 2005 bleaching event. At sites where there was no loss of coral cover, increased macroalgae may be due to declining grazing, such as at Eagle Ray. At other sites where coral cover dropped after 2005, space opened for algal colonization by coral die-off may not have been grazed in reefs where resident herbivores communities are already at the threshold of maximum grazing rates (Williams et al. 2001). These reefs include, the Buck Islands (St. Thomas and St. Croix), Cane Bay, Meri Shoal, South Capella, and Sprat Hole. The same explanation may also apply for filamentous cyanobacteria (see following section).

# BENTHIC COVER & CORAL HEALTH

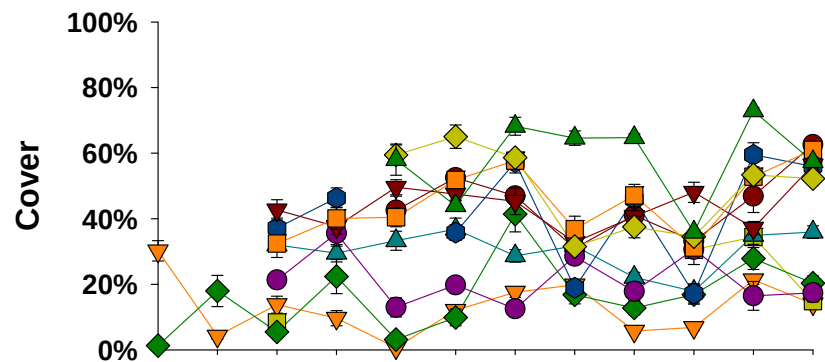
## Nearshore

- Black Point
- ▼ Botany Bay
- Brewers Bay
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- Savana Island
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- ◆ South Water
- ▲ St. James



## Mesophotic

- Cane Bay Deep
- ▼ College Shoal
- Ginsburgs Fringe
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- ▲ Hind Bank FSA
- Lang Bank EEMP
- Lang Bank FSA
- ▼ Meri Shoal
- Salt River Deep

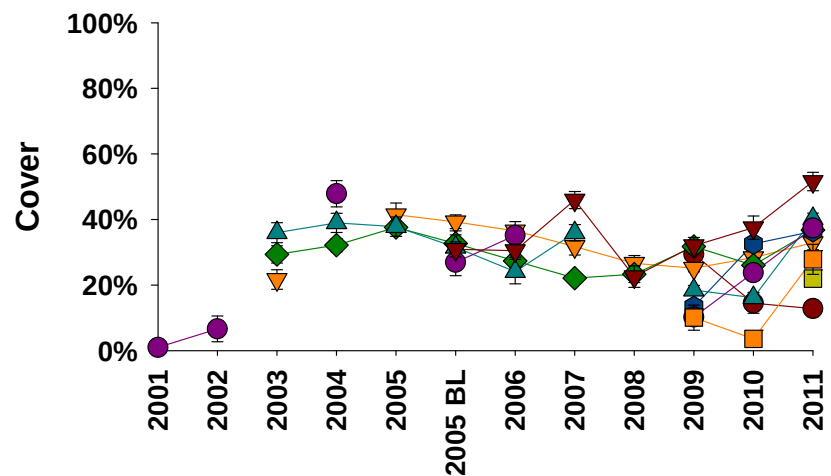


Figure 10. Macroalgae cover ( $\pm$ SE) across TCRMP monitoring sites over time.

# TCRMP MONITORING SUMMARY

## Filamentous Cyanobacteria

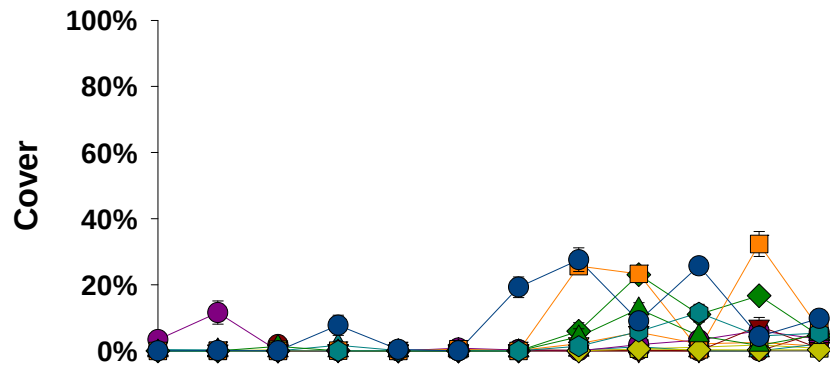
Filamentous cyanobacteria cover has been increasing at many sites in the TCRMP since the 2005 coral bleaching event. This is particularly true at many sites on St. Croix that have attained very high cover values in recent years. For example, Salt River West, Jacks Bay, Cane Bay, Sprat Hole, Mutton Snapper, Buck Island (St. Croix), Eagle Ray, Lang Bank EEMP, and Lang Bank Hind have all seen cover of filamentous cyanobacteria from 10 – 60%, with 2009 as a particularly high abundance year for offshore sites.

The increased incidence of filamentous cyanobacteria can be an indication of disturbance, increased nutrient inputs, and insufficient grazing (Fong and Paul 2011). In addition, filamentous cyanobacteria can promote increases in palatable macroalgae in coral reefs by coating and protecting algae with secondary metabolites that deter grazing (Fong et al. 2006, Smith et al. 2010a). Filamentous cyanobacteria can inhibit the recruitment of coral larvae (Kuffner et al. 2006) and have been observed interacting at the borders of adult coral (Authors, unpub. data). Monitoring the trends of filamentous cyanobacteria in USVI reef systems will be increasingly important in future years in an effort to understand the factors influencing bloom formation and which reefs are most vulnerable.

# BENTHIC COVER & CORAL HEALTH

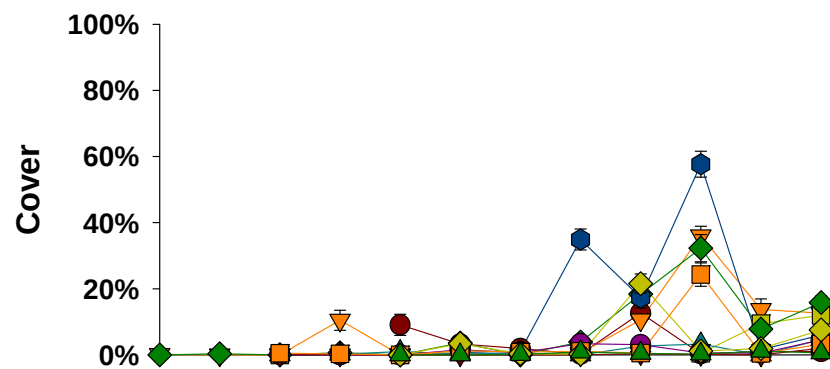
## Nearshore

- Black Point
- ▼ Botany Bay
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- ◆ Cane Bay
- ▲ Cocus Rock
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- Fish Bay
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- ◆ Kings Corner
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- Sprat Hole



## Offshore

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- ▼ Buck Island STX
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- ◆ Eagle Ray
- ▲ Flat Cay
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- Savana Island
- ▼ Seahorse
- South Capella
- ◆ South Water
- ▲ St. James



## Mesophotic

- Cane Bay Deep
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- Lang Bank EEMP
- Lang Bank FSA
- ▼ Meri Shoal
- Salt River Deep

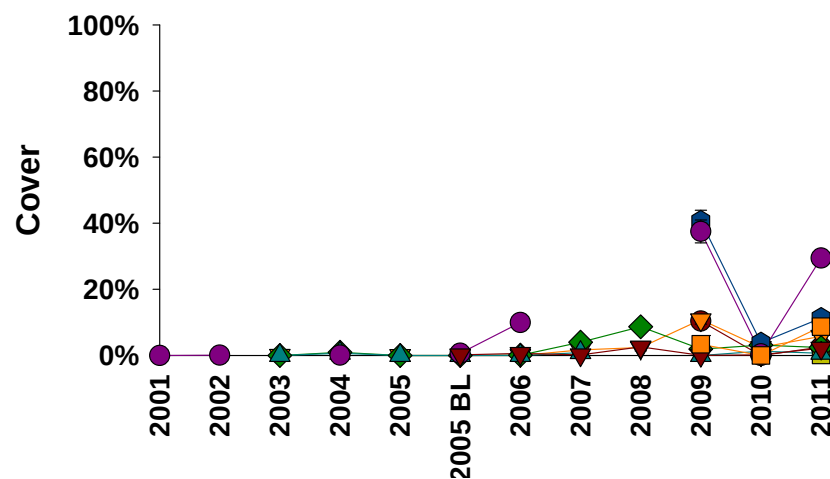


Figure 11. Filamentous cyanobacteria cover ( $\pm$ SE) across TCRMP monitoring sites over time.

# TCRMP MONITORING SUMMARY

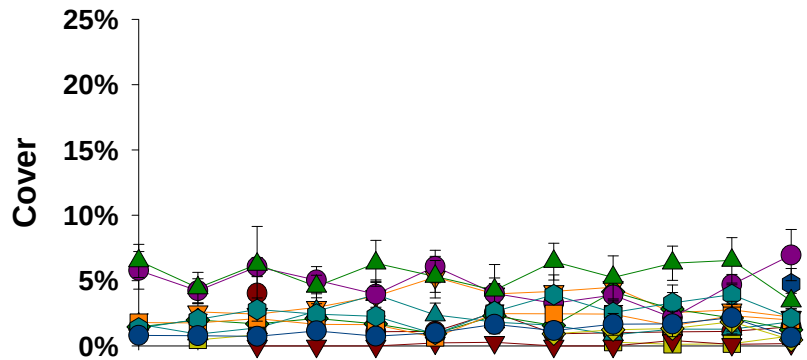
## **Gorgonian and Antipatharian Cover**

The cover of gorgonians and antipatharians has been fairly constant at most monitoring sites throughout the years of monitoring. In most cases they are a relatively minor component of cover because of their upright growth form and small branches. However, there are sites that appear to be more favorable to the growth of gorgonians, including Magens Bay, Fish Bay, Coral Bay, Buck Island (St. Croix), Savana Island, South Water, Lang Bank Hind FSA, and Salt River Deep. Note that Black Corals (antipatharians) typically tend to be more prominent in deep monitoring sites, whilst gorgonians tend to be more dominant in shallower and wave-washed sites.

# BENTHIC COVER & CORAL HEALTH

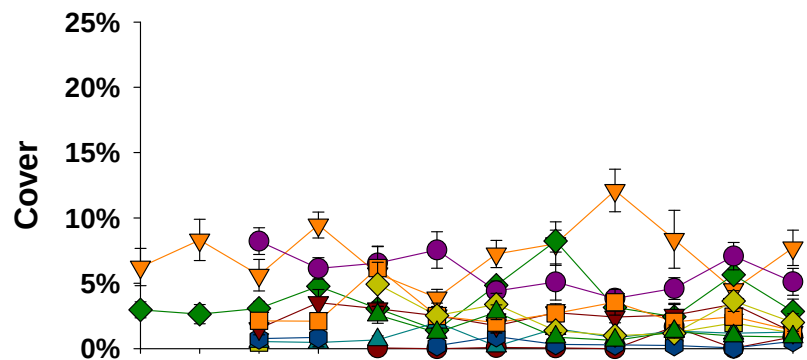
## Nearshore

- Black Point
- ▼ Botany Bay
- Brewers Bay
- ◆ Cane Bay
- ▲ Coculus Rock
- Coral Bay
- Fish Bay
- ▼ Great Pond
- Jacks Bay
- ◆ Kings Corner
- ▲ Magens Bay
- Salt River West
- Sprat Hole



## Offshore

- Buck Island STT
- ▼ Buck Island STX
- Castle
- ◆ Eagle Ray
- ▲ Flat Cay
- Mutton Snapper
- Savana Island
- ▼ Seahorse
- South Capella
- ◆ South Water
- ▲ St. James



## Mesophotic

- Cane Bay Deep
- ▼ College Shoal
- Ginsburgs Fringe
- ◆ Grammanik Tiger
- ▲ Hind Bank FSA
- Lang Bank EEMP
- Lang Bank FSA
- ▼ Meri Shoal
- Salt River Deep

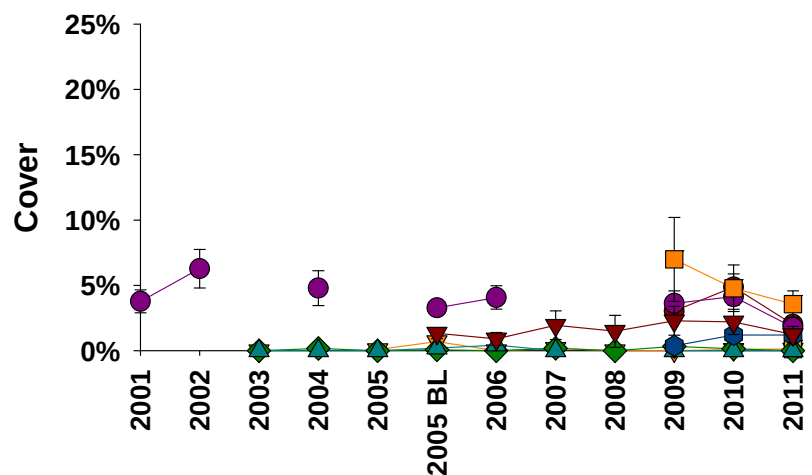


Figure 12. Gorgonian and Antipatharian cover ( $\pm$ SE) across TCRMP monitoring sites over time.

# TCRMP MONITORING SUMMARY

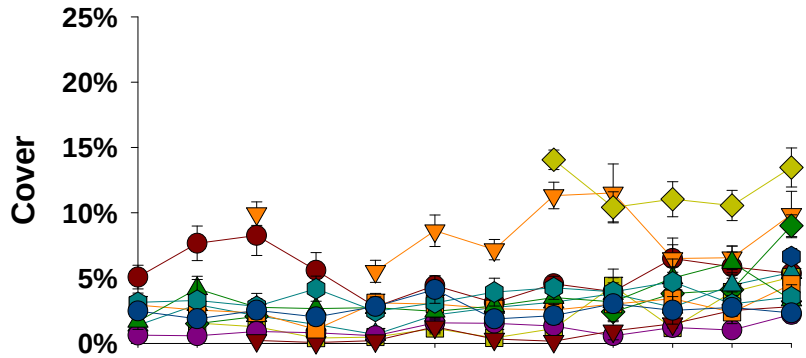
## **Sponge Cover**

Sponge cover has been constant or variable at many offshore and mesophotic sites, but there is an indication of slightly increasing sponge cover at some nearshore sites. This increase in epibenthic and boring sponges may indicate increasing supplies of food, such as bacteria and small eukaryotes, in nearshore environments. This may be a consequence of increasing nearshore nutrient pollution. Further study needs to be done to establish this linkage.

# BENTHIC COVER & CORAL HEALTH

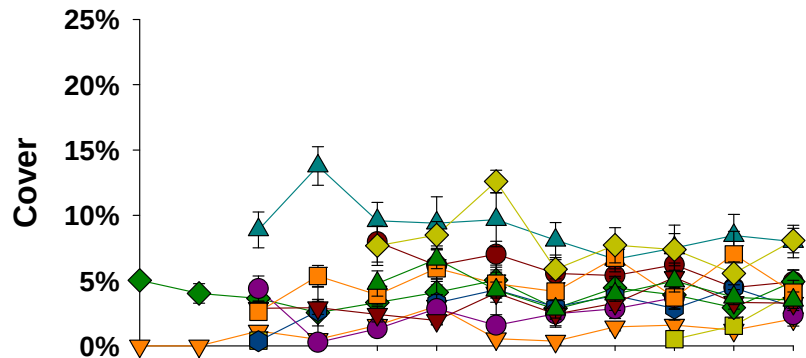
## Nearshore

- Black Point
- ▼ Botany Bay
- Brewers Bay
- ◆ Cane Bay
- ▲ Coculus Rock
- Coral Bay
- Fish Bay
- ▼ Great Pond
- Jacks Bay
- ◆ Kings Corner
- ▲ Magens Bay
- Salt River West
- Sprat Hole



## Offshore

- Buck Island STT
- ▼ Buck Island STX
- Castle
- ◆ Eagle Ray
- ▲ Flat Cay
- Mutton Snapper
- Savana Island
- ▼ Seahorse
- South Capella
- ◆ South Water
- ▲ St. James



## Mesophotic

- Cane Bay Deep
- ▼ College Shoal
- Ginsburgs Fringe
- ◆ Grammanik Tiger
- ▲ Hind Bank FSA
- Lang Bank EEMP
- Lang Bank FSA
- ▼ Meri Shoal
- Salt River Deep

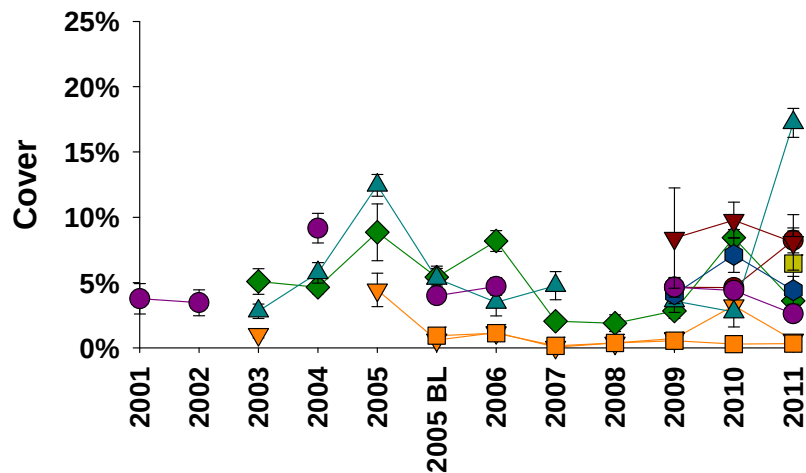


Figure 13. Sponge cover ( $\pm$ SE) across TCRMP monitoring sites over time.

# TCRMP SITE SUMMARIES

## FISH COMMUNITIES

A total of 23,325 fish representing 123 species and 33 families were recorded during belt transects across all sites off St. Croix in 2011 and 20,866 fish representing 116 species and 30 families across all sites off St Thomas. Using roving diver surveys (RDS) 118 species representing 33 families were observed in 2011 off St Croix and 117 species representing 32 families off St. Thomas (see Appendices III-VII). Species richness across all sites was greatest in RDS, designed to capture rare and cryptic species (Table 3).

Overall fish size distribution on both St. Croix and St. Thomas followed trends seen in earlier years. Fish smaller than 10cm total length (TL) predominated at all sites. Thirty five percent of the individuals counted off St. Croix were less than 5cm TL and 74% were less than 10cm TL. Off St. Thomas, 32% were smaller than 5cm and 69% were under 10cm TL. Large fish (> 40cm TL) constituted 0.2% (84 fish) of the numeric total of both islands combined. St. Thomas sites produced more of this size class, with 64 fish estimated over 40cm. Numerically the most dominant fish across the region were creole wrasse (*Clepticus parrae*; 22.3%), blue chromis (*Chromis cyanae*; 14.2%), and bicolor damselfish (*Stegastes partitus*; 7.3%), bluehead wrasse (*Thalassoma bifaciatum*), brown chromis (*C. multilineata*), and yellowhead wrasse (*Halichoeres garnoti*). These six species made up 60% of the numerical total of fish observed on all sites together. Most of these species were ubiquitous and found at all sites. The exception was creole wrasse, which was abundant on offshore, mesophotic sites, and nearshore sites adjacent to walls, but was uncommon on other shallow water sites.

# FISH COMMUNITIES

**Table 3. Species richness across sites in belt transects and roving diver surveys (RDS). Sites are divided into nearshore, offshore and mesophotic sites as described in the text above.**

|            |                        | <b>Belt Transects (25x4)</b>           |                                                                   | <b>RDS</b>                             |
|------------|------------------------|----------------------------------------|-------------------------------------------------------------------|----------------------------------------|
|            |                        | <b>Total<br/>Number of<br/>Species</b> | <b>Mean<br/>species per<br/>transect<br/>(<math>\pm</math>SE)</b> | <b>Total<br/>Number of<br/>Species</b> |
| Nearshore  | Cane Bay               | 50                                     | 25.8 $\pm$ 1.2                                                    | 58                                     |
|            | Great Pond             | 52                                     | 22.0 $\pm$ 1.7                                                    | 51                                     |
|            | Jacks Bay              | 52                                     | 18.5 $\pm$ 1.2                                                    | 65                                     |
|            | Kings Corner           | 66                                     | 26.0 $\pm$ 1.1                                                    | 70                                     |
|            | Salt River West        | 42                                     | 17.6 $\pm$ 1.2                                                    | 55                                     |
|            | Sprat Hole             | 38                                     | 25.9 $\pm$ 1.0                                                    | 66                                     |
|            | Benner Bay             | 47                                     | 18.2 $\pm$ 1.4                                                    | 66                                     |
|            | Black Point            | 52                                     | 20.1 $\pm$ 0.9                                                    | 64                                     |
|            | Brewers Bay            | 50                                     | 20.5 $\pm$ 0.6                                                    | 65                                     |
| Offshore   | Eagle Ray              | 55                                     | 24.7 $\pm$ 1.0                                                    | 56                                     |
|            | Buck Island, St. Croix | 52                                     | 22.0 $\pm$ 1.9                                                    | 46                                     |
|            | Castle                 | 60                                     | 22.0 $\pm$ 1.0                                                    | 57                                     |
|            | Mutton Snapper         | 63                                     | 20.9 $\pm$ 0.8                                                    | 55                                     |
|            | Seahorse Cottage       | 58                                     | 21.2 $\pm$ 0.8                                                    | 68                                     |
|            | South Capella          | 66                                     | 22.9 $\pm$ 0.9                                                    | 69                                     |
|            | South Water Island     | 52                                     | 19.4 $\pm$ 1.3                                                    | 65                                     |
|            | Flat Cay               | 48                                     | 26.8 $\pm$ 2.7                                                    | 64                                     |
| Mesophotic | Cane Bay Deep          | 51                                     | 19.2 $\pm$ 2.5                                                    | 47                                     |
|            | EEMP                   | 52                                     | 20.5 $\pm$ 1.0                                                    | 64                                     |
|            | Lang Bank              | 54                                     | 22.2 $\pm$ 1.3                                                    | 50                                     |
|            | Salt River Deep        | 45                                     | 19.8 $\pm$ 2.2                                                    | 50                                     |
|            | College Shoal East     | 55                                     | 19.7 $\pm$ 0.8                                                    | 56                                     |
|            | Grammanik Bank         | 65                                     | 24.5 $\pm$ 1.1                                                    | 53                                     |
|            | Hind Bank East         | 55                                     | 20.0 $\pm$ 1.3                                                    | 55                                     |

# TCRMP SITE SUMMARIES

## **Fish Abundance**

Total fish abundances across nearshore, offshore and mesophotic sites and years are shown in Fig.14. Abundance was variable across sites and years and shows no obvious pattern across time or space. Slight decreases in abundance since 2005 on St. Croix sites are thought to be an artifact of a slightly altered methodology and different survey teams. Sites are highly dominated by small pomacentrids (damselfish) and wrasses, which tend to mask trends in other fish taxa. Abundance peaks (such as Eagle Ray, 2005 and College Shoal, 2008) are generally a result of large schools of creole wrasse on the site. No change has been detected in fish communities since the coral bleaching of 2005 and subsequent high coral mortality event. Fish abundance in 2011 was similar across all sites to data collected in previous years.

# FISH COMMUNITIES

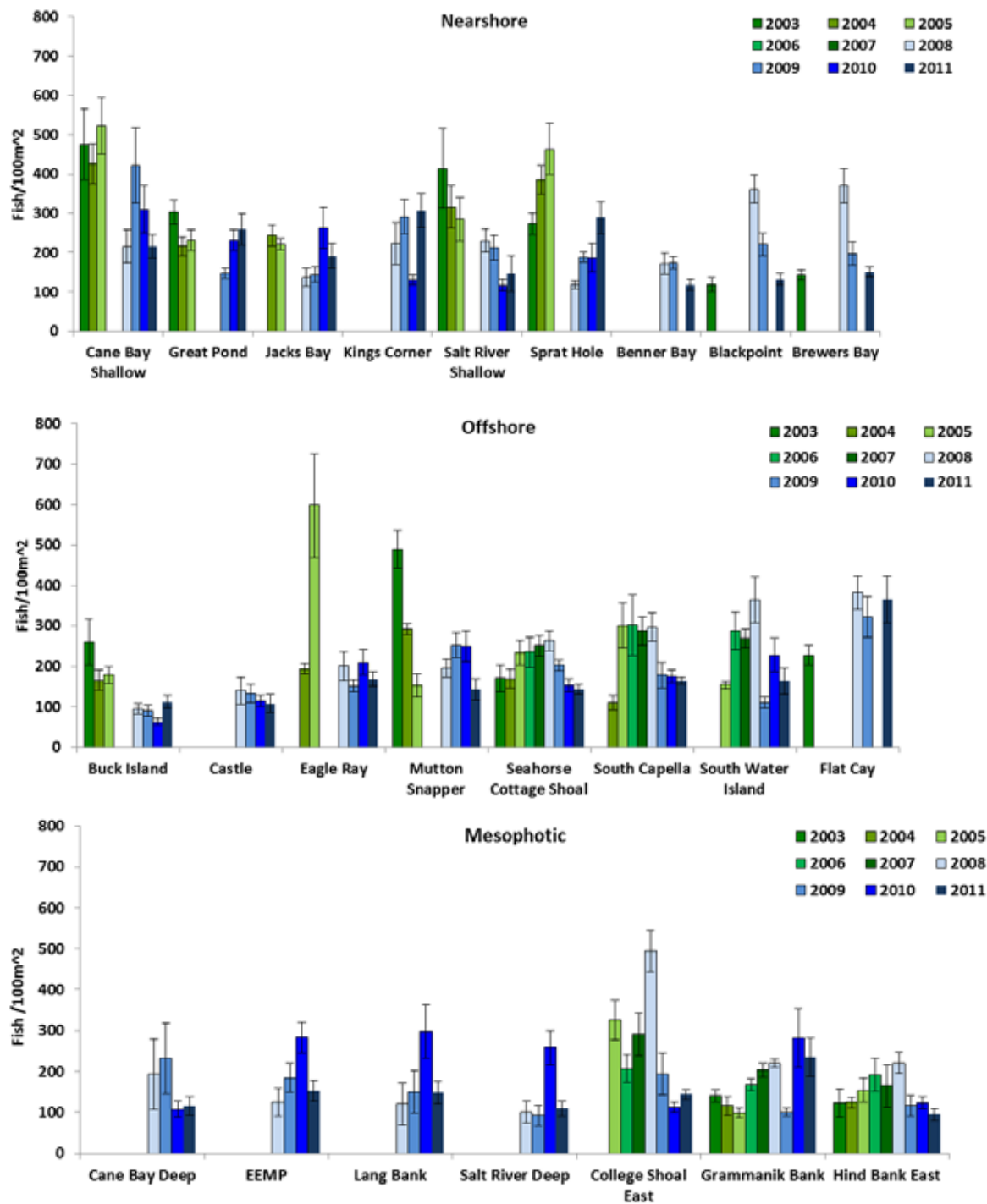


Figure 14. Fish abundance ( $\pm$ SE) across TCRMP monitoring sites over time.

# TCRMP SITE SUMMARIES

## Fish Biomass

Fish biomass across sites is shown in Fig.15. The mesophotic sites off St. Thomas (Grammanik Bank, Hind Bank and College Shoal East) have dramatically higher average biomass of fish throughout the sampling period compared to the more shallow sites and the St. Croix mesophotic sites. Abundance is similar or lower on these deep St. Thomas reefs, indicating a larger average fish size. Juveniles of several species that occur in shallow water are nearly absent on the mesophotic reefs, and pomacentrids and wrasses are much less common. The three mesophotic sites off St. Thomas are all within marine protected areas and are well offshore away from land based pollution. In addition the Grammanik Tiger and Hind Bank sites host multispecies spawning aggregations for groupers and snapper. In particular, sampling periods often overlap with aggregation periods for cubera snapper (*Lutjanus cyanopterus*) and dog snapper (*Lutjanus jocu*), and this influences biomass estimates. In contrast, two of the mesophotic sites off St. Croix (Salt River Deep and Cane Bay Deep) are very close to shore and are fished regularly. As with abundance, biomass is highly variable between years. No temporal pattern is evident, and differences in time appear to be seasonal or natural variation. The fish biomass surveyed in 2011 was similar to data collected in previous years.

# FISH COMMUNITIES

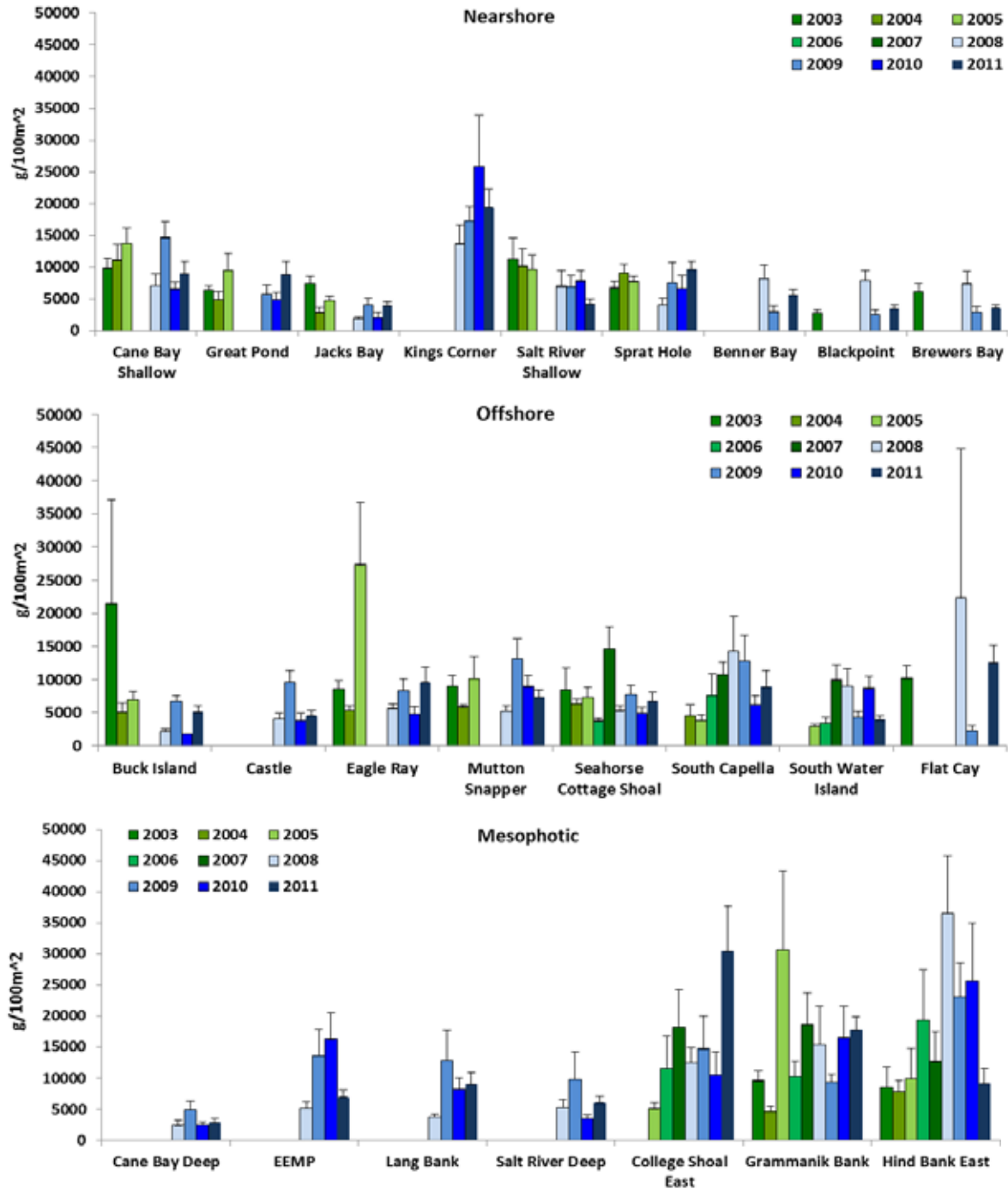


Figure 15. Mean fish biomass ( $\pm$ SE) across TCRMP monitoring sites over time.

# SEA URCHINS

## BLACK SPINY SEA URCHIN *DIADEMA ANTILLARUM*

The abundance of the black spiny sea urchin *Diadema antillarum* shows tremendous site-to-site variability (Fig. 16). In general the shallowest sites, e.g., Great Pond, support the greatest abundance of *D. antillarum*. These sites also tend to have very low macroalgal cover. Trends are not presented as year-to-year variability is generally low. Note that urchins have not yet been assessed at Coral Bay and Ginsburgs Fringe. At Coral Bay there is a high abundance of *Echinometra* spp., which seems to be the dominant grazer that effectively removes macroalgal cover. Future monitoring should take measurements of the abundance of this species.

# FISH COMMUNITIES

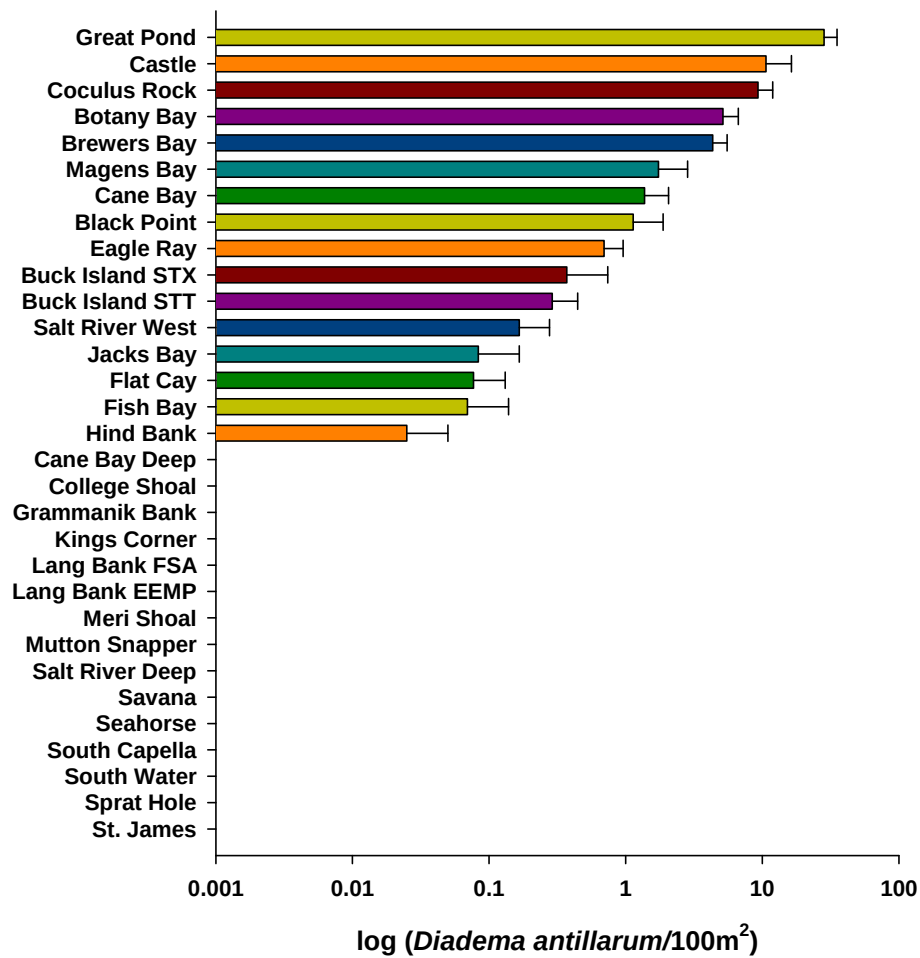


Figure 16. Abundance of the black spiny sea urchin (*Diadema antillarum*) at TCRMP monitoring sites. Note the log scale.

## Site Summaries

### RATIONALE

The purpose of this section is to provide a more comprehensive survey of TCRMP site characteristics than can be achieved in the overall data compilations. Each TCRMP monitoring site is each unique and has experienced unique responses to local and global stressors. Given the increase in sites included under this program and the inclusion of more information at each site, such as physical data, this section is designed to provide a summary that highlights the each site's characteristics and serves as a quick reference guide for managers, policy makers, and academics. The duration of surveys at most sites also now provides sufficient data from which to draw conclusions about longer term site dynamics and the processes that might be contributing to recent trajectories of health, development, and degradation.

### SITE SUMMMARY ELEMENTS

TCRMP site information is presented in six pages that provide a brief description of the setting and the potential susceptibility to local and global stressors and disturbances. Sub-sections include a description of (1) the physical environment, (2) the benthic community and (3) the fish community.

**Benthic community structure** is presented as the mean ( $\pm$ SE) cover of coral, macroalgae, cyanobacteria, and epilithic algae. Epilithic algal communities are diminutive turf and filamentous algae that cover hardbottom surfaces, whilst macroalgae have identifiable thallus differentiation and structure. Any open hardbottom space is assumed to host an epilithic algal community even if algae cannot be resolved in video images. The loss of coral cover due to the 2005 bleaching event was calculated as the relative change in coral cover from 2005 to 2007, unless otherwise noted for sites not sampled in these years. In addition, the percent recovery from the 2005 bleaching event was calculated as the amount of coral cover regained by 2011  $(\text{Cover}_{2011} - \text{Cover}_{2007}) / (\text{Cover}_{2005} - \text{Cover}_{2007})$ . Change calculations must be treated with caution for sites where transects were not made permanent until after the 2005 bleaching event or where percent cover is low, since the conditions introduce an unknown amount of error.

# SITE SUMMARY

Benthic community pie charts were constructed from all years of data. The sessile epibenthic animal community includes *Agaricia* spp., *Colpophyllia natans*, *Diploria strigosa*, *Montastraea annularis*, *Montastraea annularis* species complex (*M. faveolata*, *M. franksi*, + unidentified MACX), *Montastraea cavernosa*, *Porites astreoides*, branching *Porites* species, *Siderastrea siderea*, other corals, sponges, gorgonians. The algae/non-living substrata category includes cyanobacteria, epilithic algae (“DCA”), *Lobophora variegata*, *Dictyota* spp., *Halimeda* spp. crustose coralline algae, and sand/sediment.

**Coral Health** is presented as the mean ( $\pm$ SE) of coral bleaching prevalence (proportion of population affected) and extent (proportion of colony affected), disease prevalence, and partial mortality prevalence.

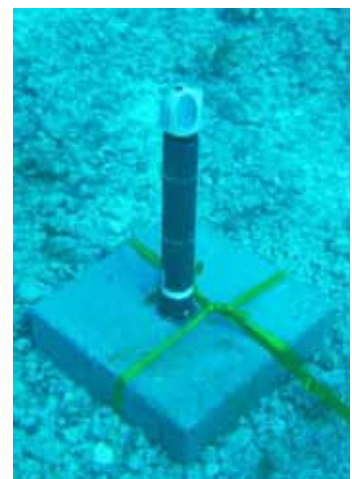
## PHYSICAL CHARACTERISTICS.

**Temperature.** Benthic temperatures were recorded at each site with a HoboTemp™ thermistor data logger (Onset Computer Corporation, Bourne, Massachusetts). Thermistors were affixed within transects and set to record at intervals of 15 minutes.



Records are presented as daily averages across months, February 29<sup>th</sup> excluded. Each temperature figure includes the climatological monthly maximum mean temperature (28.5°C), and the bleaching threshold temperature (29.5°C) established for the region (NOAA 2006). Data for 2005 was taken from current profilers or federal data sources.

**Currents.** Water currents were recorded at a subset of sites and times with Nortek Aquadopp™ Acoustic Doppler Current Profilers (ADCPs). Profilers were set in bases on the seafloor and set to record current speed and direction within predefined depth bins above the substrate. The bin closest to the substrate and closest to the coral reef was selected for display. Compass rose figures were developed that show the frequency of current in magnetic directions 0, 22.5, 45, 67.5, 90, 112.5, 135, 157.5,



## SITE SUMMARIES

180, 202.5, 225, 247.5, 270, 292.5, 315, 337.5, 360°. Within each direction the frequency of current speed within bins of  $0.1 \text{ m s}^{-1}$  were plotted. For Flat Cay, current data was retrieved with an Aandaraa 2-D current meter that measured current speed and direction directly over the sensor head.

**Chlorophyll and Turbidity.** Continuous fluorometric measurements of chlorophyll and turbidity were conducted at some sites for short periods (Black Point, Grammanik, Magens Bay). Wetlabs ECOFLNT fluorometers with antifouling bio-wipers were deployed and set to record for one minute at hourly intervals. Water column chlorophyll measurements detect phytoplankton abundance. Fluorometric measurements of chlorophyll are proxies for true chlorophyll concentrations. Direct chlorophyll measurements to calibrate fluorometric measurements have not been conducted at the monitoring sites.



St.Croix



# SITE SUMMARIES

## BUCK ISLAND, ST. CROIX

**Description.** The Buck Island, St. Croix site is seaward extension of the southeast Buck Island barrier reef complex in water depth of 15 m. The reef is a low framework surrounded by a sand plain to the west and a rolling reef/hardbottom to the east. The Buck Island, St. Croix site is largely composed of large living and dead *M. annularis* heads surrounded by sand. The site has been monitored since 2001, with three permanent benthic transects installed in 2001, and three additional transects installed in 2003.

**Outstanding Feature.** The Buck Island, St. Croix site is within the expanded (2001) Buck Island Reef National Monument. The reef fish populations may show recovery due to the restriction of fishing.

**Threats.** Due to its protected area status and remoteness from land-based pollution Buck Island, St. Croix is primarily threatened by changing climate as its populations of *M. annularis* were shown to be susceptible during the 2005 bleaching event.

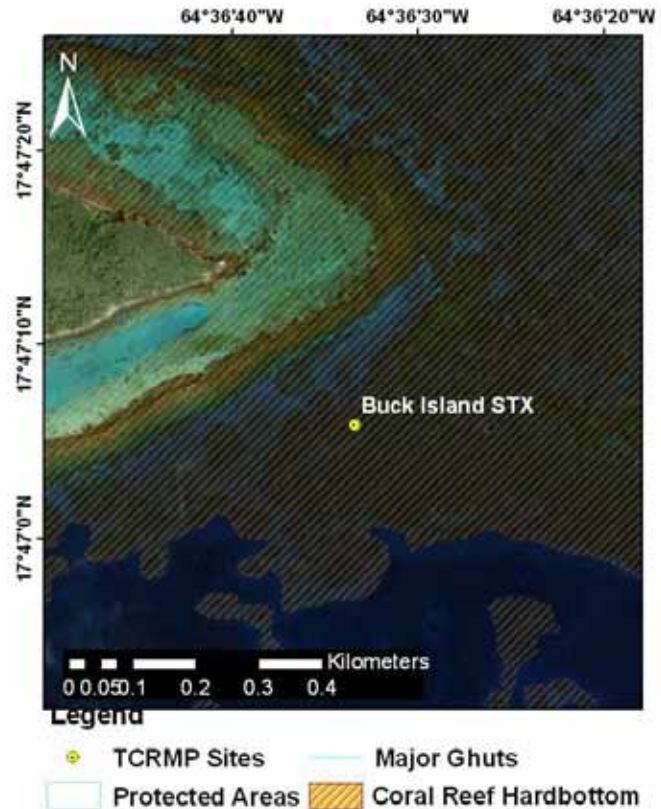


**Figure 17. The Buck Island, St. Croix.** (top) Position in the Buck Island Reef National Monument. (right)A representative photo.



# BUCK ISLAND, ST. CROIX

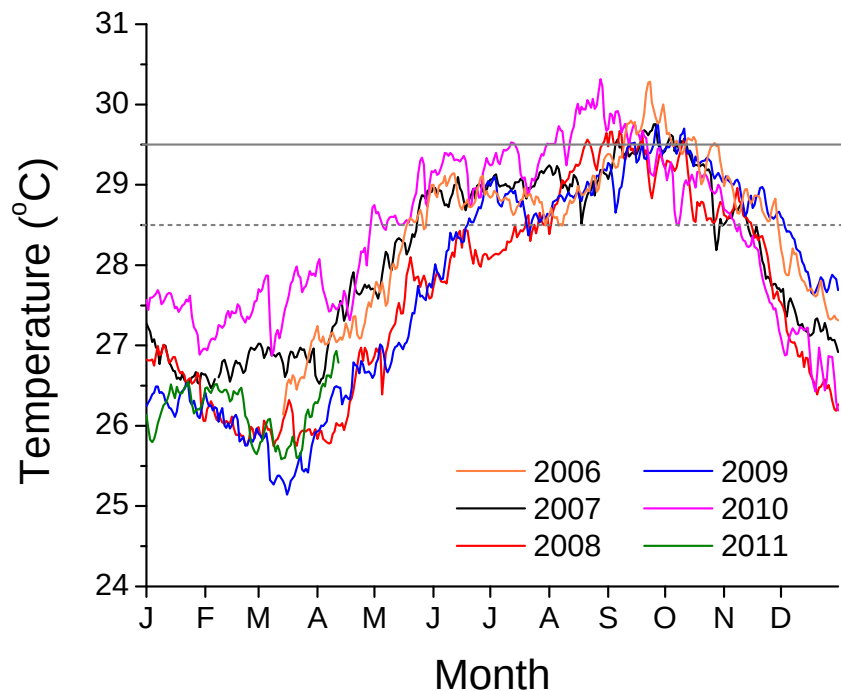


Figure 18. Buck Island, St. Croix benthic temperatures (14 m depth). Data provided by the National Park Service (site BUIS\_SFR).

## Physical Characteristics

**Current.** Currents have not been recorded at the Buck Island, St. Croix monitoring site. Unidirectional currents have always been light during monitoring. Oscillatory currents occasionally impact the site when swell is from the east.

**Temperature.** Temperatures at the Buck Island, St. Croix monitoring sites can get very warm and surpassed the bleaching threshold significantly in 2006 and 2010. There were no site records for the 2005 bleaching event.

# SITE SUMMARIES

**Benthic Community.** The Buck Island, St. Croix hard coral community is dominated by the boulder star coral *Montastraea annularis*; however, the most abundant sessile epibenthic animals are gorgonians. Epilithic algae dominate the algal community, with a low cover of macroalgae relative to other sites. There is a high proportion of sand.

This coral community lost 65.5% of its coral cover in the 2005 bleaching event and had only regained 6% of coral cover by 2011. Filamentous cyanobacteria showed very large increases in cover after the 2005 bleaching event.

**Coral Health.** Buck Island, St. Croix corals were likely severely affected during the 2005 bleaching event; however, bleaching health surveys were not completed until Jan. 13, 2006 when recovery had already commenced. Bleaching surveys were not conducted during the 2010 bleaching event. The prevalence of coral diseases was high on *M. annularis*, with frequent incidence of yellow band disease and white disease following the 2005 bleaching event. Old partial mortality was very prevalent after the 2005 coral bleaching event and then decreased to 2011.

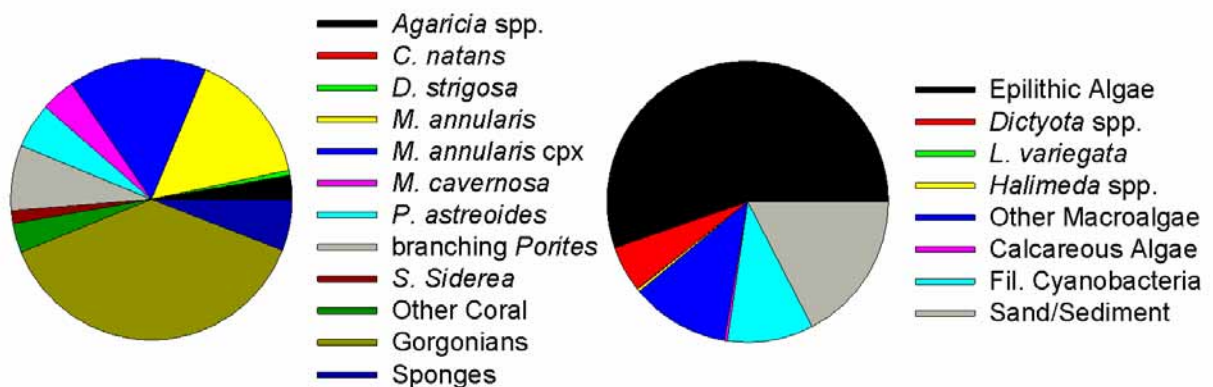
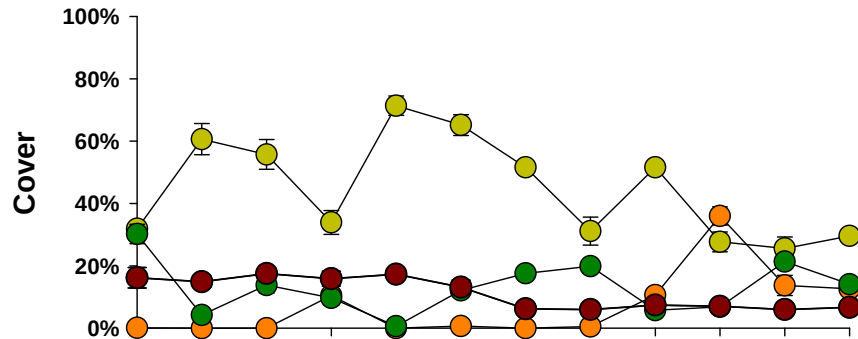


Figure 19. Buck Island, St. Croix. (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

# BUCK ISLAND, ST. CROIX

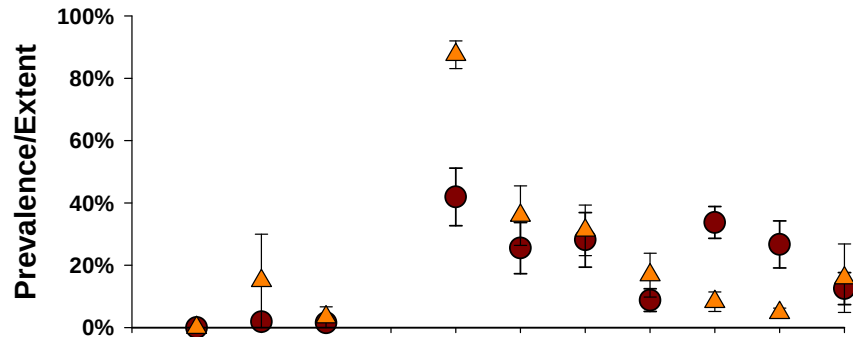
## Benthic Community

- Coral
- Cyanobacteria
- Epilithic Algae
- Macroalgae



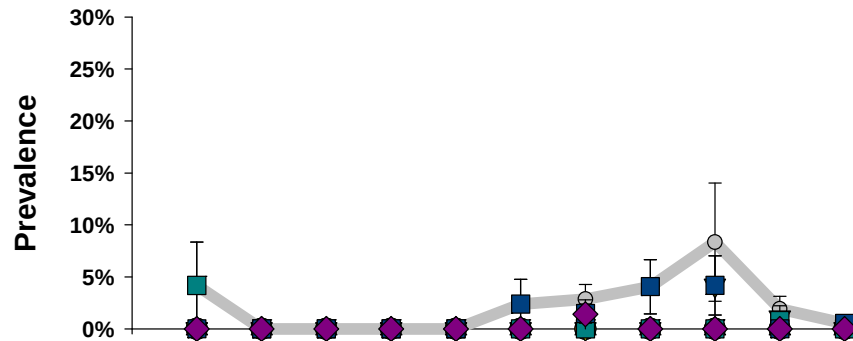
## Bleaching

- Prevalence
- ▲ Extent



## Disease

- All disease
- Black Band
- Lesion
- ▼ Dark Spots
- ▲ Intercostal
- White Disease
- Yellow Band
- ◆ Unknown



## Partial Mortality

- Old
- ▲ Recent

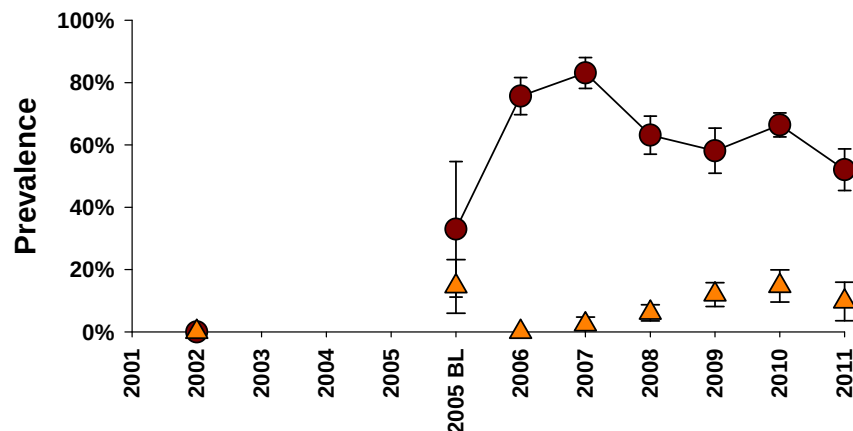


Figure 20. Buck Island, St. Croix benthic cover and coral health through time (mean  $\pm$  SE).

## SITE SUMMARIES

**Fish Community.** Buck Island is a low patchy reef community surrounded by and interspersed with sand. The fish community is largely dominated in biomass by herbivores with a very high biomass of stoplight parrotfish. Close to the monitoring site are “the Haystacks”, large *Acropora palmata* skeletal remains that provide ample grazing areas for the large parrotfish. In addition, the Buck Island site is within the National Monument and the fish inhabitants are theoretically protected from spearfishing and nets. There is also a high biomass of invertivorous fishes, which are dominated by the yellowhead wrasse. Invertivores are diverse on the site and include several species of grunts (tomtate, French, Spanish, white and bluestriped) as well as many wrasses (yellowhead, bluehead, clown, yellowcheek, slippery dick and creole wrasse). Piscivores are uncommon, and the only groupers observed during transects in 2011 included small red hind and graysby. Snapper were limited to one mahogany snapper.

# BUCK ISLAND, ST. CROIX

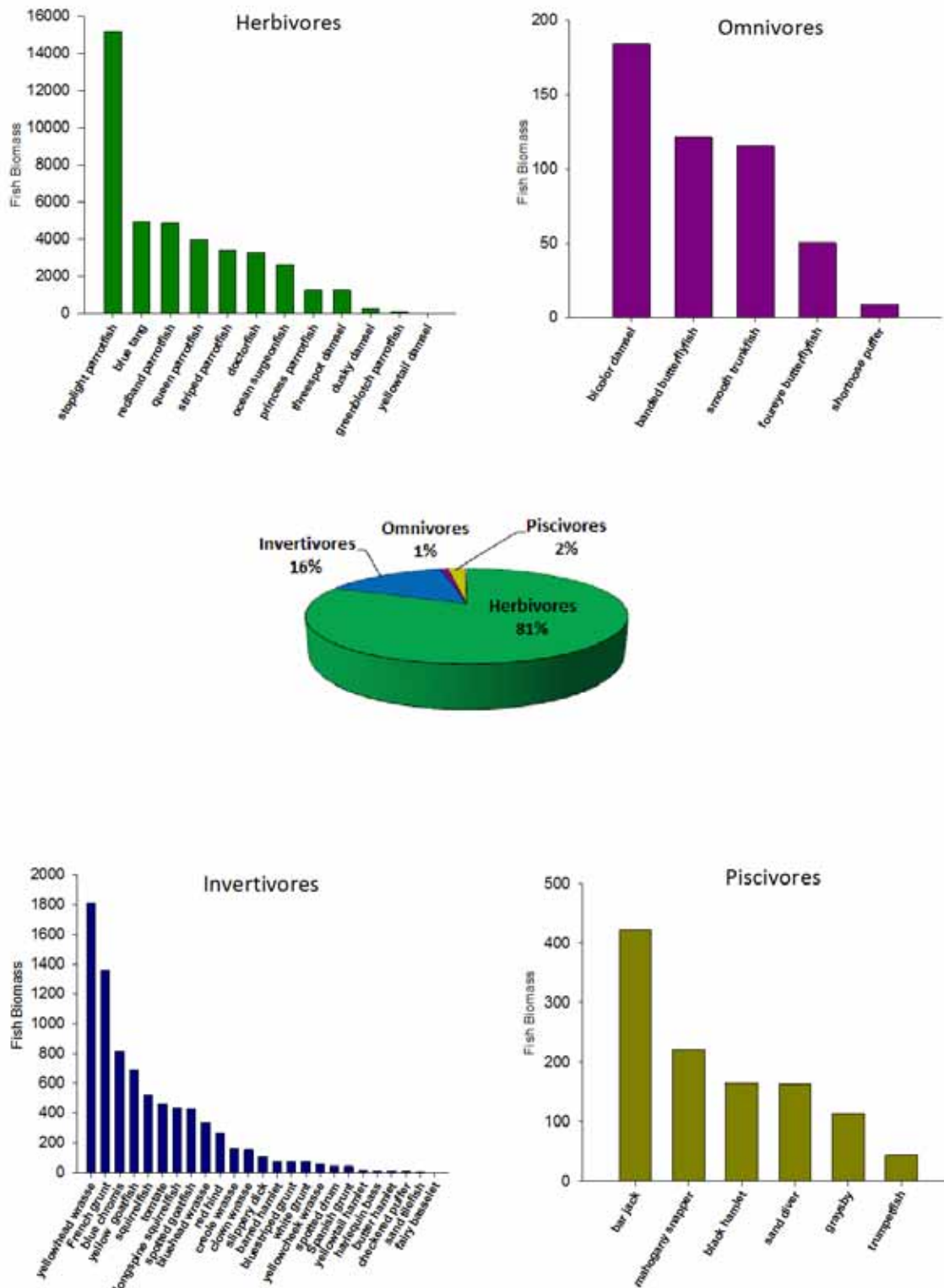


Figure 21. The Buck Island, St. Croix fish community by absolute and relative biomass.

# SITE SUMMARIES

## CANE BAY

**Description.** The Cane Bay monitoring site is a nearshore/shelf edge fringing reef on the northwest coast of St. Croix. Transects follow the trend of the leeward spur and groove formations. Cane Bay has been monitored since 2001.

**Outstanding Feature.** Cane Bay is one of the most well developed nearshore reefs on St. Croix. It is also one of the most heavily visited dive sites by both tourists and residents in the Virgin Islands due to its proximity to the wall, considered by some to be the precipitous submarine drop off in the world. The reef has been under scientific investigation since the 1970's.

**Threats.** Although the Cane Bay reef is a singular treasure for the Virgin Islands, it is threatened by pollution, fishing, climate change, and recreational overuse. The watershed above Cane Bay has been planned for residential development with potential for the influx of terrestrial sediment. The reef is also fished commercially, and teams of spearfishers on SCUBA have been observed. This reef also lost half its coral cover in the 2005 bleaching event, suggesting it is vulnerable to warming ocean temperatures.



**Figure 22. Cane Bay. (top) Location. (right) A representative photo of the reef.**

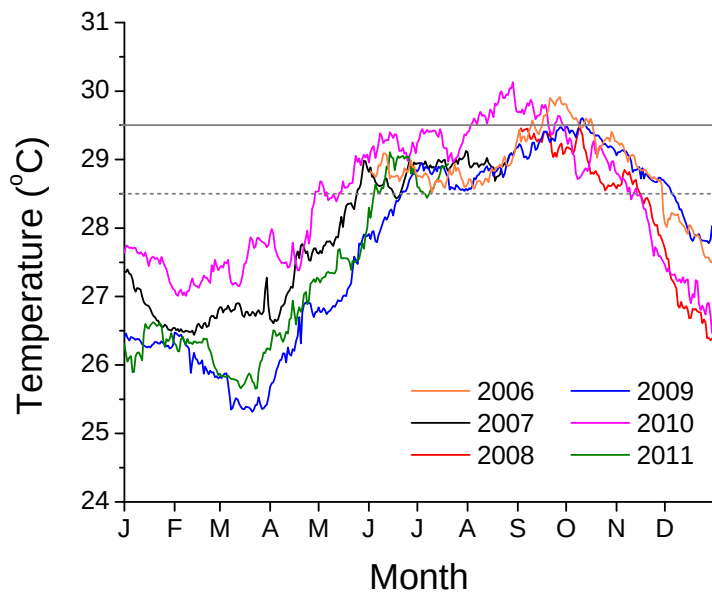


**Figure 23. Cane Bay benthic temperatures (8 m depth)**

## Physical Characteristics

**Current.** Cane Bay currents have not been directly measured by the TCRMP. However, this site typically has moderate unidirectional currents with the occasional exposure to strong north swell. The current at the site may be part of an eddy formed by the dominant westward flowing current wrapping around the eastern point. Its downstream location from the entire north coast of St Croix may also make this site a recruitment sink for larvae, potentially adding to the diversity.

**Temperature.** Cane Bay is a relatively open and clear environment, and the temperatures tend to stay cooler, but the propensity for bleaching may be increased by the high light transmission.

# SITE SUMMARIES

**Benthic Community.** Cane Bay supports a very diverse coral community, with dominance by the *Montastraea annularis* spp. complex. Open substrates were mostly epilithic algal community; however, epilithic algae cover has declined since the 2005 bleaching event with increases in the cover of macroalgae and filamentous cyanobacteria. This indicates that the resident herbivore community was not able to effectively graze substrates opened by coral mortality. This coral community lost 46.8% of its coral cover in the 2005 bleaching event and lost 6% more as of 2011, a troubling sign.

**Coral Health.** Cane Bay corals were severely affected during the 2005 bleaching event with nearly all colonies bleached over 80% of the colony surface. The prevalence of bleaching was also high in 2010, yet at a low extent. The prevalence of coral diseases was low before 2005, but outbreaks of white, yellow band, and dark spots disease have occurred more recently, another indication of declining health at this reef. Old and recent partial mortality became very prevalent after the 2005 coral bleaching event and have remained nearly steady or increased since.

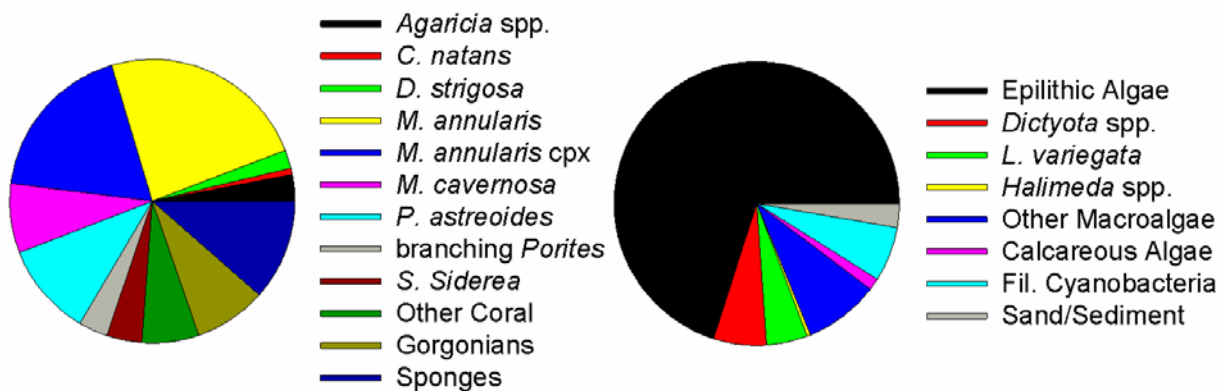
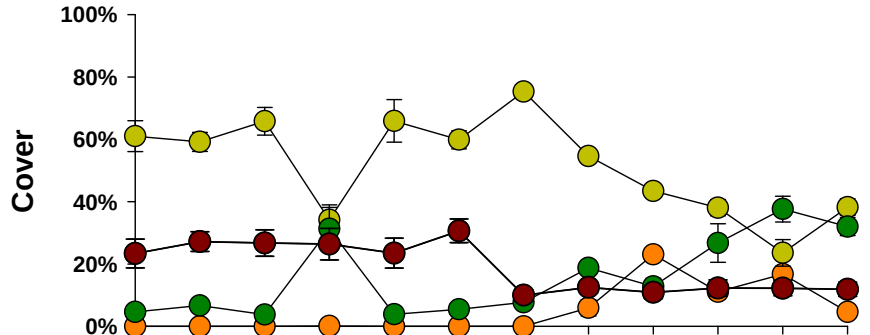


Figure 24. Cane Bay. (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

# CANE BAY

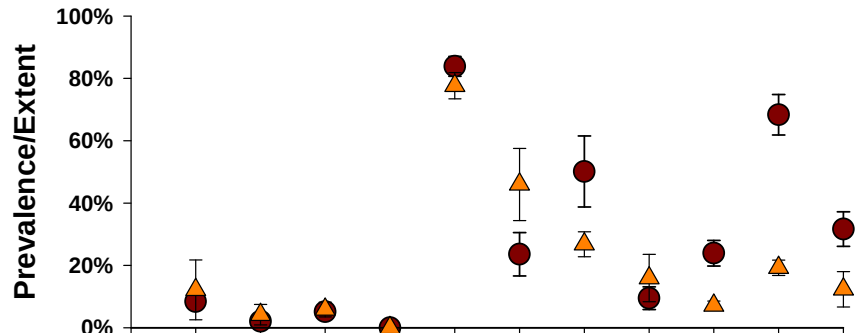
## Benthic Community

- Coral
- Cyanobacteria
- Epilithic Algae
- Macroalgae



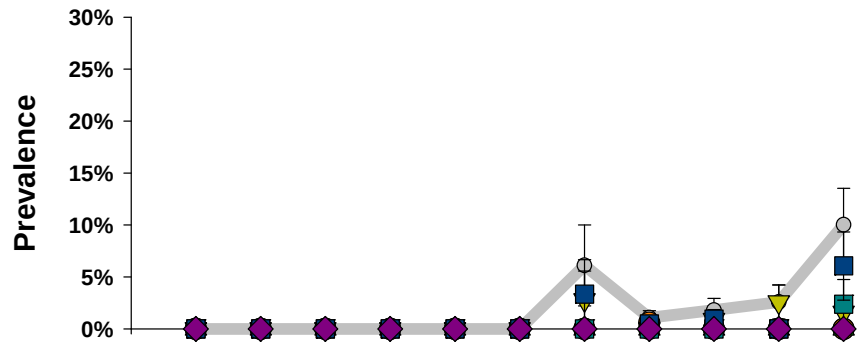
## Bleaching

- Prevalence
- ▲ Extent



## Disease

- All disease
- Black Band
- Lesion
- ▼ Dark Spots
- ▲ Intercostal
- White Disease
- Yellow Band
- ◆ Unknown



## Partial Mortality

- Old
- ▲ Recent

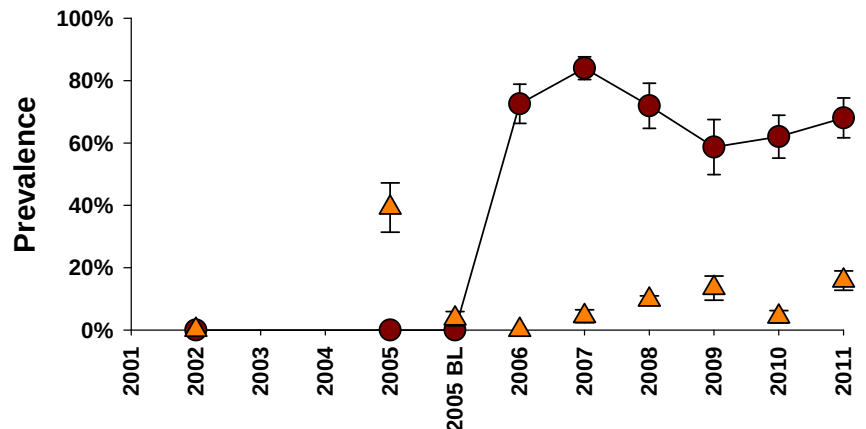


Figure 25. Cane Bay benthic cover and coral health through time (mean  $\pm$  SE).

## SITE SUMMARIES

**Fish Community.** Cane Bay has a high diversity, abundance and biomass of fish, reflecting the benthic diversity and high coral cover of the site. The most dominant fish species in terms of both abundance and biomass are creole wrasse, zooplankton feeders. Also very common are other planktivorous fishes, the black durgelon, yellowtail snapper, and blue and brown chromis. Several large parrotfishes can regularly be observed on the Cane Bay site, including adult queen and stoplight parrotfish. A variety of other herbivores are very common, including the princess and redband parrotfish, as well as the blue tang. Schoolmaster and mahogany snapper dominates piscivores. Very few serranids are typically counted on the Cane Bay reef; in 2011 only one graysby and one small red hind were observed on transects. Nonetheless the site has a high diversity of fish, with several butterflyfish and squirrelfish species present, as well as some deeper water species (sunshinefish, longsnout butterflyfish and fairy basslet) due to the site's close proximity to the deep wall drop.

# CANE BAY

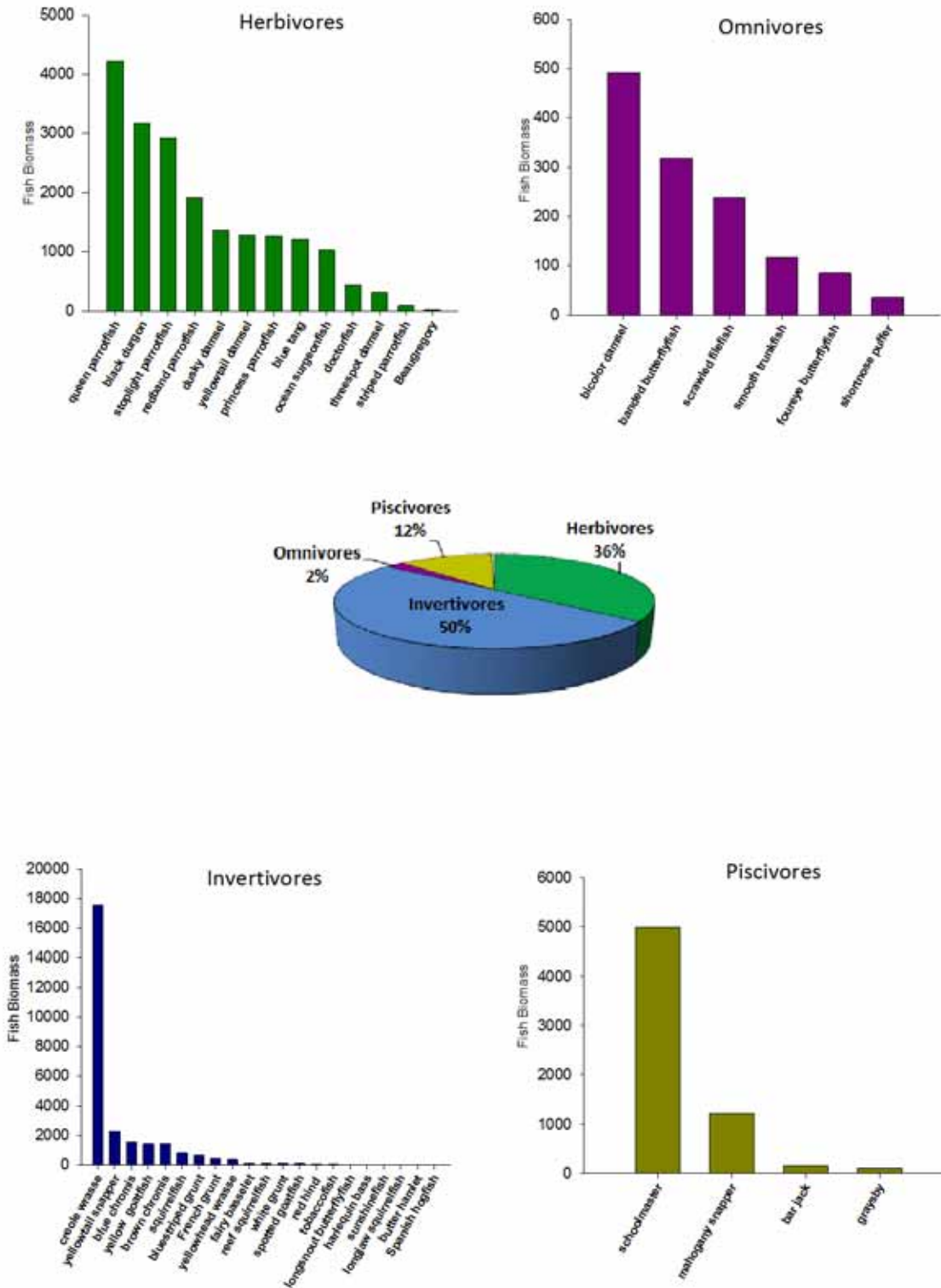


Figure 26. The Cane Bay fish community by absolute and relative biomass.

# SITE SUMMARIES

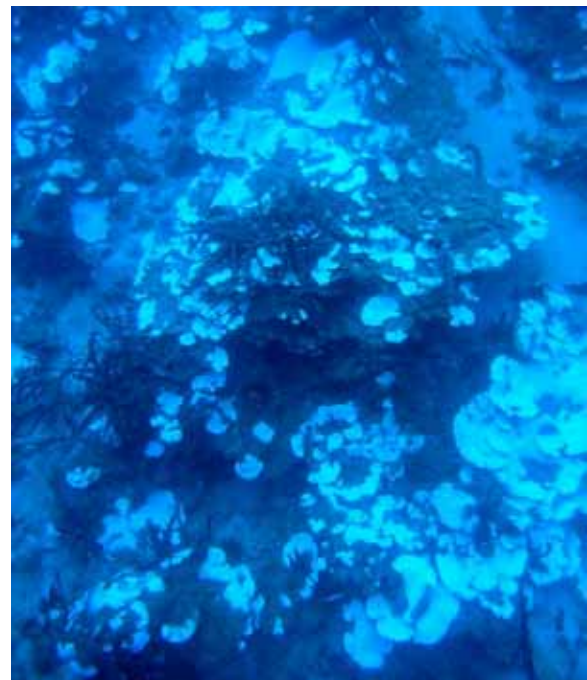
## CANE BAY DEEP

**Description.** The Cane Bay Deep monitoring site is a mesophotic wall coral reef environment just downslope from the Cane Bay site. The reef is composed of deep spurs of coral interspersed with sediment. Cane Bay Deep was first surveyed during the 2005 coral bleaching event, but a permanent monitoring site was not established until 2009.

**Outstanding Feature.** Cane Bay Deep is one of the most impressive wall environments in the Caribbean and is the crown jewel for St. Croix dive tourism and biodiversity.

**Threats.** Although Cane Bay is economically important via dive tourism, it is under no special protection. Cane Bay Deep is threatened by sediment, fishing, climate change, and recreational overuse. Sediment cascades down for the shallow reef. Fishing occurs even at the deep reef and this is shown by the presence of lost gear (monofilament and trap lines).

**Figure 27. Cane Bay Deep. (top) Location. (right) A representative photo of the reef during the 2005 bleaching event. Bleached colonies are 0.5 – 3 m wide.**



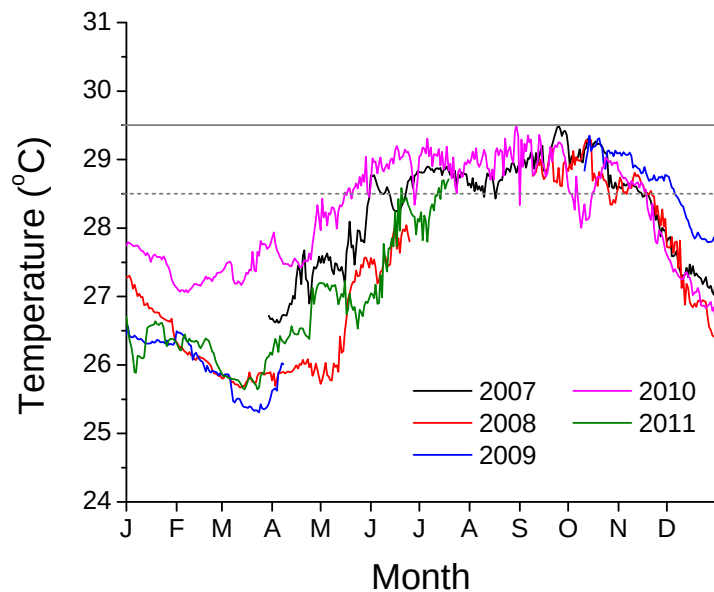


**Figure 28. Cane Bay Deep temperature (39 m depth).**

## Physical Characteristics

**Current.** Cane Bay deep is a calm wall environment that is buffered from water motion. However, it does receive sediment cascades from particles resuspended from the upper reef terrace. These flows are directed in the depressions between spurs.

**Temperature.** Cane Bay Deep temperatures are buffered in the warmest months by the presence of the thermocline. However, internal tide activity at this site is not as strong in deep (~40 m) sites on the south shelf of St. Thomas, leading to less diurnal variability in temperatures. This may make the mesophotic wall environments more susceptible to bleaching than other mesophotic sites on the southern Puerto Rican shelf.

# SITE SUMMARIES

**Benthic Community.** Cane Bay deep is a mesophotic plating coral community dominated by lettuce corals (*Agaricia* spp.), sponges, gorgonians, and black coral. The algal community is mostly epilithic algae, but there are also quantities of *Dictyota* spp. and *Lobophora* variegata. A high proportion of the substrate is soft sediment that flows from the upper shelf to deposit in grooves. Benthic cover was not measured until 2009.

**Coral Health.** Surprisingly for a dim and cooler mesophotic reef, Cane Bay Deep corals bleached heavily in the 2005 coral bleaching event by both prevalence and extent. Low-extent coral bleaching is very prevalent even in year without thermal stress, a likely result of sediment deposition. Unknown and dark spots diseases are prevalent in some years. Old partial mortality increased after 2005, and remained high and steady from 2009-2011.

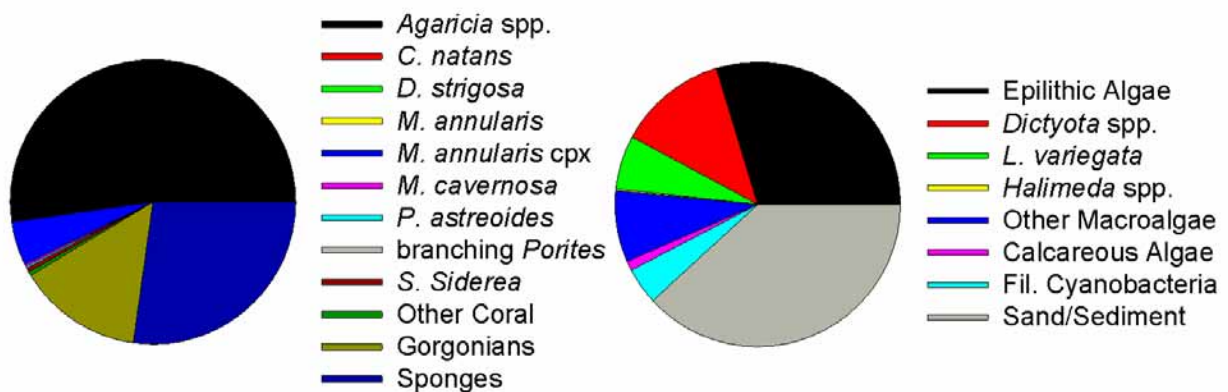


Figure 29. Cane Bay Deep. (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

# CANE BAY DEEP

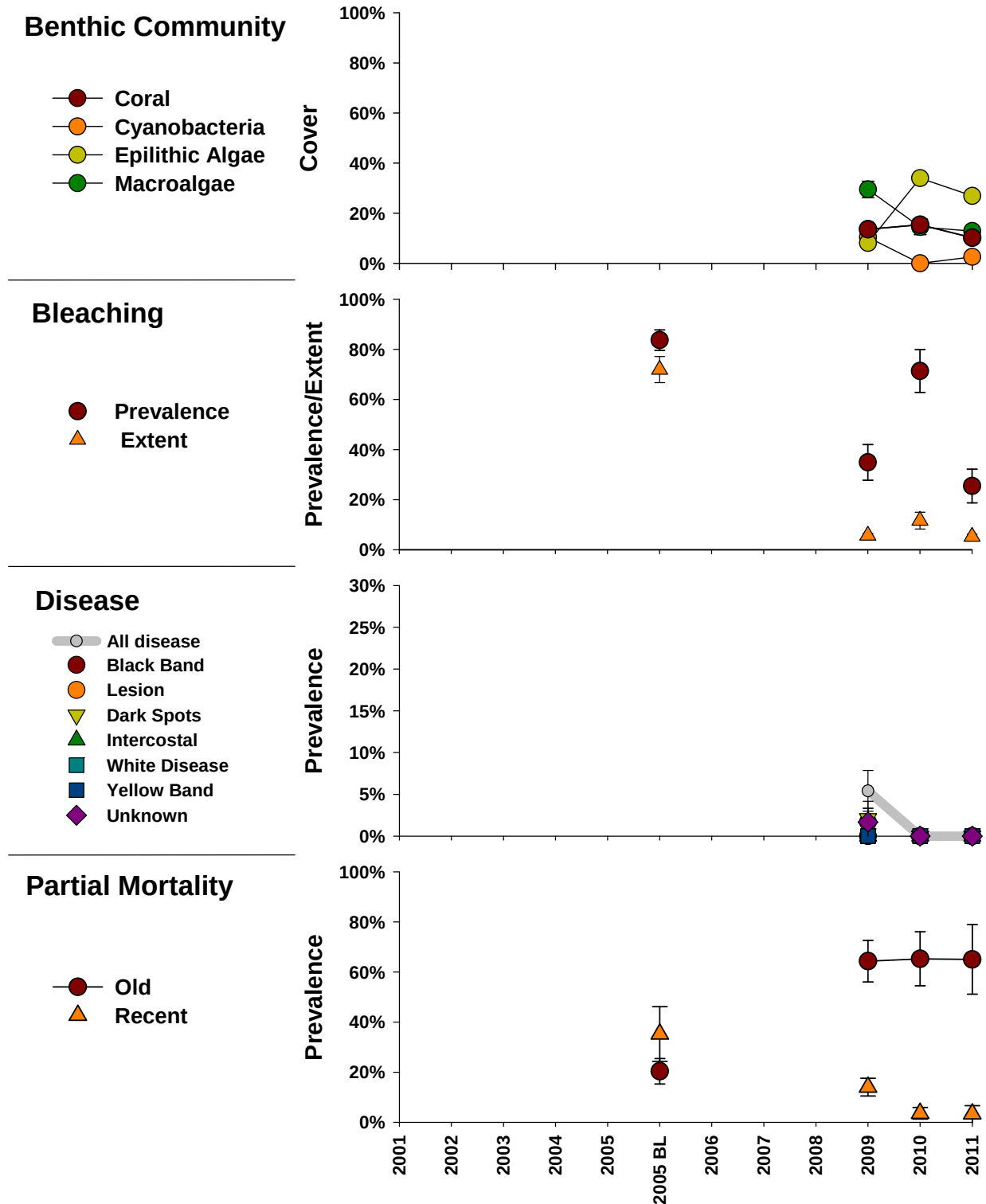


Figure 30. Cane Bay Deep benthic cover and coral health through time (mean  $\pm$  SE).

## SITE SUMMARIES

**Fish Community.** Cane Bay Deep has maintained a very low fish biomass over the three year sampling period compared to both other mesophotic sites and shallow and midshelf sites of St. Croix. The site is dominated by invertivores, primarily planktivorous creole wrasse and blue chromis. This planktivorous community is depauperate compared to that of Salt River Deep, the reef wall site slightly east, probably due to less water movement and sediment deposition. Herbivores are primarily benthic feeders: sub-adult princess parrotfish, redband parrotfish, and doctorfish. There is very low piscivorous biomass on the reef, made up in 2011 of barracuda, graysby, and peacock flounder. Deepwater species such as the bantum bass, fairly basslet and sunshine fish are common.

# CANE BAY DEEP

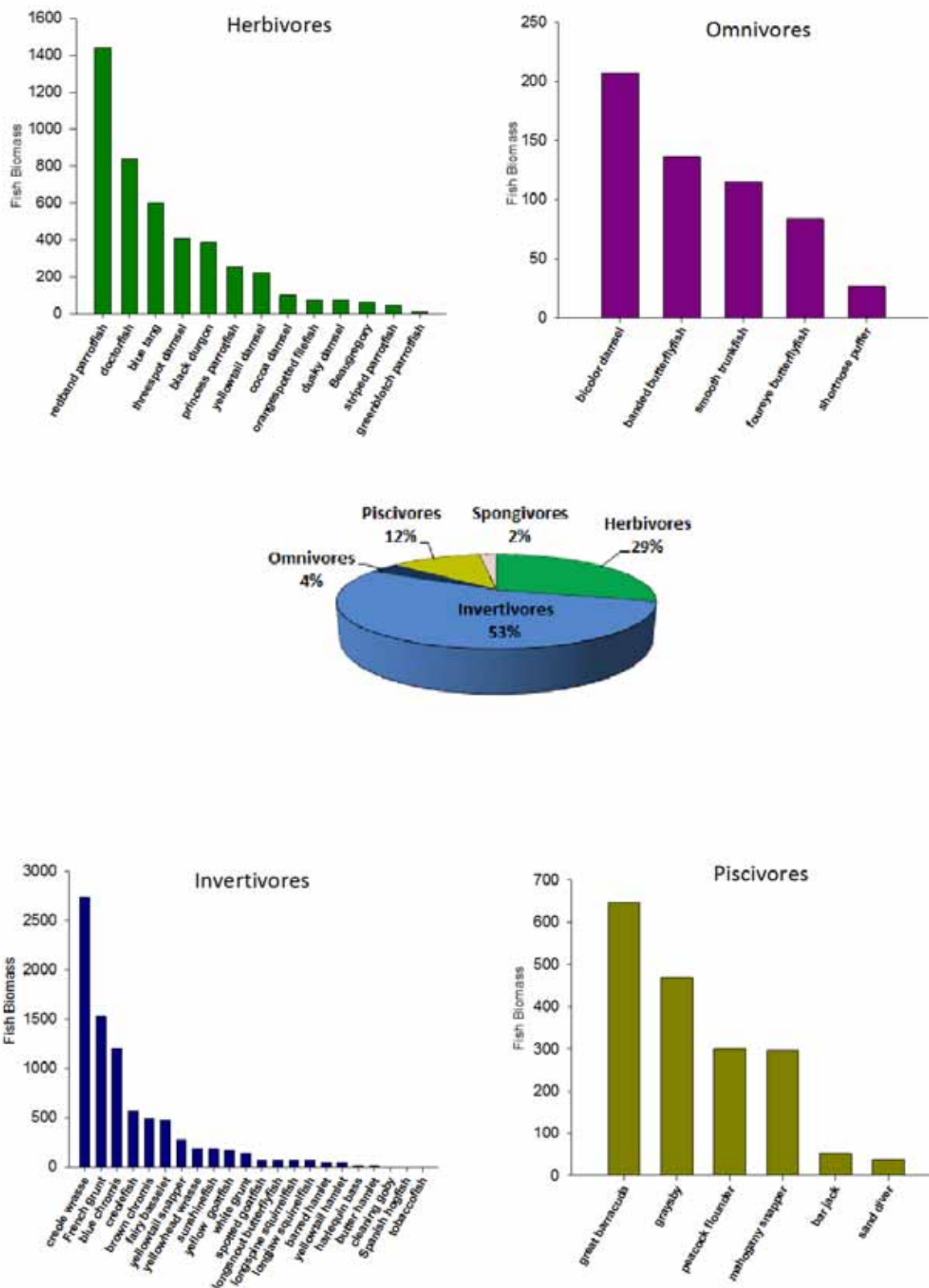


Figure 31. The Cane Bay Deep fish community by absolute and relative biomass.

# SITE SUMMARIES

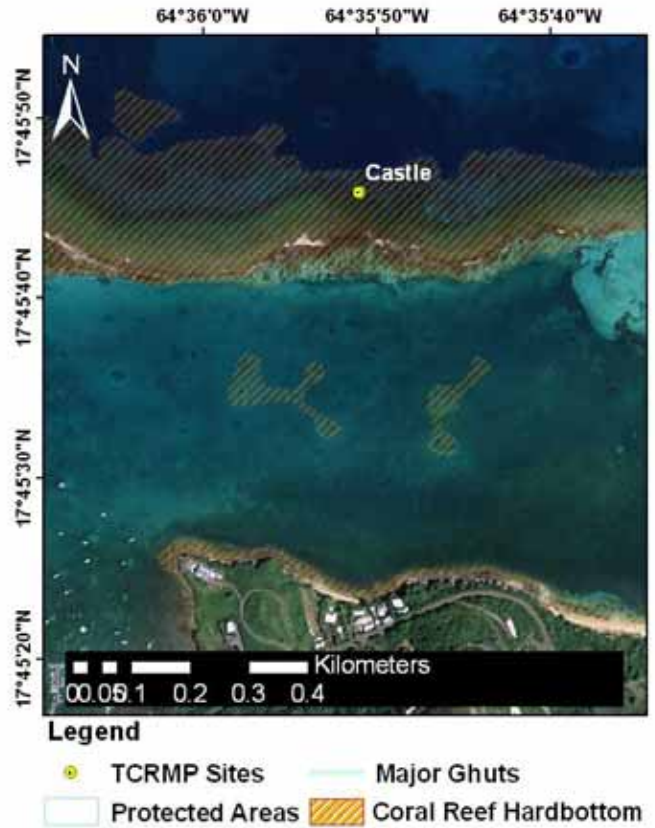
## CASTLE

**Description.** Castle (aka. West Indies Lab) is part of the seaward northeastern St. Croix barrier reef complex outside Teague Bay. The reef starts at sea level as a relict elkhorn coral reef and is dominated by boulder star corals along the seaward edge. The area around the Castle site was monitored initially in 2003, but permanent transect were not installed. Permanent benthic transects were installed in 2008.

**Outstanding Feature.** Castle is part of the once luxurious living elkhorn coral barrier reef that protects the northeastern St. Croix shoreline. It was a research area of the former West Indies Laboratory of Farleigh Dickenson University, which was a seminal area for global coral reef research from the 1970's and 1980's.

**Threats.** The barrier reef outside Teague Bay is inside the St. Croix East End Marine Park, but is in the open fishing zone. There is relatively low potential for land-based sources of pollution due to the sites midshelf location in front of a lightly populated area. Clear water and warm temperatures make this an area of potential concern during bleaching events.

**Figure 32. Castle. (top) Location. (right) A representative photo of the reef.**



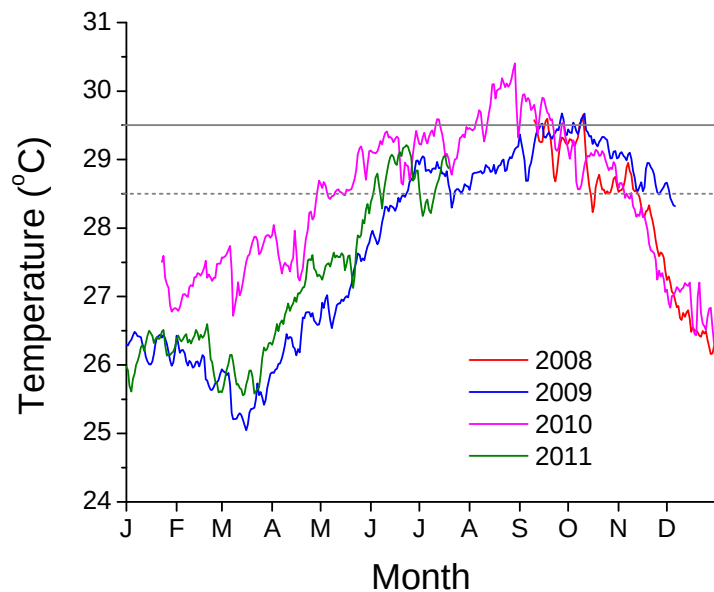


**Figure 33.** Castle benthic temperatures (9 m depth).

## Physical Characteristics

**Current.** Little is know about the current at the Castle site. It is under the influence of wave-driven oscillatory flow in the shallows, but strong directional currents have not been experienced during monitoring activities.

**Temperature.** Castle has the potential to develop very warm temperatures and spent nearly a month above the bleaching threshold in 2010.

# SITE SUMMARIES

**Benthic Community.** The Castle site is unusual or its dominance of branching *Porites* corals along the slope and concentrations of *Montastraea annularis* spp. complex corals at the outer fringe adjacent to sand. The algal community is dominated by epilithic algae, with lesser abundance of *Dictyota* spp.. Macroalgae and filamentous cyanobacteria are also common. The impacts of the 2005 bleaching event are not known since monitoring in 2003 was not necessarily in exactly the same spot and the site was not monitored in 2005.

**Coral Health.** Bleaching is mild at the site. Corals were assessed prior to but not during the 2010 coral bleaching event. Old partial mortality is high in prevalence and steady. Recent partial mortality is particularly high at the site, and this may be a consequence of numerous damselfish (*Stegastes* spp.) and predatory snails (*Coralliophila* spp.) on large *Montastraea annularis* spp. colonies.

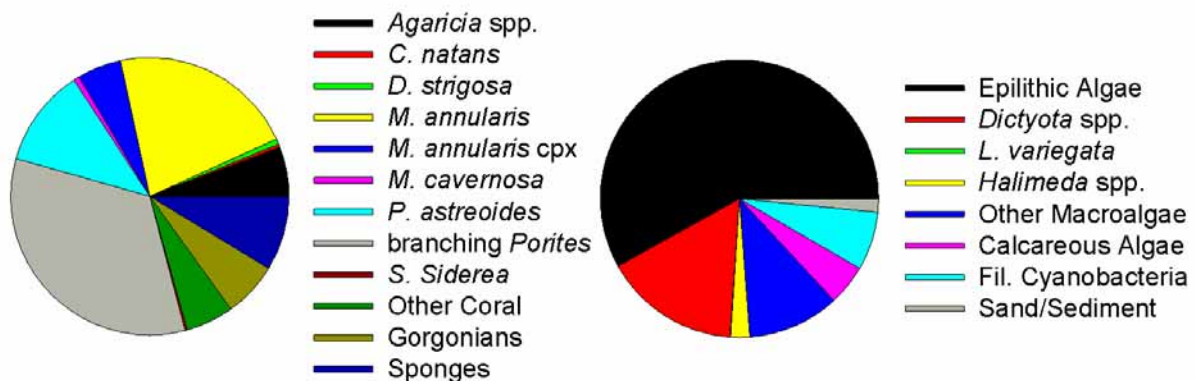


Figure 34. Castle. (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

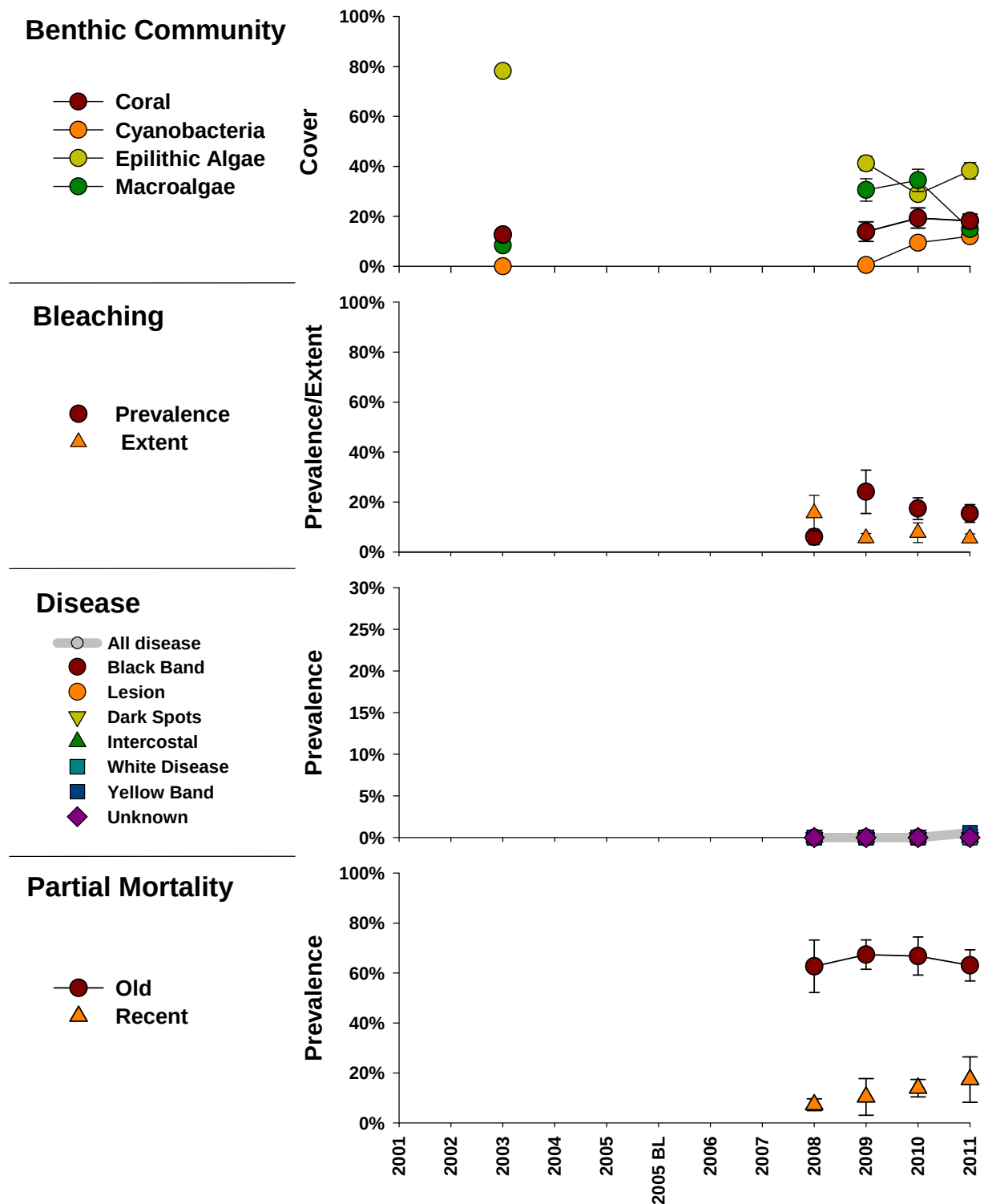


Figure 35. Castle benthic cover and coral health through time (mean  $\pm$ SE).

## SITE SUMMARIES

**Fish Community.** The Castle fish community is typically lower in overall abundance and biomass than most of the St. Croix offshore sites. It is dominated by herbivores in biomass, driven by a few large stoplight parrotfish. Sub-adult and juvenile redband, striped and princess parrotfish are however numerically much more common than stoplight. All three Acanthurids (ocean surgeonfish, blue tang and doctorfish) are common, as are many species of damselfish. Invertivores are also fairly high in biomass and are a diverse group; dominated in 2011 by benthic feeders such as spotted goatfish, Caesar grunts, gray snapper and yellowfin mojarra. Piscivores in 2011 were heavily dominated by the bar jack, with few piscivorous snapper and no grouper observed. A red lionfish was present on a transect survey in 2011 representing the first observation of that species on the Castle site.

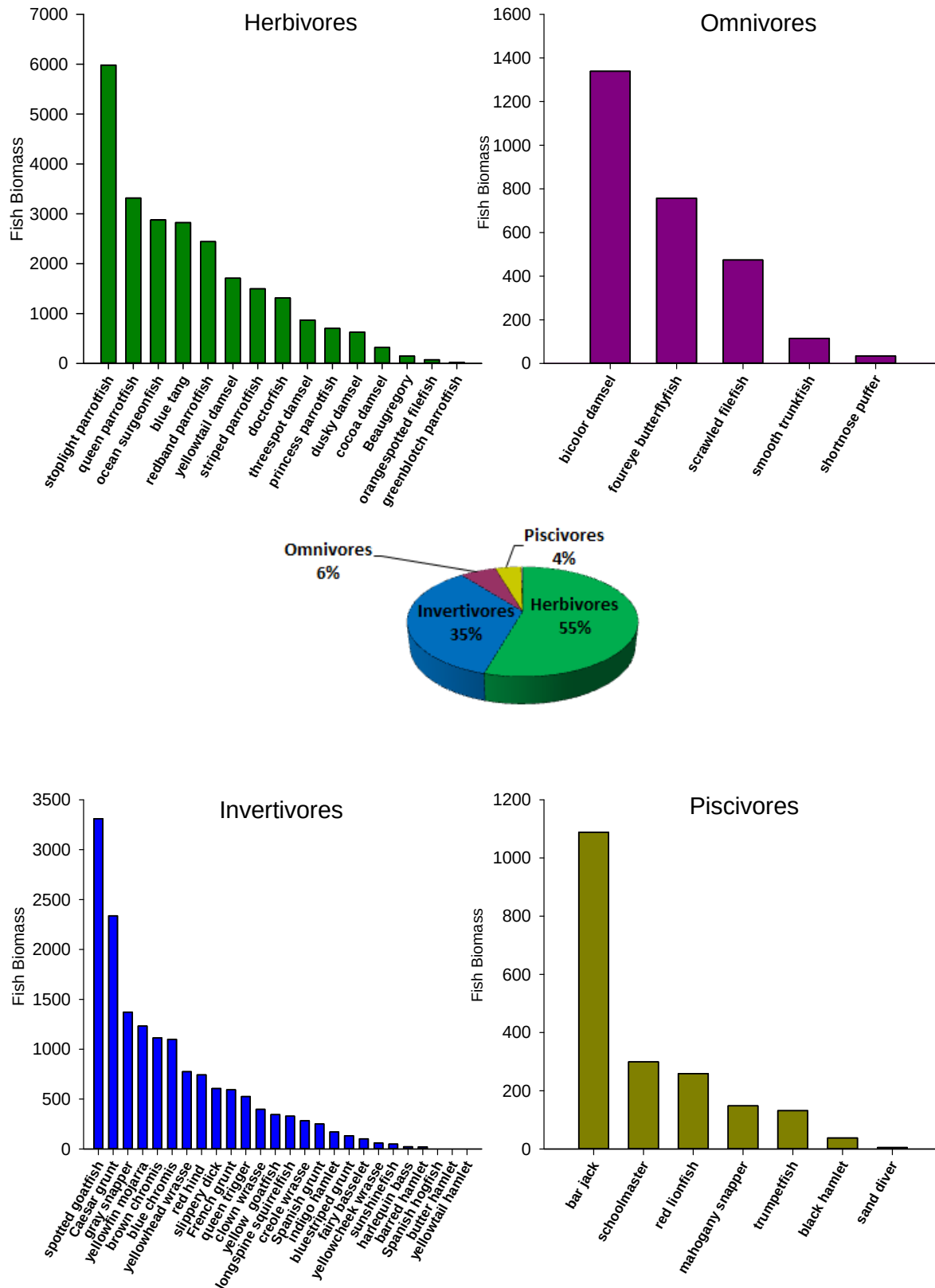


Figure 36. The Castle fish community by absolute and relative biomass.

# SITE SUMMARIES

## EAGLE RAY

**Description.** The Eagle Ray site is a shallow seaward barrier reef located at west dive buoy 1 outside the main Christiansted access channel. The monitoring site is colonized hardbottom to coral reef, with more extensive development of reef at the seaward edge. Eagle Ray has been monitored since 2001.

**Outstanding Feature.** Eagle Ray is one of the most visited dive sites due to its proximity to Christiansted.

**Threats.** Proximity to Christiansted increases the potential for land-based sources of pollution, such as sewage, run-off, and marine debris. The site is frequented by small fishing craft that venture just out of port, likely increasing the fishing pressure.

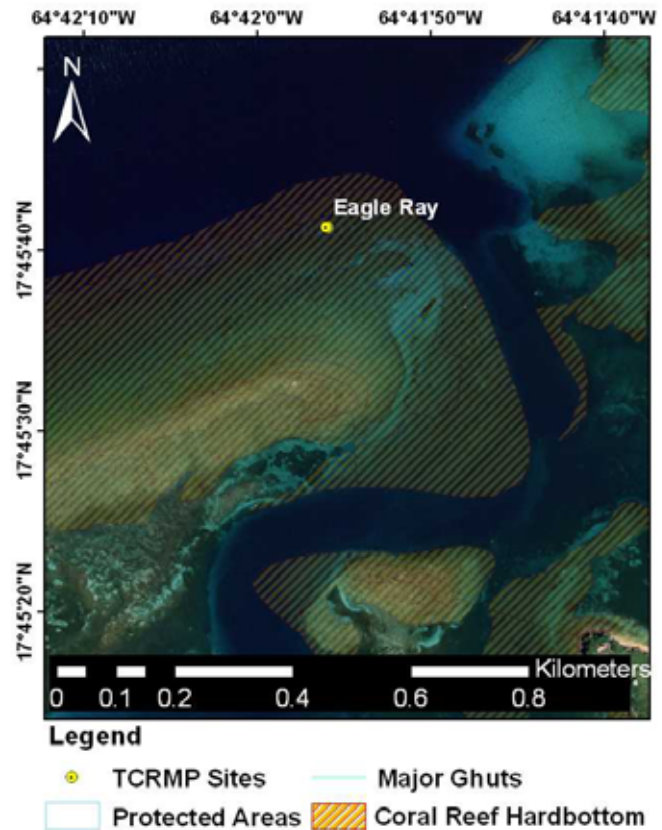


**Figure 37. Eagle Ray. (top) Location. (right) A representative photo of the reef.**



# EAGLE RAY

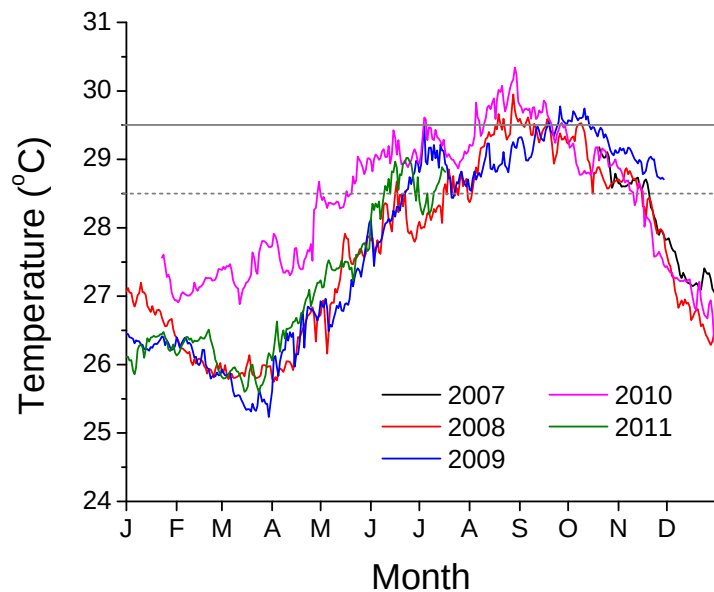


Figure 38. Eagle Ray benthic temperature at 9 m depth

## Physical Characteristics

**Current.** Currents have not been measured at Eagle Ray, however strong unidirectional currents seem rare. There are increased oscillatory current near the shallow portion of the site.

**Temperature.** Eagle Ray is shallow but near deep water on two sides, which may potentially help to reduce thermal stress.

# SITE SUMMARIES

**Benthic Community.** Eagle Ray supports a diverse community of small coral colonies, but sponges and gorgonians compose half the sessile epibenthic animal community. Coral cover has been low and less than 10% throughout the monitoring period. Coral cover decreased only slightly with the 2005 coral bleaching event, 11.7%, but cover has come back and actually increased above pre-bleaching values. The limited response may be partly due to the high relative abundance of more thermally resistant coral species. The site was dominated with epilithic algae; however, this has declined after the 2005 bleaching event with a concomitant increase in macroalgae and filamentous cyanobacteria.

**Coral Health.** Eagle Ray corals were severely affected during the 2005 bleaching event with nearly all colonies bleached over about 80% of the colony surface. Low-level bleaching is also common in years without thermal stress. The site was only monitored prior to the 2010 bleaching event. Diseases are a common feature of the site, with black band, yellow band, and dark spots disease having outbreaks in certain years. Lesions were also common during the 2005 coral bleaching event. Old partial mortality became very prevalent after the 2005 coral bleaching event and subsided in the following years.

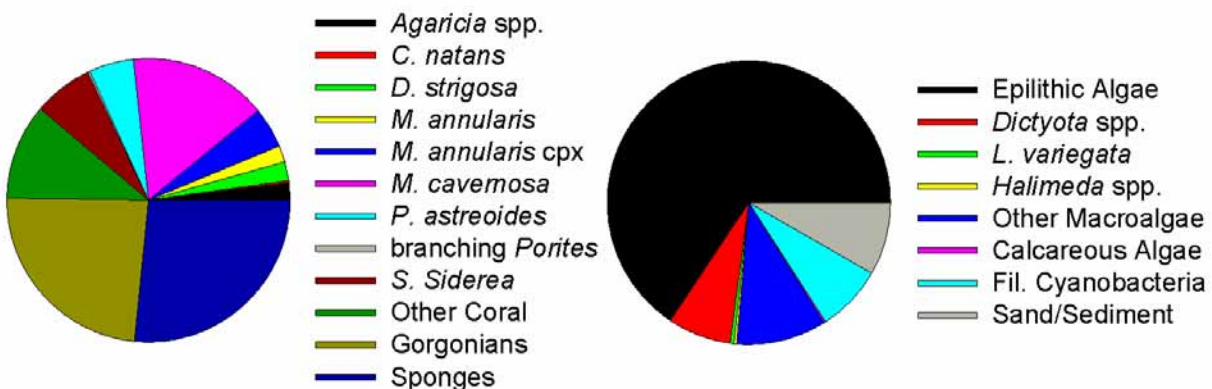
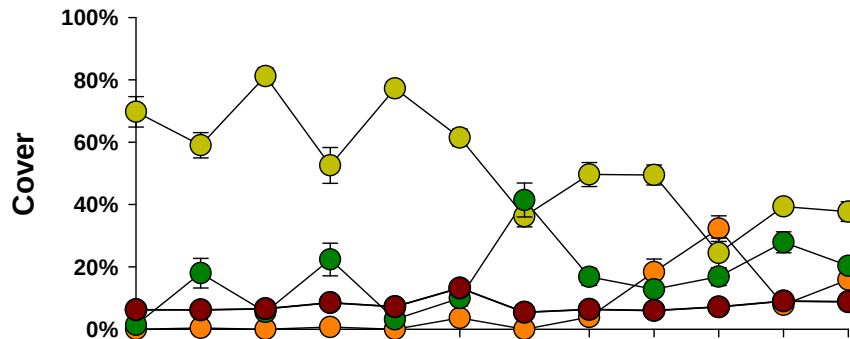


Figure 39. Eagle Ray. (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

# EAGLE RAY

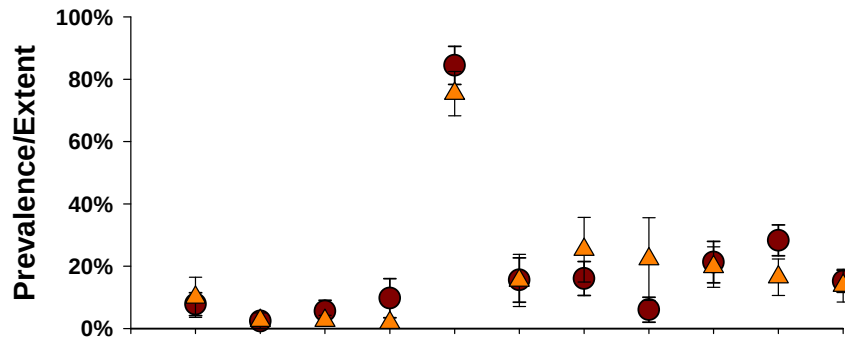
## Benthic Community

- Coral
- Cyanobacteria
- Epilithic Algae
- Macroalgae



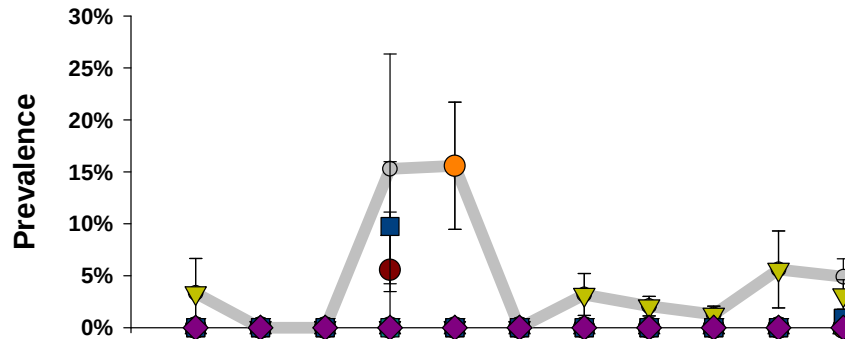
## Bleaching

- Prevalence
- ▲ Extent



## Disease

- All disease
- Black Band
- Lesion
- ▼ Dark Spots
- ▲ Intercostal
- White Disease
- Yellow Band
- ◆ Unknown



## Partial Mortality

- Old
- ▲ Recent

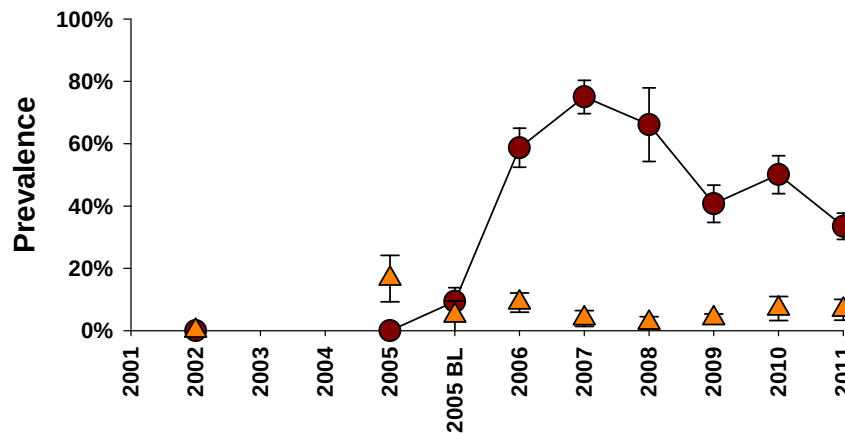


Figure 40. Eagle Ray benthic cover and coral health through time (mean  $\pm$  SE).

## SITE SUMMARIES

**Fish Community.** Eagle Ray is a fairly diverse and rich site, especially considering the fishing and diving pressure it receives, as well as the proximity of Christiansted Harbor. It is dominated by invertivores, primarily benthic feeds such as the blackbar soldierfish and yellow goatfish. Ocean surgeonfish are also very abundant, leading the herbivore trophic group. Juvenile and sub-adult redband, princess and striped parrotfish are common herbivores. The piscivores are dominated by mahogany snapper and schoolmaster snapper. Graysby are also common. In 2011 no other grouper were observed on the Eagle Ray site. Proximity to open deep water is evidenced by the occurrence of fairly high numbers of planktivorous creole wrasse and black durgon, which are rare or absent on shallow, nearshore sites.

# EAGLE RAY

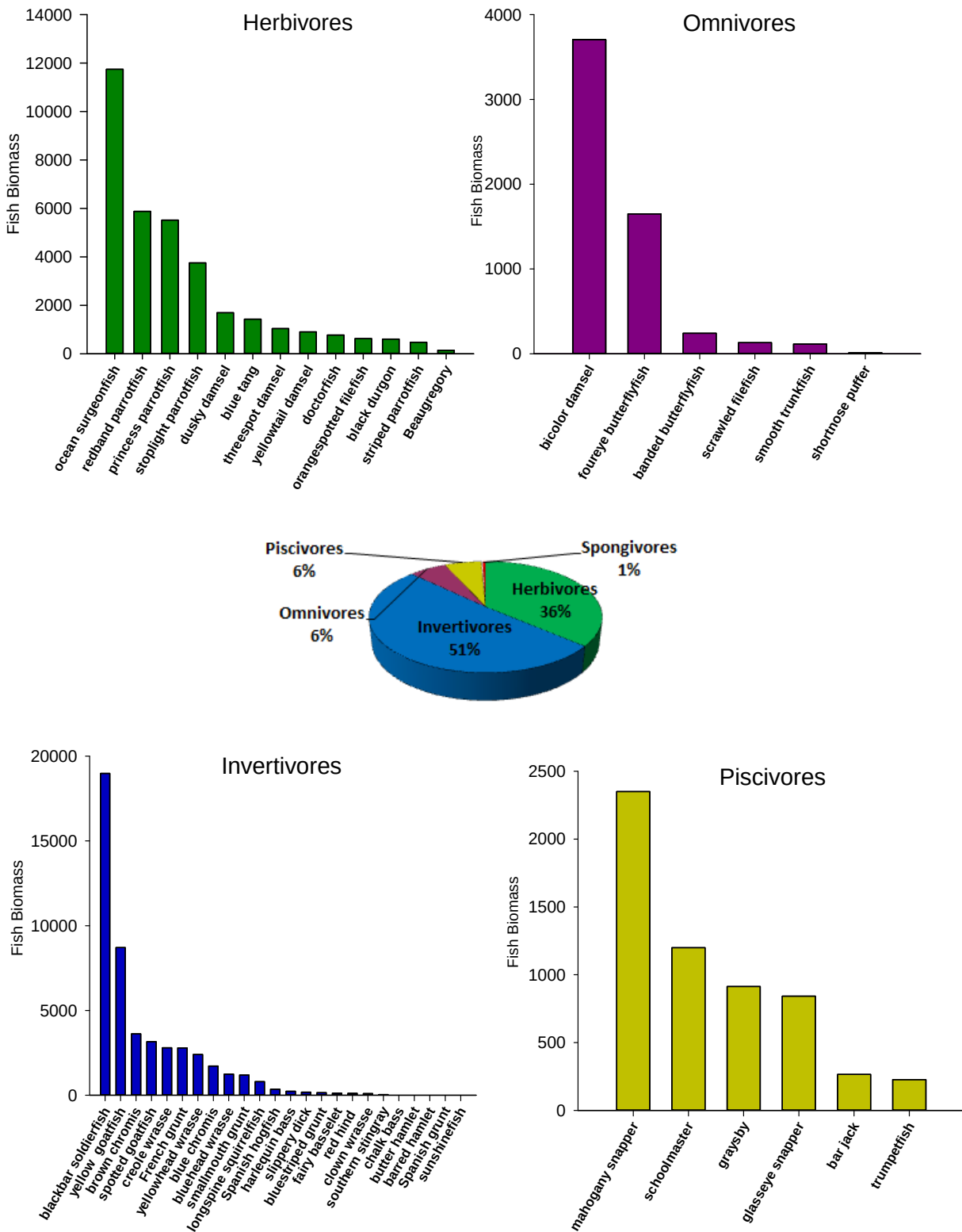


Figure 41. The Eagle Ray fish community by absolute and relative biomass.

# SITE SUMMARIES

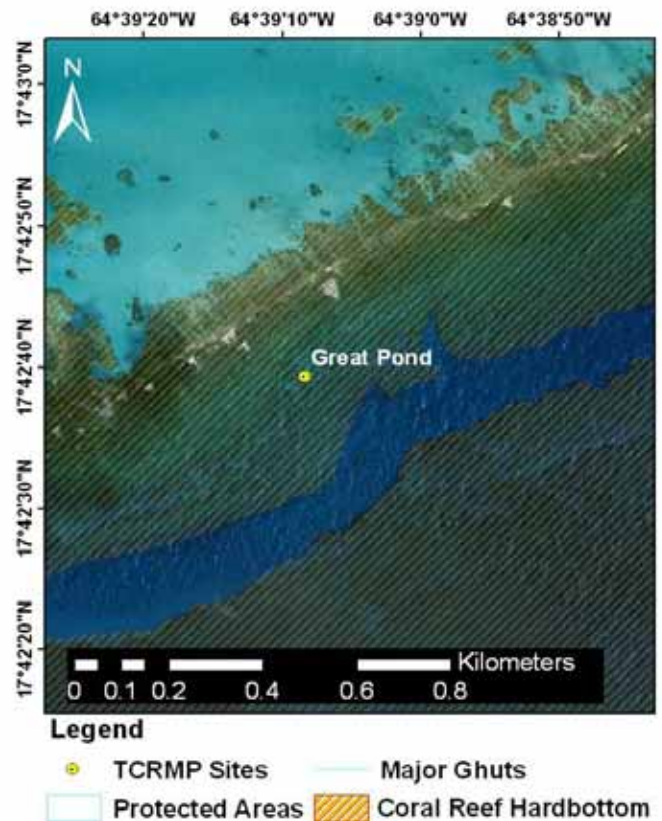
## GREAT POND

**Description.** The Great Pond Monitoring site is a wave-washed shallow barrier reef that was formerly an elkhorn coral reef in depths of 5-7 m. The reef is part of the barrier reef front surrounded by patch reefs and sand. Great Pond has been monitored since 2003.

**Outstanding Feature.** Great Pond hosts the largest population of the black spiny urchin *Diadema antillarum* of any TCRMP monitoring site, likely because of its shallow depth. It also hosts an abundance of large-bodied stoplight (*Sparisoma virde*) and yellowfin parrotfish (*Sparisoma rubripinne*) that likely spawn near the site.

**Threats.** The Great Pond monitoring site is located in the St. Croix East End Marine Park but outside the no-take fishery zone. If park rules are enforced this site could see a return of fisheries species by spillover from adjacent protected areas. Because of high turbulence and low watershed development sediment is not considered a problem; however, large industrial sites operate within 10 km, including the Hovensa Refinery, and could contribute to pollution.

**Figure 42. Great Pond. (top) Location. (right) A representative photo of the reef.**



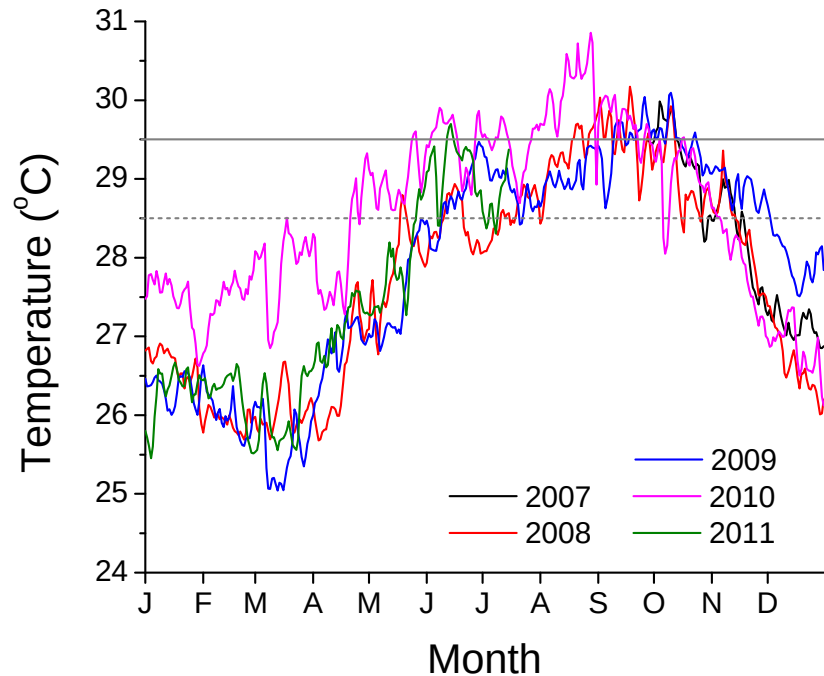


Figure 43. Great Pond benthic temperature (5 m depth).

## Physical Characteristics

**Current.** Great Pond currents have not been measured directly. Wave-generated oscillatory currents dominate and this is the most regularly swell-influenced site in the TCRMP making work conditions difficult on all but the calmest day. Strong unidirectional currents have not been experienced.

**Temperature.** Great Pond typically experiences very high temperatures in August to October, with temperatures nearly peaking at 31°C in 2010.

# SITE SUMMARIES

**Benthic Community.** The Great Pond site is unusually dominated with the mustard hill coral (*Porites astreoides*) and *Diploria strigosa*. It is also the only site with high abundance of *Diploria clivosa*. The site lost 55.9% of its coral cover in the 2005 bleaching event, but has regained about half of the cover as of 2011. The site is dominated by epilithic algae, with occasional years where macroalgae blooms (2007 and 2011).

**Coral Health.** Great Pond corals were moderately affected during the 2005 coral bleaching event, which may be a reflection of this high composition of resistant coral species and the regular exposure to high temperatures. The site was not monitored during the height of the 2010 coral bleaching event. Patchy, low-level bleaching is common in some years. Diseases were almost non-existent at the monitoring site. Partial mortality is variable and has not shown consistent trends over years.

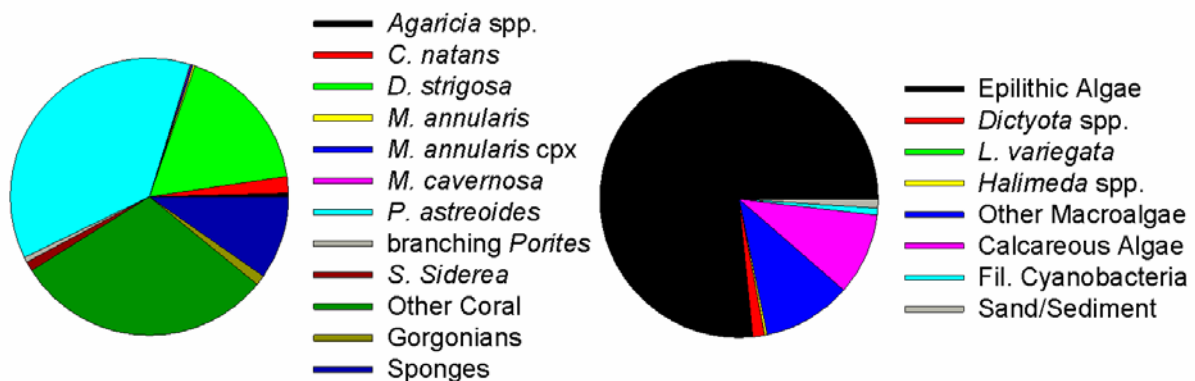


Figure 44. Great Pond (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

# GREAT POND

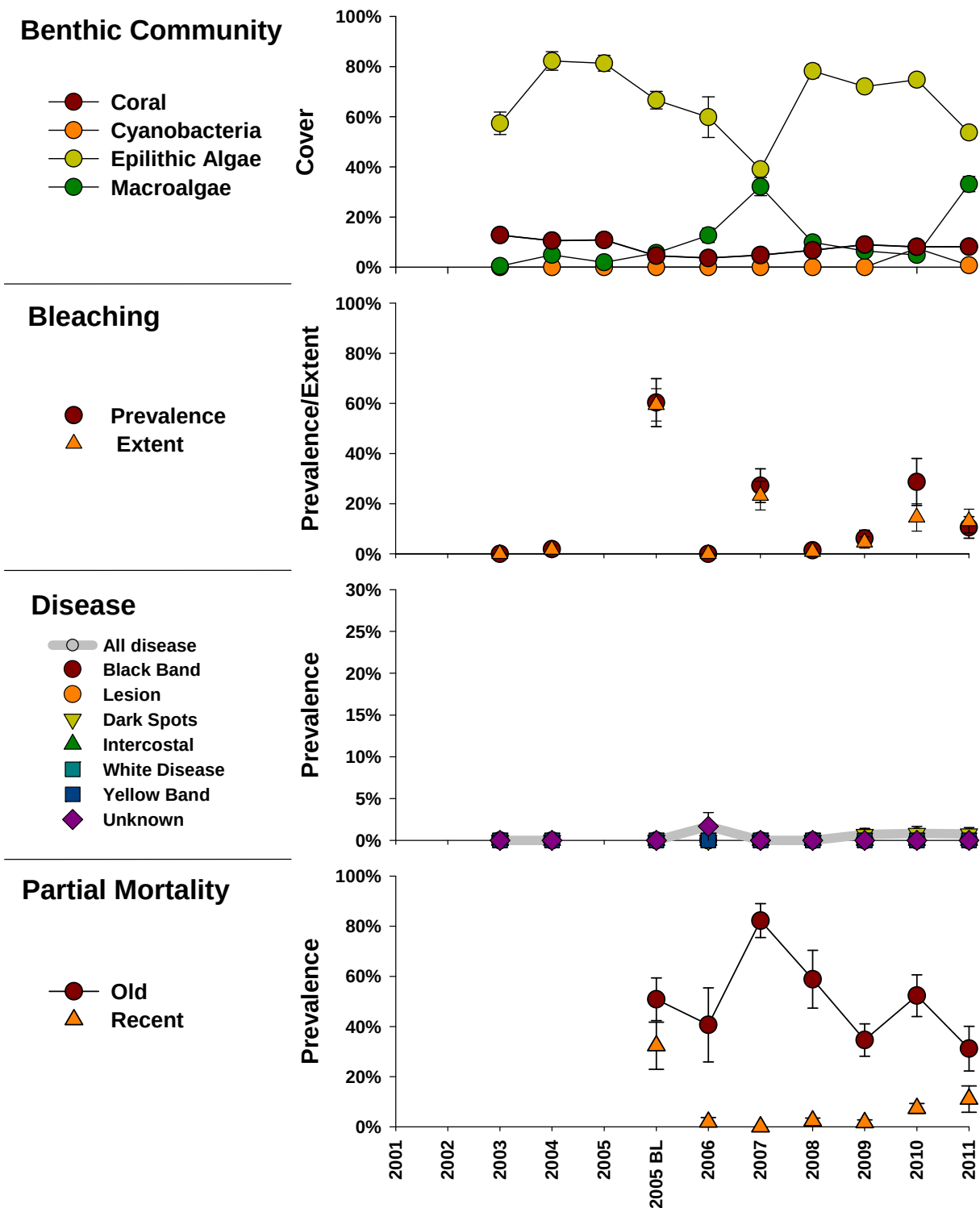


Figure 45. Great Pond benthic cover and coral health through time (mean  $\pm$  SE).

## SITE SUMMARIES

**Fish Community.** The Great Pond fish community is dominated by herbivores, both benthic and planktonic. The primary benthic herbivore at the site is the blue tang, which swims in foraging schools feeding on algae covering the relict elkhorn coral. Also present are large queen and stoplight parrotfish, which can also be seen in large groups, probably spawning in the late afternoon and evening hours. These fish concentrate around the “piles” of skeletal remains of *Acropora* across the site. Between these areas, fish biomass is low and is primarily made up of wrasses, brown chromis and juvenile parrotfish. Piscivores at Great Pond are limited nearly entirely to mahogany snapper and bar jacks. Benthic invertivores are dominated by bluestriped grunts. Grunts and mahogany snapper are also associated with the relict elkhorn structures and are very patchy across the reef.

# GREAT POND

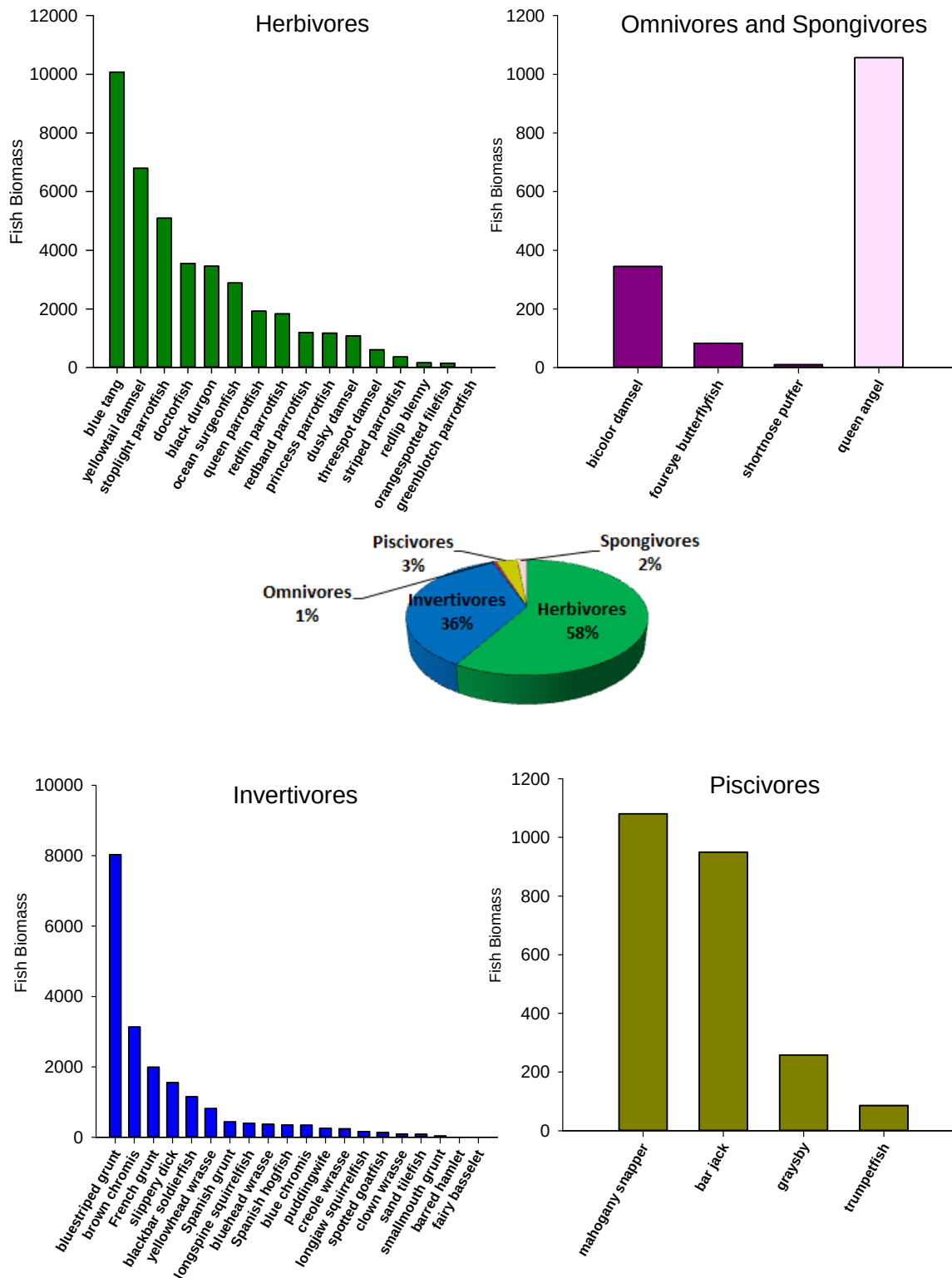


Figure 46. The Great Pond fish community by absolute and relative biomass.

# SITE SUMMARIES

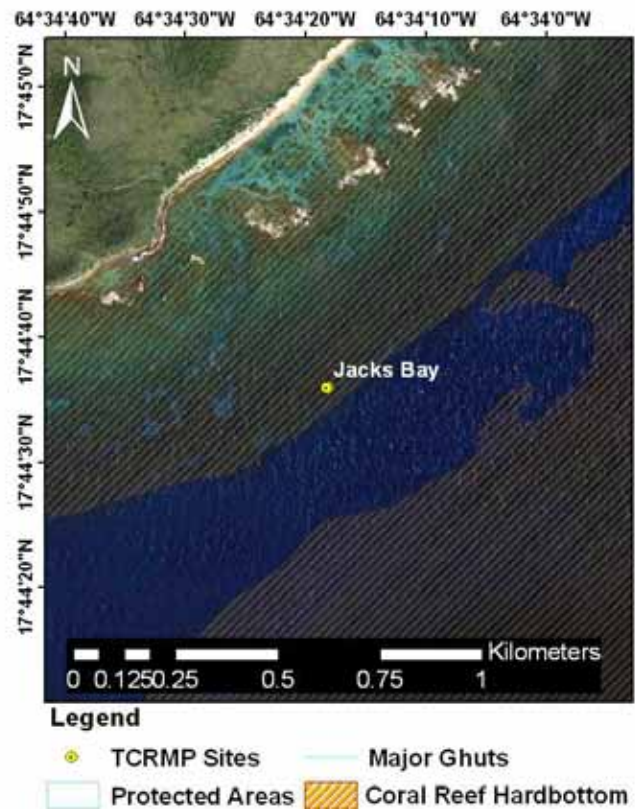
## JACKS BAY

**Description.** The Jacks Bay monitoring site (aka Jacks/Isaacs Bay) is part of fringing reef, colonized hardbottom on the southeast point of St. Croix in water depths of 13-16 m. The monitoring site is just inward from the shelf break and seaward reef slope, which terminates in a sand plain at about 20 m depth. Jacks Bay is largely a carbonate hardbottom with scattered hard coral, although there are some large coral heads seaward of the transects. Permanent transects were installed at Jacks Bay in 2001.

**Outstanding Feature.** Jacks Bay hosts a unique fish community with high abundance of small wrasses and the occasional occurrence of red hind (*Epinephelus guttatus*).

**Threats.** Jacks Bay is within the St. Croix East End Marine Park but lies just outside the restricted fisheries area and is open to fishing. High turbulence and no watershed development mean there is low threat of land-based sources of pollution at this nearshore site.

**Figure 47. Jacks Bay. (top) Location. (right) A representative photo of the reef.**



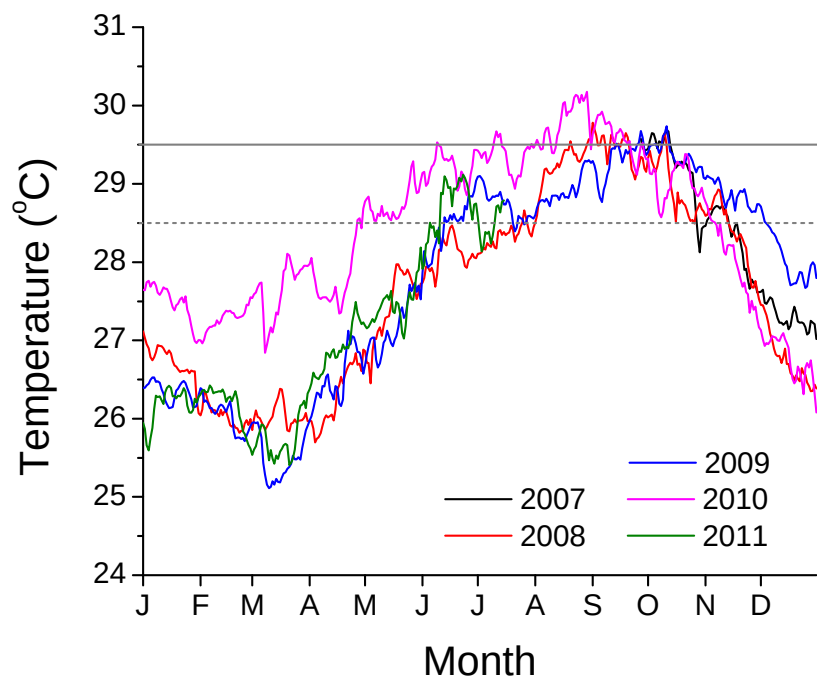


Figure 48. Jacks Bay benthic temperature at 12 m depth

## Physical Characteristics

**Current.** Jacks Bay currents have not been measured directly. There are weak unidirectional currents, but a propensity for strong wave-generated oscillatory currents due the open coast southeast exposure.

**Temperature.** Jacks Bay can experience high temperatures during August to October.

# SITE SUMMARIES

**Benthic Community.** The Jacks Bay site has low coral cover (<10%) and is the only TCRMP site dominated by the great star coral *Montastraea cavernosa*. Jacks Bay lost 44.7% of its coral cover in the 2005 coral bleaching event, but had regained about 32% of the loss by 2011. Over half of the sessile epibenthic community is composed of gorgonians and sponges. The direct area of the site might be considered more a colonized hardbottom than true coral reef. The algal community is composed of high proportions each of epilithic algae, macroalgae, and filamentous cyanobacteria. These algal groups show high inter-annual variability.

**Coral Health.** The Jacks Bay site was strongly affected during the 2005 bleaching event and was moderately affected during the 2010 bleaching event. Disease prevalence was low and only dark spots disease was present. Recent partial mortality was high during the 2005 bleaching event, likely reflecting the fact that surveys were conducted in November 2005 when mortality had begun. Old partial mortality increased greatly after the 2005 bleaching and then declined to stable levels in 2009-2011.

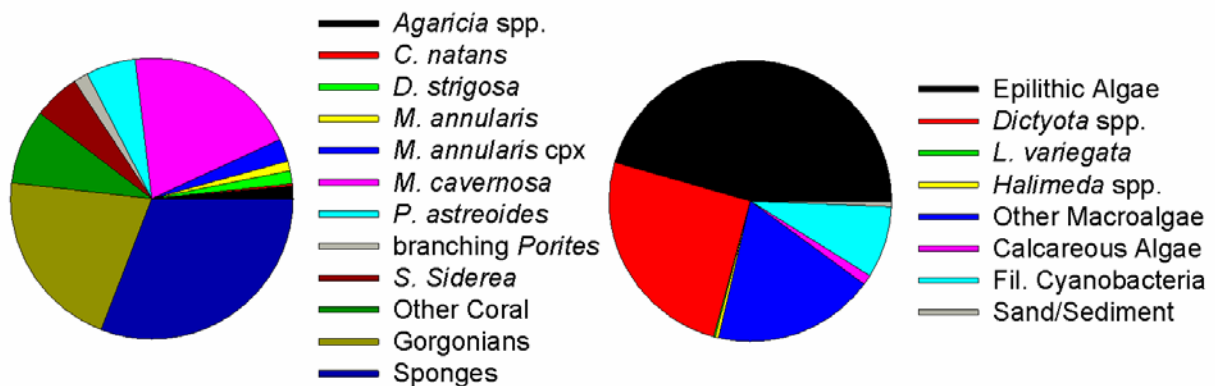
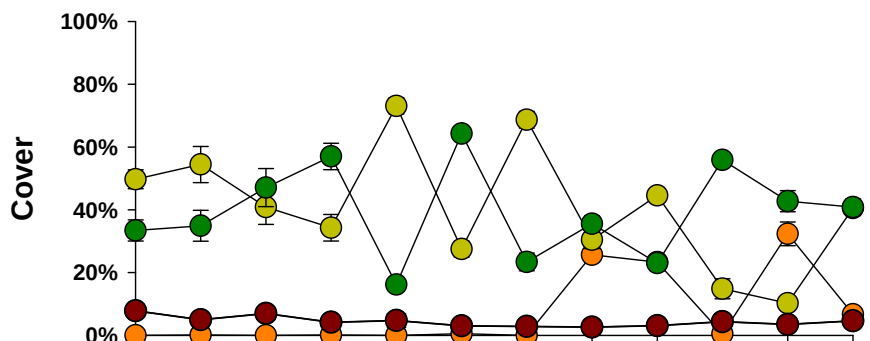


Figure 49. Jacks Bay (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

# JACKS BAY

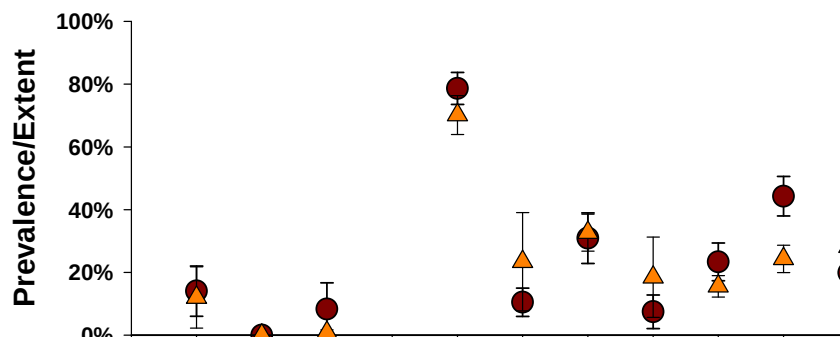
## Benthic Community

- Coral
- Cyanobacteria
- Epilithic Algae
- Macroalgae



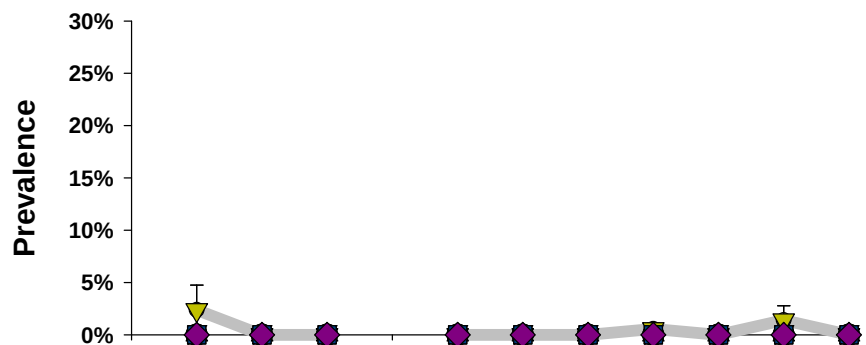
## Bleaching

- Prevalence
- ▲ Extent



## Disease

- All disease
- Black Band
- Lesion
- ▼ Dark Spots
- ▲ Intercostal
- White Disease
- Yellow Band
- ◆ Unknown



## Partial Mortality

- Old
- ▲ Recent

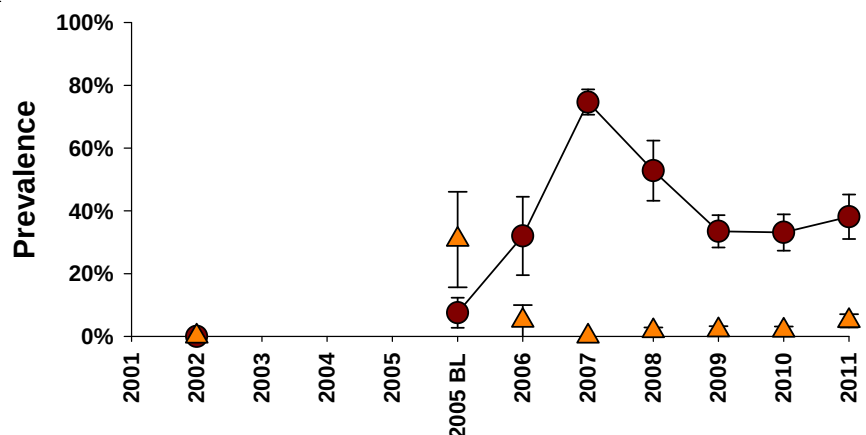


Figure 50. Jacks Bay benthic cover and coral health through time (mean  $\pm$  SE).

## SITE SUMMARIES

**Fish Community.** The Jacks Bay fish community is characterized by very low fish biomass and abundance but relatively high diversity. The site is primarily hard bottom, adjacent to more developed coral reef on the seaward edge, over which larger fishes are observed. The hardbottom community is highly dominated numerically by blue chromis, yellowhead wrasse and bicolor damselfish. Juvenile wrasses and parrotfish swim and hover in mixed schools among the rubble and gorgonians. Slippery dicks, clown wrasse, rainbow wrasse and blackear wrasse can be observed. Angelfishes are common across the hardbottom, as are juvenile red hind. Piscivores are rare and limited to peacock flounder, redspotted hawkfish, juvenile graysby, and trumpetfish. Medium to larger sized fishes are very rare, and nearly all of these species are seen at Jacks Bay in the juvenile life history stage.

# JACKS BAY

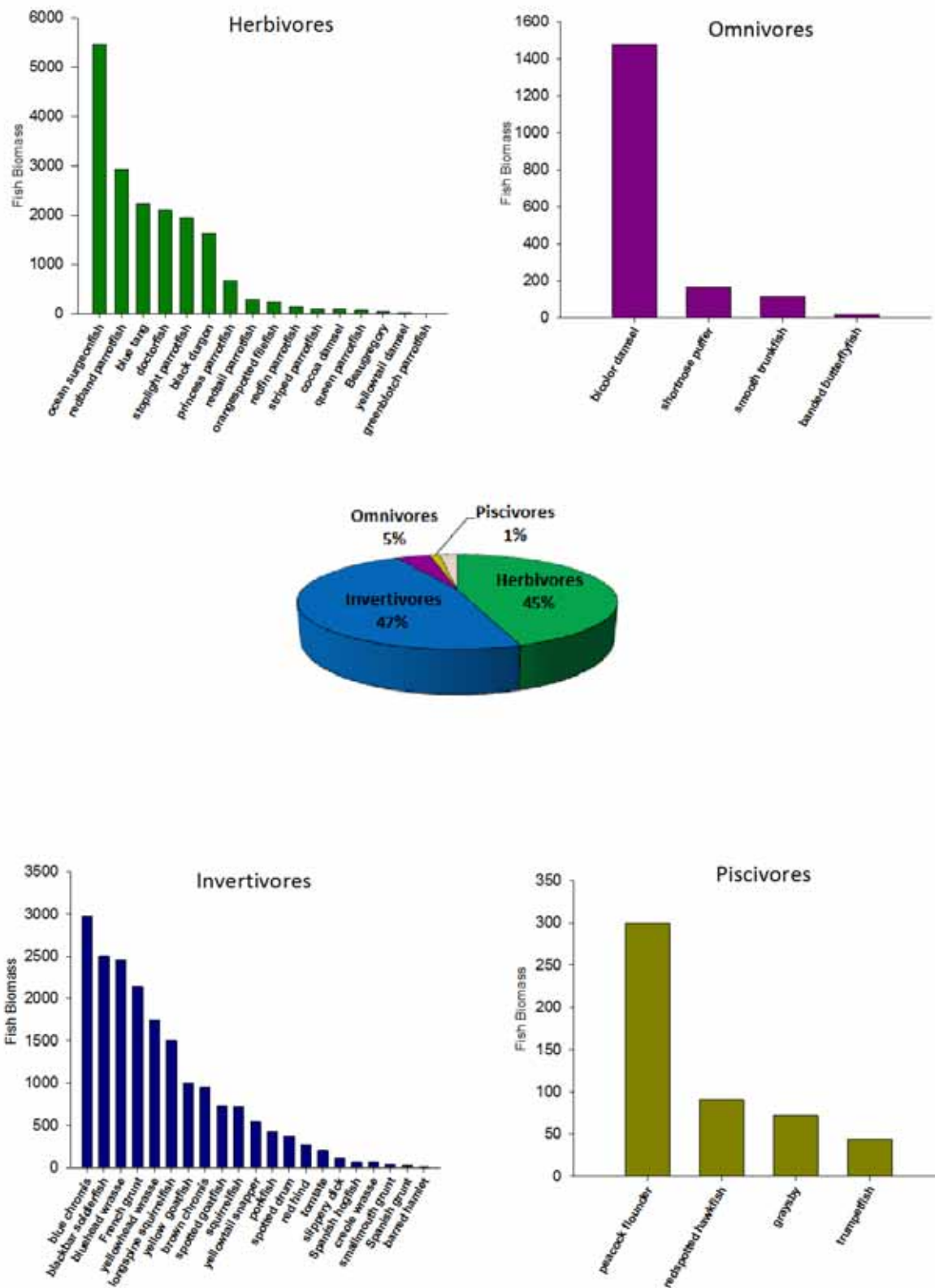


Figure 51. The Jacks Bay fish community by absolute and relative biomass.

# SITE SUMMARIES

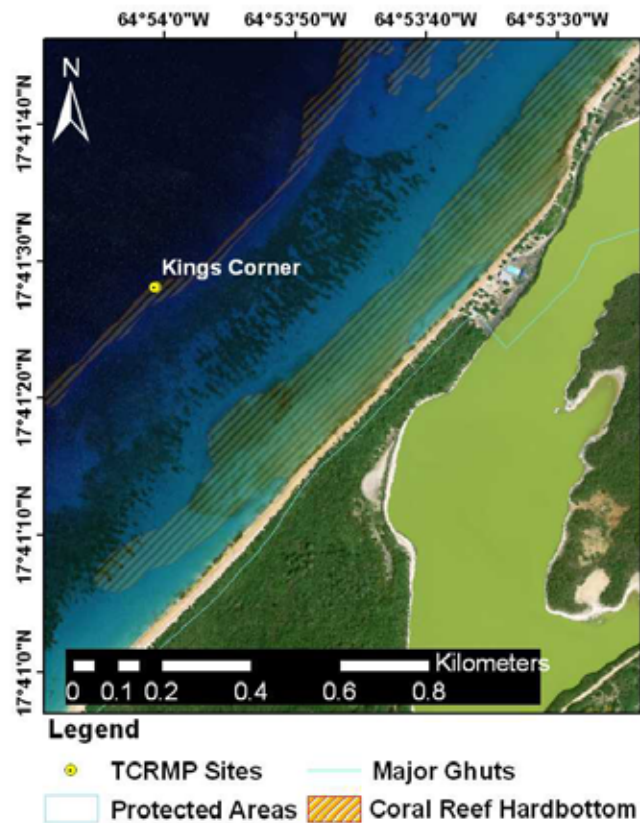
## KINGS CORNER

**Description.** The Kings Corner monitoring site is a part of a patchy reef complex along the steeply sloping west coast of St. Croix in depths of 15-25 m. The reef contains a high diversity of corals and sponges on mounds surrounded by sand. Kings Corner has been monitored since 2006, with permanent transects installed in 2007.

**Outstanding Feature.** Kings Corner is a commercially important recreational dive site. The site supports a high diversity and density of fishes. It also a very aesthetically pleasing site with high topographic relief.

**Threats.** Kings Corner is open to fishing and is easily accessible as part of the calm lee of western St. Croix near Frederiksted. Derelict fishing lines, fish traps, fish weights, and other marine debris are in evidence in and around the site. Large plumes of sediment that wrap around Sandy Point from the south coast of St. Croix also periodically affect the site. Plumes can drop visibility to near zero and lead to high incidence of sediment on coral and spotty bleaching.

**Figure 52. Kings Corner. (top) Location. (right) A representative photo of the reef with a school of lane snapper (*Lutjaussynagris*).**



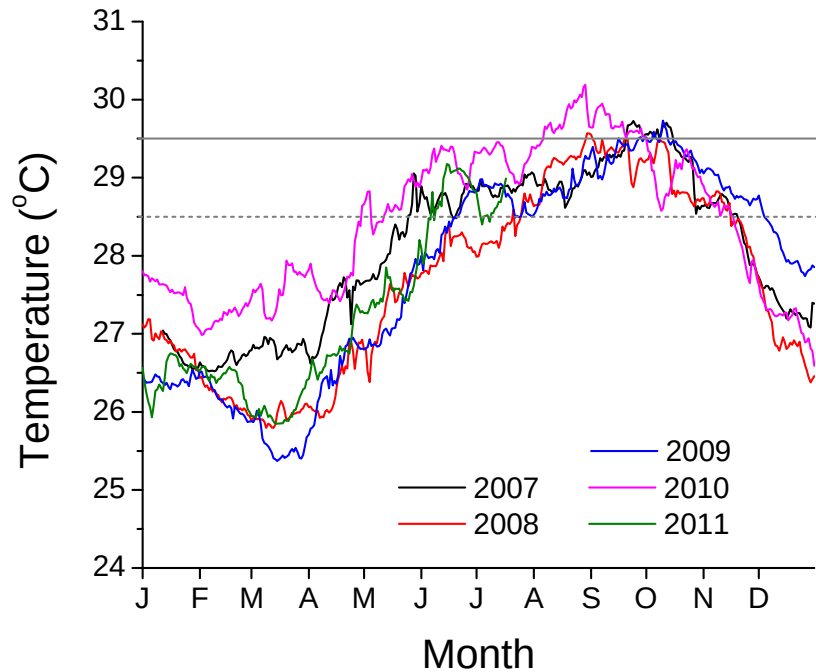


Figure 53. Kings Corner benthic temperature (17 m depth)

## Physical Characteristics

**Current.** Kings Corner currents have not been measured directly. The site is very protected from wave action, but can experience strong unidirectional currents at times, particularly at shallower depths.

**Temperature.** Kings Corner has moderately high temperatures.

# SITE SUMMARIES

**Benthic Community.** The Kings Corner site supports a diverse community of hard corals dominated by the *Montastraea annularis* spp. complex. The site also had a very abundant population of sponges. This site was not monitored until after the 2005 bleaching event, so the impacts on coral cover are not known. Epilithic algae dominate the algal community at Kings Corner, with very low abundance of macroalgae and filamentous cyanobacteria. Sand is prominently interspersed among the coral banks.

**Coral Health.** Non-thermal bleaching with moderate prevalence but low extent on colonies is a common feature at this site, likely as the result of chronic sedimentation. The prevalence of coral diseases was low with dark spots disease predominating. Old partial mortality has been very high at this site since monitoring started and may be an indication of impacts from the 2005 coral bleaching event.

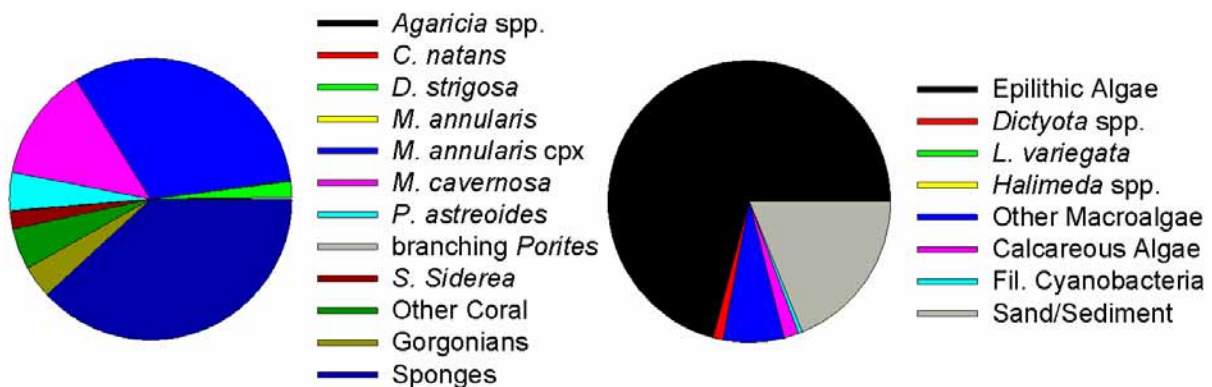


Figure 54. Kings Corner (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

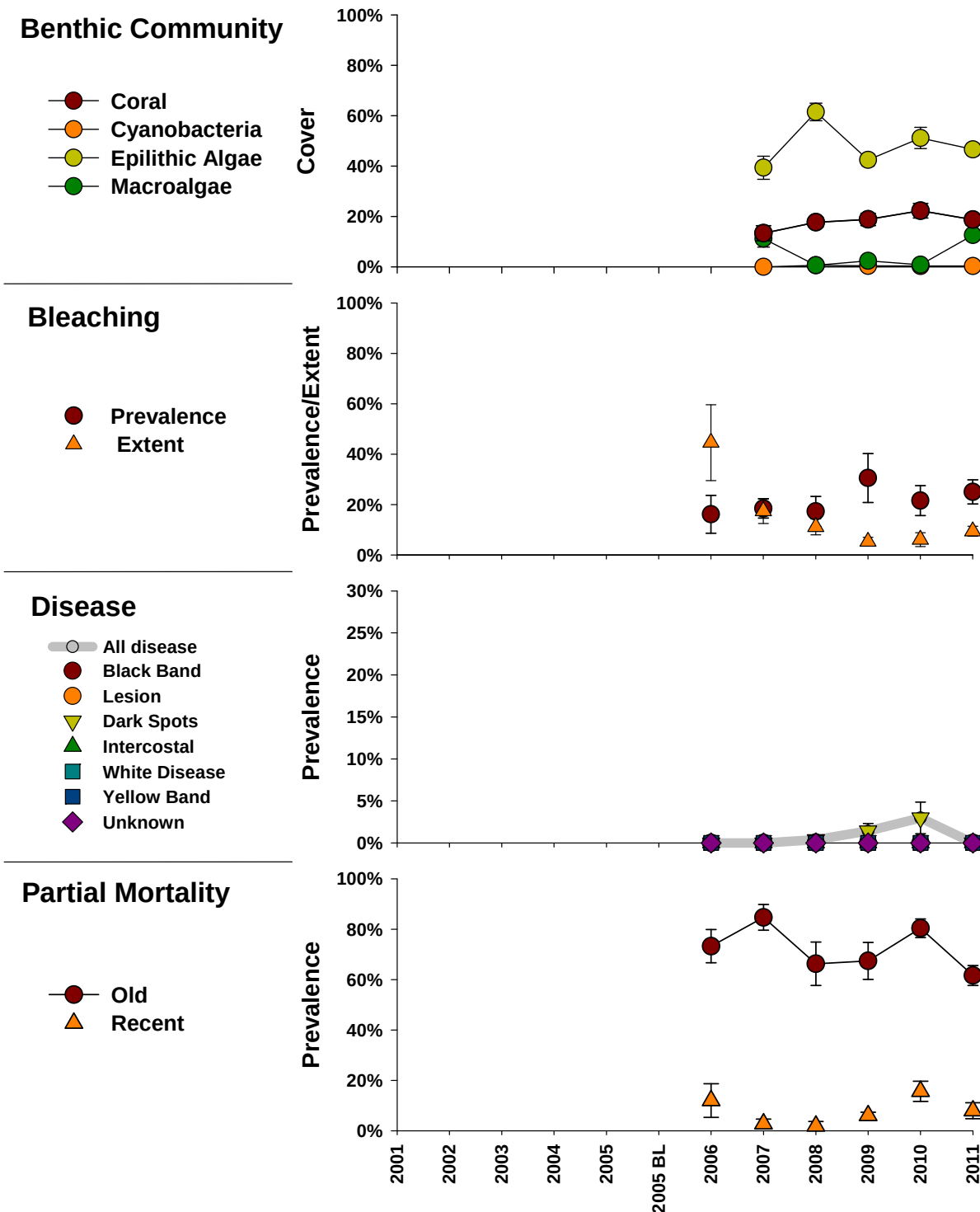


Figure 55. Kings Corner benthic cover and coral health through time (mean  $\pm$  SE).

## SITE SUMMARIES

**Fish Community.** Kings Corner represents the most diverse fish community with the highest fish biomass in the St Croix monitoring program. The site is dominated by invertivores, influenced highly by the large numbers of adult blackbar soldierfish and tomtate grunts. Although the blackbar soldierfish is a nocturnal zooplanktivore, the tomtate is more opportunistic and feeds on benthic invertebrates as well as some zooplankton and benthic algae. This illustrates the variety of resources available to the fishes at Kings Corner. Other common planktonic feeders include the common black surgeon, creole wrasse, bar jack and yellowtail snapper, as well as the less common rainbow runner. Common benthic herbivores include princess, redband, stoplight, queen, striped and redfin parrotfish, as well as blue tang and ocean surgeonfish. Seven species of grunts were included in transects during the 2011 census, as well as three species of squirrelfish and four species of butterflyfish. Piscivores were also in relatively high biomass, represented primarily as bar jacks, graysby and mahogany snapper.

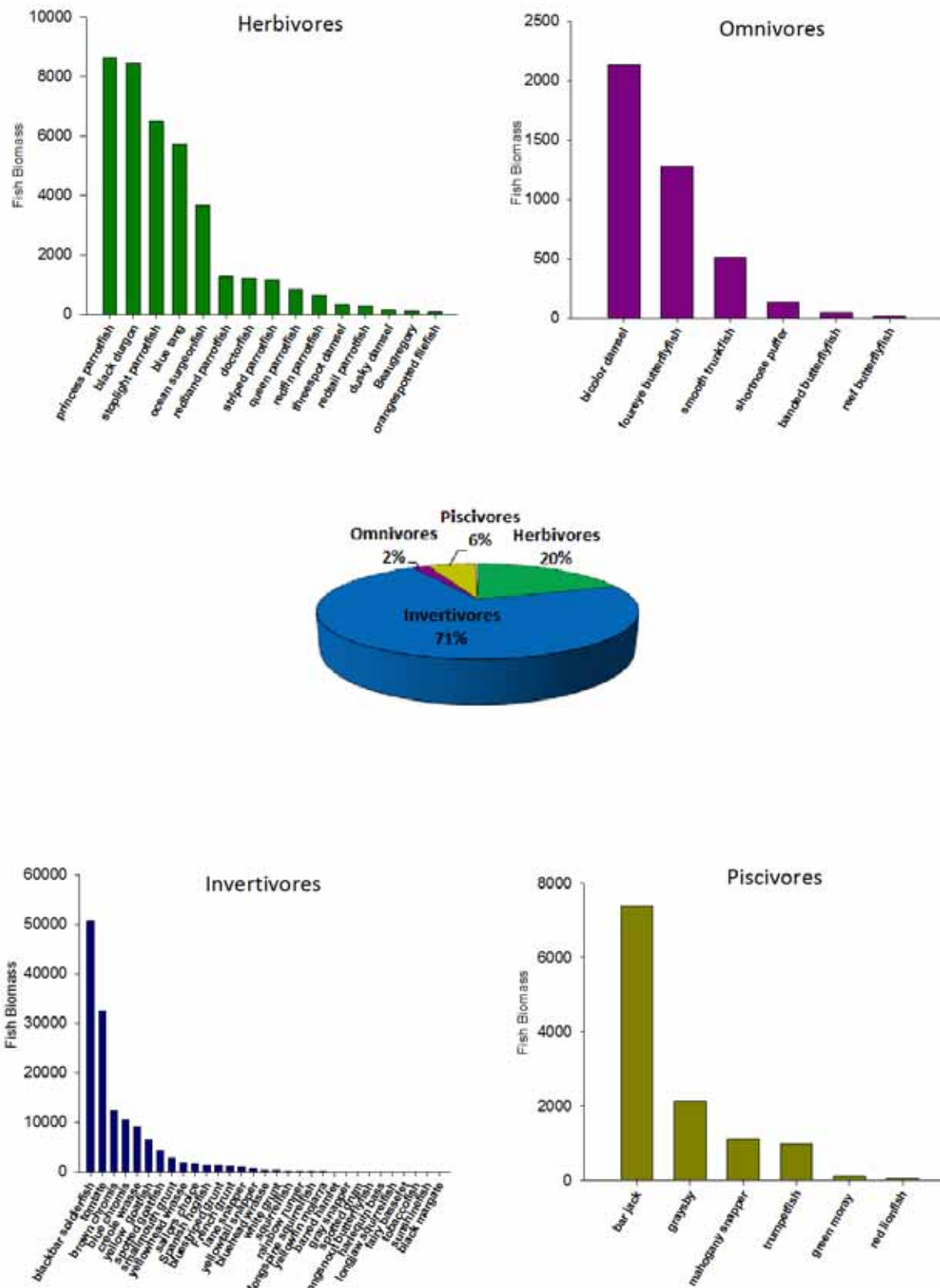


**Figure 56. The Kings Corner fish community by absolute and relative biomass.**

## SITE SUMMARIES

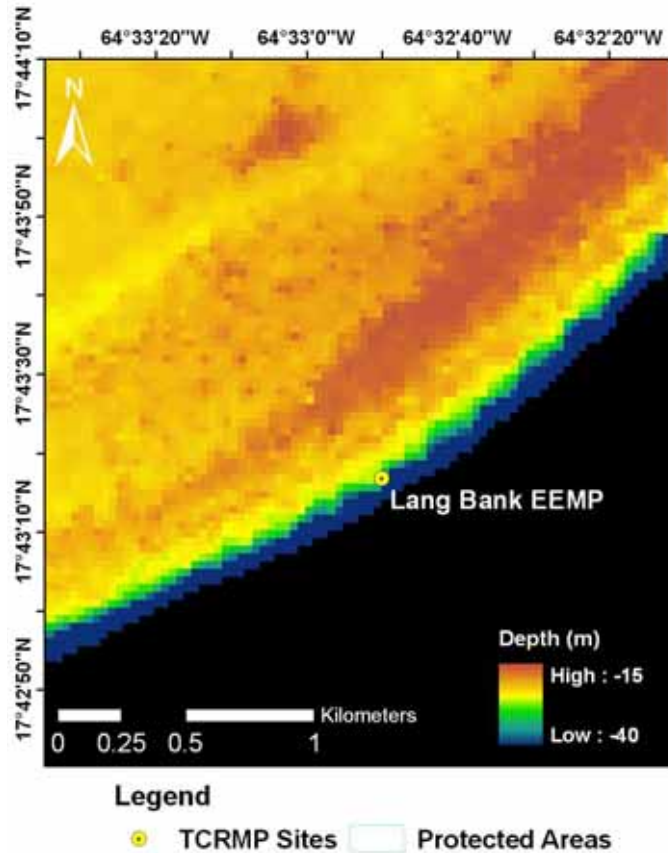
### LANG BANK EAST END MARINE PARK

**Description.** The Lang Bank EEMP site is a shelf edge mesophotic coral reef located at a depth of 27 – 30 m. The monitoring site sits just above a steep shelf break and is composed of rolling coral knolls dominated by boulder star corals (*Montastraea annularis* spp. complex). This site was established in 2009.

**Outstanding Feature.** The Lang Bank EEMP site appears to be a well-developed mesophotic boulder star coral reef on St. Croix, where these reef are rarer than the northern US Virgin Islands.

**Threats.** The Lang Bank EEMP is in the outer park area and is open to fishing year-round. Therefore fisheries pressure is present. Its offshore location protects it from land-based sources of pollution.

**Figure 57. Lang Bank EEMP. (top) Location. (right) A representative photo of the reef.**



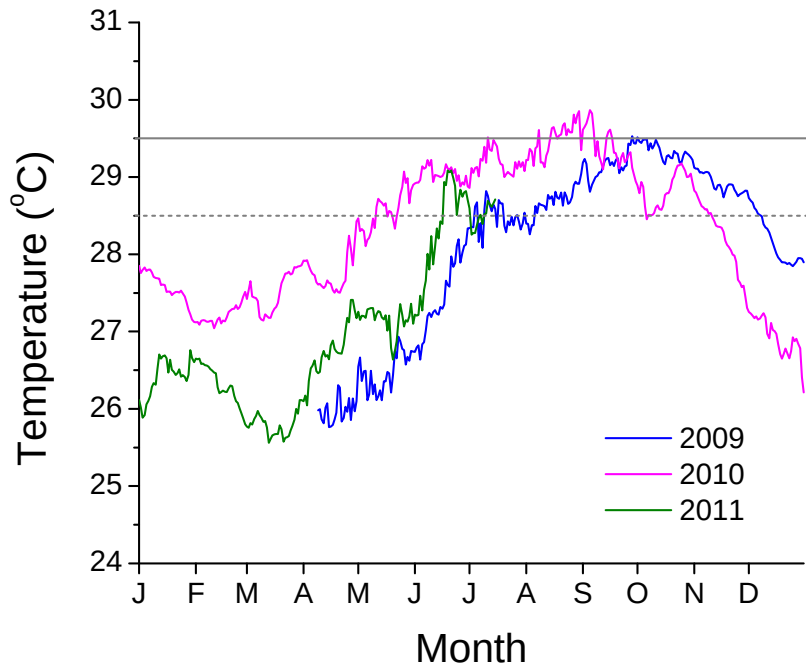


Figure 58. Lang Bank EEMP benthic temperature (28 m depth)

## Physical Characteristics

**Current.** Direct current measurements have not been taken at Lang Bank EEMP. The depth buffers the site from wave-driven oscillatory currents. Only weak unidirectional benthic currents have been experienced at the site during monitoring; however, midwater and surface currents can be moderate to strong ( $>10\text{cm s}^{-1}$ ).

**Temperature.** Lang Bank EEMP has temperature that is reduced relative to shallow water sites, as shown by the relatively mild temperatures experienced during the warm water event of August to September 2010. This may be protective during mass bleaching events, but temperatures are not as reduced at other mesophotic sites.

# SITE SUMMARIES

**Benthic Community.** Lang Bank EEMP supports many coral species but is dominated by the *Montastraea annularis* spp. complex. Sponges are also quite prominent and make up a quarter of the sessile epibenthic animal community. Epilithic algae, *Lobophora variegata*, and filamentous cyanobacteria near equally represent the algal community. The prominence of filamentous cyanobacteria is quite striking and has reached almost 40% of the substrate in some years.

**Coral Health.** Background, non-thermal bleaching prevalence is quite high at Lang Bank EEMP. White disease showed an outbreak in 2011. Lang Bank EEMP was not initially monitored until well after the 2005 coral bleaching event; however, a high prevalence of old partial mortality suggests that corals were impacted. Many of the large faviids show lesion patterns that are consistent with the large lunate dead areas caused by white diseases following bleaching in 2005.

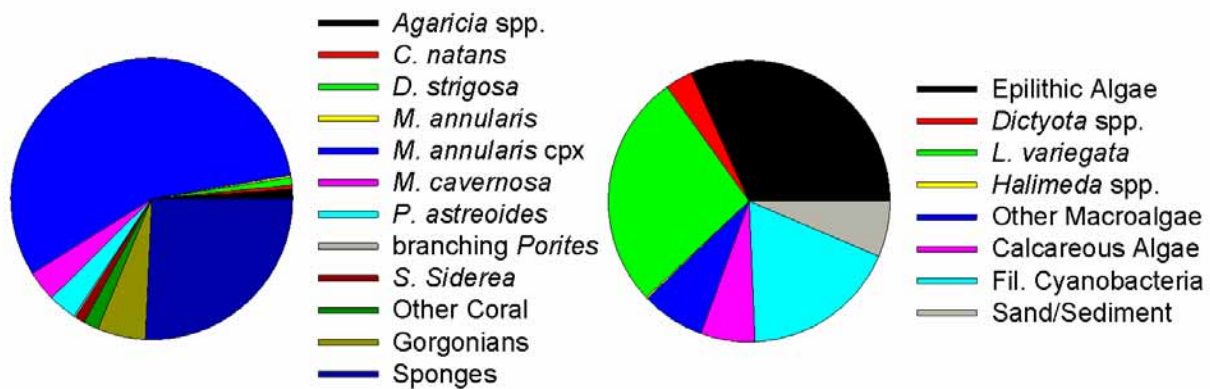


**Figure 59. Lang Bank East End Marine Park (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.**

# LANG BANK EEMP

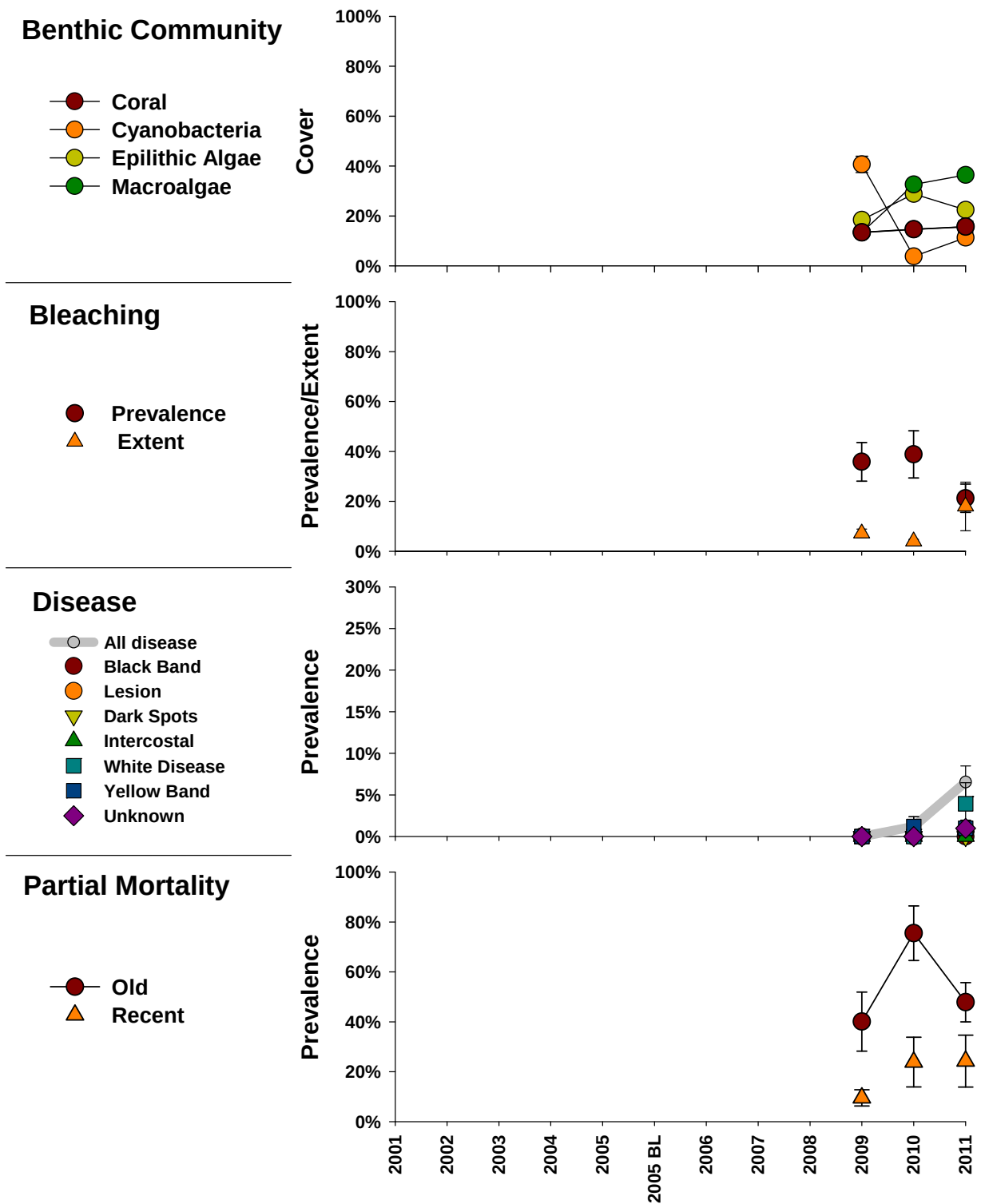


Figure 60. Lang Bank EEMP benthic cover and coral health through time (mean  $\pm$  SE).

## SITE SUMMARIES

**Fish Community.** The Lang Bank East End Marine Park site represents a mesophotic reef community that is characterized by large numbers of planktonic feeders including herbivores, invertivores and omnivores. The planktivorous ocean triggerfish, black durgelon, and blackbar soldierfish are the three fish comprising the highest biomass at the site. Other deep water planktivores common to the site include the yellowtail snapper and creole wrasse. Benthic herbivores are dominated numerically and in biomass by the redband parrotfish, and benthic invertivores by the smallmouth and French grunts. Piscivores are highly dominated by the graysby. The graysby was the only grouper observed during transects in 2011, although coney were occasionally observed during roving dives. Other piscivores included the barracuda and cero mackerel, also indicators of a deep water community. Two lionfish were observed on the East End Marine Park site in 2011 during roving dives.

# LANG BANK EEMP

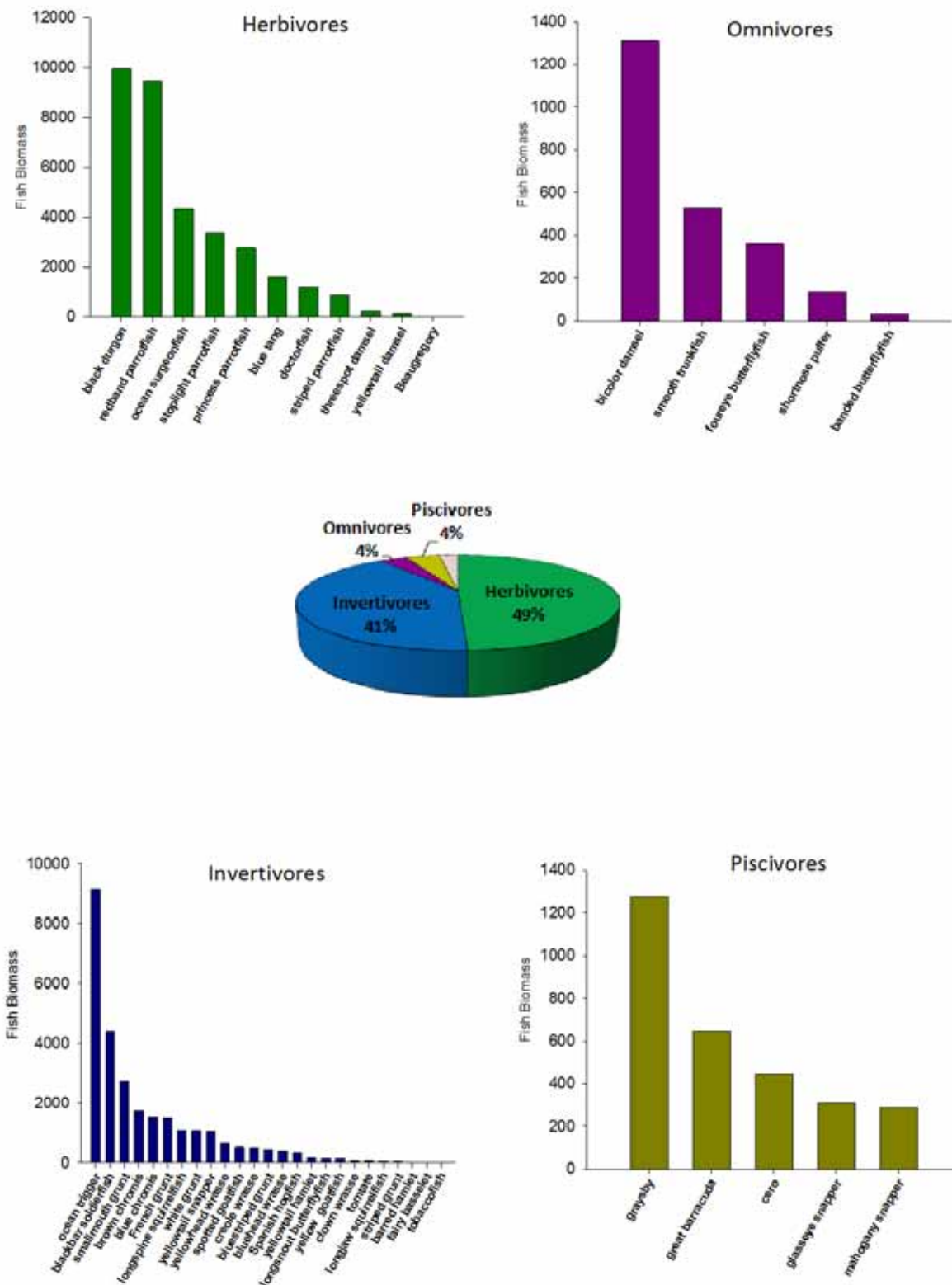


Figure 61. The Lang Bank EEMP fish community by absolute and relative biomass.

# SITE SUMMARIES

## LANG BANK RED HIND FISH SPAWNING AGGREGATION

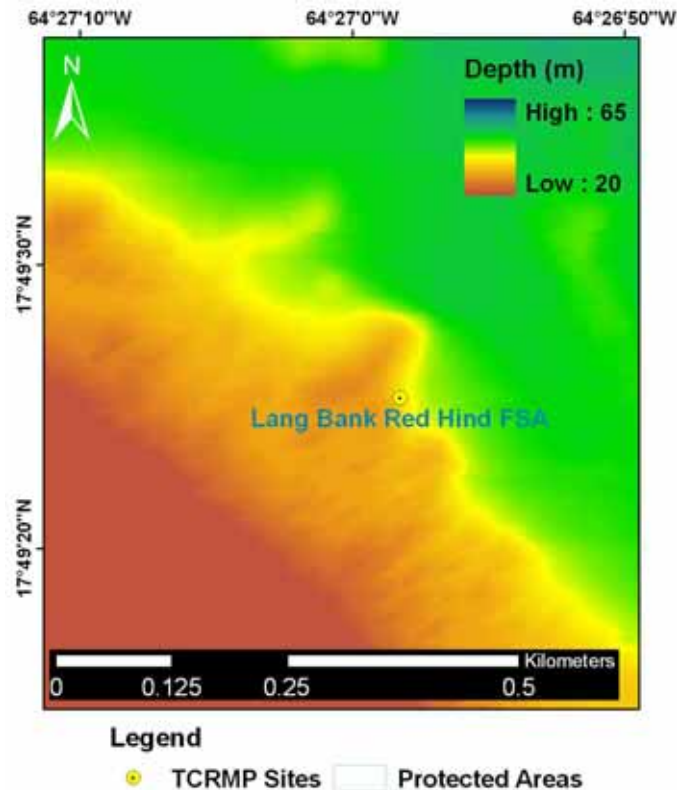
**Description.** The Lang Bank Red Hind Fish Spawning Aggregation (Lang Hind) monitoring site is a mesophotic reef of relict spur and groove structure at a depth of 30 – 35 m. The site is perched on the southeast side of the spur, which is a large finger that rises to 24 m to the west and drops on all other sides to a rhodolith/sand plain at about 50 m. Lang Hind was initially monitored in 2001 at a site on the shallower (24 m) portion of the bank to the west.

Monitoring in 2004-2007 occurred along random transects in a deeper portion of the reef (~33 m depth) and benthic transects were made permanent in this area in 2009

**Outstanding Feature.** Lang Hind supports an annual fish spawning aggregation of the red hind (*Epinephelus guttatus*). This site also possesses high water clarity and an abundance of fishes, including sharks.

**Threats.** The Lang Hind site is removed from land-based stressors. Fishing of the red hind aggregation was common prior to closure of the area to fishing in 1993. However, the aggregation is near the closure boundary.

**Figure 62. Lang Bank EEMP. (top) Location. (right) A representative photo of the reef.**



# LANG BANK RED HIND FSA

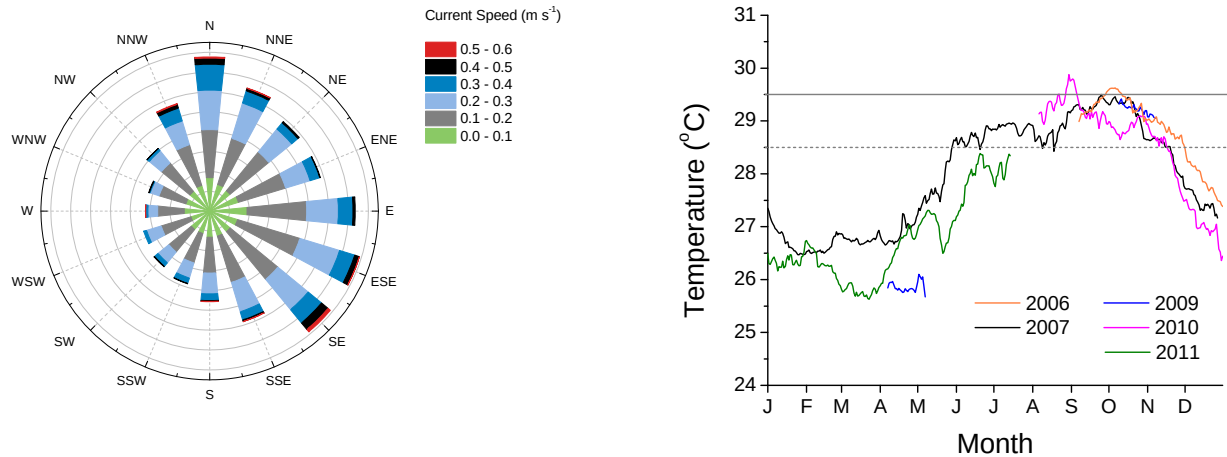


Figure 63. Lang Bank Hind current speed (left) and benthic temperature (right; 33m depth)

## Physical Characteristics

**Current.** Lang Hind had benthic currents recorded with ADCP every 30 minutes from 11/20/05 to 8/20/06, and 12/11/06 to 3/10/07. Bottom currents most typically alternate between north and southeast and can attain strong speeds periodically exceeding  $0.4\text{ m s}^{-1}$ .

**Temperature.** Lang Hind has temperatures that are reduced due to the deep depth and proximity of the warm season thermocline. However, temperatures are not as cool or variable as sites on the southern Puerto Rican shelf, indicating that this site may be more susceptible to warming ocean temperatures.

# SITE SUMMARIES

**Benthic Community.** Lang Hind has a diverse sessile epibenthic community dominated by hard corals, predominantly *Montastraea annularis* spp. complex, gorgonians and sponges. Coral cover actually increased by 110% between the coral bleaching event and re-monitoring in 2006, but this may reflect the fact that transects were laid in random, rather than permanent, locations prior to 2009. The algal community is largely open epilithic algal communities, but also contains large proportions of *Lobophora variegata* and filamentous cyanobacteria. The algal community shows high inter-annual variability.

**Coral Health.** Lang Hind was heavily affected during the 2005 coral bleaching event, with a very high prevalence of corals that were 100% bleached over the colony surface. Non-thermal bleaching with moderate prevalence and low extent on colonies also occurred in later years. The site was heavily affected with white diseases after the coral bleaching event and has had high disease prevalence in all years of monitoring. Old partial mortality jumped after the 2005 bleaching event and was variable in later years. Recent partial mortality is unusually high at Lang Hind, largely as the result of fish bites and predation by the corallivorous snail *Coralliophila* spp.

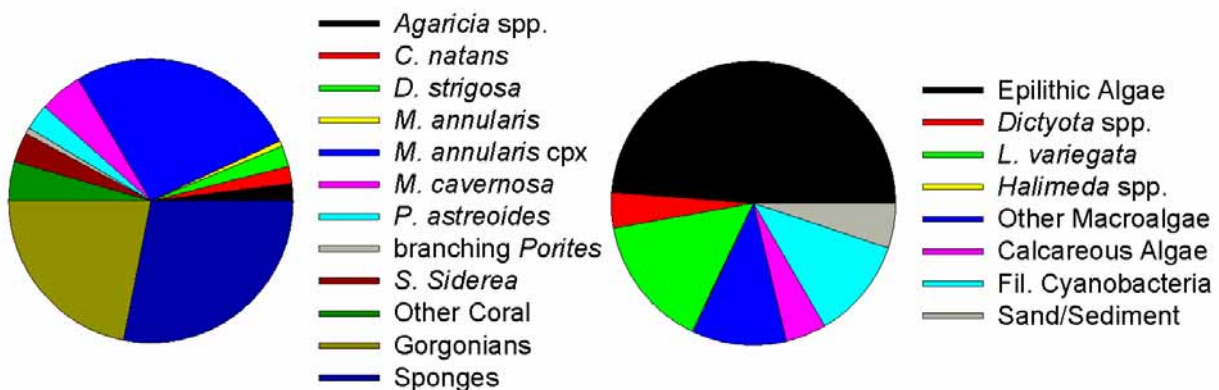


Figure 64. Lang Bank Red Hind FSA (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

# LANG BANK RED HIND FSA

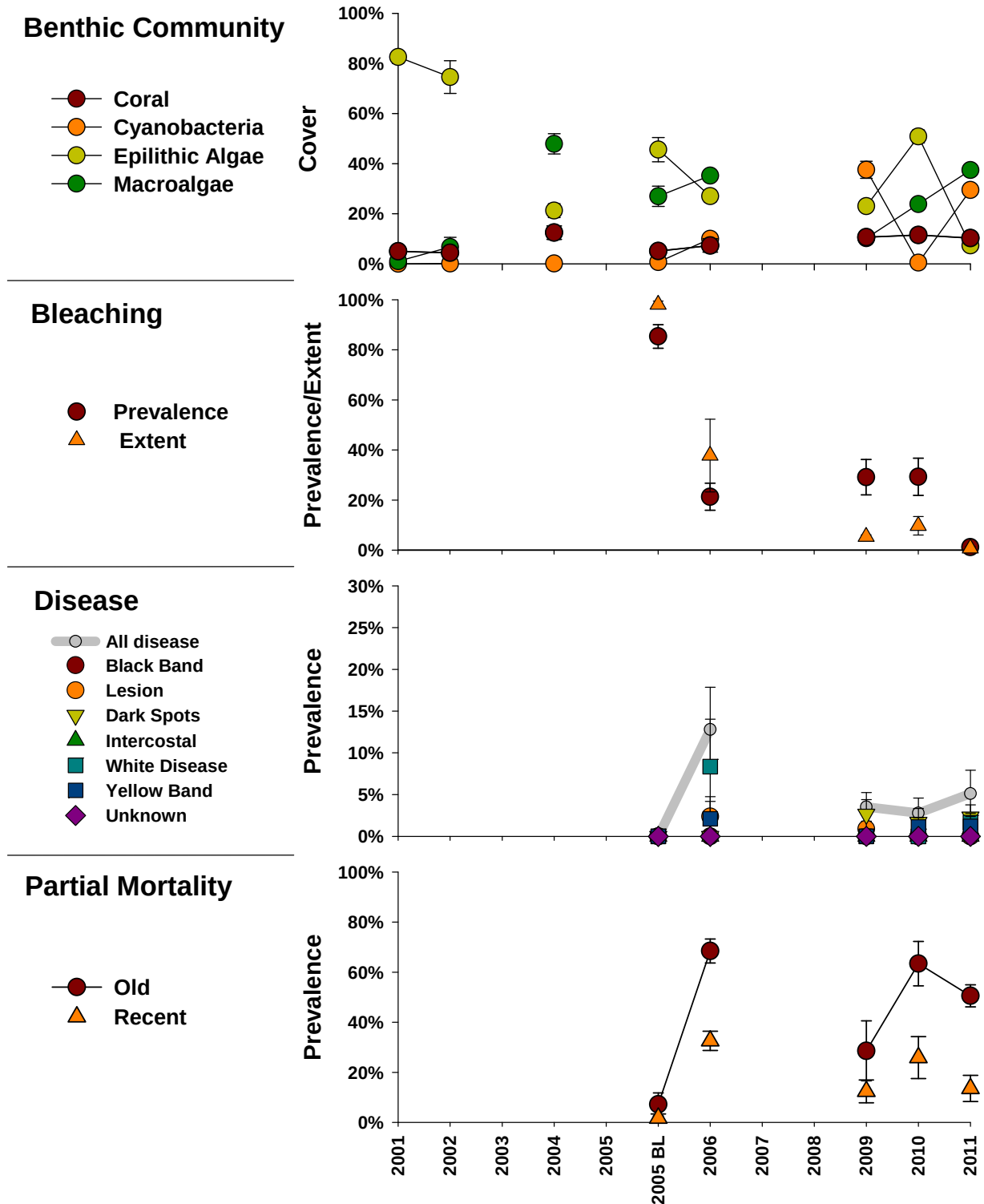


Figure 65. Lang Bank Red Hind FSA benthic cover and coral health through time (mean  $\pm$  SE).

## SITE SUMMARIES

**Fish Community.** The fish community at Lang Hind is indicative of a mesophotic reef system. High water column planktonic feeders are abundant and include the black surgeon wrasse, creole wrasse, yellowtail snapper and creolefish. Bicolor damselfish are numerous while herbivorous damselfishes uncommon. Benthic herbivores are relatively low in diversity, abundance and biomass compared to nearshore sites. Invertebrates are diverse and include many planktivores as well as benthic feeders, utilizing the varied resources of the bank. Four species of angelfish were observed during transects reflecting the high sponge cover. Lang Hind supports a red hind spawning site, active during December through February each year, and several red hind were observed in 2011 on both roving dives and transects. In addition one Nassau grouper was observed in 2011; a first observation across all St. Croix monitoring sites. There is reportedly a historic Nassau grouper spawning site near the Lang Hind monitoring site, and with the bank now closed to trap fishing there is hope of some re-establishment of the species on St. Croix. Mahogany snapper dominated piscivorous fish on Lang Hind. No other large groupers or snappers were observed although a Caribbean reef shark was seen. Sharks are commonly observed while diving the deep bank.

# LANG BANK RED HIND FSA

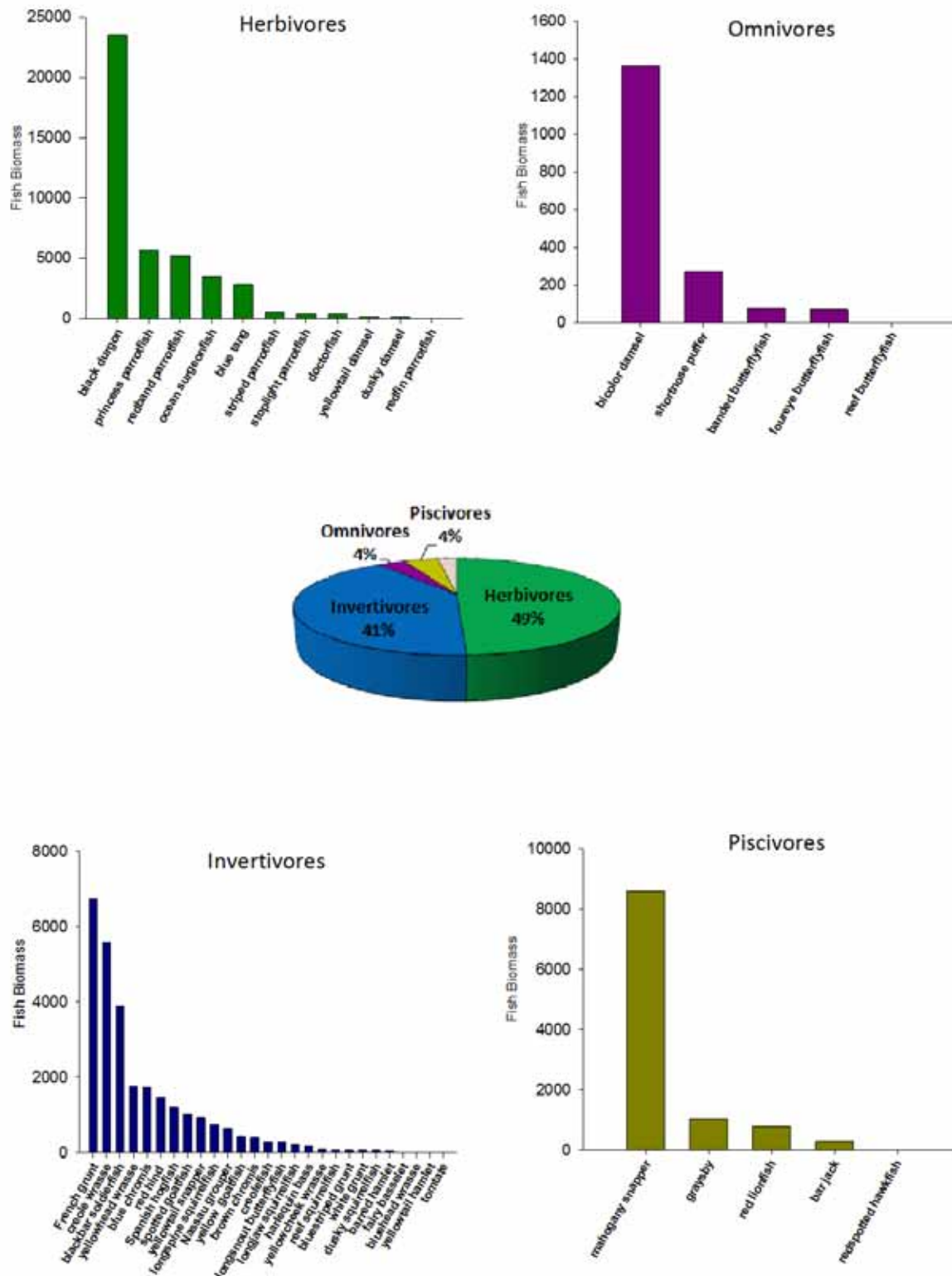


Figure 66. The Lang Bank Red Hind FSA fish community by absolute and relative biomass.

# SITE SUMMARIES

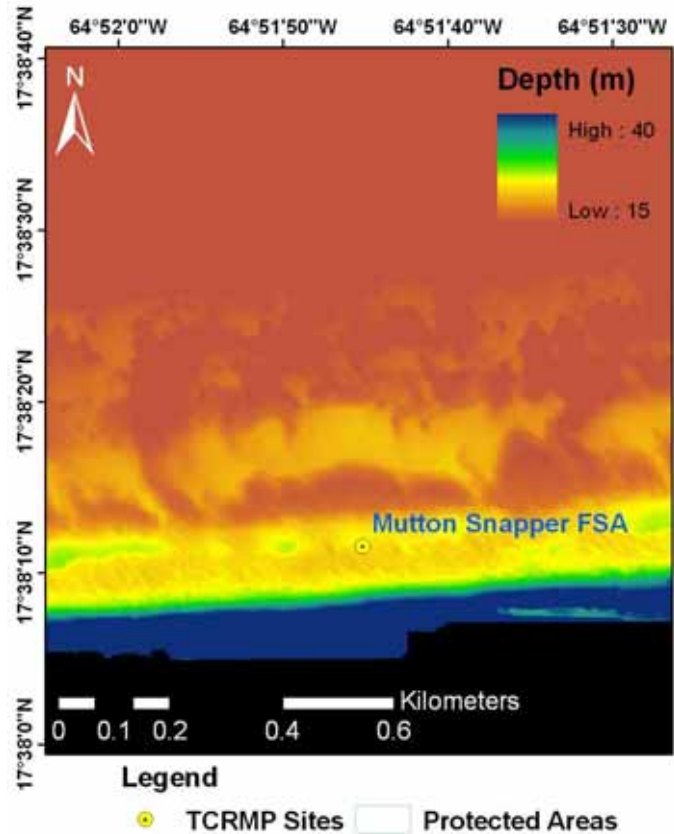
## MUTTON SNAPPER

**Description.** The Mutton Snapper site is located on the landward side of a shelf edge spur and groove reef on the southwest shelf of St Croix in depths of 22-24 m. The reef was dominated by boulder star coral (primarily *Montastraea franksi*) until a mass coral die-off following the 2005 bleaching event. Mutton Snapper has been monitored since 2003.

**Outstanding Feature.** The Mutton Snapper site was located in conjunction with the possible proximity of a mutton snapper (*Lutjanus analis*) spawning aggregation. It is seasonally closed to fishing. The site was devastated by the 2005 coral bleaching event, with a 87% drop in coral cover and a concomitant increase in algae.

**Threats.** The Mutton Snapper site is threatened by fishing pressure as evidenced by the abundance of fishing line and fishing trap debris. This site is offshore and less likely threatened by land-based stressors. The clear waters and warm temperatures make this site vulnerable to long-term seawater warming.

**Figure 67. Mutton Snapper. (top) Location. (right) A representative photo of the reef.**



# MUTTON SNAPPER

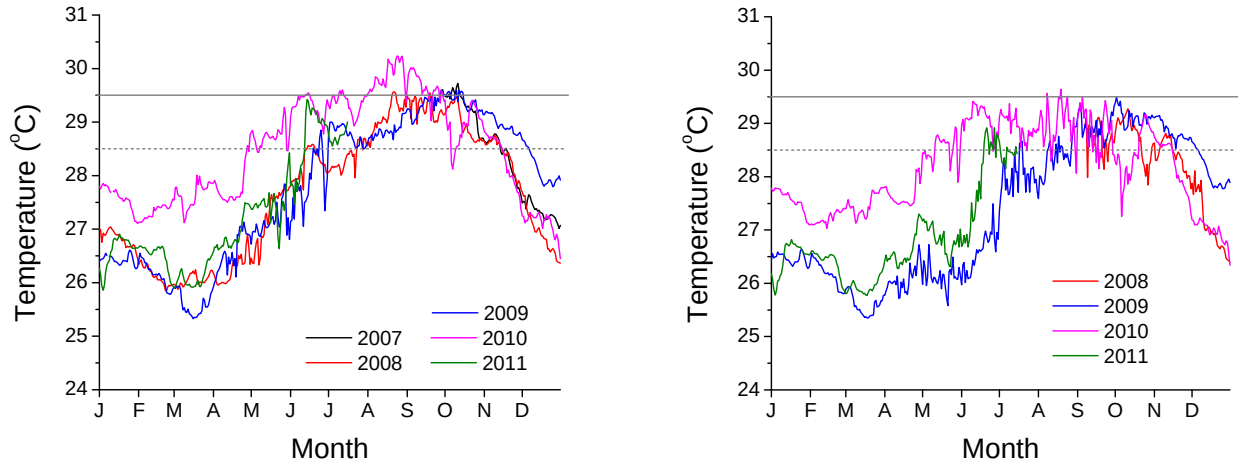


Figure 68. Mutton Snapper benthic temperature record at 23 m (left) and 39 m depth (right).

## Physical Characteristics.

**Current.** Current records have not been taken at Mutton Snapper. There seems to be little wave-driven oscillatory flow. There are often strong unidirectional currents in a westward direction that penetrate to near bottom.

**Temperature.** Benthic temperatures at the Mutton Snapper site (23 m) show warming above the bleaching threshold during the 2010 bleaching event, whereas benthic temperatures just off-shelf from the site (40 m) show few excursions above the bleaching threshold.

# SITE SUMMARIES

**Benthic Community.** The Mutton Snapper site sessile epibenthic animal community is dominated the boulder star coral (*Montastraea annularis* spp. complex), with sub-dominance of sponges. This site lost an extreme amount of coral cover (87.0%) in the 2005 coral bleaching event and has not regained any cover (-2.3%) as of 2011. *Lobophora variegata*, epilithic algae, and filamentous cyanobacteria dominate the algal community. Apparent is the rise in the abundance of macroalgae and filamentous cyanobacteria after 2005. Filamentous cyanobacteria reached extreme cover values (57.7%) in 2009. Current levels of herbivory no longer appear able to control algal abundance.

**Coral Health.** Mutton Snapper bleached heavily in the 2005, with 100% of corals bleaching over 90% of the colony surface. Bleaching prevalence has remained high for most years since 2005, but at low colony extent, indicating continued impairment of corals. White disease has been at consistently high values through many years of monitoring. Old partial mortality increased after 2005, and then subsided as whole colonies were lost from the system. Impairment of this site is puzzling as stressors besides fishing appear to be low. Clear water and low genetic diversity of corals may increase susceptibility to environmental stress and white disease.

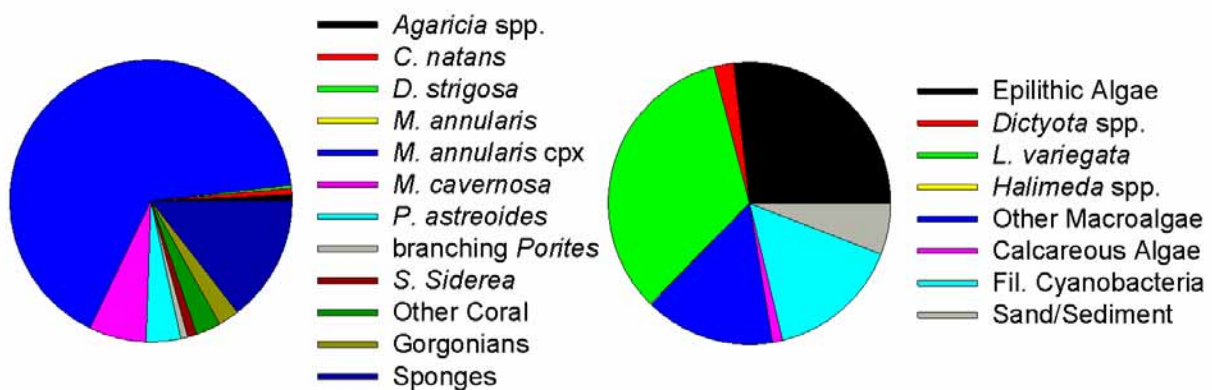
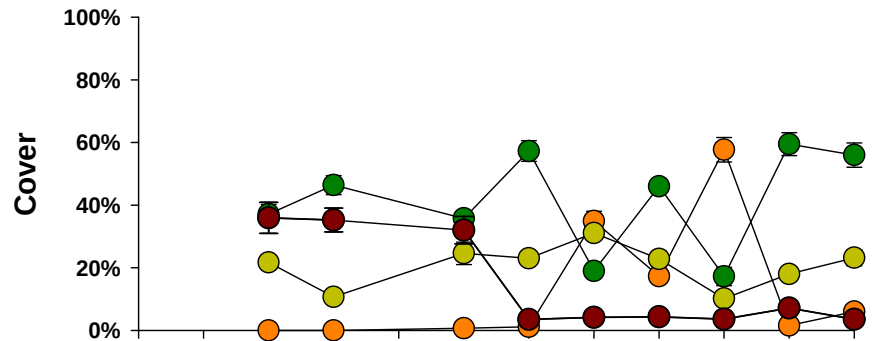


Figure 69. Mutton Snapper (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

# MUTTON SNAPPER

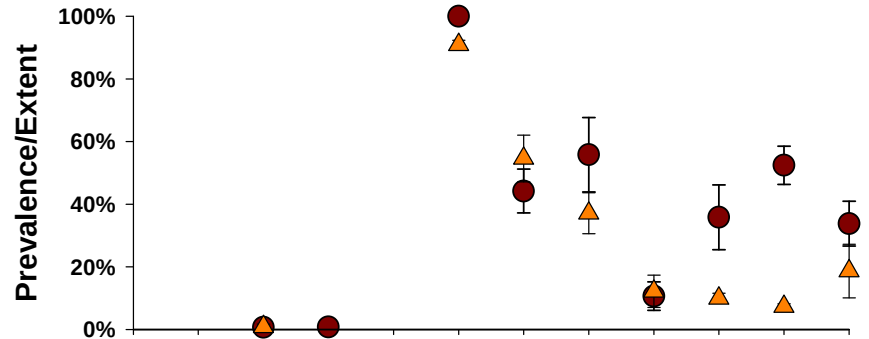
## Benthic Community

- Coral
- Cyanobacteria
- Epilithic Algae
- Macroalgae



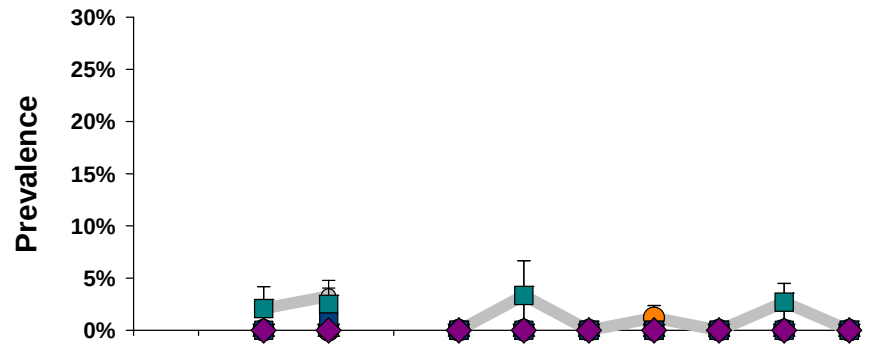
## Bleaching

- Prevalence
- ▲ Extent



## Disease

- All disease
- Black Band
- Lesion
- ▼ Dark Spots
- ▲ Intercostal
- White Disease
- Yellow Band
- ◆ Unknown



## Partial Mortality

- Old
- ▲ Recent

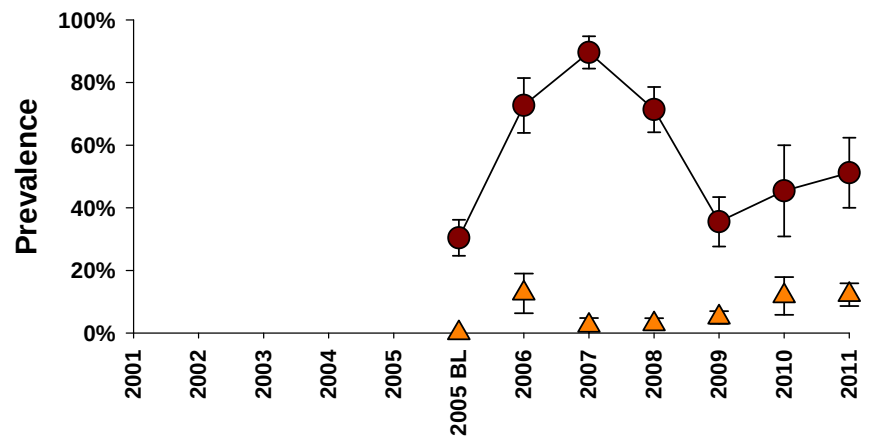


Figure 70. Mutton Snapper benthic cover and coral health through time (mean  $\pm$  SE).

## SITE SUMMARIES

**Fish Community.** The Mutton Snapper site is an offshelf site with a fairly diverse and rich fish community. It is reportedly in an area that mutton snapper spawn, however mutton snapper have been very rare in surveys conducted at the site over the past 4 years. Mutton Snapper is very highly dominated in biomass by the black durgon, a phytoplankton feeder, and numerically dominated by the creole wrasse, a zooplankton feeder. Princess parrotfish and ocean surgeonfish contribute most biomass to the benthic herbivore group, and although several parrotfish species can be found on the reef, sub-adult and juveniles are by far the majority encountered. The invertivore group is diverse, indicative of the variety of resources available on the reef. Queen trigger are fairly common. Piscivores are not common on Mutton Snapper. In 2011 the group was dominated on transects numerically by the graysby, and in biomass by a singular medium sized barracuda. One red hind was observed on Mutton Snapper in 2011, however no other groupers were encountered, and no large snappers.

# MUTTON SNAPPER

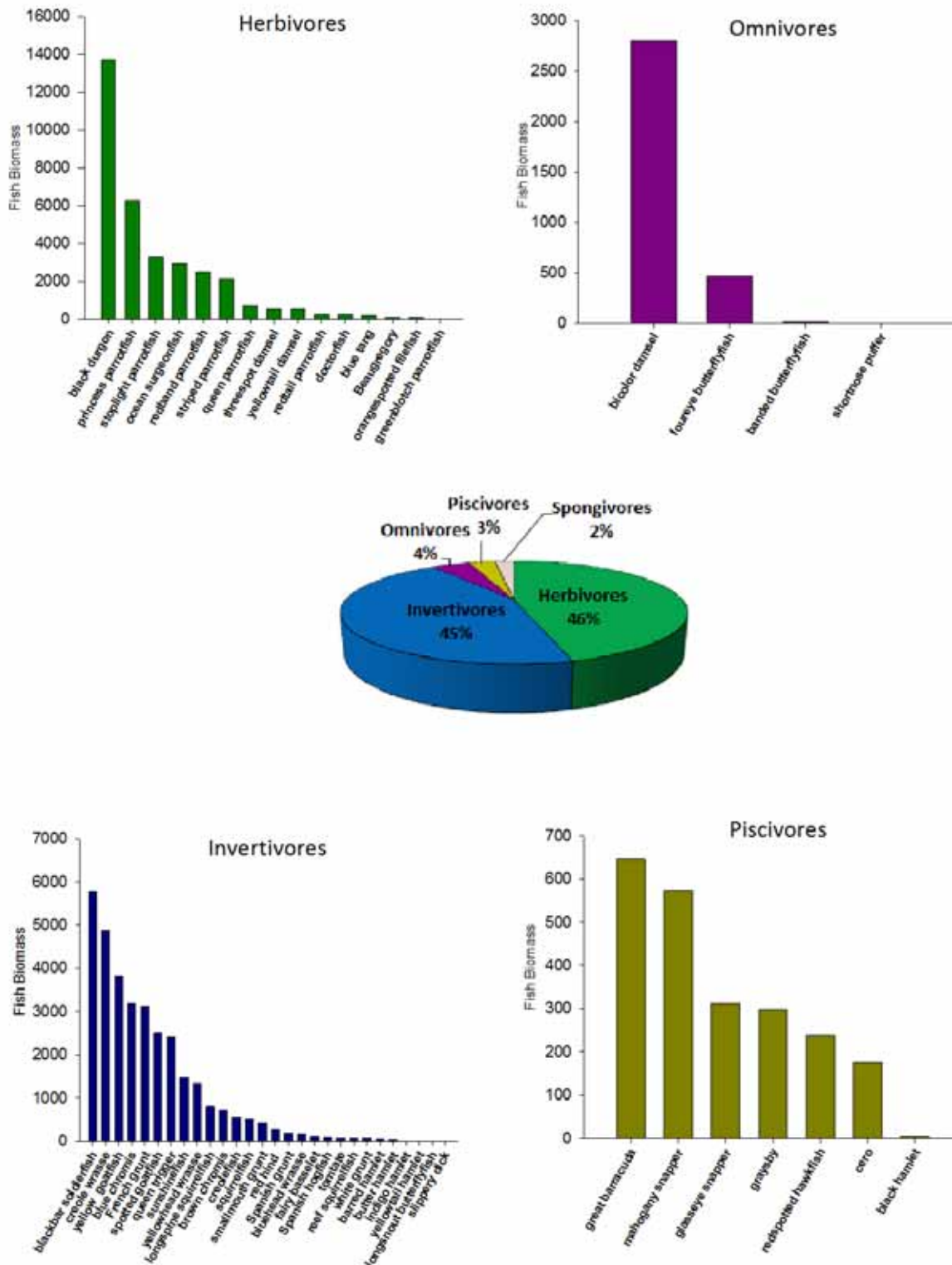


Figure 71. The Mutton Snapper fish community by absolute and relative biomass.

# SITE SUMMARIES

## SALT RIVER WEST

**Description.** Salt River West lies just atop the Salt River Canyon west wall in a depth of 9 m. The reef is a flat colonized hardbottom/coral community atop ancient carbonates. Salt River West has been monitored since 2001.

**Outstanding Feature.** Salt River West is a popular tourist dive site with a unique sharp drop to the wall environment.

**Threats.** Salt River West is exposed to the outflow from the Salt River Canyon and resuspension of sediment from the Salt River eastern flats. The site is now within in the Salt River National Historic Park and Ecological Preserve.

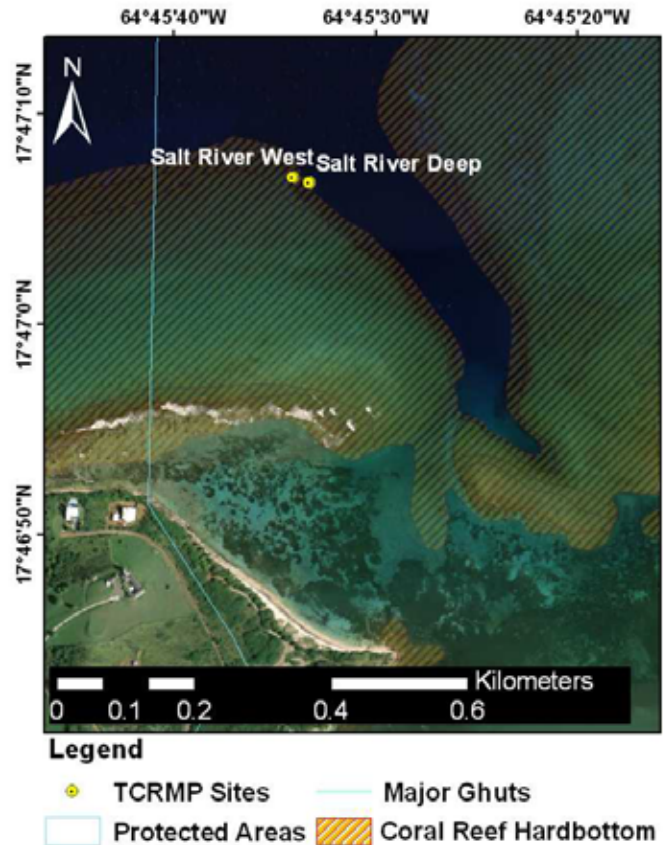


Figure 72. Salt River. (top) Location. (right) A representative photo of the reef.

# SALT RIVER WEST

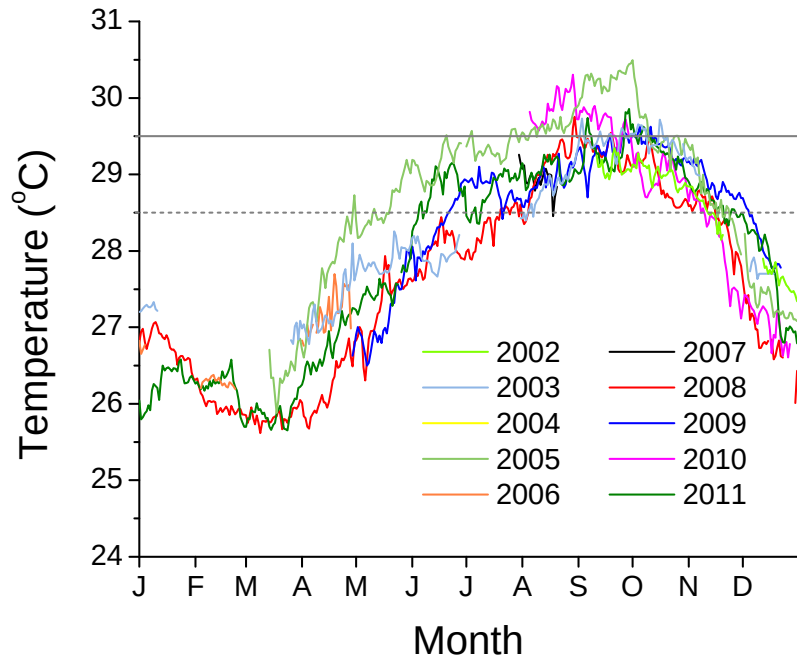


Figure 73. Salt River West surface-benthic temperature record (1 and 5m depths). Data provided by the NOAA ICON monitoring network.

## Physical Characteristics.

**Current.** Currents have not been directly measured by the TCRMP. Due to the northern exposure and shallow depth, Salt River West experiences wave-driven oscillatory flow, which can be strong. Unidirectional benthic currents are typically weak to moderate ( $<15\text{cm s}^{-1}$ ).

**Temperature.** The temperature at Salt River West can be very warm and in 2005 surpassed the bleaching threshold ( $29.5^{\circ}\text{C}$ ) for approximately 2.5 months between August and October. The record also shows how 2010 was actually warmer than 2005 until the passage of Hurricane Earl in late August dropped temperatures precipitously.

# SITE SUMMARIES

**Benthic Community.** The Salt River West epibenthic sessile animal community has a diverse hard coral community of small massive head corals and large proportions of sponges and gorgonians. The site lost an imperceptible amount of coral cover in the 2005 coral bleaching event (-13.6%) and had regained nearly half of that cover by 2011 (37.1%). The algal community shows extreme dominance by epilithic algae and low abundance of macroalgae and filamentous cyanobacteria. However, filamentous cyanobacteria have increased slightly since 2005.

**Coral Health.** Corals were severely bleached during the 2005 coral bleaching event, with over 90% of corals bleached over 80% of the colony surface. Corals were assessed just prior to the 2010 bleaching event in August, but were showing increased prevalence of low colony extent bleaching by then. Diseases are typically low, with the outstanding case of dark spots disease, which attains some of the highest values seen in TCRMP sites. Of note, is the fact that dark spots disease actually decreased following severe bleaching and recovery in 2005 and 2006. Old partial mortality increased rapidly after the 2005 bleaching and then subsided somewhat by 2011. Recent partial mortality can be high and is primarily caused by fish biting, such as from parrotfish. However, extent is quite low (data not shown).



Figure 74. Salt River West (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

# SALT RIVER WEST

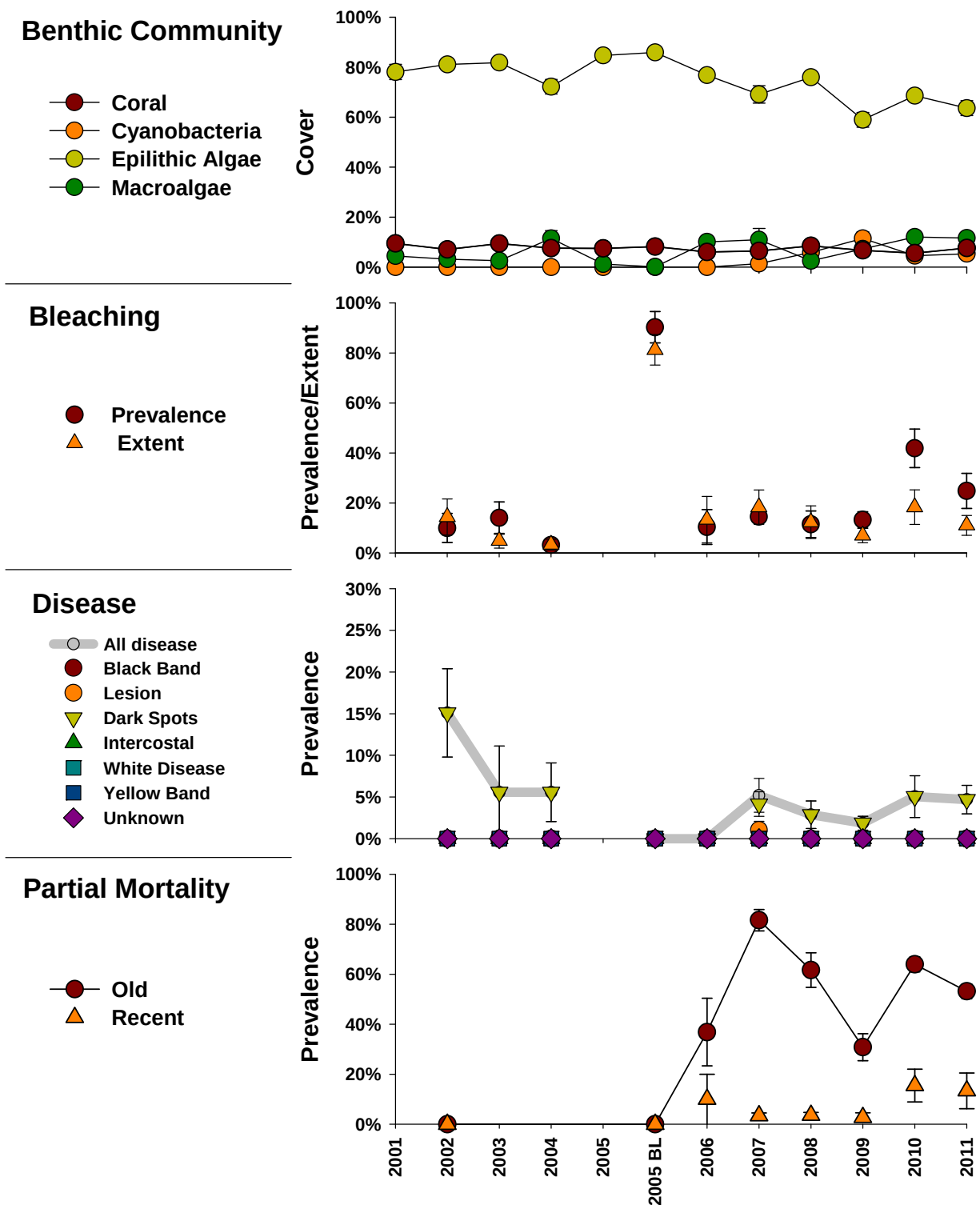


Figure 75. Salt River West benthic cover and coral health through time (mean  $\pm$  SE).

## SITE SUMMARIES

**Fish Community.** Fish biomass is relatively low on the Salt River West site, and species composition includes primarily small fishes and juveniles of the larger species. Larger fishes can be seen closer to the edge of the site, near the Salt River wall, however the top of the reef has little structure for larger fishes, with low lying coral heads, gorgonians and sponges. Numerically the most dominant species is the bluehead wrasse, followed closely by bicolor damselfish. These two species made up 67% of the numeric total of fish on Salt River West in 2011. Ocean surgeonfish dominated the site in biomass, followed by princess parrotfish, blue tang, doctorfish and redband parrotfish. This dominance by benthic herbivores is consistent with characteristics for nearshore coral reef. Piscivores were dominated in both biomass and number by the graysby. Other groupers were observed on the roving dives, including two red hind and several coney. One mutton snapper was encountered on a belt transect, however no other large snappers were observed in either belt transects or roving dives.

# SALT RIVER WEST

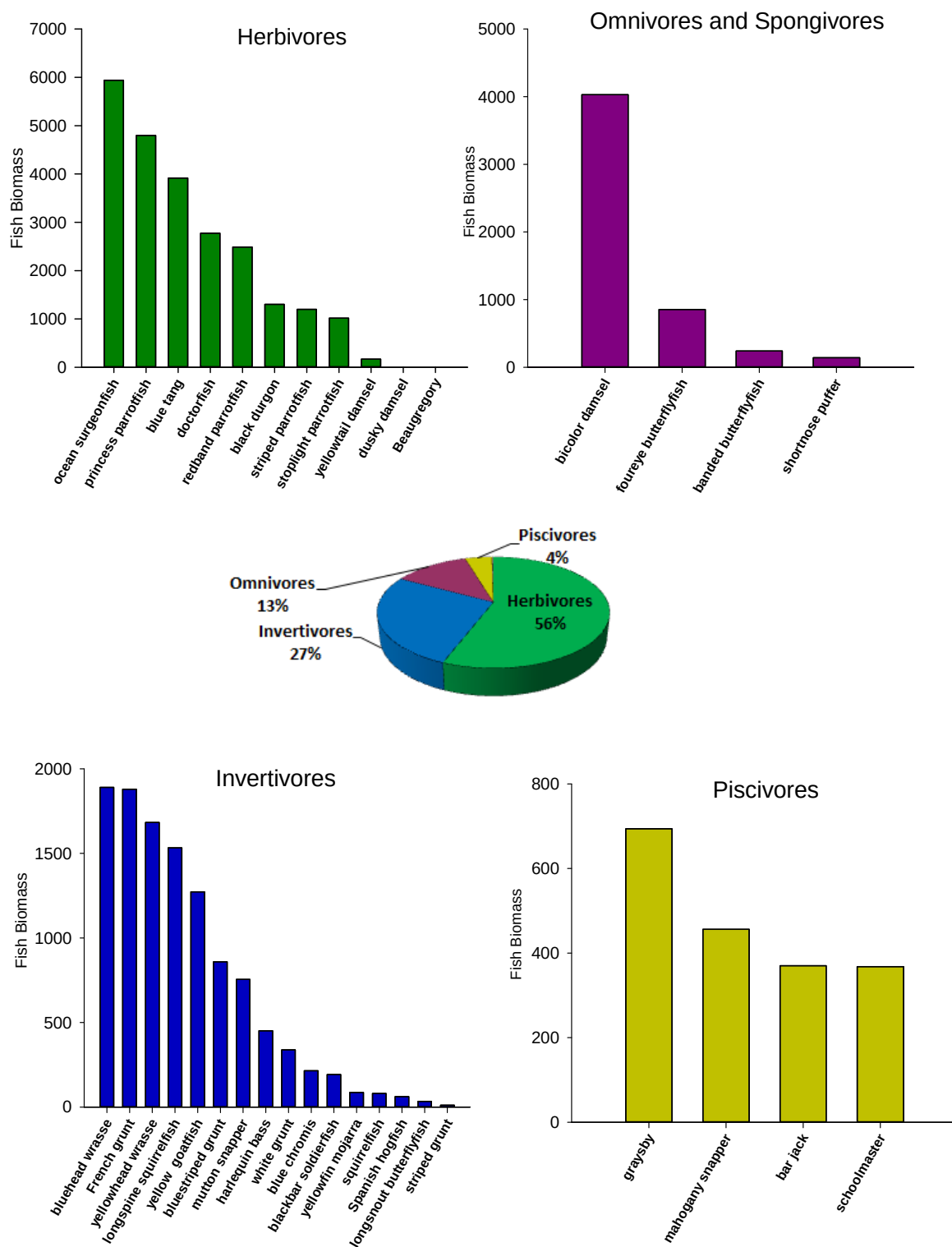


Figure 76. The Salt River West fish community by absolute and relative biomass.

# SITE SUMMARIES

## SALT RIVER DEEP

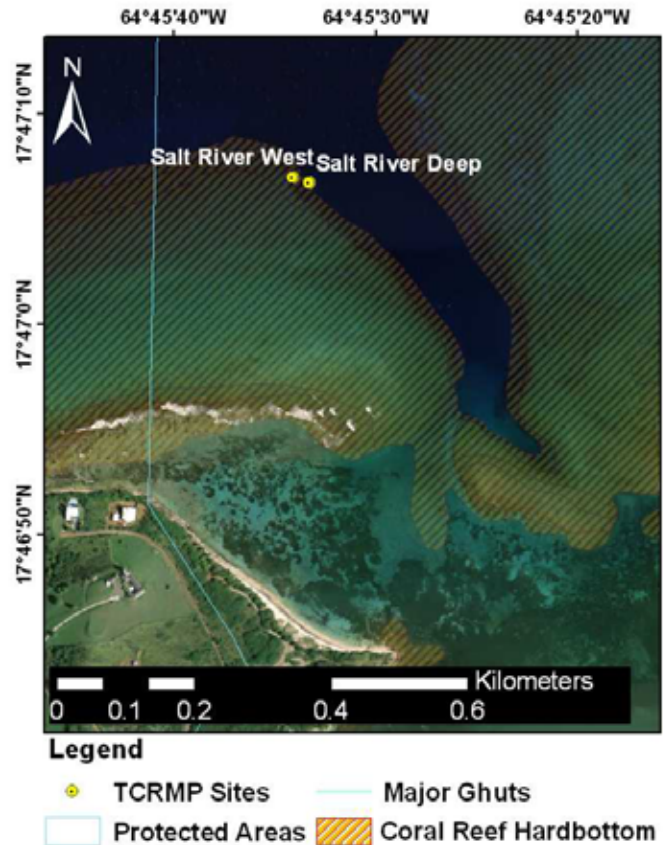
**Description.** The Salt River Deep site is located on the steep canyon wall just below the Salt River West monitoring site. The reef consists of vertical buttresses surrounded by extensive sand deposits. The reef is largely formed of plating coral at these deep, mesophotic depths. The initial site was deployed in 2009 with two transects at 30 m depth and 4 transects at 40 m. Due to low coral cover at 40 m transects were moved to 30m in 2010.

**Outstanding Feature.** Salt River Deep is a heavily visited recreational dive site.

The site has been under scientific investigation since the 1970's. The underwater HYDROLAB habitat was maintained near the site from 1977 to 1985 and the Aquarius habitat from 1986 to 1989.

**Threats.** Salt River Deep is threatened by land-based sources of pollution due to its proximity to the Salt River Canyon outflow. The site may also be susceptible to warming temperatures.

**Figure 77. Salt River Deep. (top) Location. (right) A representative photo of the reef.**



# SALT RIVER DEEP

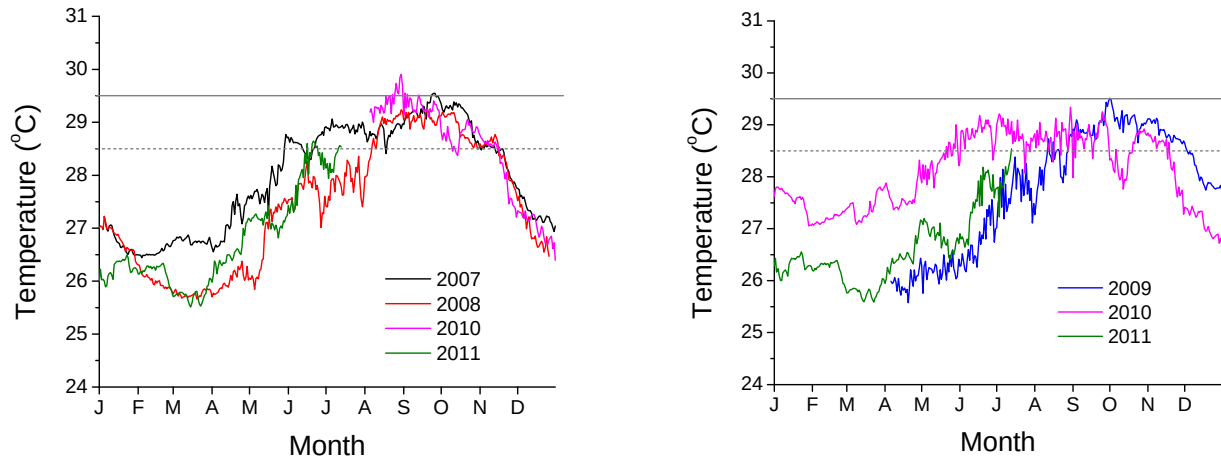


Figure 78. Salt River Deep benthic temperature at 30 m depth (left) and 40 m depth (right).

## Physical Characteristics.

**Current.** Salt River deep currents have not been measured directly by the TCRMP. Only very weak oscillatory and unidirectional currents have been experienced at the site.

**Temperature.** Temperatures on the wall have been measured at two depth levels at 30m and 40m. Both sites have temperatures that are much cooler than the shallow site. The 40m site experiences even greater cooling and experiences more diel variability (not shown) and day-to-day variability due to the influence of internal waves. Despite some interaction with the thermocline, cooling is not as great as at the mesophotic reefs at similar depths on the southern Puerto Rican Shelf.

# SITE SUMMARIES

**Benthic Community.** Hard coral community of the Salt River Deep monitoring site is dominated by plating lettuce corals (*Agaricia* spp.); however, sponges, gorgonians, and black corals dominate the overall sessile epibenthic animal community. The site was not monitored during the 2005 bleaching event, but as with the Cane Bay Deep site, severe bleaching was observed down to depths of 40m. The algal community is dominated by epilithic algae and unidentified diminutive macroalgae. The site is notable for the high composition of sediment, which cascades from the upper reef between spurs and buttresses.

**Coral Health.** Low extent coral bleaching is typically in moderate to high prevalence at the Salt River Deep site. Interaction data (not shown) indicates that sediment and *Lobophora variegata* overgrowth are responsible for much of the bleaching. Diseases have not been observed. Old partial mortality is high on corals, which may be a reflection of the 2005 bleaching event and cumulative impacts from interaction with sediment and algae.

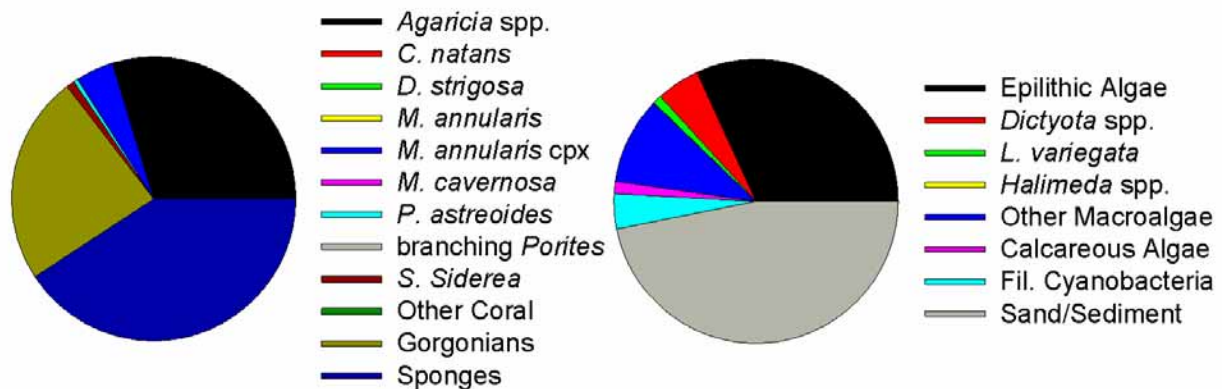


Figure 79. Salt River Deep (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

# SALT RIVER DEEP

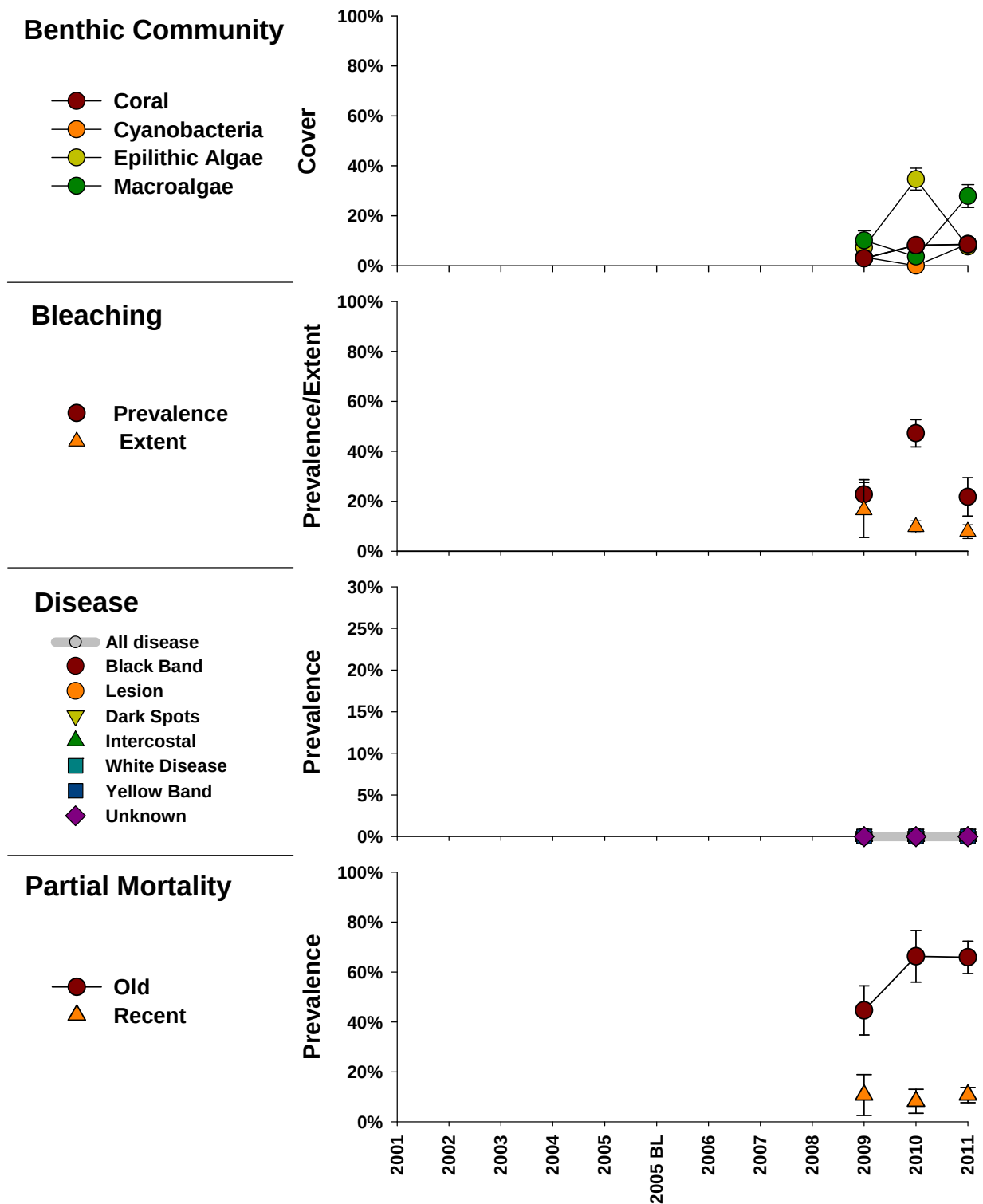


Figure 80. Salt River Deep benthic cover and coral health through time (mean  $\pm$  SE).

## SITE SUMMARIES

**Fish Community.** The relatively high turbidity and high composition of sand and silt bottom, as a consequence of river discharge, influences the fish community of Salt River Deep. The mesophotic reef wall site is characterized by a primarily invertivore fish community, leading in both biomass and species richness. Invertivores are dominated numerically by the functionally plantivorous blue chromis and creole wrasse. The benthic feeding goatfish, both yellow and spotted, as well as three grunts (black margate, tomtate and French grunt) contribute significantly to fish biomass. Piscivores are dominated numerically by mahogany and schoolmaster snapper, and herbivores by adult and sub-adult princess and redband parrotfish. Juvenile parrotfish are very uncommon, and large parrotfish absent. Characteristic deepwater fishes observed commonly on Salt Water Deep include the sunshinefish, bantum bass, fairy basslet and longsnout butterflyfish. As on the Cane Bay Deep site, occasional cubera snapper (*Lutjanus cyanopterus*), mutton snapper (*L. analis*) or southern stingrays (*Dasyatis americana*) are observed during roving dives on the wall, and commonly one or two Caribbean reef sharks (*Carcharhinus perezii*) are present.

# SALT RIVER DEEP

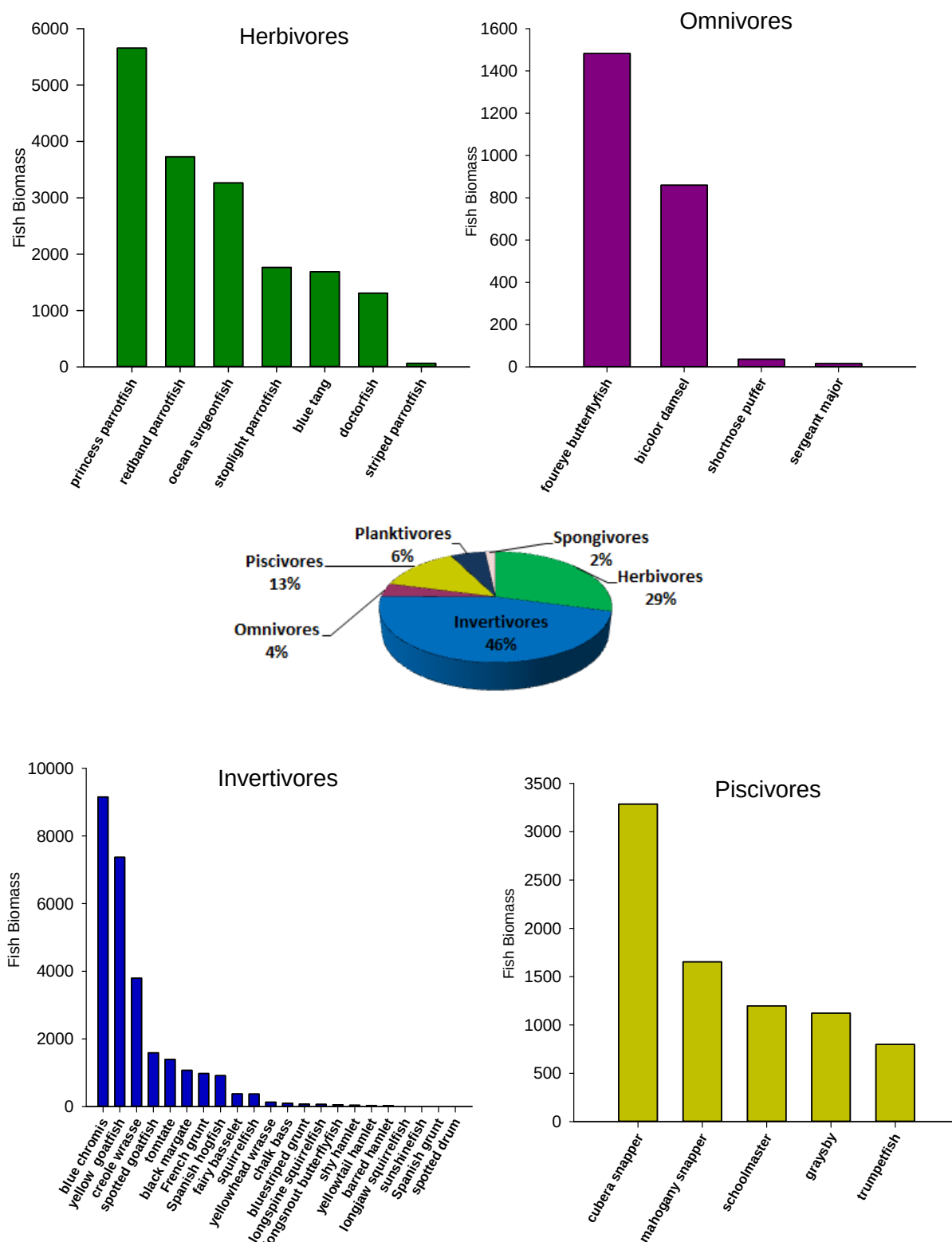


Figure 81. The Salt River Deep fish community by absolute and relative biomass.

# SITE SUMMARIES

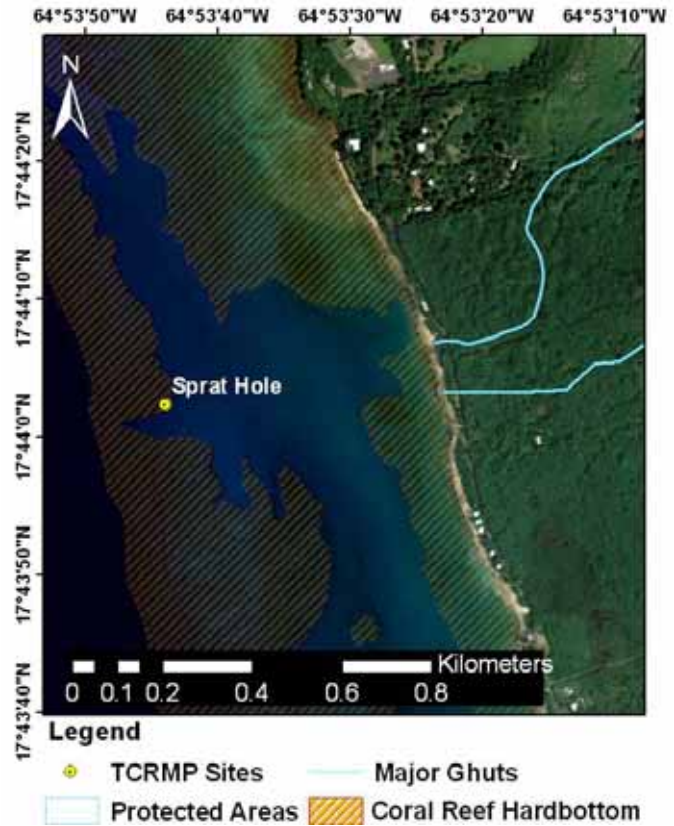
## SPRAT HOLE

**Description.** The Sprat Hole site is a nearshore/shelf-edge fringing reef in depths of 7 – 10 m. The site is a rolling boulder star coral (*Montastraea annularis*) reef. The slope to the west drops off to an attractive mixed coral community with abundant fish. Sprat Hole has been monitored since 2001.

**Outstanding Feature.** Sprat Hole is a heavily visited reef for snorkel and dive tours.

**Threats.** The Sprat Hole reef is vulnerable to land based sources of pollution if there is increased development of the watershed. Low wave action and light currents favor settling of small particles of terrestrial sediment that injure corals. The site is also frequently fished and there is derelict fishing gear in abundance. Recreational overuse may also be a threat.

**Figure 82. Sprat Hole. (top) Location. (right) A representative photo of the reef.**



# SPRAT HOLE

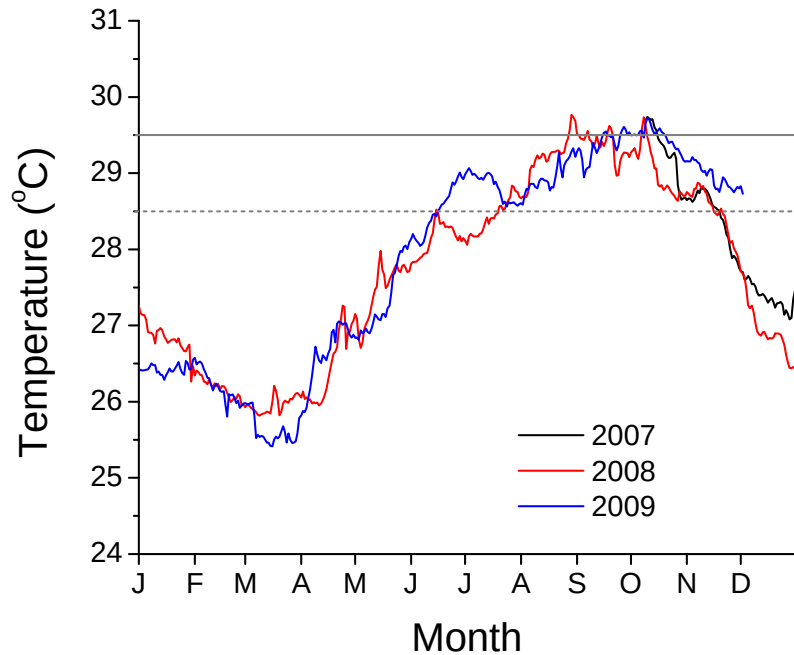


Figure 83. Sprat Hole benthic temperature (7 m depth).

## Physical Characteristics.

**Current.** Currents have not been measured at Sprat Hole. Oscillatory currents are typically weak on the western lee of St. Croix. Unidirectional currents during monitoring have always been weak ( $<10\text{cm s}^{-1}$ ).

**Temperature.** Sprat Hole temperature has not been monitored over many years due to loss of probes. This is likely due to the high exposure to recreational and commercial fishing divers. In general Sprat Hole appears to be a warm site.

# SITE SUMMARIES

**Benthic Community.** Sprat Hole is a fringing *Montastraea annularis* dominated reef, with a good diversity of other coral species. There was a 62.3% decline in coral cover due to the 2005 coral bleaching event, with a regain of 11.9% of cover by 2011. Epilithic algae dominate the algal community, with smaller amounts of a diverse group of macroalgae, including *Dictyota* spp. and *Halimeda* spp. There has variable, but increasing cover of filamentous cyanobacteria since 2005.

**Coral Health.** The coral community at Sprat Hole was heavily affected during the 2005 coral bleaching event, with a high prevalence of bleaching at a very high extent. Bleaching prevalence has tended to be higher since the event. Disease prevalence can be quite high, particularly for white disease. Dark spots disease has also been in high prevalence in certain years. Old partial mortality was high on colonies from 2005 to 2011, and low when recorded in 2002. In this case, old partial mortality is a very common feature of *M. annularis* and it is likely that low values are due to a observer bias and a different method for estimating partial mortality. Recent partial mortality is consistently very high at Sprat Hole and this is due in large part to the high abundance of territorial damselfish (*Stegastes* spp.) forming algal lawns on *M. annularis*.

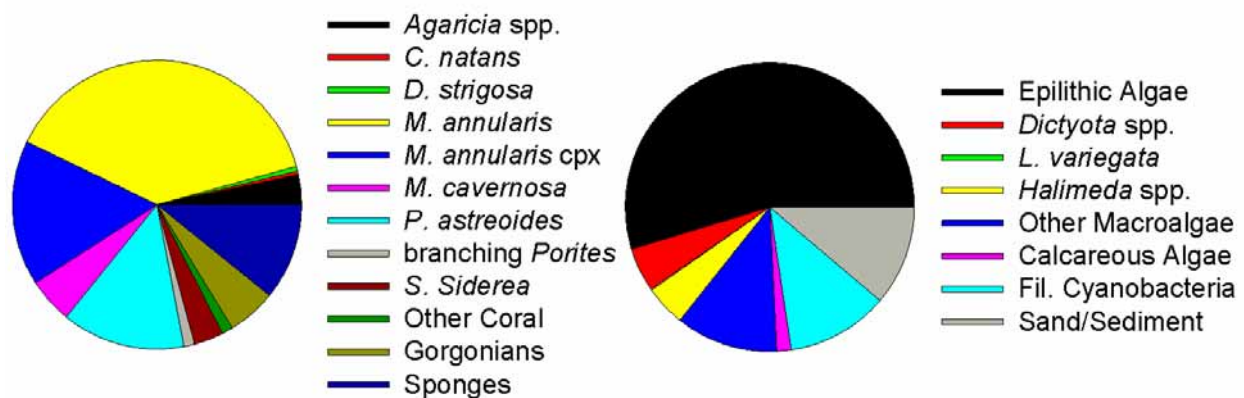
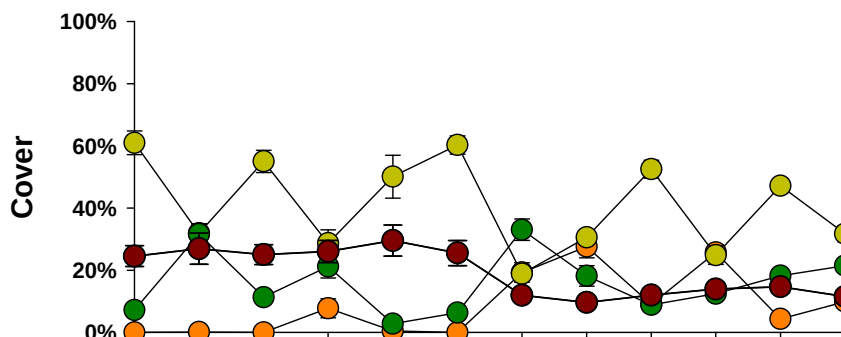


Figure 84. Sprat Hole (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

# SPRAT HOLE

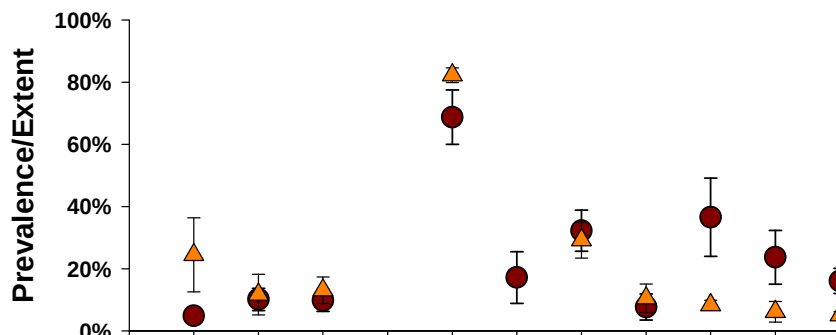
## Benthic Community

- Coral
- Cyanobacteria
- Epilithic Algae
- Macroalgae



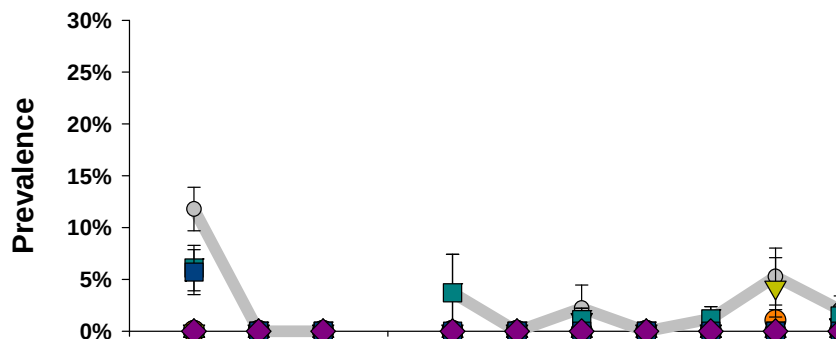
## Bleaching

- Prevalence
- ▲ Extent



## Disease

- All disease
- Black Band
- Lesion
- ▼ Dark Spots
- ▲ Intercostal
- White Disease
- Yellow Band
- ◆ Unknown



## Partial Mortality

- Old
- ▲ Recent

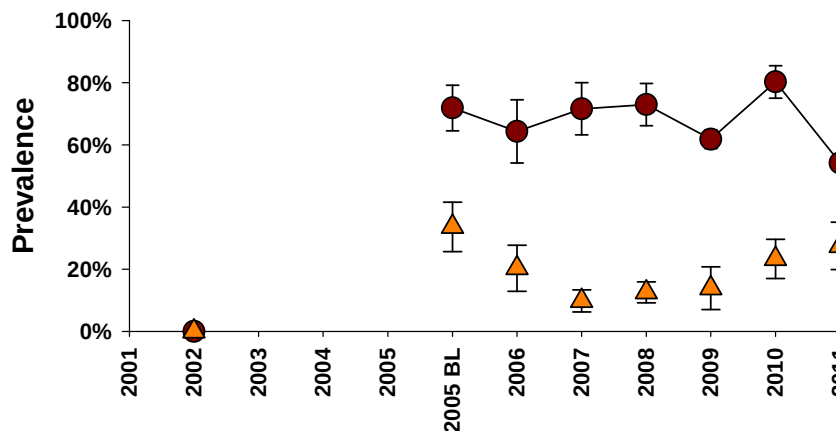


Figure 85. Sprat Hole benthic cover and coral health through time (mean  $\pm$  SE).

## SITE SUMMARIES

**Fish Community.** Sprat Hole exhibits a fairly typical fish community structure for nearshore coral reef ecosystem receiving moderate amounts of terrestrial runoff from the watershed. Fish biomass is moderate, and the site is dramatically dominated both numerically and in biomass by the blue chromis, a planktivorous invertivore. Benthic herbivores are common and include small parrotfish and all three acanthurid species (doctorfish). Invertivores are more diverse and include both planktivores and benthic feeders, mostly in small numbers. Numerically the piscivores were dominated by the mahogany snapper; however one cubera snapper was observed on a transect. Schoolmaster snapper and graysby were also common on the reef and two red hind were observed on the roving dives.

# SPRAT HOLE

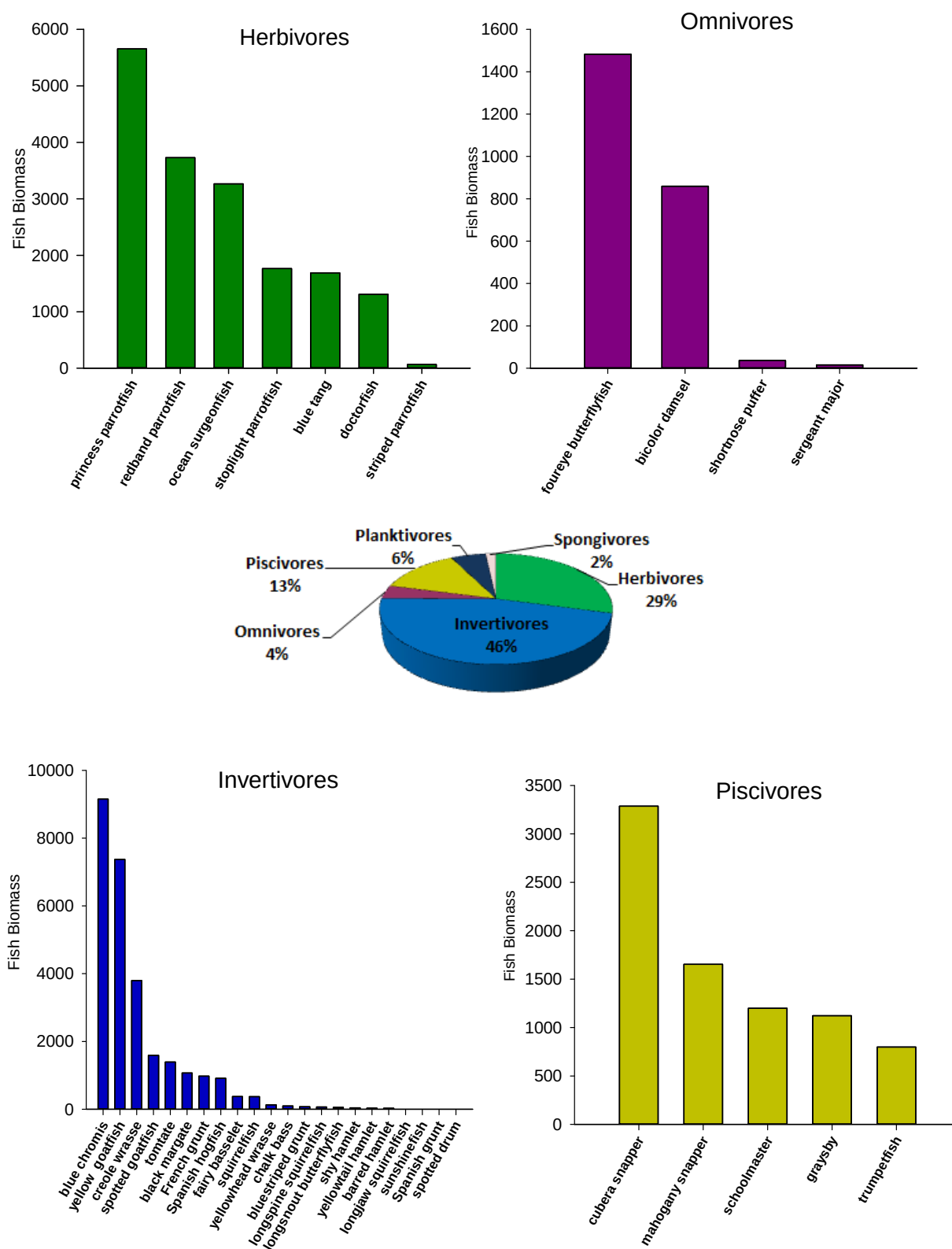


Figure 86. The Sprat Hole fish community by absolute and relative biomass.

### St. John



# SITE SUMMARIES

## CORAL BAY

**Description.** The Coral Bay site is atop a patch reef complex at the southeast mouth of Coral Harbor. The reef is a low carbonate build up with high coral diversity. Black Point appears to be a true reef with a well-developed carbonate framework over bedrock. Coral Bay monitoring was initiated in 2011 with two sampling periods.

**Outstanding Feature.** Coral Bay supports a high diversity of coral and an apparent high rate of coral recruitment.

**Threats.** Coral Bay is subject to land-based sources of pollution, primarily as sediment influx from the large and steep Coral Bay watershed. Recent restoration activities in the watershed are expected to decrease the sediment influx. Coral Bay may also be threatened by maritime activities within Coral Harbor. Proximity to land makes this site in territorial waters potentially vulnerable to fishing.

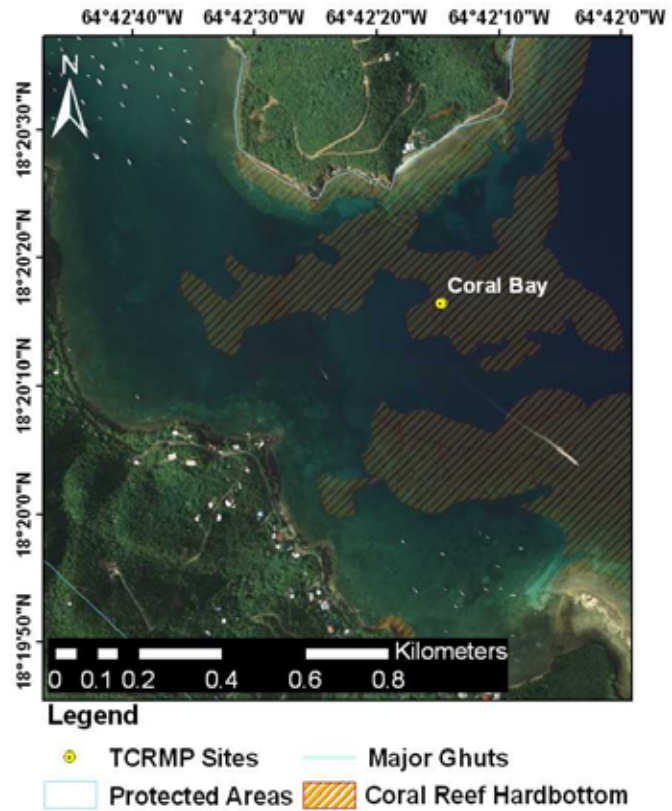
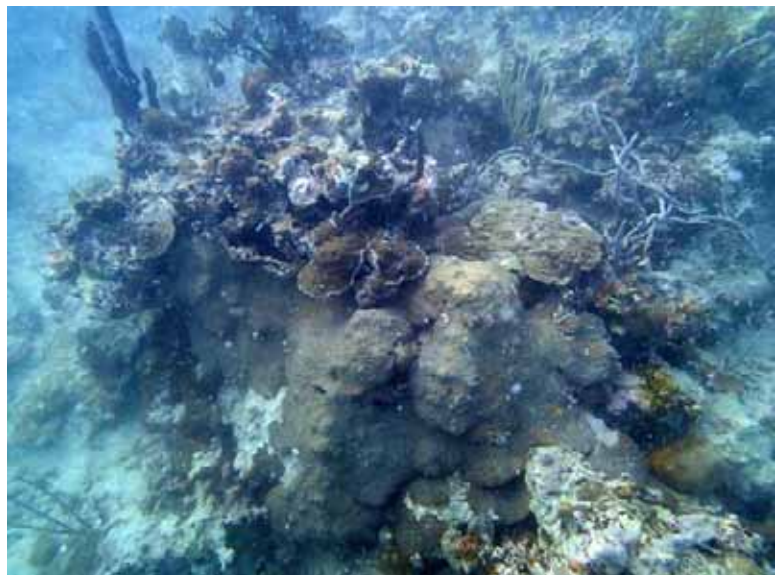


**Figure 87. Coral Bay. (top) Location. (right) A representative photo of the reef.**



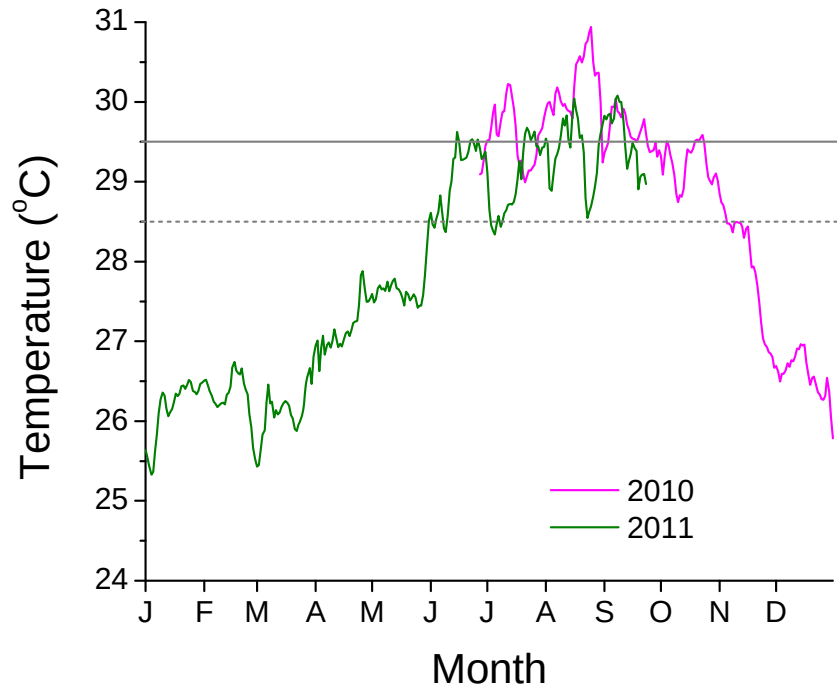


Figure 88. Coral Bay benthic temperature (9 m depth)

## Physical Characteristics.

**Current.** Currents have not been measured by the TCRMP, however, Dr. Sarah Gray (University of San Diego) has measured 2-D near bottom measurements for some years between 2009-2011. Oscillatory currents are expected to be light and only weak unidirectional currents have been experienced.

**Temperature.** Coral Bay may have restricted water circulation and had very high temperatures during the 2010 bleaching event.

**Other.** This site and the wider Coral Bay area have been under investigation for land-based sources of pollution impacts since 2009. Projects have been involved terrestrial sediment measurement/modeling, marine sediment flux, coral demographic plots, and biological monitoring. The area has also been involved in water quality monitoring.

# SITE SUMMARIES

**Benthic Community.** Coral Bay has a very diverse coral community, with no clear dominance of cover. In contrast to most sites, the mustard hill coral *Porites astreoides* has the greatest cover among coral species. Sponges and gorgonians are also very common at this site. The algal community is dominated by epilithic algae and a high abundance of crustose coralline algae, with very low abundance of macroalgae. This is surprising at this turbid reef site that likely receives high inputs of particulate and dissolved nutrient sources, and indicates that grazing is quite high. Although fish communities will not be assessed until 2012, there is not a high abundance of herbivorous fish and only the occasional occurrence of *Diadema antillarum*. However, there is a great abundance of the rock boring urchin *Echinometra* spp. that appears to be the dominant grazer. This genus is not monitored in TCRMP protocols, but perhaps should be included in future years.

**Coral Health.** It is not known how corals were affected by bleaching in 2005. There was a low prevalence of low extent bleaching in 2011. Diseases were not recorded in 2011. Old partial mortality prevalence was low in 2011, but this may partly be explained by the high abundance of small coral colonies that are less prone old partial mortality. Recent mortality had low prevalence in 2011.



Figure 89. Coral Bay (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

# CORAL BAY

## Benthic Community

- Coral
- Cyanobacteria
- Epilithic Algae
- Macroalgae

Cover

## Bleaching

- Prevalence
- ▲ Extent

Prevalence/Extent

## Disease

- All disease
- Black Band
- Lesion
- ▼ Dark Spots
- ▲ Intercostal
- White Disease
- Yellow Band
- ◆ Unknown

Prevalence

## Partial Mortality

- Old
- ▲ Recent

Prevalence

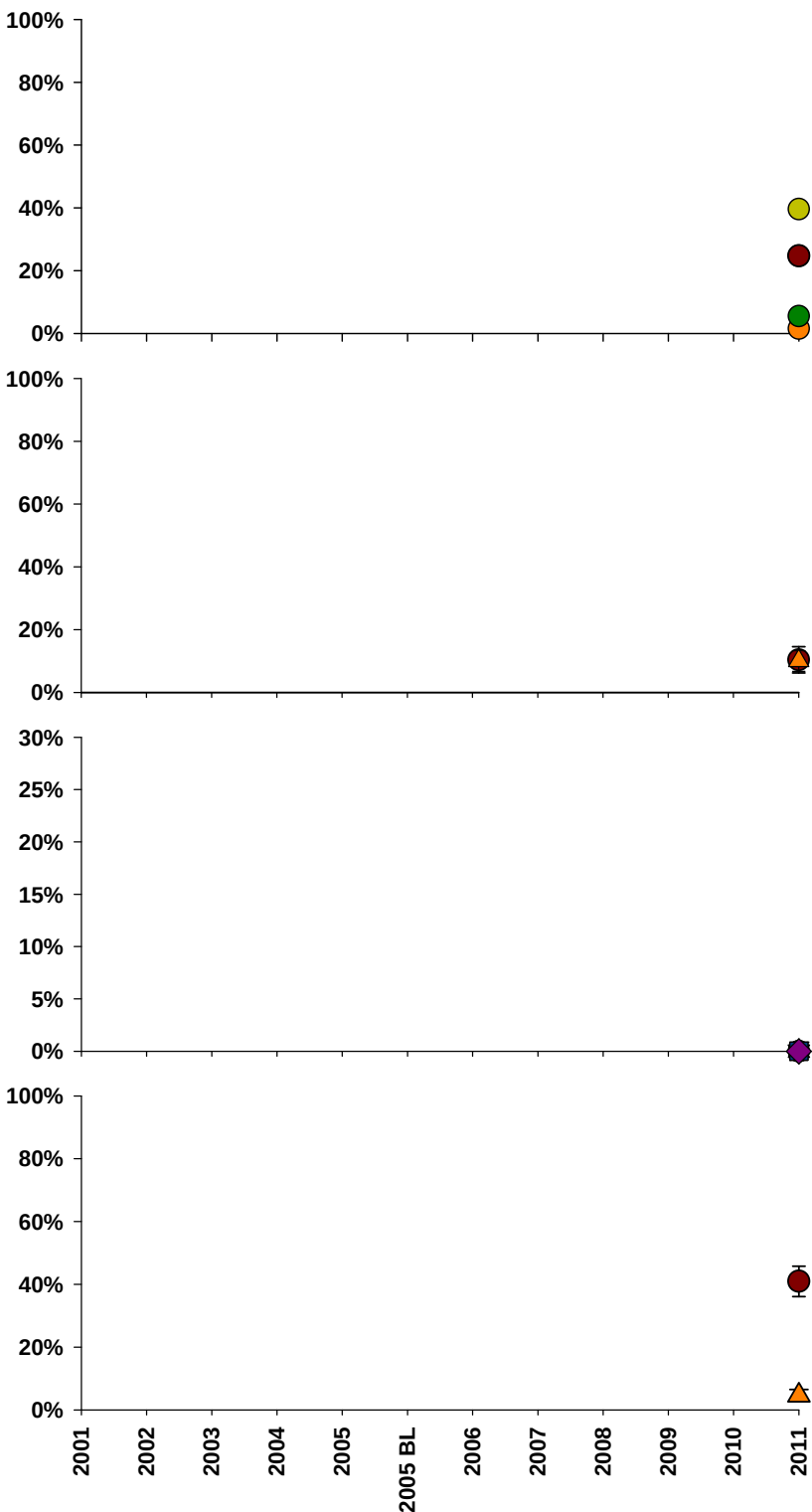


Figure 90. Coral Bay benthic cover and coral health in 2011 (mean  $\pm$  SE).

# SITE SUMMARIES

## FISH BAY

**Description.** Fish Bay is a nearshore Fringing Reef in territorial waters. The monitoring site is a sharp edge of a shallow water coral community dropping to sand at 7 m depth. The site has been monitored since 2001.

**Outstanding Feature.** Fish Bay inner transects (1 – 3) are heavily sediment impacted, which outer transects (4-6) support large boulder star corals (*Montastraea faveolata*).

**Threats.** Fish Bay subjected to land-based sources of pollution and tends to have turbid water and overgrowth by macroalgae on inner transects. This site may also be vulnerable to fishing impacts.

**Figure 91.** Coral Bay. (top) Location. (right) A representative photo of the reef.



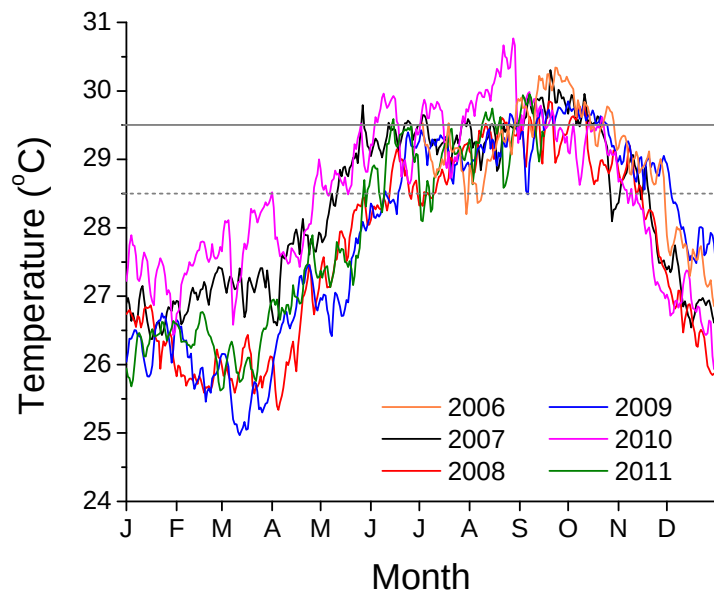


Figure 92. Fish Bay benthic temperature record (6m depth).

## Physical Characteristics.

**Current.** Fish Bay currents have not been measured directly by the TCRMP. Unidirectional currents are mild to slack. Because of the southeast exposure, wave driven oscillatory currents can be quite intense, particularly on the outer transects.

**Temperature.** Fish Bay has relatively high mean temperatures and was very far over the local bleaching threshold in 2010.

# SITE SUMMARIES

**Benthic Community.** The coral community of Fish Bay is dominated by the boulder star coral *Montastraea annularis* spp. complex. In particular, large (>2m wide) colonies of *M. faveolata* are common on the seaward transects (4-6). The inner transects (1-3) are mostly depauperate of coral (< 4% cover as of 2011). The site lost 37.1% of its cover due to the 2005 coral bleaching event, but had regained 136.1% of cover by 2011. Gorgonians are also very common on the wave-washed outer transects. The algal community is dominated by equal parts epilithic algae and the macroalgae *Dictyota* spp. The site also has a high abundance of *Halimeda opuntia*, which can be very abundant on inner transects closest to land-based sources of pollution.

**Coral Health.** Fish Bay corals were very severely affected in the 2005 with 100% of corals showing almost 100% bleaching. Bleaching is also normally high at this site even in years without thermal stress, a likely consequence of sediment and macroalgal interactions. Diseases, particularly dark spots disease and white disease can have very high prevalence at Fish Bay. Old partial mortality did increase after the 2005 coral bleaching event, with a decline in 2010 and resurgence in 2011. Recent partial mortality can also be relatively high compared with other sites, largely as the results of bites from site-attached damselfish (*Stegastes* spp.).

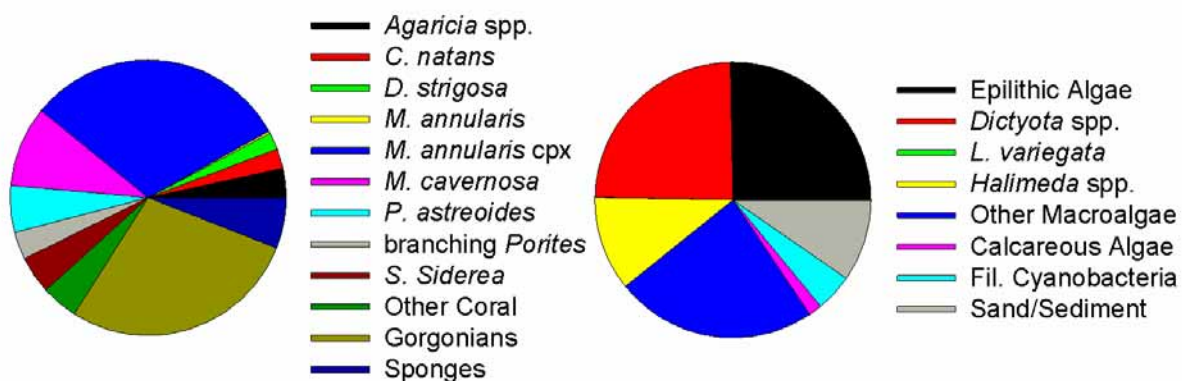
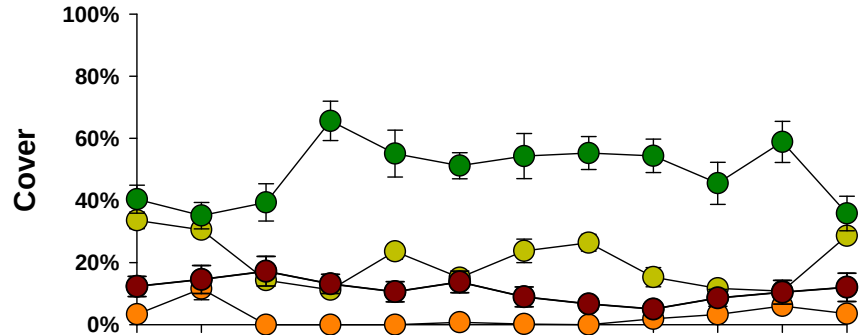


Figure 93. Fish Bay (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

# FISH BAY

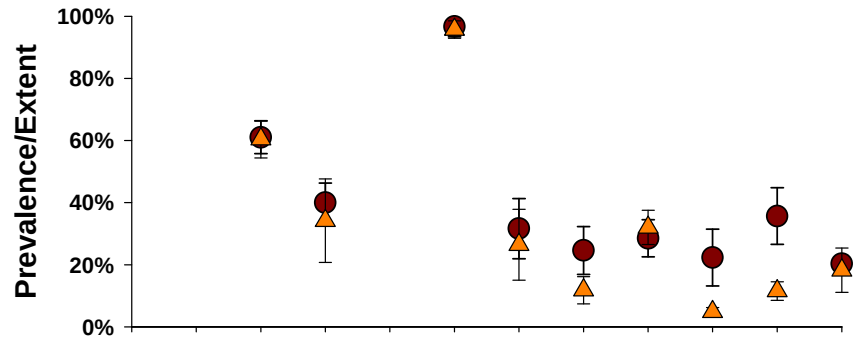
## Benthic Community

- Coral
- Cyanobacteria
- Epilithic Algae
- Macroalgae



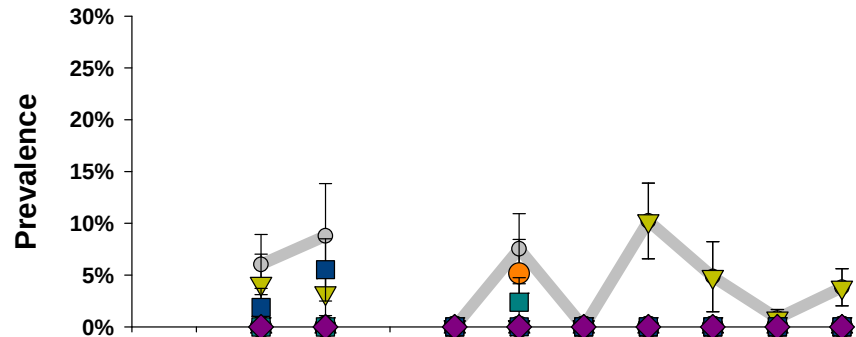
## Bleaching

- Prevalence
- ▲ Extent



## Disease

- All disease
- Black Band
- Lesion
- ▼ Dark Spots
- ▲ Intercostal
- White Disease
- Yellow Band
- ◆ Unknown



## Partial Mortality

- Old
- ▲ Recent

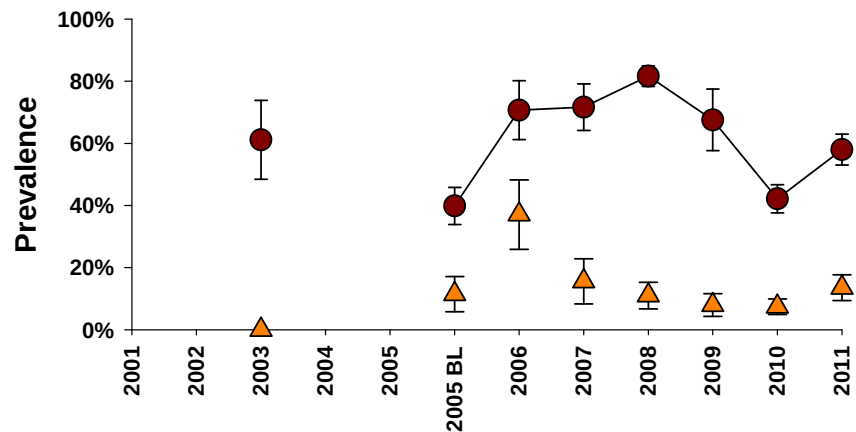
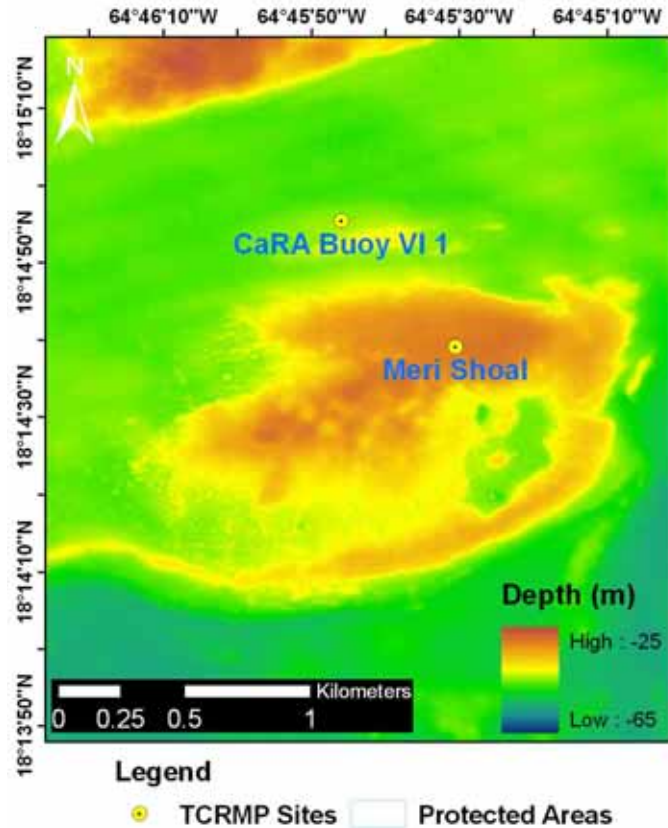


Figure 94. Fish Bay benthic cover and coral health through time (mean  $\pm$  SE).

# SITE SUMMARIES

## MERI SHOAL

**Description.** Meri Shoal is an offshore mesophotic coral bank 30 m depth. The reef is located four miles south of St. John and is on the southernmost of two impressive midshelf coral banks. The reef is dominated by interlocking colonies of boulder star corals (*Montastraea annularis* spp. complex). The reef top is very flat coral plain. The site is named for Dr. Meri Whitaker, former director of the VI EPSCoR Program who passed away in 2009. Meri Shoal has been monitored since 2005.



**Outstanding Feature.** Meri Shoal has the highest star coral abundance of any site in the TCRMP and is bathed in clear, clean water.

**Threats.** Meri Shoal is vulnerable to fishing impacts, as it is outside any marine protected area. The high density of corals may make this sight vulnerable to disease impacts..

**Figure 95. Meri Shoal. (top) Location. (right) A representative photo of the reef during the 2005 coral bleaching event (Oct. 6, 2005). The brain coral in the foreground is 1.8m wide.**



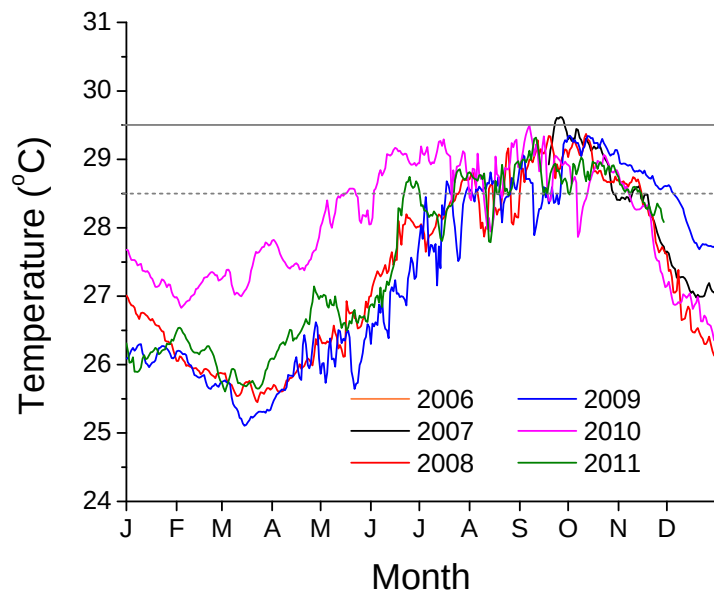


Figure 96. Meri Shoal benthic temperature record (30m depth).

## Physical Characteristics.

**Current.** Currents have not been measured directly at the Meri Shoal site, although the Caribbean Regional Association buoy VI 1 is located within 700 m and its downward focused ADCP has been recording data since April 2011.

**Temperature.** Black Point has low circulation and relatively high mean temperatures with very low day to day variability.

# SITE SUMMARIES

**Benthic Community.** The Meri Shoal site is exceptional for its domination by boulder star corals (*Montastraea annularis* spp. complex). Cover of this and other coral species was exceptionally high when the site was first monitored during the 2005 coral bleaching event, but declined by 36.0% after bleaching and had not recovered any cover as of 2011 (-9.6%). Surprisingly given the high coral cover, the algal community is dominated by *Lobophora variegata* and not epilithic algae and there has been a trend of increasing macroalgal cover since 2008.

**Coral Health.** Coral bleaching was relatively high for a mesophotic site during the coral bleaching event in 2005. Bleaching was again at high prevalence, but low extent in the thermal stress of 2010. However, low-extent bleaching at moderate prevalence is a persistent feature of Meri Shoal. Disease, particularly white disease and lesions that are likely the remnants of white disease, are highly prevalent, particularly in years following high thermal anomalies, such as 2006 and 2011. Old partial mortality climbed steeply from the 2005 coral bleaching event onwards and reached very high levels by 2006. Recent partial mortality has also been consistently high as the result of white disease and disease lesions.

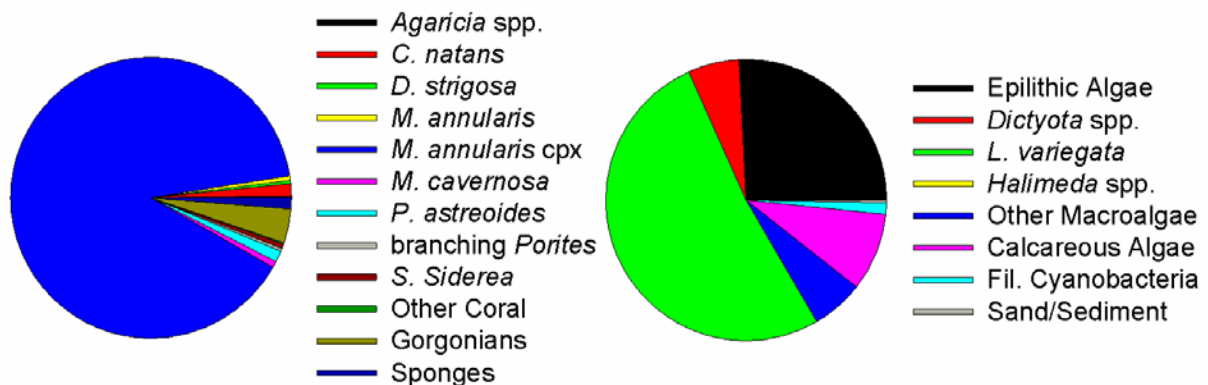


Figure 97. Meri Shoal (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

# MERI SHOAL

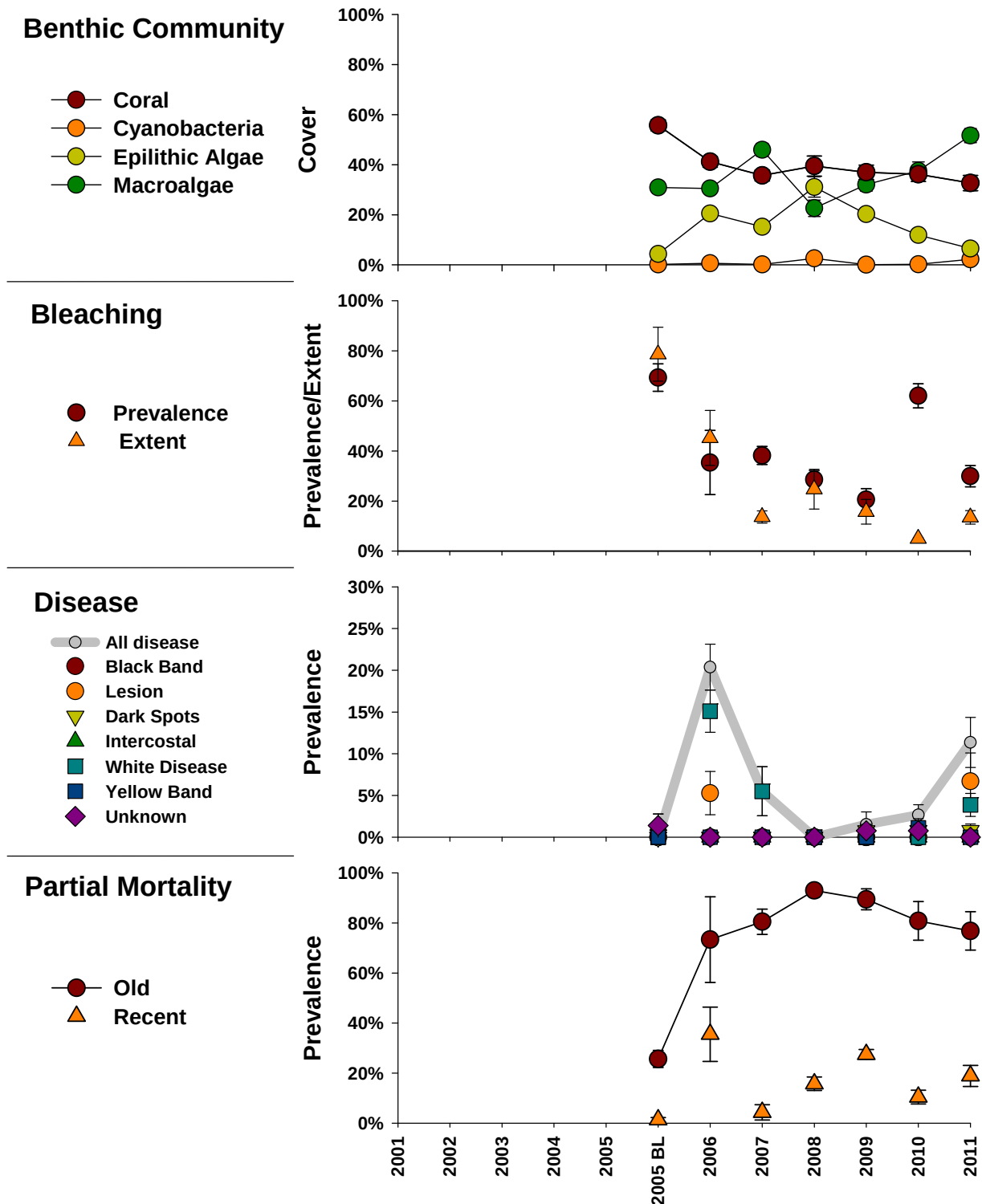


Figure 98. Meri Shoal benthic cover and coral health through time (mean  $\pm$  SE).

### St. Thomas



# SITE SUMMARIES

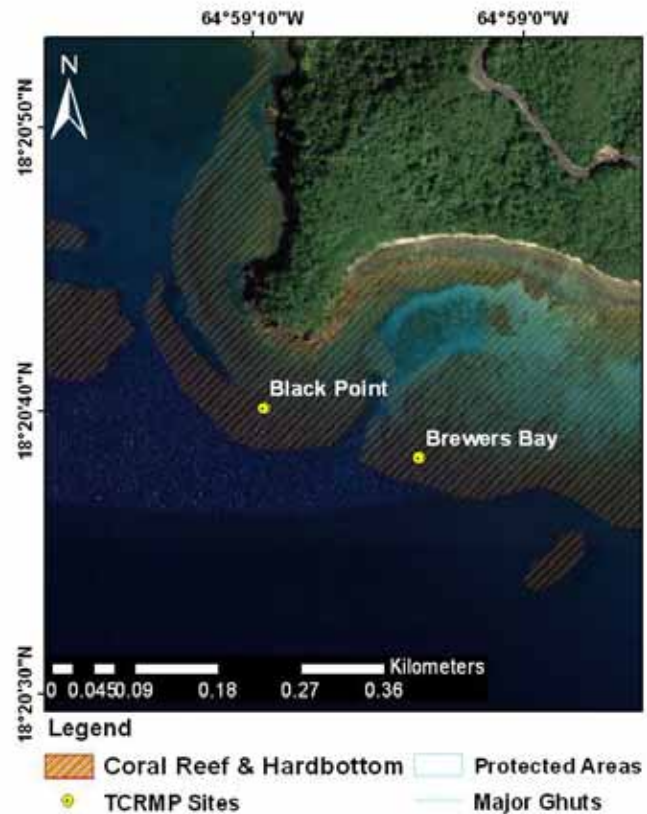
## BLACK POINT

**Description.** Black Point is a nearshore fringing reef located at the mouth of Brewers Bay along the southwest coast of St. Thomas in water depths of 7 – 17 m. The reef has a sharp break in slope leading to a steep escarpment that terminates in a sediment plain at the reef base. Black Point appears to be a true reef with a well-developed carbonate framework over bedrock. Black Point has been monitored since 2003, with permanent benthic transects installed in 2007. A ciguatera fish poisoning study with monthly sampling has been ongoing since 2009.

**Outstanding Feature.** Black Point supports a fish spawning aggregation of striped parrotfish (*Scarus iserti*) that engage in daily afternoon mating at the edge of the upper reef break.

**Threats.** Brewers Bay subjected to land-based sources of pollution and tends to have turbid water and overgrowth by heterotrophic organisms, such as sponges. Recreational/artisanal fishers with handline and spear frequently fish this site.

**Figure 99. Black Point. (top) Location. (right) A representative photo of the reef.**



# BLACK POINT

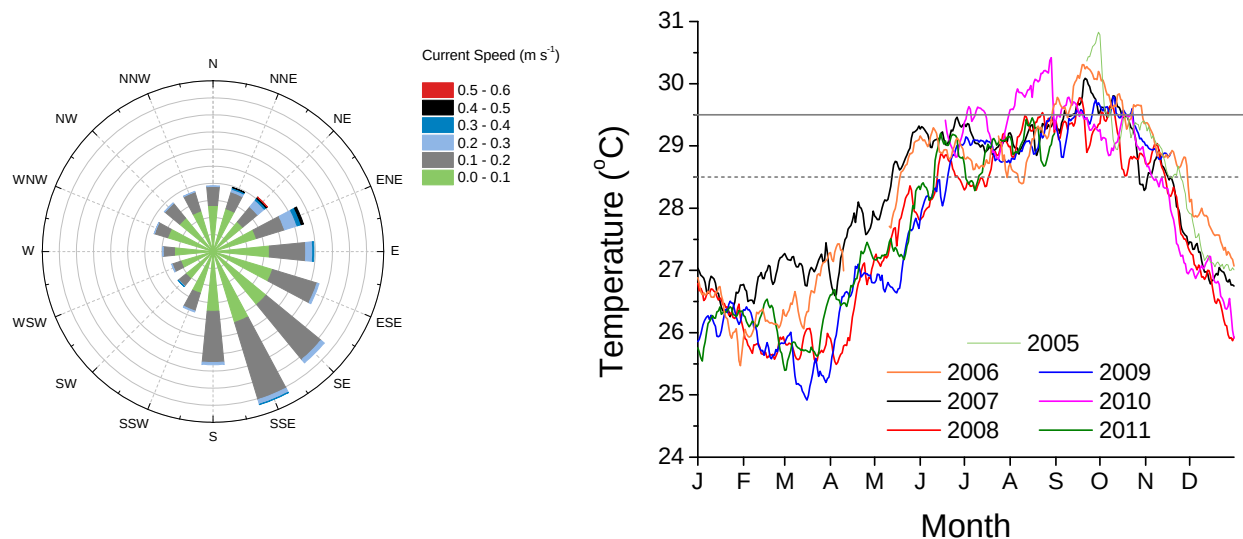


Figure 100. Black point current speed and benthic temperature record (8 m depth).

**Physical Characteristics. Current.** Black Point has restricted water flow dominated by weak currents running counter or orthogonally to the left of the dominant wind direction. This may indicate that there is a counter flowing eddy from Perseverance Bay to the west that impinges on the headland. Current data are based on average data taken every 30 min. (11/29/06 to 3/1/2007) and hourly (4/19/07 to 9/5/07). **Temperature.** Black Point has low circulation and relatively high mean temperatures with very low day-to-day variability. **Chlorophyll & Turbidity.** Chlorophyll tends to be high at Black Point, likely due to inputs of land-based nutrients that fuel pelagic productivity. There are also exists a very prominent tidal signature that reflects switching source currents at the reef.

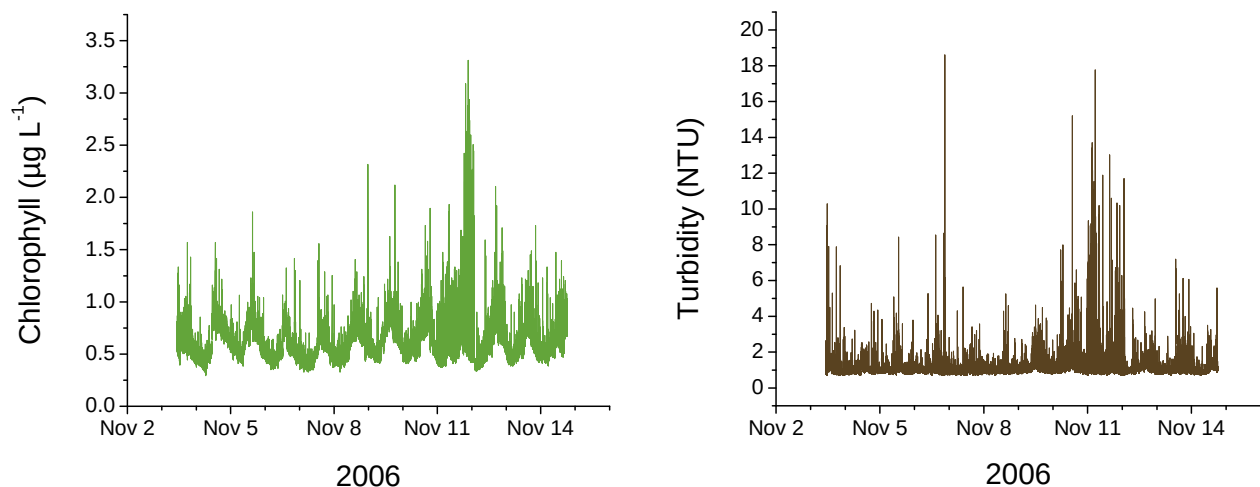


Figure 101. Black Point chlorophyll (left) and turbidity (right) record (16 m depth)

# SITE SUMMARIES

**Benthic Community.** Black Point supports a very diverse coral community with very equal representation by many coral species. However, large colonies (> 100 cm diameter) of *Montastraea annularis* and *Montastraea faveolata* occur on the eastern edge of the site, with a few occurring within transects. This coral community lost 40.5% of its coral cover in the 2005 bleaching event; however, by 2011 it had regained 103.5% of its coral cover. The algal community at Black Point is co-dominated by epilithic algae and the macroalga *Dictyota* spp..

**Coral Health.** Black point corals were severely affected during the 2005 bleaching event with nearly all colonies bleached over 100% of the colony surface. The prevalence of coral diseases was moderate with dark spots disease predominating. However, white disease outbreaks occurred at least twice over the sampling period. Old partial mortality became very prevalent after the 2005 coral bleaching event and subsided in the following two years.

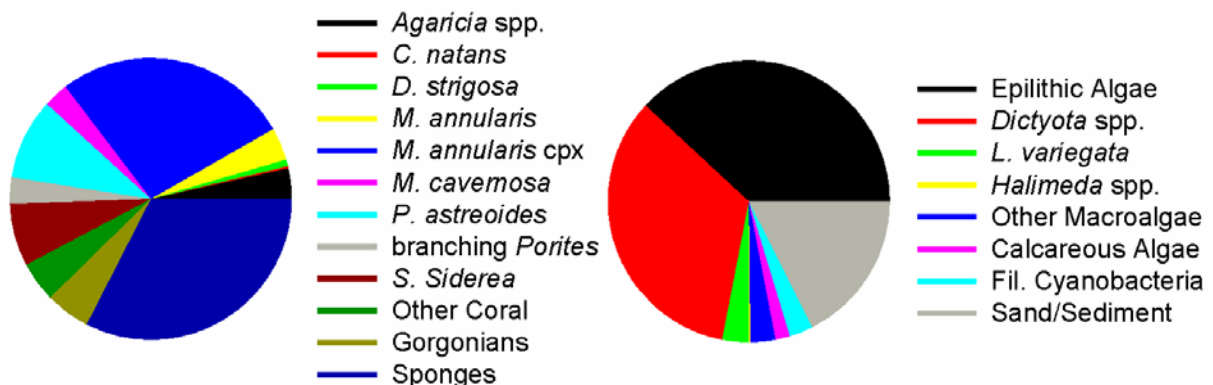


Figure 102. Black Point. (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

# BLACK POINT

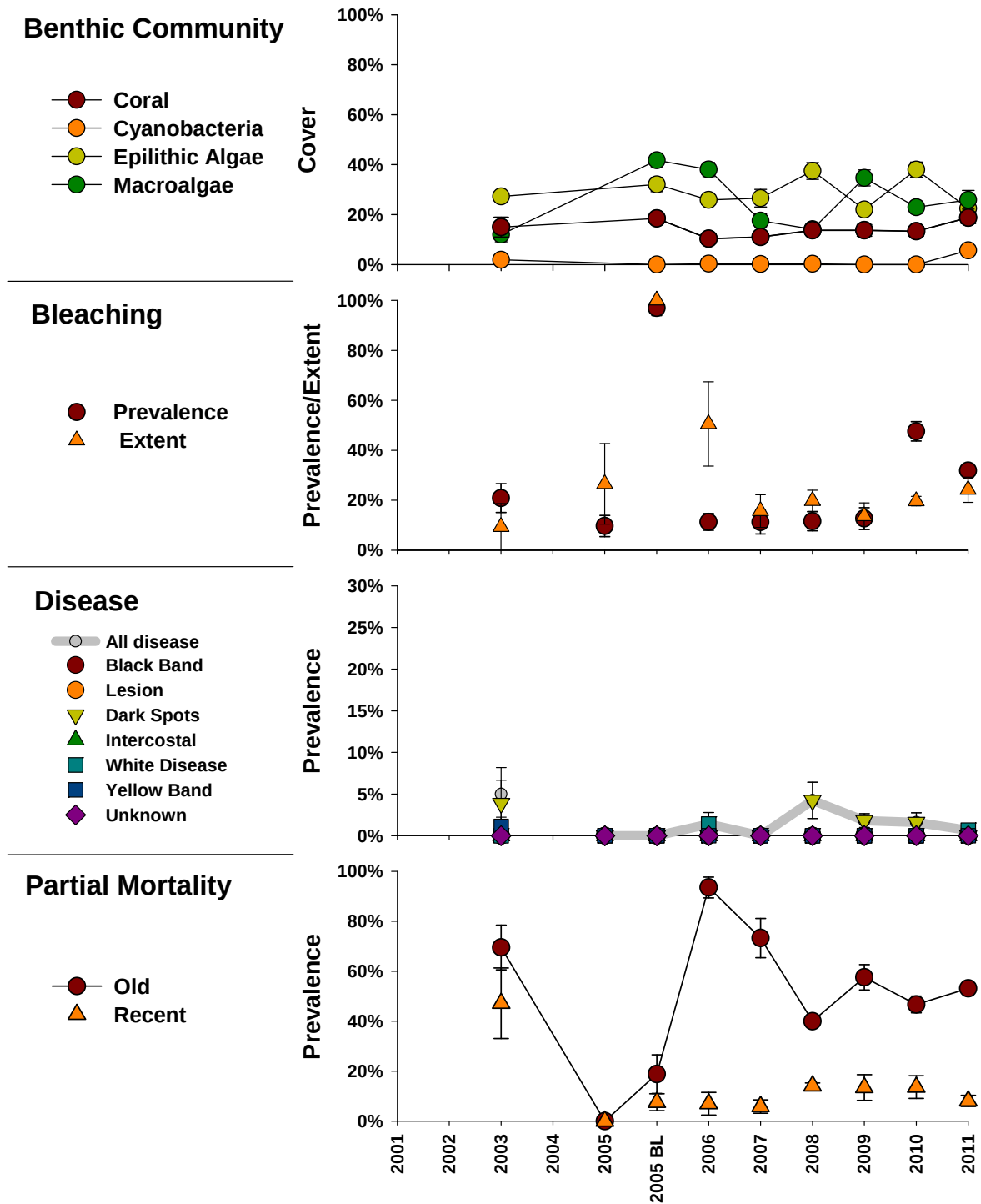


Figure 103. Black Point benthic cover and coral health through time (mean  $\pm$  SE).

## SITE SUMMARIES

**Fish Community.** Black Point is highly dominated by herbivores. Juvenile parrotfish and damselfish are numerous. Brown chromis are equally abundant. The site is turbid and holds very few large fish, although the occasional cubera snapper, Nassau grouper, and yellowfin grouper are spotted. A resident mutton snapper is regularly observed cruising the sand line at the bottom of the reef. Hamlets are diverse and common. The black hamlet is especially abundant among the hamlets. In the mid to late afternoon striped parrotfish (*Scarus iserti*) spawn at Black Point. They can be seen swimming along the reef edge in large groups beginning in the early afternoon. Spawning goes in to the late afternoon and involves tens of fish. Black Point is close to shore and is not trapped often; however, divers can swim to the reef from the beach to spearfish. It is notably absent of large edible fish.

# BLACK POINT

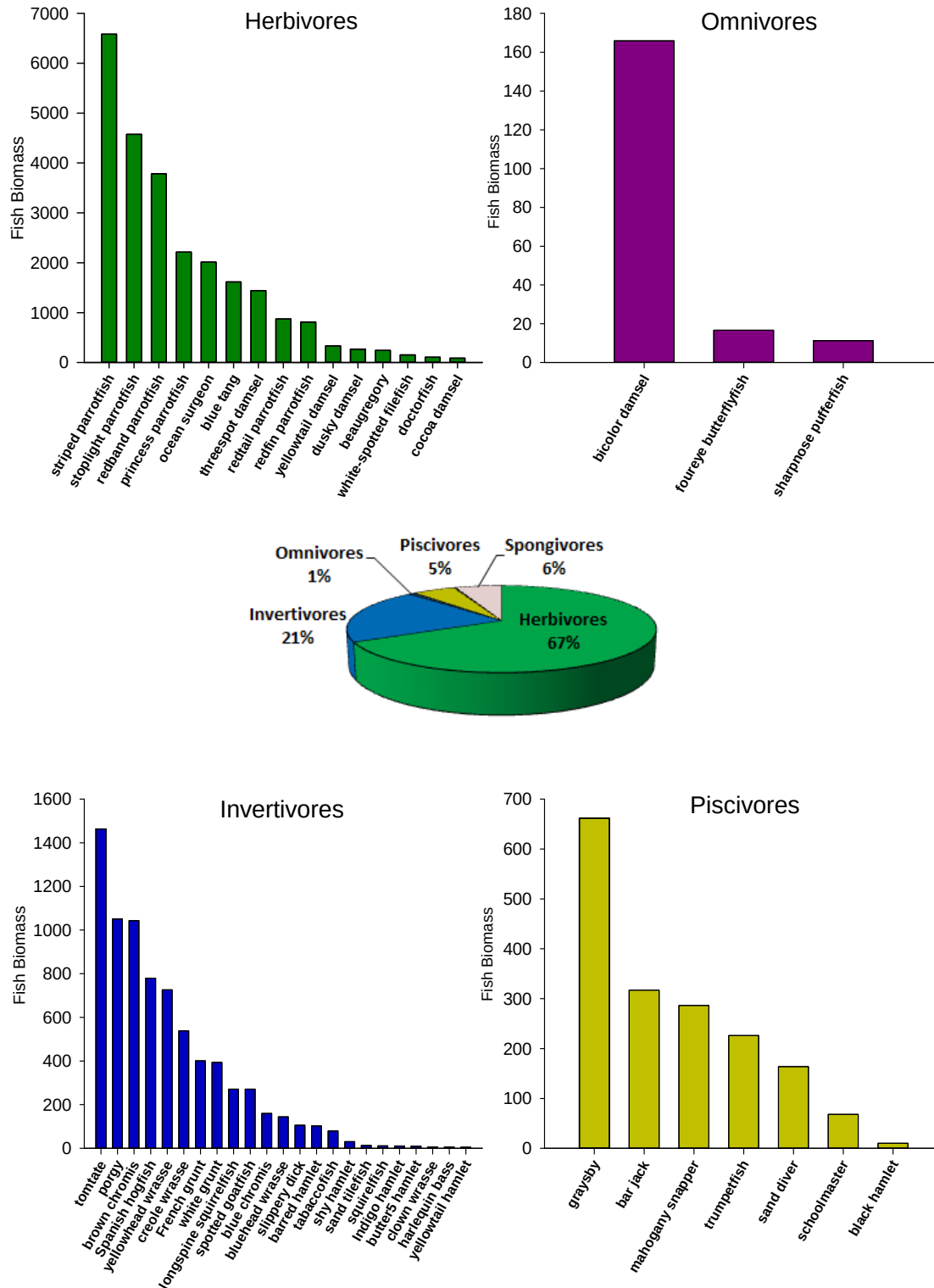


Figure 104. The Black Point fish community by absolute and relative biomass.

# SITE SUMMARIES

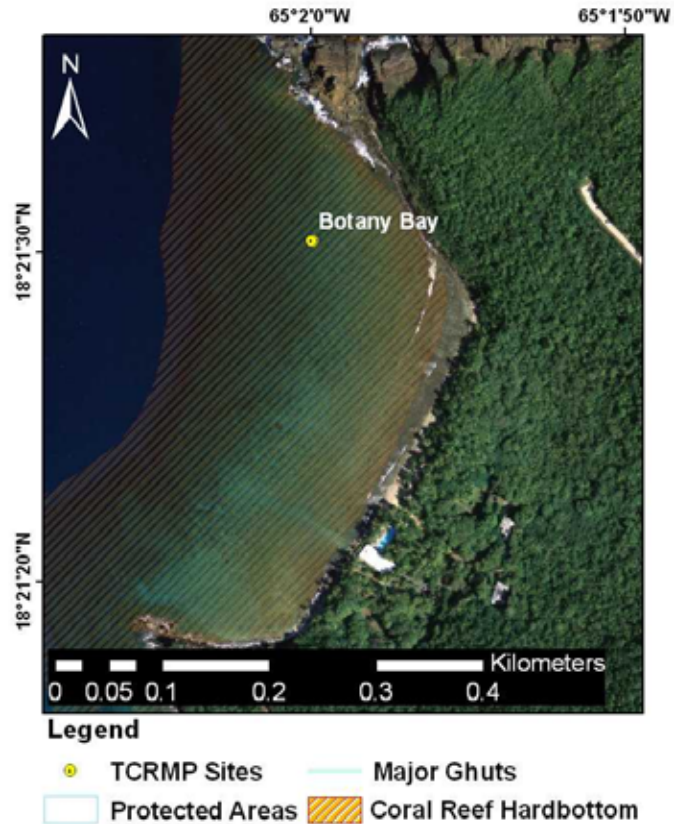
## BOTANY BAY

**Description.** The Botany Bay site is located on the fore slope of a nearshore fringing reef in water depths of 5 – 17 m. The reef crest is a distinct spur-and-groove, with a sharp break in slope leading to an escarpment that terminates in a sand/sediment plain at the reef base. Botany Bay has been monitored since 2002.

**Outstanding Feature.** Botany Bay supports a diverse and productive reef that is one of the prettiest nearshore reefs in the Virgin Islands and is surrounded by one of the most aesthetically pleasing locales on St. Thomas.

**Threats.** Botany Bay is threatened by development of the previously fully vegetated watershed and increased land-based sources of pollution. The area is open to fishing. Increased residential development in the watershed may lead to increased recreational use of the reef, including fishing and collecting. The area is also occasionally impacted by large Atlantic swells, causing breakage of corals.

**Figure 105. Botany Bay. (top) Location. (right) A representative photo of the reef.**



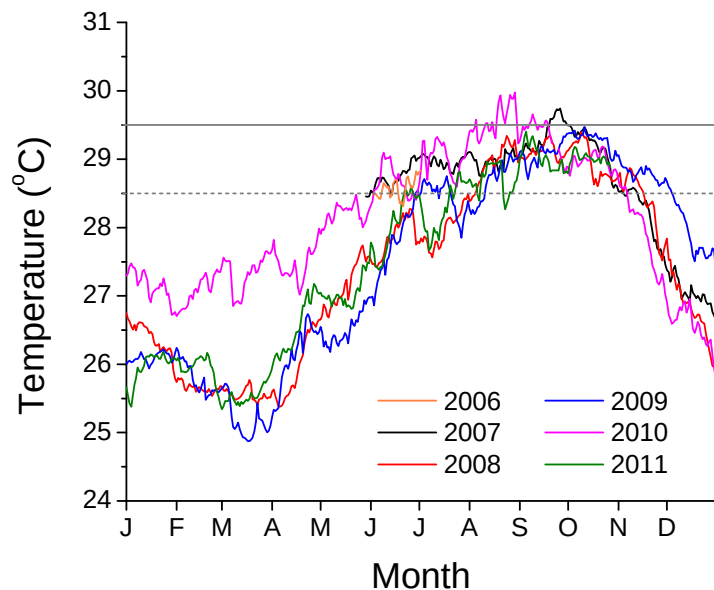


**Figure 106. Botany Bay benthic temperature record (11 m depth).**

**Physical Characteristics. Current.** Currents have not been measured at directly at Botany Bay. Unidirectional currents do not tend to be strong. Wave-driven oscillatory currents can impact the reef crest and fore reef. The site is vulnerable to impacts from large Atlantic swells. Many corals were broken and toppled during the 2009 March swell event when offshore swells reached heights to 4 m. **Temperature.** Botany Bay tends to have slightly cooler temperatures than other nearshore sites, likely owing to its open position facing the Atlantic.



**Figure 107. A large colony of pillar coral (*Dendrogyra cylindrica*) dislodge, toppled, and diseased after the 2009 swell event (Botany Bay, June 25, 2009).**

# SITE SUMMARIES

**Benthic Community.** The Botany Bay site coral community is unique for the dominance of branching *Porites* spp., particularly *Porites porites*. The site lost 38.9% of its coral cover in the 2005 bleaching event and had regained 10.6% by 2011. There is a high abundance of gorgonians on the seaward slope exposed to wave swell. The Botany Bay algal community is co-dominated by epilithic algae and the macroalga *Dictyota* spp., which tend to negatively covary.

**Coral Health.** Bleaching was extremely severe during 2005, with nearly 100% of corals bleached or pale over 100% of their surface. There was also a high prevalence of bleaching in 2002 at an unknown extent and in 2010 at a low extent. Non-thermal stress years have seen variable bleaching. Coral diseases can be high at Botany Bay, with a preponderance of white and dark spots diseases, and lesions that are likely related to white disease. Old partial mortality shows a pattern that is difficult to explain before 2005. During bleaching and afterwards consistent observers have done partial mortality assessments and this data is valid. There was a large increase in old partial mortality after the 2005 bleaching event, then some subsidence and leveling off after 2008. Recent partial mortality was high through most years of monitoring, largely due to biting by territorial damselfish (*Stegastes* spp.; data not shown).

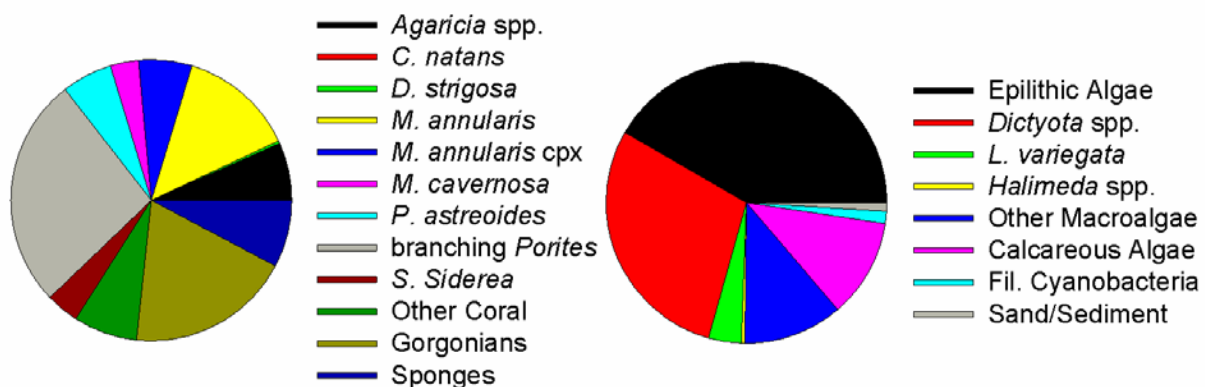
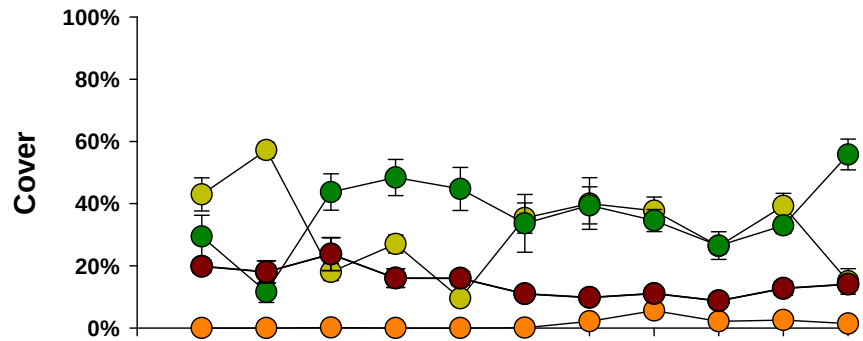


Figure 108. Botany Bay. (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

# BOTANY BAY

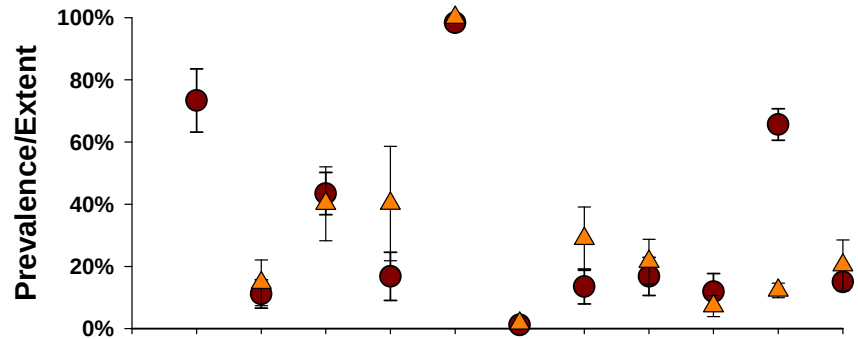
## Benthic Community

- Coral
- Cyanobacteria
- Epilithic Algae
- Macroalgae



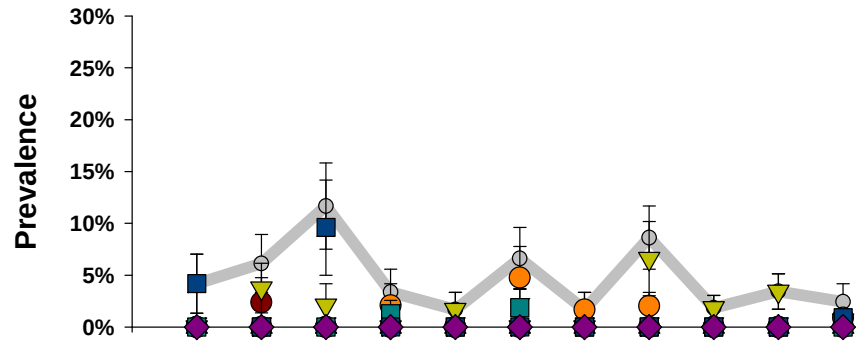
## Bleaching

- Prevalence
- ▲ Extent



## Disease

- All disease
- Black Band
- Lesion
- ▼ Dark Spots
- ▲ Intercostal
- White Disease
- Yellow Band
- ◆ Unknown



## Partial Mortality

- Old
- ▲ Recent

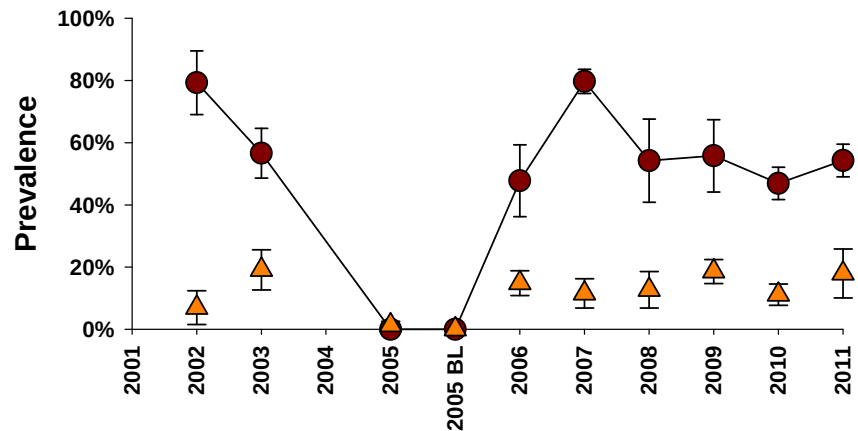


Figure 109. Botany Bay benthic cover and coral health through time (mean  $\pm$  SE).

# SITE SUMMARIES

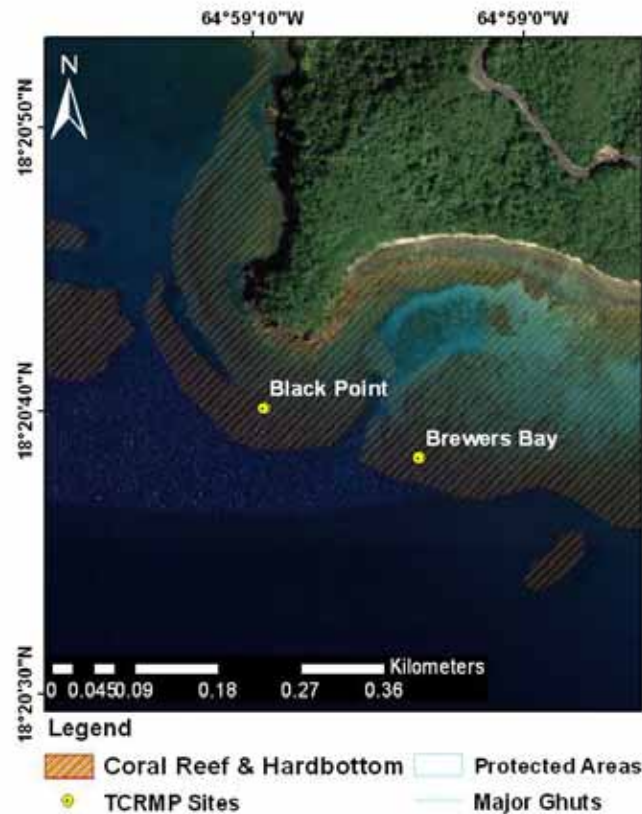
## BREWERS BAY

**Description.** Brewers Bay is a nearshore fringing reef located at the mouth of Brewers Bay along the southwest coast of St. Thomas in water depths of 7 – 17 m. Brewers Bay is a very well develop boulder star coral (*Montastraea annularis*) dominated reef. Brewers Bay was initially monitored in 2002/2003, but was abandoned due to its proximity to the Black Point site. It was picked-up again in 2008 due the excellent coral development and resistance to bleaching impacts.

**Outstanding Feature.** Brewers Bay is very good example of a nearshore boulder star coral fringing reef and has fared better than other reefs of this type over the 2005 mass coral bleaching event.

**Threats.** Brewers Bay is subjected to land-based sources of pollution, is located directly below a trash dumpster collection area, and tends to have turbid water and overgrowth by heterotrophic organisms, such as sponges. Recreational/artisanal fishers frequently fish Brewers Bay with hand line and spear. The site has a great deal of marine debris, including boat hulls, rope, and metal pieces.

**Figure 110. Brewers Bay. (top) Location. (right) A representative photo of the reef.**



# BREWERS BAY

## Physical Characteristics.

**Current.** Brewers Bay currents have not been measured directly, but both unidirectional and oscillatory currents are usually very low in magnitude. See also the Black Point physical data, which was taken within 500m distance.

**Temperature.** Brewers Bay temperatures have not been recorded directly, but see the Black Point temperature data. The site has restricted flow and should develop high warm season temperatures.

# SITE SUMMARIES

**Benthic Community.** The Brewers Bay site is highly dominated by the boulder coral *Montastraea annularis* and exhibits the highest coral cover of any nearshore site in the TCRMP, with a coral cover of 32% in 2011. Coral cover was not monitored between 2003 and 2008; however there was a 28.4% decline in cover that could largely be attributed to the 2005 coral bleaching event. The algal community at Brewers Bay is dominated by epilithic algae, with lesser amounts of the macroalga *Dictyota* spp..

**Coral Health.** Corals at the Brewers Bay site were not monitored for health over the 2005 bleaching event. However, corals exhibited some of the highest prevalence of bleaching during the 2010 coral bleaching event, albeit at a low extent. In other years bleaching prevalence remained high, with a low extent. Yellow band disease outbreaks were severe and affected the *M. annularis* community in 2002 and 2003. Old partial mortality is a prominent and persistent feature of the large *M. annularis* colonies. Recent mortality is very high and largely attributable to the biting of large populations of the territorial three-spot damselfish (*Stegastes planifrons*; data not shown).

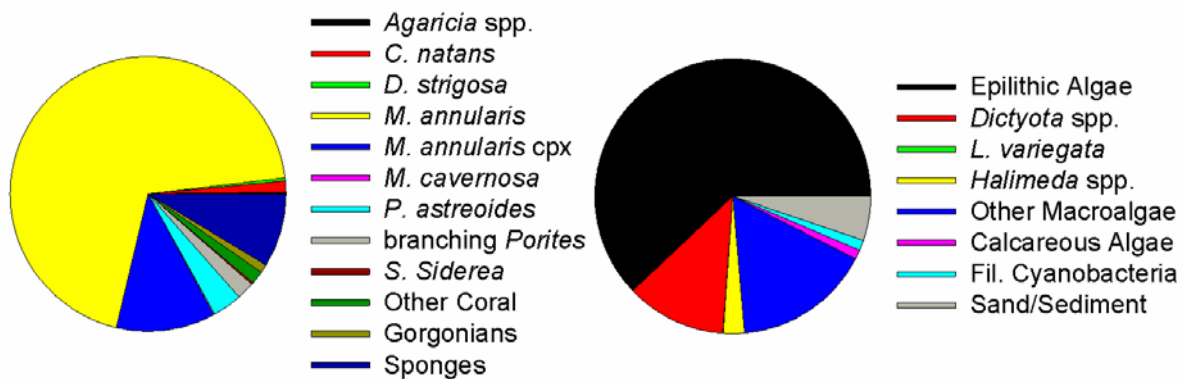


Figure 111. Brewers Bay. (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

# BREWERS BAY

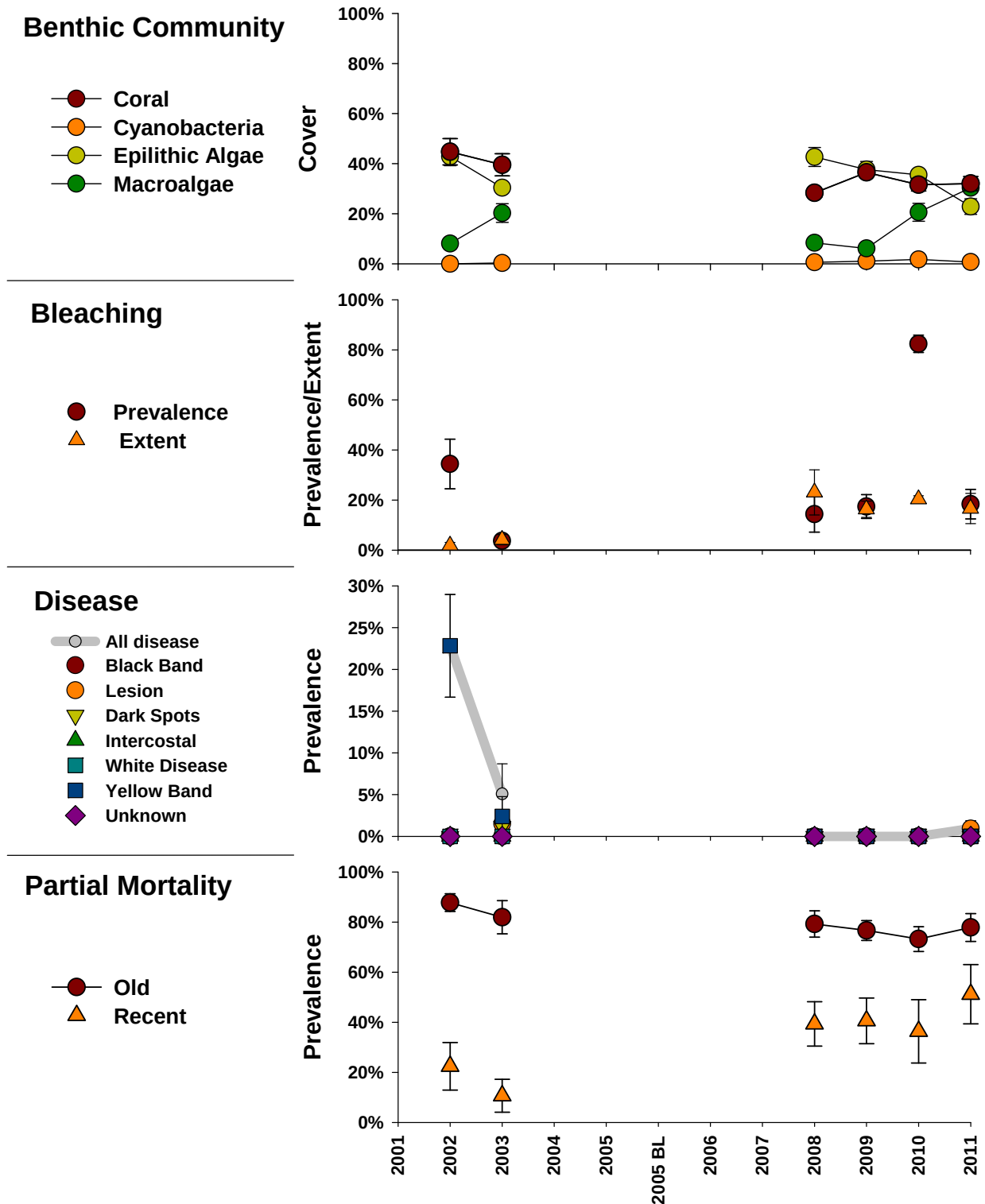


Figure 112. Brewers Bay benthic cover and coral health through time (mean  $\pm$  SE)

## SITE SUMMARIES

**Fish Community.** Brewers Bay is characterized by a high fish abundance dominated by herbivores. The site holds large numbers of parrotfish. Numerically the herbivores are dominated by juvenile striped parrotfish that swim over the reef in groups of mixed parrotfish and wrasse. Both yellowhead and bluehead wrasse are prolific and school with the juvenile parrotfish. Piscivores are limited in biomass but are fairly diverse and generally include inshore pelagics such as cero mackerel and bar jacks or yellow jacks. Hamlets (*Hypoplectrus*) are very common and diverse, represented by 6 to 7 species in each annual survey.

# BREWERS BAY

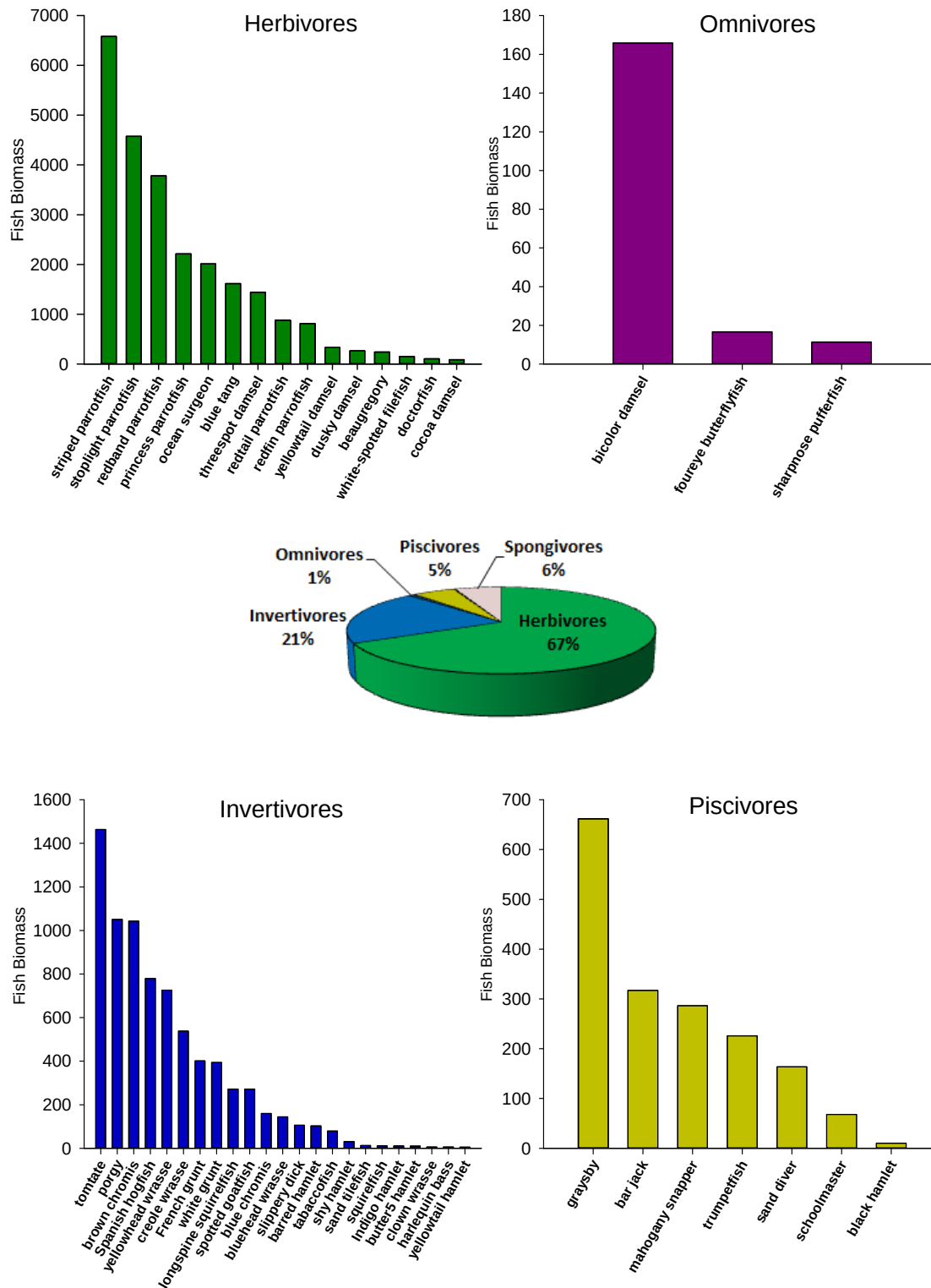


Figure 113. The Brewers Bay fish community by absolute and relative biomass.

# SITE SUMMARIES

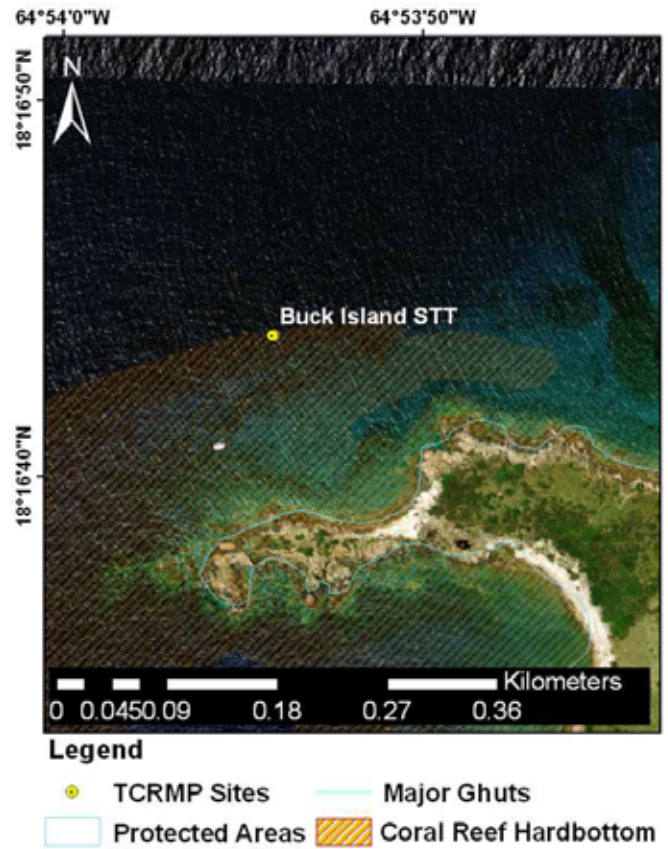
## BUCK ISLAND, ST. THOMAS

**Description.** Buck Island, St. Thomas is a midshelf reef fringing the northwest coast of an uninhabited offshore island in water depths of 7 – 20 m. The reef has a sharp break in slope leading to a steep escarpment that terminates in a sand/sediment plain at the reef base. The monitoring site is located on that slope. Buck Island, St. Thomas has been monitored since 2005, with permanent benthic transects installed in 2007.

**Outstanding Feature.** Buck Island, St. Thomas is one of the most important tourist sites in the Virgin Islands, with frequent visitation by cruise ship passengers on day boats.

**Threats.** Buck Island, St. Thomas is very heavily used as a recreational dive site with the potential for cumulative impacts. The water surrounding Buck Island, St. Thomas is open to fishing. Commercial trap fishermen frequently target this site, and trap strings have been laid over the monitoring transects. Federally protected Nassau Grouper (*Epinephelus striatus*) have been observed within traps. In addition, derelict traps are common around the site.

**Figure 114. Buck Island, St. Thomas.** (top) Location. (right) A representative photo of the reef.



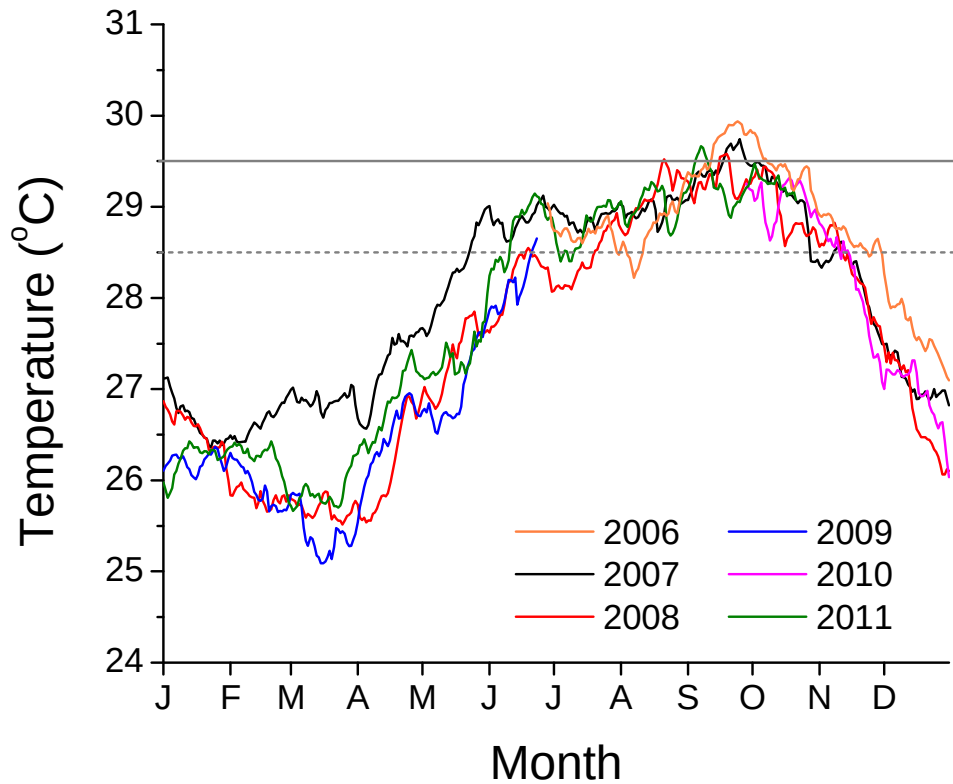


Figure 115. Buck Island, St. Thomas benthic temperature record (12 m depth).

## Physical Characteristics.

**Current.** Buck Island, St. Thomas currents have not been measured directly. Moderately strong unidirectional currents occasionally influence the site, however, in general currents are very weak.

**Temperature.** Buck Island, St. Thomas may develop high temperatures. Unfortunately the temperature probe placed during the 2010 coral bleaching event was lost.

# SITE SUMMARIES

**Benthic Community.** The Buck Island, St. Thomas site coral community is dominated by the boulder star coral (*Montastraea annularis* spp. complex), but shows high and even representation of other species. Coral cover declined by 23.4% due to the 2005 coral bleaching event and the site had regained 13.4% of this cover by 2011. Among sessile epibenthic animals a high proportion of the community is composed of sponges. The algal community is co-dominated by epilithic algae and the macroalgae *Dictyota* spp. and *Lobophora variegata*. Filamentous cyanobacteria were also abundant in 2008.

**Coral Health.** The Buck Island, St. Thomas site was severely bleached in the 2005 coral bleaching event, with over 80% of colonies bleached over 100% of the colony surface. Bleaching was also high during the 2010 bleaching event, but at a low extent on colonies. Low prevalence of low-extent bleaching was common in other years of study. Coral diseases were usually low, in prevalence with the striking exception of 2006, when white diseases and lesions consistent with recent white disease reached extremely high prevalence. Old partial mortality increased rapidly after the 2005 bleaching event and then declined steadily in following years.

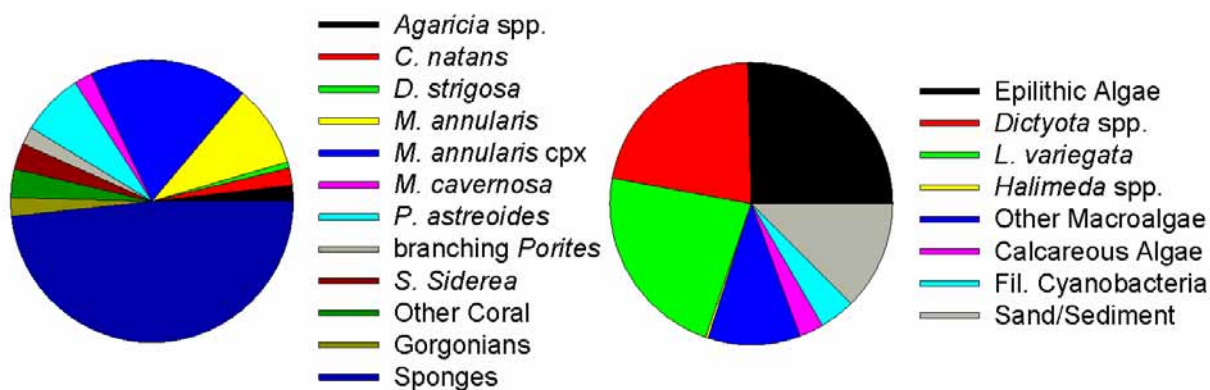
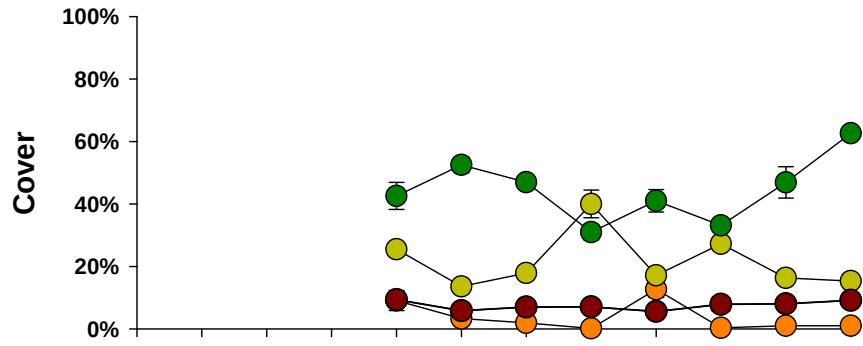


**Figure 116. Buck Island, St. Thomas. (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.**

# BREWERS BAY

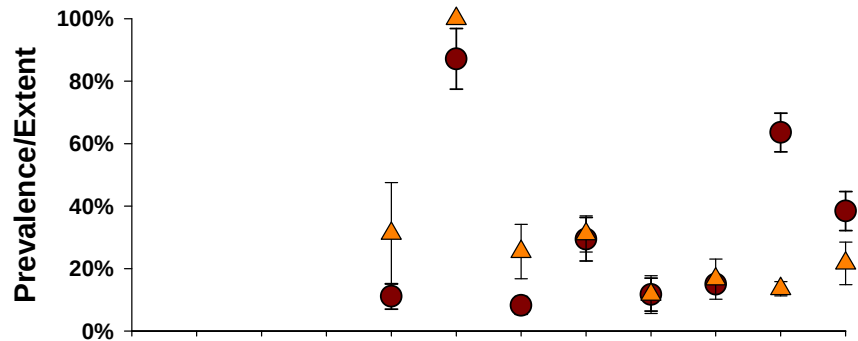
## Benthic Community

- Coral
- Cyanobacteria
- Epilithic Algae
- Macroalgae



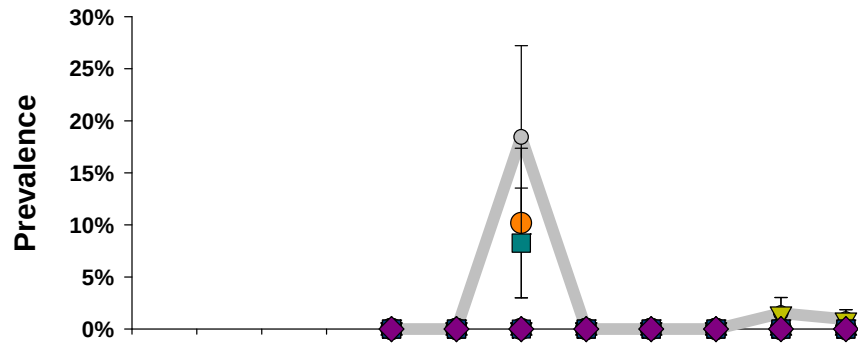
## Bleaching

- Prevalence
- ▲ Extent



## Disease

- All disease
- Black Band
- Lesion
- ▼ Dark Spots
- ▲ Intercostal
- White Disease
- Yellow Band
- ◆ Unknown



## Partial Mortality

- Old
- ▲ Recent

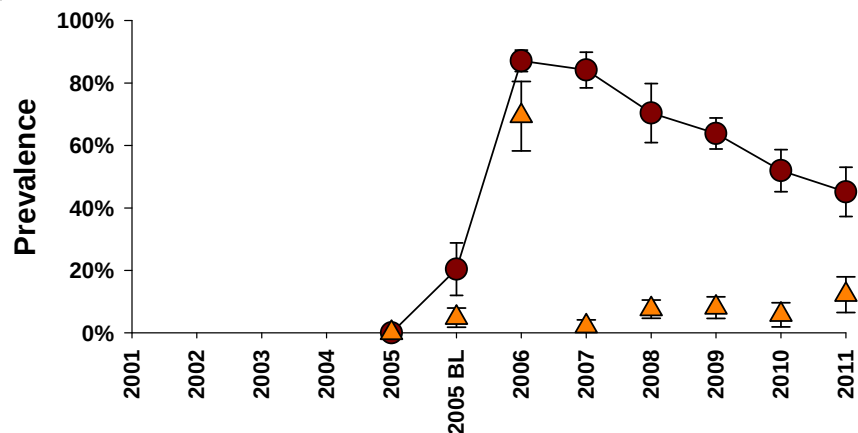


Figure 117. Buck Island, St. Thomas benthic cover and coral health through time (mean  $\pm$  SE).

# SITE SUMMARIES

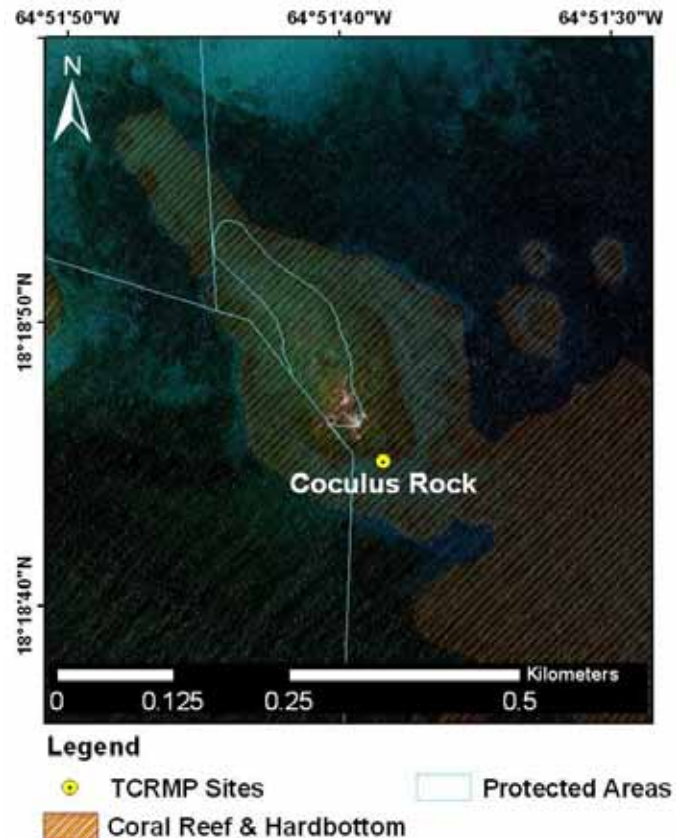
## COCULUS ROCK

**Description.** The Coculus Rock site is a coral community on bedrock and pavement in depths of 4 – 7 m. The reef is formed between emergent rocks and a sand plain at 7m. Coculus Rock has been monitored since 2001, with fish community assessment starting in 2009. A ciguatera fish poisoning study with monthly sampling has been ongoing since 2009.

**Outstanding Feature.** Coculus Rock is located in the St. Thomas East End Reserve and is closed to taking of reef fishes. The site supports a fish spawning aggregation of yellowtail parrotfish (*Sparisoma rubripinne*). These 100+ fish engage in daily afternoon mating at southeast reef corner. A ciguatera study with monthly sampling has been ongoing since 2009.

**Threats.** Coculus Rock is subject to land-based sources of pollution from the Turpentine Gut drainage of the Tutu watershed and the numerous industrial maritime activities in Benner Bay.

**Figure 118. Coculus Rock. (top) Location. (right) A representative photo of the reef showing the aggregation of yellowtail parrotfish.**



# COCULUS ROCK

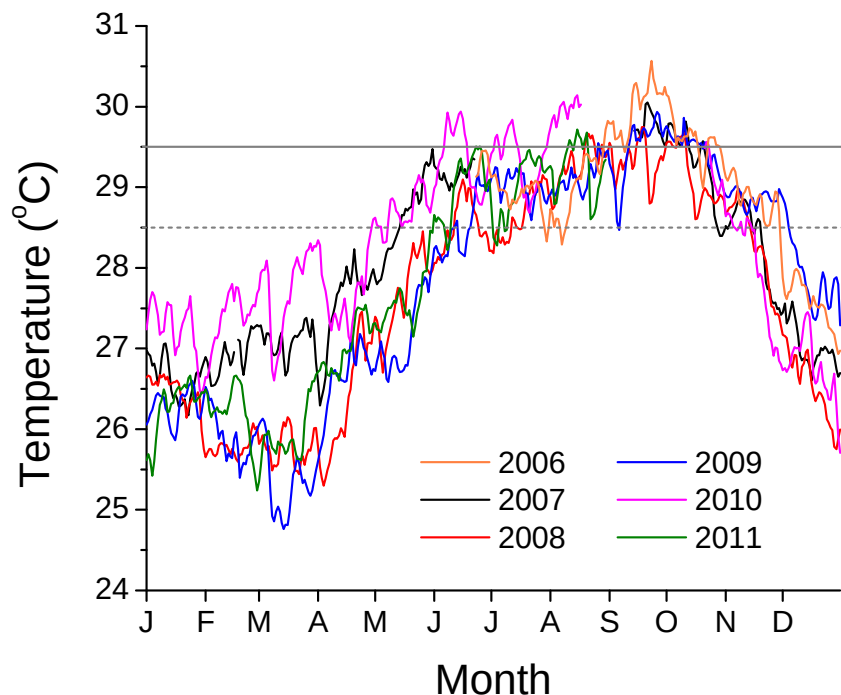


Figure 119. Cocus Rock benthic temperature record (7m depth).

## Physical Characteristics.

**Current.** Cocus Rock currents have not been measured directly. Only weak unidirectional currents have been experienced. Wave-driven oscillatory currents can be intense from swells coming from the southeast.

**Temperature.** Cocus Rock can experience very high temperatures during the peak warm season.

# SITE SUMMARIES

**Benthic Community.** The Cocus Rock site is a coral community on bedrock and thin carbonate pavement that supports a very diverse coral community with no dominance by any species. The site lost 10.7% of its coral cover in the 2005 bleaching event, but had regained 76.0% of this lost cover by 2011. Sponges are a very prominent component of the sessile epibenthic animal community. The algal community is co-dominated by epilithic algae and the macroalga *Dictyota* spp., which tend to covary.

**Coral Health.** Corals at Cocus Rock were relatively moderately impacted by the 2005 coral bleaching event in both prevalence and extent on colonies. This may be due to a coral species assemblage composed of small massive species that tend to be less susceptible to bleaching (Smith et al., unpublished manuscript). A modest prevalence of low extent bleaching was also evident in the 2010 coral bleaching event. In years without high thermal stress there tends to be a relatively high prevalence of bleaching relative to other sites, and prior to 2004 this was at high extent over colonies. Coral diseases, represented almost exclusively by dark spots disease, can be quite high in some years. Old partial mortality has been fairly high and consistent over time, with a slight increase after the 2005 and 2010 bleaching events. Recent partial mortality tends to be quite low in prevalence.

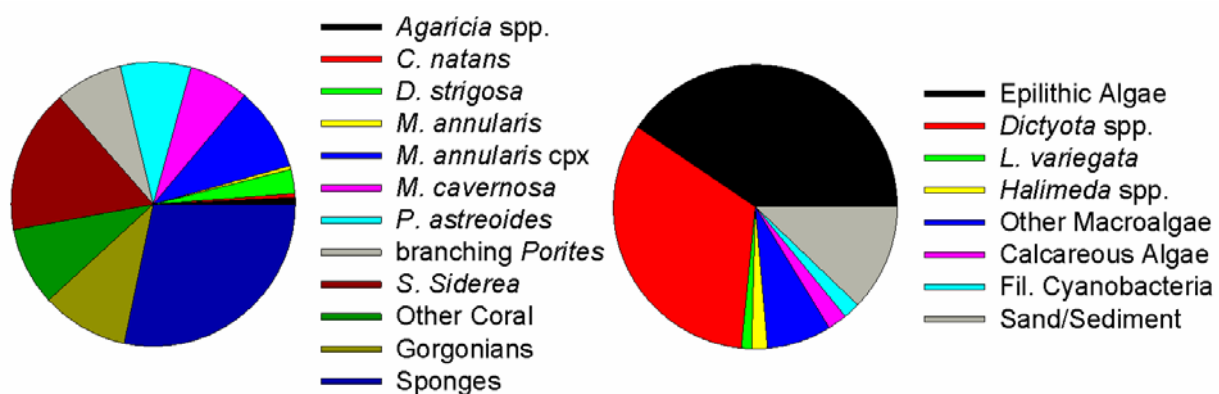
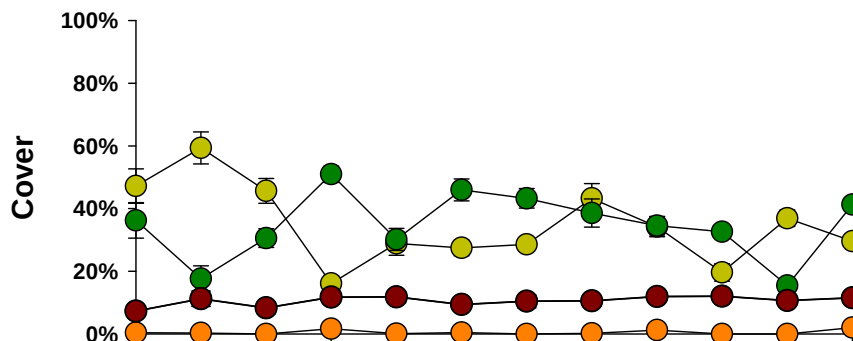


Figure 120. Cocus Rock. (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

# COCULUS ROCK

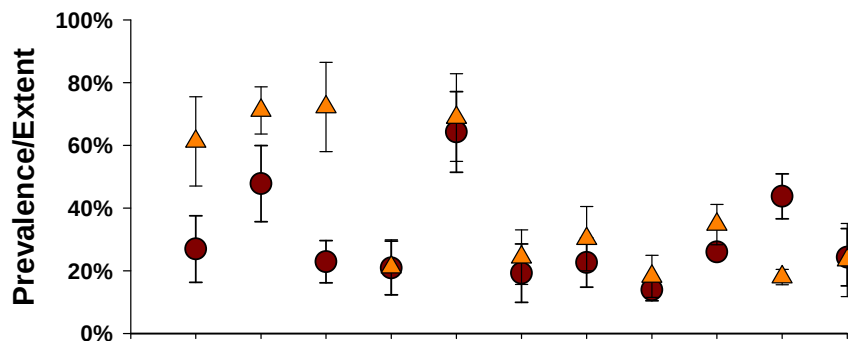
## Benthic Community

- Coral
- Cyanobacteria
- Epilithic Algae
- Macroalgae



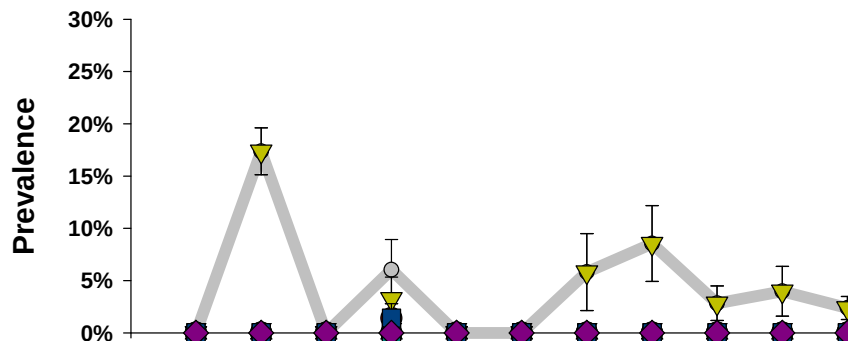
## Bleaching

- Prevalence
- ▲ Extent



## Disease

- All disease
- Black Band
- Lesion
- ▼ Dark Spots
- ▲ Intercostal
- White Disease
- Yellow Band
- ◆ Unknown



## Partial Mortality

- Old
- ▲ Recent

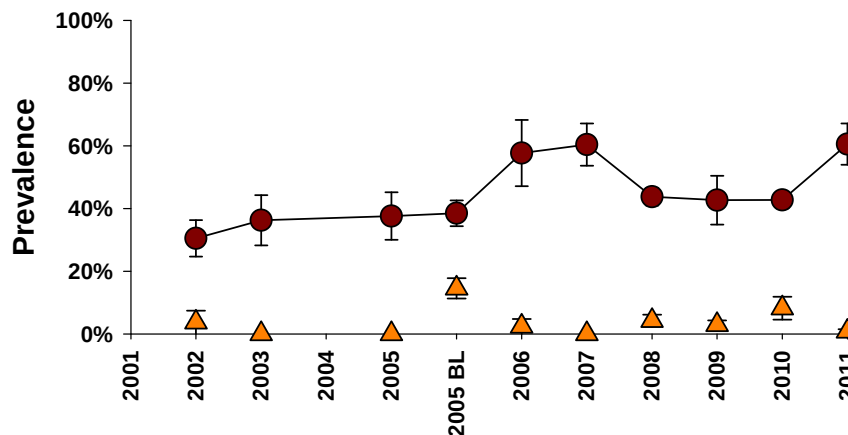


Figure 121. Coculus Rock benthic cover and coral health through time (mean  $\pm$  SE).

# SITE SUMMARIES

## COLLEGE SHOAL

**Description.** College Shoal is part of a mesophotic bank located in the Red Hind Marine Conservation District (est. 1999) in depths of 28 – 33 m. The densely populated coral reef is surrounded by continuous reef structure dominated by boulder star corals (*Montastraea annularis* spp.). College Shoal has been monitored since 2003, with permanent benthic transects installed in 2007.

**Outstanding Feature.** College Shoal is notable for possessing high water clarity, relatively strong currents, a high density of corals (>30% coral cover), and a great abundance of fishes, including commercially important groupers and snappers. College Shoal is one of the most aesthetically pleasing reefs for diving due to its relatively pristine condition.

**Threats.** College Shoal has experienced coral white diseases at chronically high levels (> 1% prevalence). This reef also supports a high abundance of the invasive Indo-Pacific Lionfish (*Pterois volitans*).

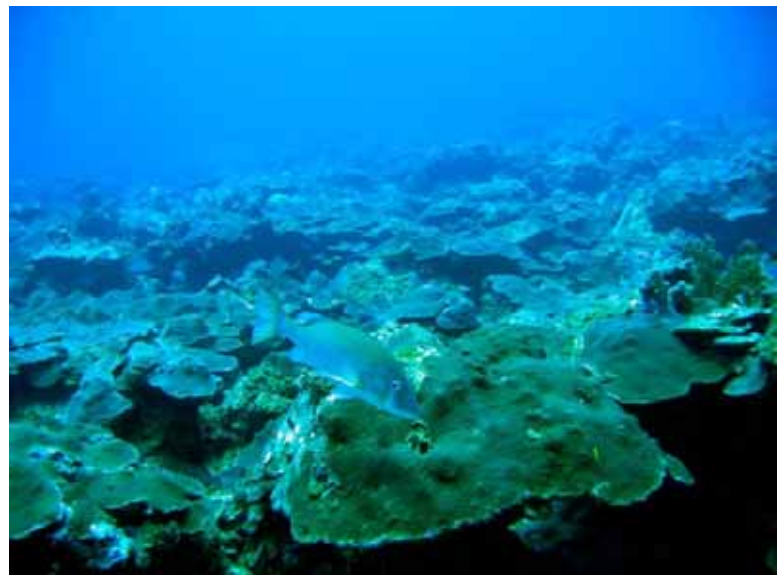
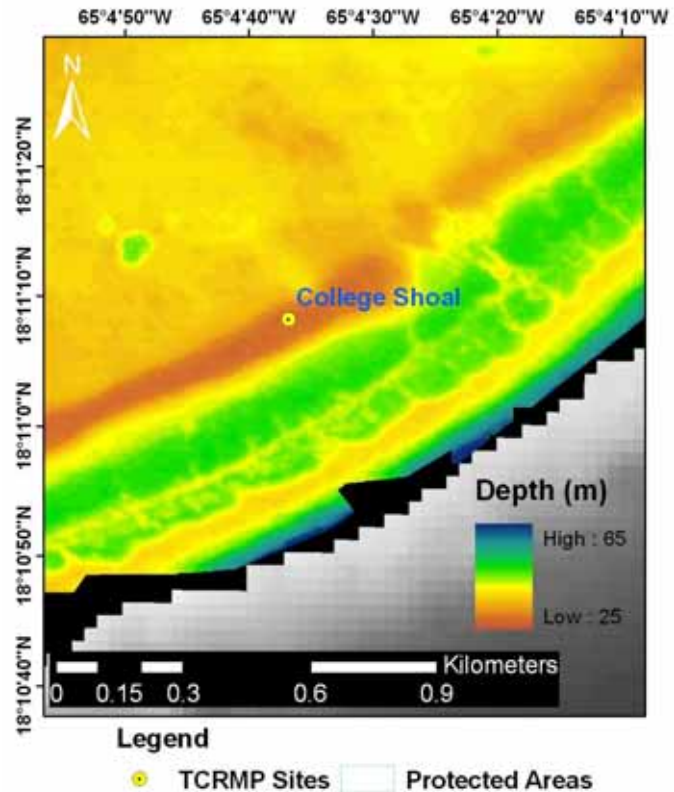


**Figure 122. College Shoal. (top) Location. (right) A representative photo of the reef.**

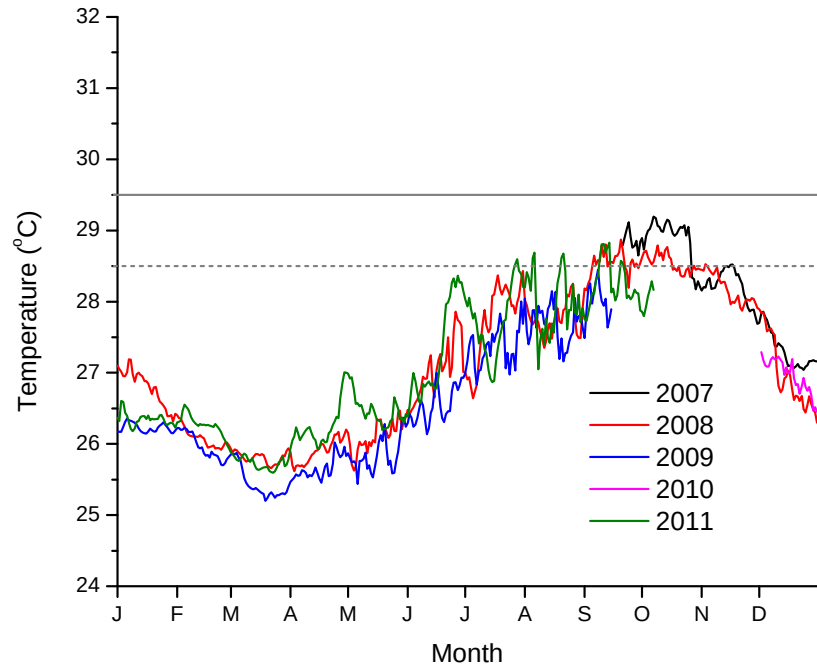


Figure 123. College Shoal benthic temperature record (29m depth).

## Physical Characteristics.

**Currents.** Although not measured directly, College Shoal has strong unidirectional driven currents that seem to be tidally driven and follow a pattern of increasing strength during spring tides.

**Temperature.** Benthic temperatures are ameliorated in the warm season by the proximity of the thermocline. The presence of the thermocline causes temperatures that are cool and diurnally variable from May to October. Unfortunately the thermistor re-initialized improperly in 2009 and the 2010 coral bleaching event temperatures were missed at this site.

# SITE SUMMARIES

**Benthic Community.** College Shoal is among the TCRMP sites with the highest coral cover (38.2% in 2011) and, similar to other bank mesophotic sites south of the St. Thomas, is dominated by the boulder star coral (*Montastraea annularis* spp. complex). This site lost only 10.1% of its coral cover in the 2005 bleaching event, but had not regained cover since then (-1.3%); however, these estimates have some additional error since transects were not made permanent until 2007. Sponges and gorgonians are in very low relative abundance. The algal community is dominated by the macroalga *Lobophora variegata* and lesser representation by epilithic algae. There is also a relatively high proportion of crustose coralline algae.

**Coral Health.** College Shoal bleached at a relatively low prevalence during the 2005 mass coral bleaching event, although corals that were bleached tended to lose color over their entire surface. The 2010 coral bleaching event had no apparent effect above background bleaching levels. Bleaching in years without thermal stress tends to be moderate. Diseases were dominated by white disease, which reached very high prevalence after the 2005 bleaching event, with an outbreak that lasted for two years in 2006 and 2007. This disease was again very prevalent in 2011 after the 2010 bleaching event, even without apparent thermal bleaching. Old partial mortality was elevated on corals after the mortality from the 2005 bleaching event, and this level has remained stable through 2011. Recent partial mortality is always relatively high, much of it attributable to fish bites.

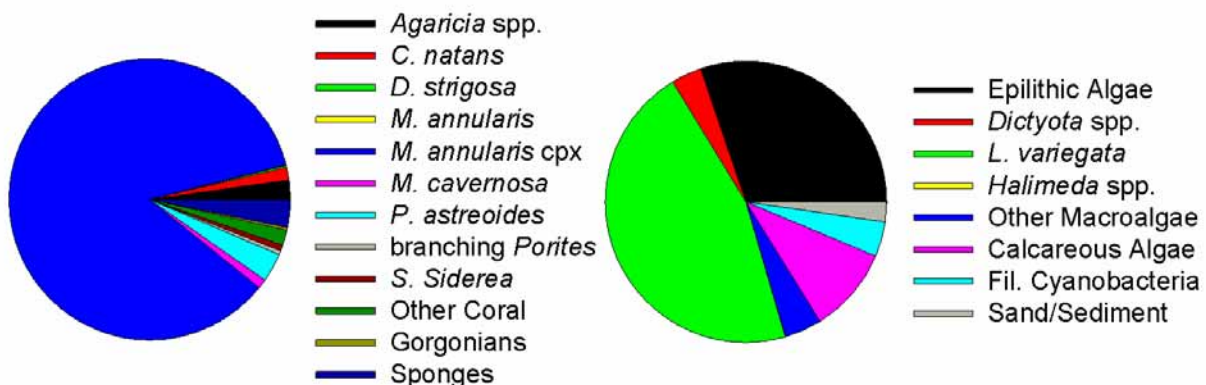


Figure 124. College Shoal (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

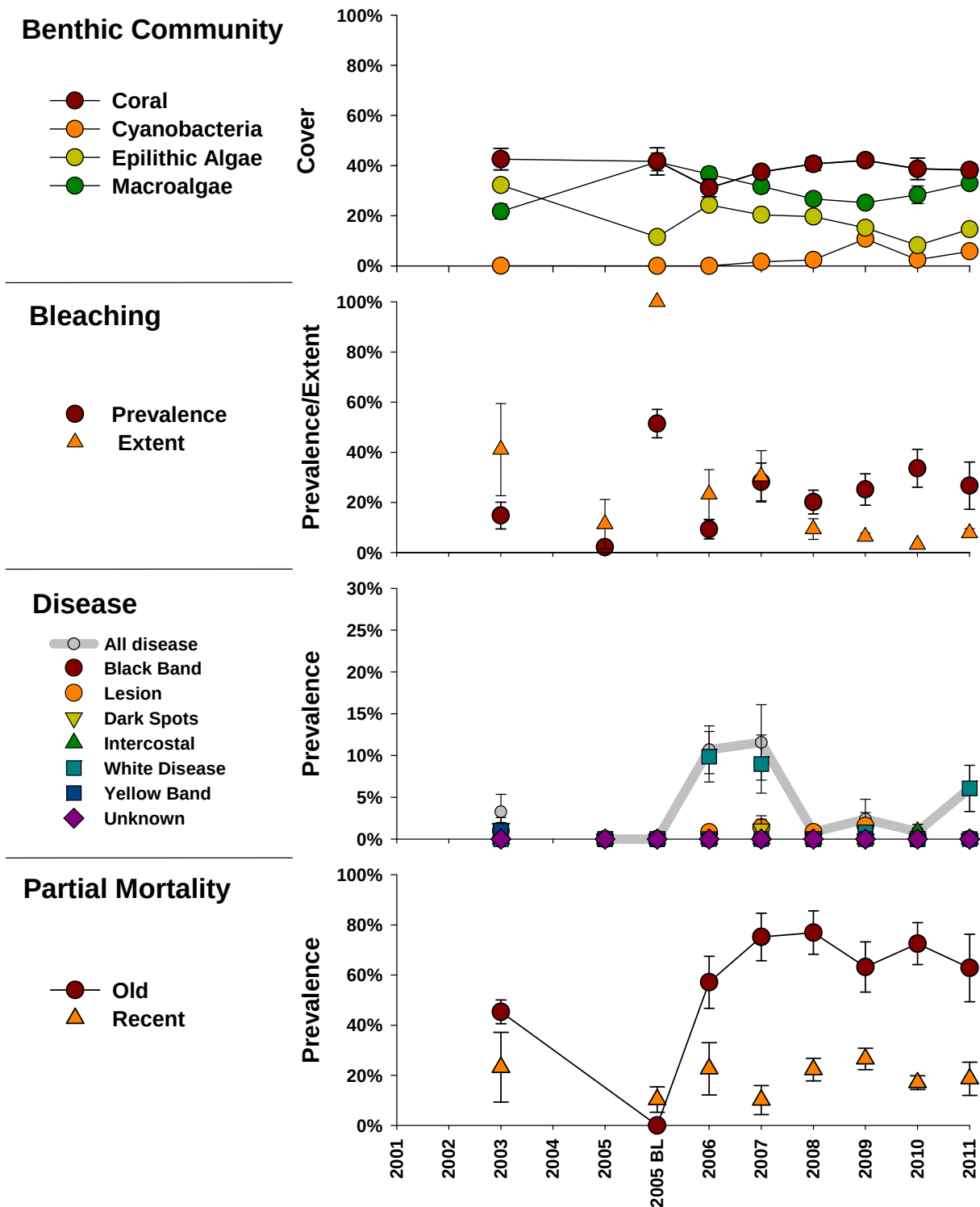


Figure 125. College Shoal benthic cover and coral health through time (mean  $\pm$  SE).

## SITE SUMMARIES

**Fish Community.** College Shoal is characterized by a high fish biomass and high species diversity. Large planktivores are also characteristic of College Shoal, including ocean triggerfish, Atlantic spadefish, black jacks and yellowtail snapper. Numerically, the site is dominated by creole wrasse; however large jacks, snappers, ocean triggerfish and black durgelon are common. College Shoal lies within the Marine Conservation District (MCD) and is protected year round from all fishing. Nassau, yellowfin, yellowmouth and tiger grouper are occasionally observed on the site. The mesophotic, high coral cover reef supports less herbivores than the more shallow near and offshore sites, however more herbivores (ocean surgeonfish) are present than on the significantly deeper Hind Bank and Grammanik Bank. Diversity is high in all trophic guilds indicating a high variety of micro-niches available for fishes.

# COLLEGE SHOAL

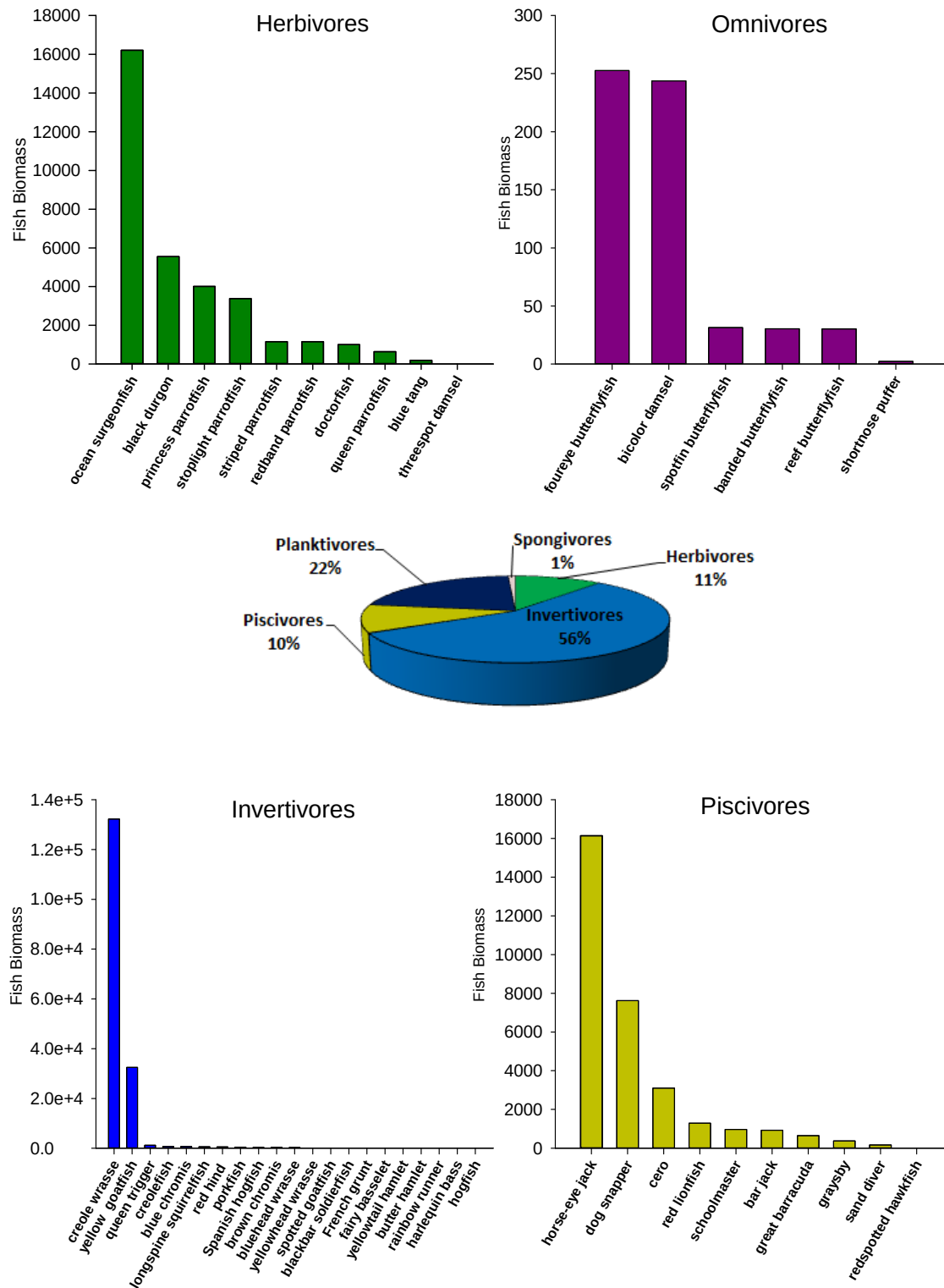


Figure 126. The College Shoal fish community by absolute and relative biomass.

# SITE SUMMARIES

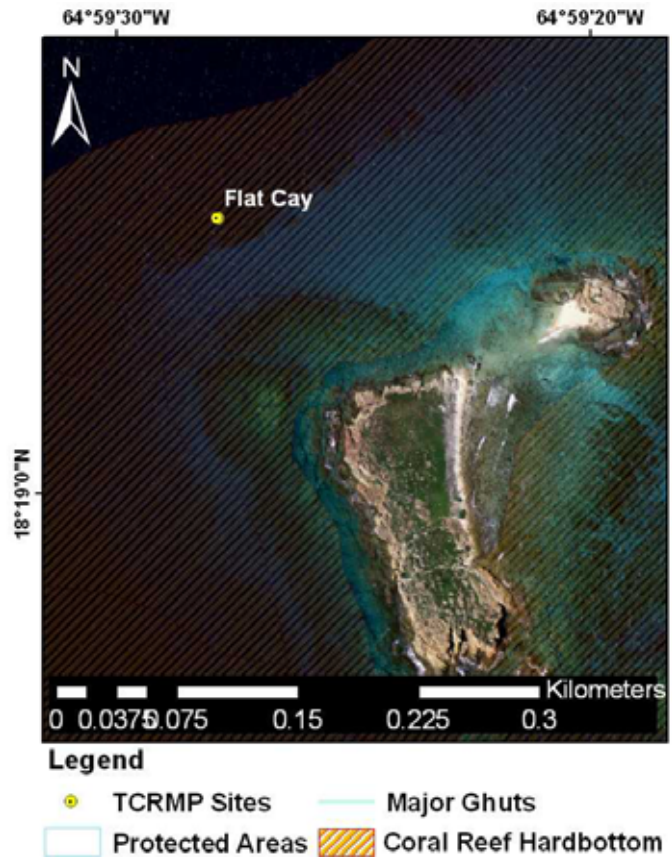
## FLAT CAY

**Description.** This monitoring site wraps around the northwest corner depths of Flat Cay in depths of 10 – 17 m. Black Point has been monitored since 2003, with permanent benthic transects installed in 2007. A ciguatera fish poisoning study with monthly sampling has been ongoing since 2009.

**Outstanding Feature.** Flat Cay supports a lush coral community, including dense populations of the endangered elkhorn and staghorn corals (*Acropora* spp.) outside the TCRMP monitoring site. The site is a popular tourist dive site and is an important site for research by local and international investigators.

**Threats.** Flat Cay is down current of industrial port activities and a major sewage outfall. Mollusks, including the commercially important queen conch (*Strombus gigas*) show sterility (imposex) as a likely result of exposure to hormone mimics released from boat hulls coated with marine antifouling paint containing Tributyltin (Strand et al. 2009). The area experiences heavy fishing and damage from anchoring within the reef.

**Figure 127. Flat Cay. (top) Location. (right) A representative photo of the reef.**



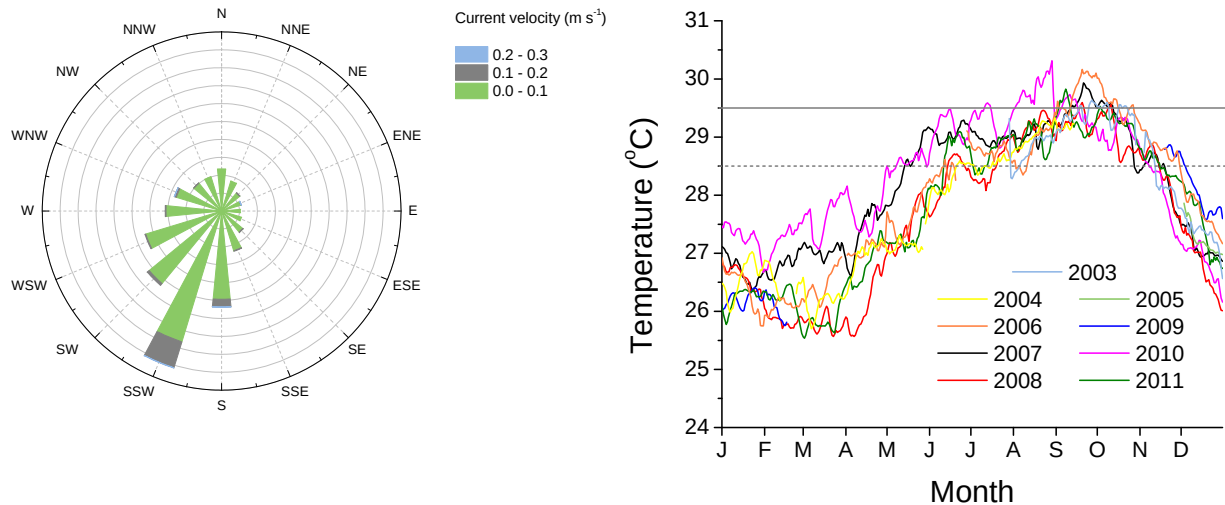


Figure 128. Flat Cay benthic current speed (left) and temperature record (right) (14m depth).

## Physical Characteristics.

**Current.** The benthic current at the Flat Cay site is weak and dominated by a south-southwesterly flow. This may be an effect of the wrapping of the generally westward and occasionally strong surface current. Currents were measured with an Aandaraa 2-D current meter measuring 1m above the seafloor.

**Temperature.** Flat Cay experiences moderate warming for a shallow water site and rapid cooling with the passage of tropical storms.

# SITE SUMMARIES

**Benthic Community.** Flat Cay supports a diverse coral community with dominance of boulder star corals (*Montastraea annularis* spp. complex). The sessile epibenthic animal community also shows a high abundance of sponges. The site lost a moderate 21.9% of cover in the 2005 bleaching event and had regained 159.3% of this cover by 2011. A caveat is that transects were not made permanent until 2007. Epilithic algae and the macroalga *Dictyota* spp., with lesser amounts of *Lobophora variegata*, dominate the algal community. Sand in pockets between coral also makes up a fair amount of the non-living substrate.

**Coral Health.** Corals were severely affected during the 2005 coral bleaching event, with over 90% of corals bleached at 100% extent of the colony surface. Bleaching was also moderately prevalent in the 2010 bleaching event, but at low extent. Coral diseases, particularly dark spots disease can be very prevalent at Flat Cay. There was an unusual outbreak of black band disease in 2004. This disease is rare at the depths of Flat Cay. White disease was somewhat prevalent after the 2005 bleaching. Old partial mortality increased rapidly after the 2005 bleaching event and has not decreased in the intervening years. Recent mortality can be moderate and is due to a variety of causes.

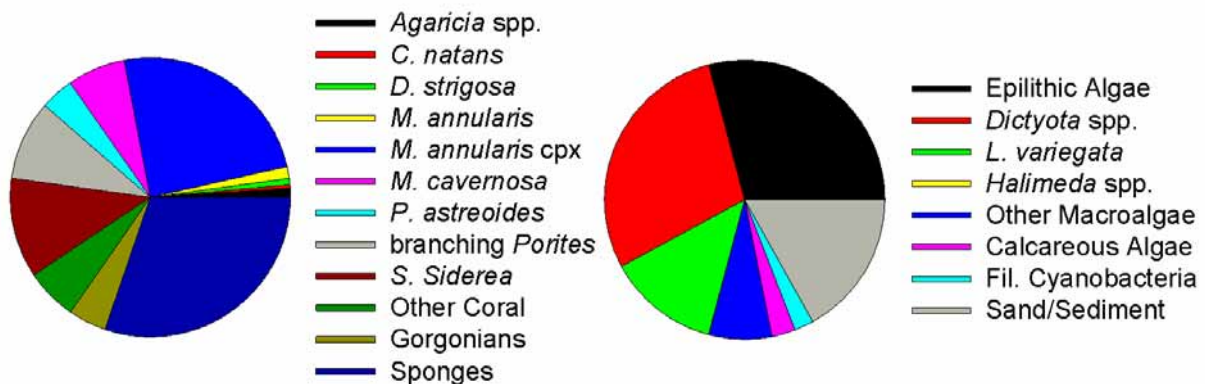


**Figure 129.** Flat Cay (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

## Benthic Community

- Coral
- Cyanobacteria
- Epilithic Algae
- Macroalgae

Cover

## Bleaching

- Prevalence
- ▲ Extent

Prevalence/Extent

## Disease

- All disease
- Black Band
- Lesion
- ▼ Dark Spots
- ▲ Intercostal
- White Disease
- Yellow Band
- ◆ Unknown

Prevalence

## Partial Mortality

- Old
- ▲ Recent

Prevalence

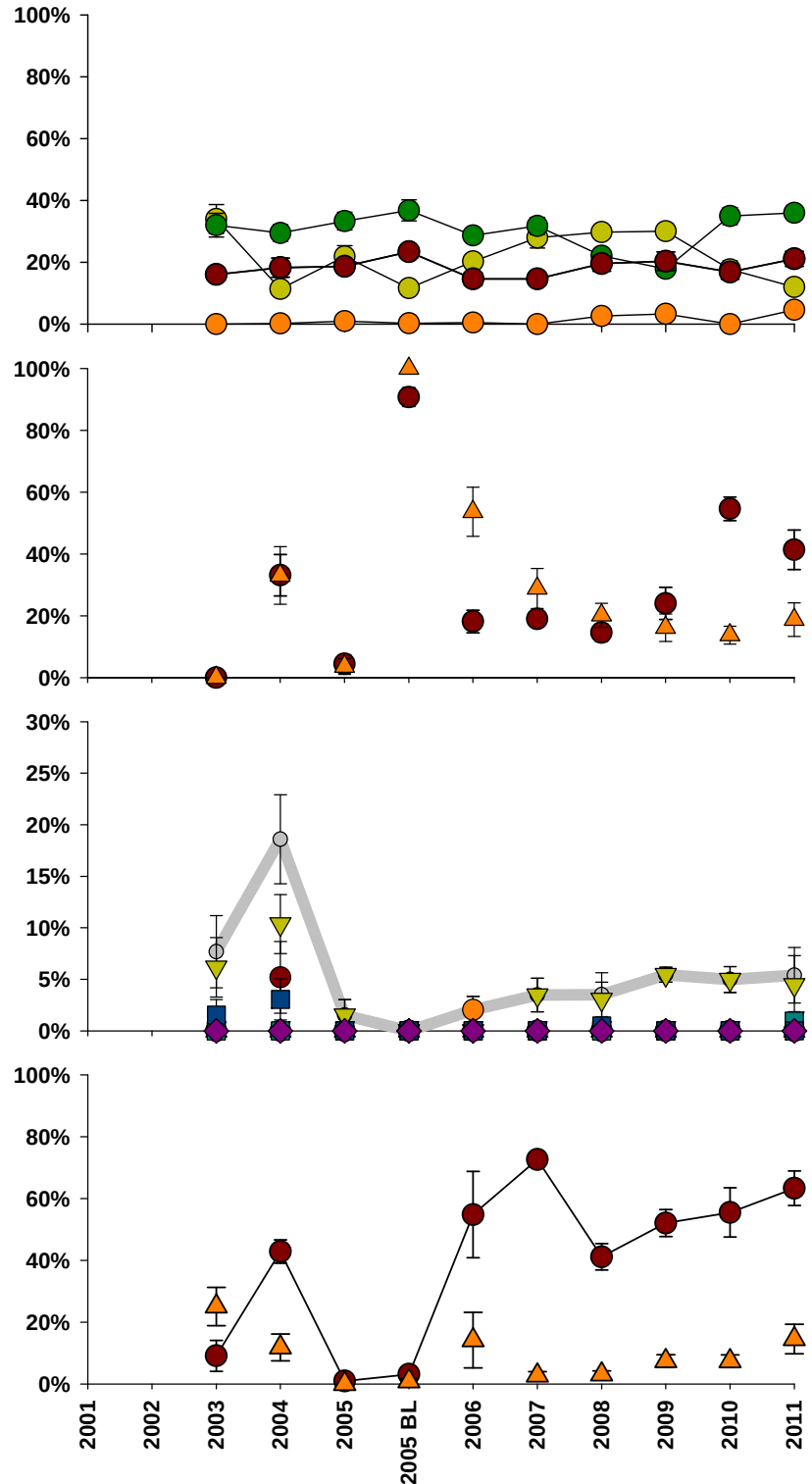


Figure 130. Flat Cay benthic cover and coral health through time (mean  $\pm$  SE).

**Fish Community.** Flat Cay is characterized by a large diversity of fish evenly distributed across trophic guilds. There is a higher biomass of invertivores than other groups due to the regular occurrence of large schools of creole wrasse. Herbivores are dominated by redband and striped parrotfish; however, there is a diversity of parrotfish species. Juvenile parrotfish are prevalent. Carangids frequent the reef and dominate the piscivore trophic group. Occasional large groupers (Nassau, yellowfin, black) have been observed on Flat Cay over the past eight years. The occasional occurrence of black grouper is notable, since this species is absent throughout the majority of monitoring sites. The reef is highly used as a recreational dive site and spearfishing occurs regularly. Where the reef meets the sand offshore, schools of grunts, gray snapper, and goatfish occur. Small reef sharks are seen out over the sand regularly. Chromis, especially brown, are quite numerous.

# FLAT CAY

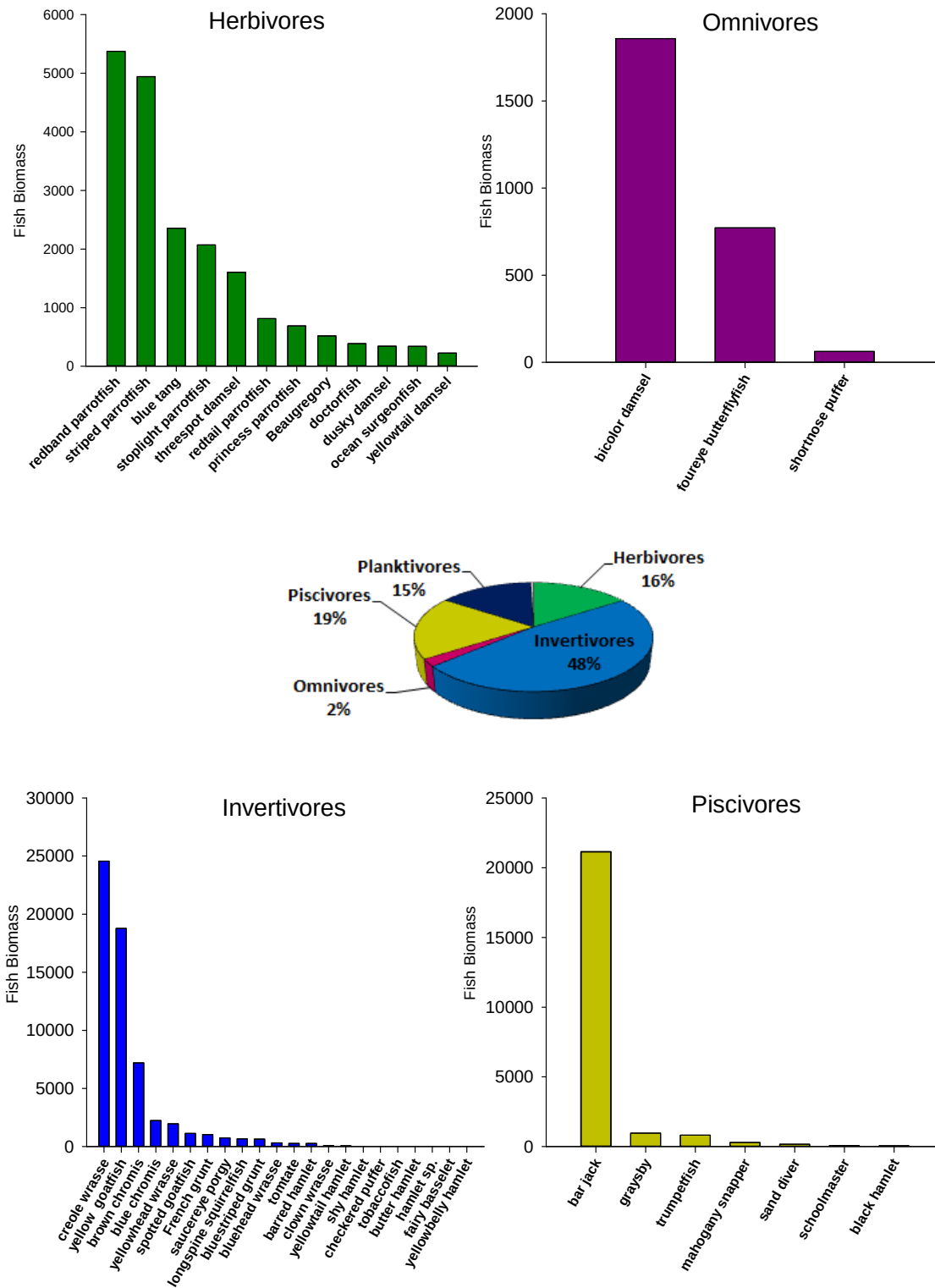


Figure 131. The Flat Cay fish community by absolute and relative biomass.

# SITE SUMMARIES

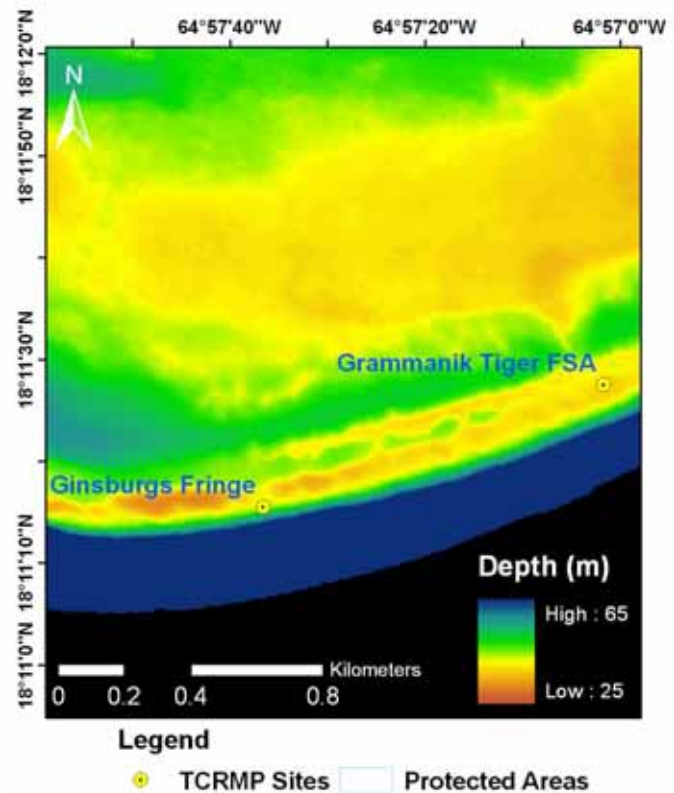
## GINSBURGS FRINGE

**Description.** Ginsburgs Fringe is a mesophotic lettuce coral (*Agaricia* spp.) reef at depths of 60-75m. The reef is on a steep escarpment dropping into the abyssal Virgin Islands trough. Ginsburgs Fringe has been monitored since 2011 and permanent transects have been installed.

**Outstanding Feature.** Ginsburgs Fringe had the highest 2011 coral cover among all TCRMP monitoring sites (44%), with living colonies of lettuce corals over 6m (20') wide. This site is the epicenter of a multispecies fish spawning aggregation, including the threatened Nassau grouper (*Epinephelus striatus*). The site name honors the father of comparative sedimentology and mesophotic coral studies, Dr. Robert N. Ginsburg.

**Threats.** Although little is known about conditions in deep mesophotic lettuce coral reefs, Ginsburgs Fringe appears to be almost unscathed by recent mass coral bleaching events. Lettuce corals at these depths are potato chip thin and fragile, making them vulnerable to damage, such as the laying of benthic cables. The site is being heavily invaded by the Indo-Pacific lionfish (*Pterois volitans*).

**Figure 132. Ginsburgs Fringe. (top) Location. (right) A representative photo of the reef showing whorled lettuce coral colonies up to 7m in width.**



# GINSBURGS FRINGE

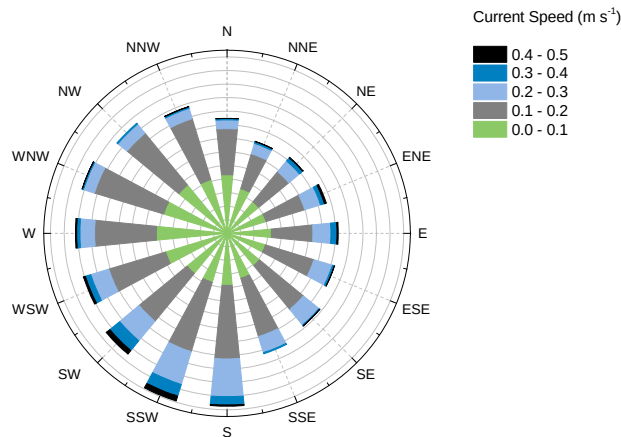


Figure 133. Ginsburgs Fringe current speed (50m depth).

## Physical Characteristics.

**Current.** Currents have been measured above the site in 50 m depth. There is a strong offshelf downwelling (southward) that occurs just above the site, potentially carrying larvae and heterotrophic food supplies to the site.

**Temperature.** Temperature loggers have not yet been retrieved from the site, but a thermistor string is in place at and above the site, with loggers at 30, 40, 50, and 63 m depth.

# SITE SUMMARIES

**Benthic Community.** The coral community at Ginsburgs Fringe is almost exclusively lettuce corals of the genus *Agaricia*. Among the agariciid genus, the rank abundance of species is *A. undata* (30.8% absolute cover), *A. grahamae* (8.2%), and *A. lamarcki* (2.3%), with no colonies of *A. agaricites* and *A. fragilis* occurring in transects. Although not well represented in cover, individual colonies of *Montastraea cavernosa* and *Siderastrea siderea* also occur at the site. The algal community is dominated by the macroalga *Lobophora variegata*, which is surprising for these depths, and epilithic algae. Crustose coralline algae are also in high abundance, as well as a variety of unidentified algal species.

**Coral Health.** Coral health is not directly monitored at Ginsburgs Fringe due to the depth and difficulties assessing colonies greater than 3m width. However, some observations have been made. What appears to be warm season bleaching appears to occur. Colonies have a fair degree of partial mortality and recent mortality is very common. In some cases it appears that shaded colony portions die back due to lack of light. The corallivorous snail, *Coralliophila abbreviata*, has been observed feeding on lettuce corals.

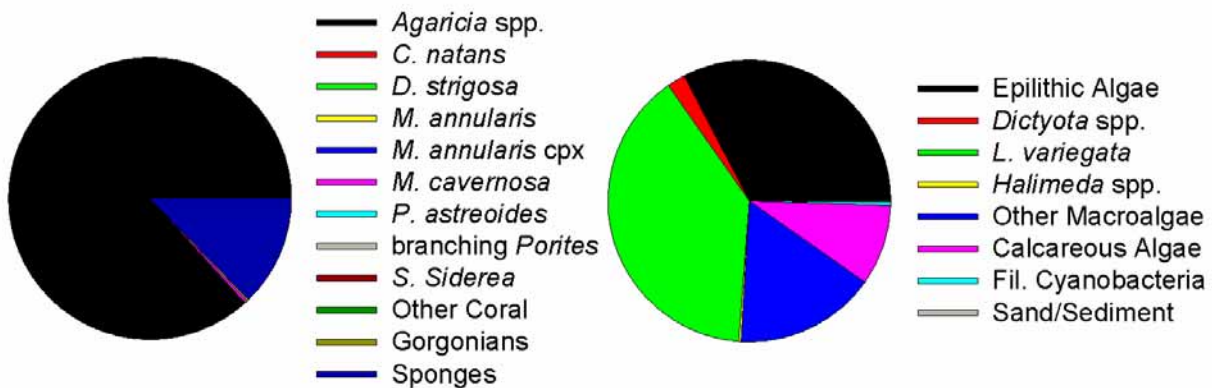


Figure 134. Ginsburgs Fringe. (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

# GINSBURGS FRINGE

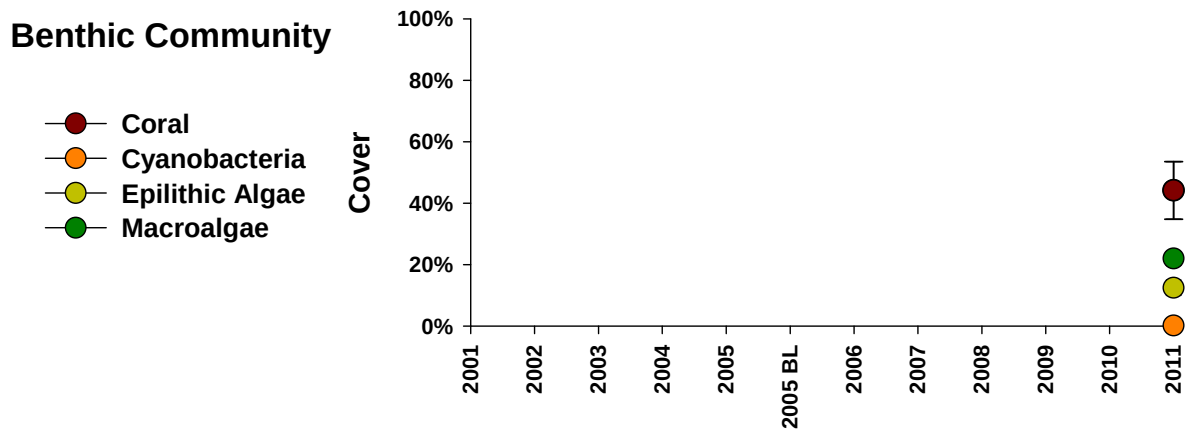


Figure 135. Ginsburgs Fringe benthic cover through time (mean  $\pm$  SE).

# SITE SUMMARIES

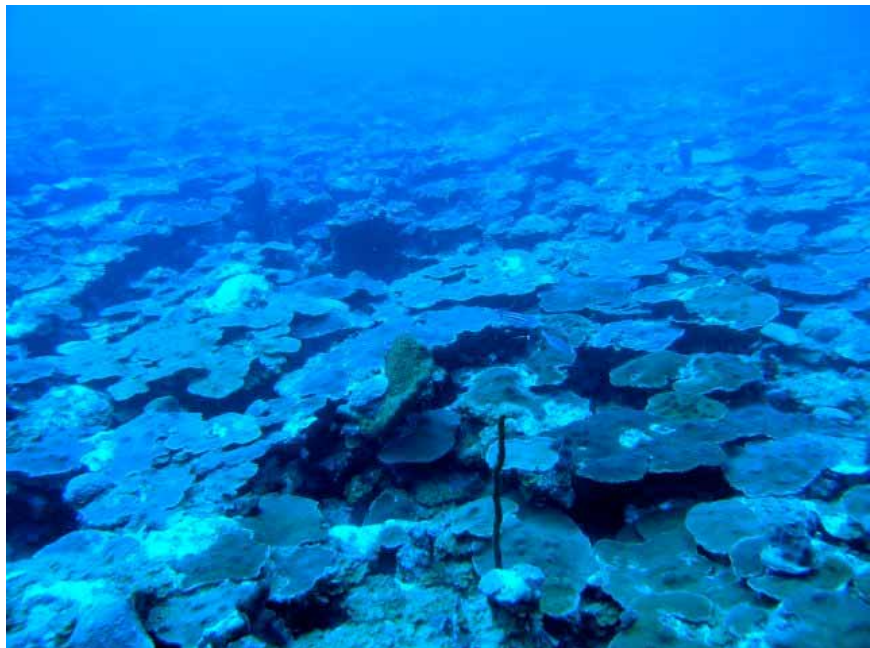
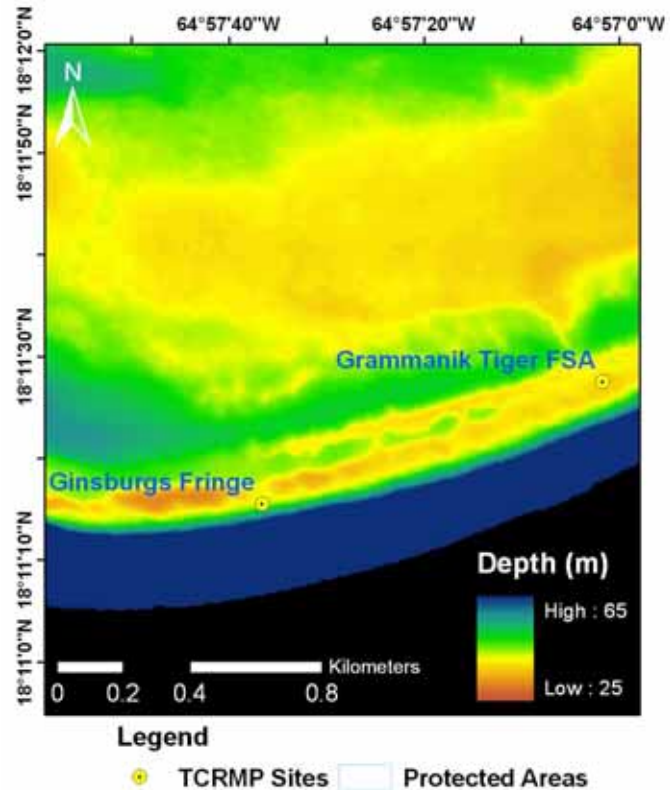
## GRAMMANIK TIGER

**Description.** The Grammanik Tiger monitoring site is a primary bank mesophotic reef in depths of 37 – 41m. Boulder star corals (*Montastraea annularis* spp.) dominate the reef structure. Grammanik Tiger has been monitored since 2003, with permanent transects installed in 2007.

**Outstanding Feature.** The Grammanik Tiger monitoring site supports a dense coral community that is a staging area for annual multi-species fish spawning events, including the threatened Nassau grouper (*Epinephelus striatus*).

**Threats.** Although the Grammanik Tiger site and surrounding dense reefs are somewhat buffered from high thermal stress, but they are susceptible to chronic coral white diseases. Periodic disease outbreaks follow coral bleaching events. The Indo-Pacific lionfish (*Pterois volitans*) has formed dense populations within the study area and may be affecting native fish populations.

**Figure 136. Grammanik Tiger (top) Location. (right) A representative photo of the reef.**



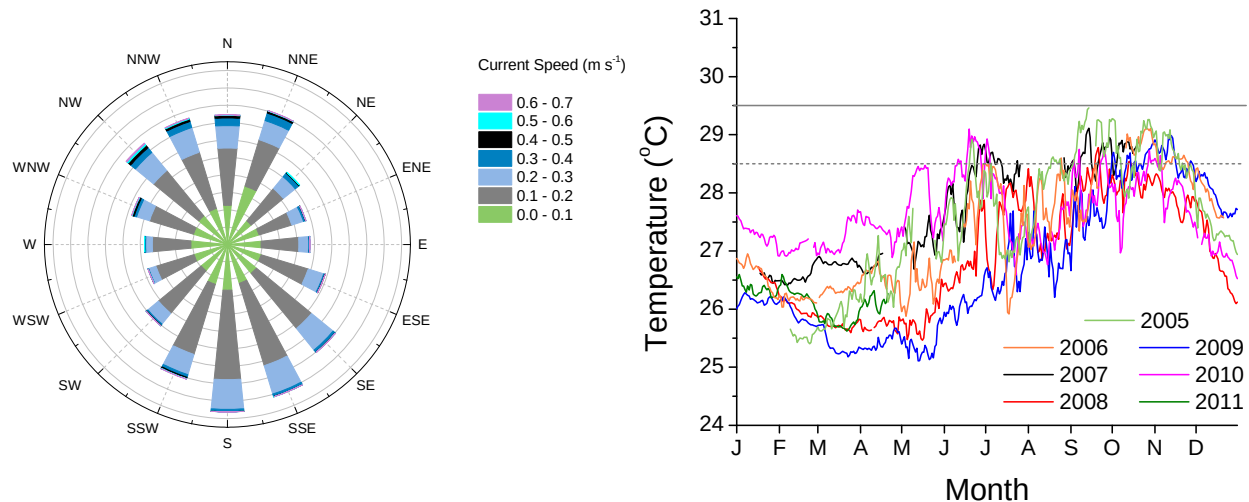


**Figure 137. Grammanik Tiger benthic currents speed and temperature record (38 m depth).**

## Physical Characteristics.

**Current.** Unidirectional benthic currents at the Grammanik Tiger site are generally north-south, with the strongest current from the north-northeast to the northwest. Currents are typically weak to moderate, but occasionally reach strengths greater than  $30\text{ cm s}^{-1}$ . Current speeds are based on near-continuous ADCP deployments from February 2005 to April 2009, with measurements at 30 or 60 minute intervals. Oscillatory currents are nil at this depth, with the possible exception of long period swells generated by tropical storms, although this has not been measured.

**Temperature.** Benthic temperatures at Grammanik Tiger are ameliorated by the passage of tidally driven internal tides in the warm season (May-November). Even in 2005 and 2010 when shallow waters were there warmest during monitoring, temperatures at this site were less than the shallow water bleaching threshold. However, the monthly maximum mean of surface waters established for the region is routinely surpassed. Inter-annual variability creates temperatures that can be up to  $2^{\circ}\text{C}$  different for the same Julian Day.

# SITE SUMMARIES

**Benthic Community.** Boulder star corals (*Montastraea annularis* spp. complex) dominated the coral community of the Grammanik Tiger site; however, there is representation by a high number of other species that are also present in shallow water reefs. Grammanik Tiger lost only 5.4% of its coral cover in the 2005 bleaching event, but had not regained any cover (-129.6%) by 2011. A caveat is that transects were not made permanent until 2007. Other prominent members of the sessile epibenthic animal community are sponges. The macroalga *Lobophora variegata* and epilithic algae dominate the algal community. There are also a relatively high proportion of crustose coralline algae and various other macroalgae species.

**Coral Health.** Corals at Grammanik Tiger were very weakly affected by bleaching in 2005, with only about 10% of corals exhibiting bleaching; however, those that bleached had nearly 70% of the colony surface affected. The 2010 bleaching event was not detectable above background bleaching levels. The prevalence of bleaching in normal years is quite high, but at low extent. This and other mesophotic reefs dominated by *M. annularis* spp. complex exhibit a type of granular bleaching, whereby pigmented spots are surrounded by bleached areas. Coral diseases are very prevalent with high representation of white disease. Yellow band disease was reported at high prevalence in the first years of monitoring. Old partial mortality was low, but increased rapidly after the 2005 coral bleaching event. Recent partial mortality is typically very high and is caused by disease lesions, predations, and fish bites.

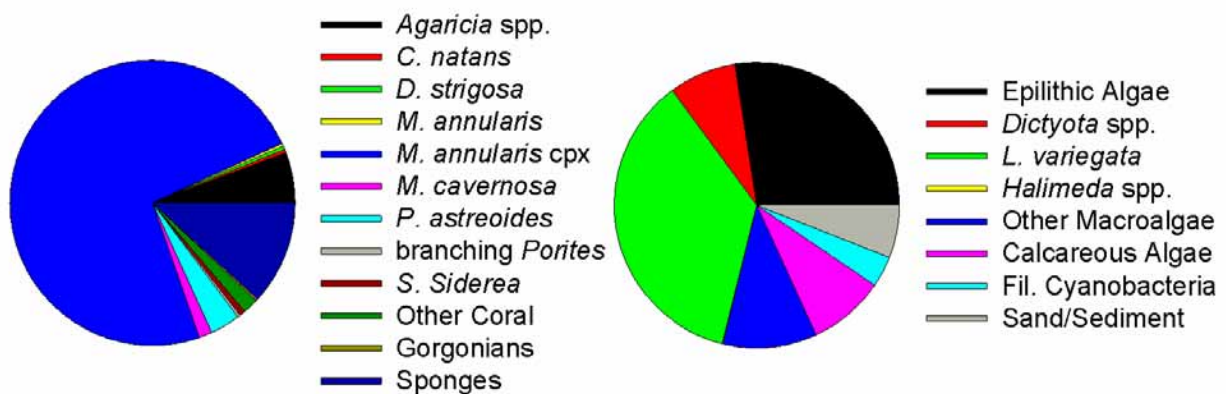


**Figure 138. Grammanik Tiger FSA. (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.**

# GRAMMANIK TIGER

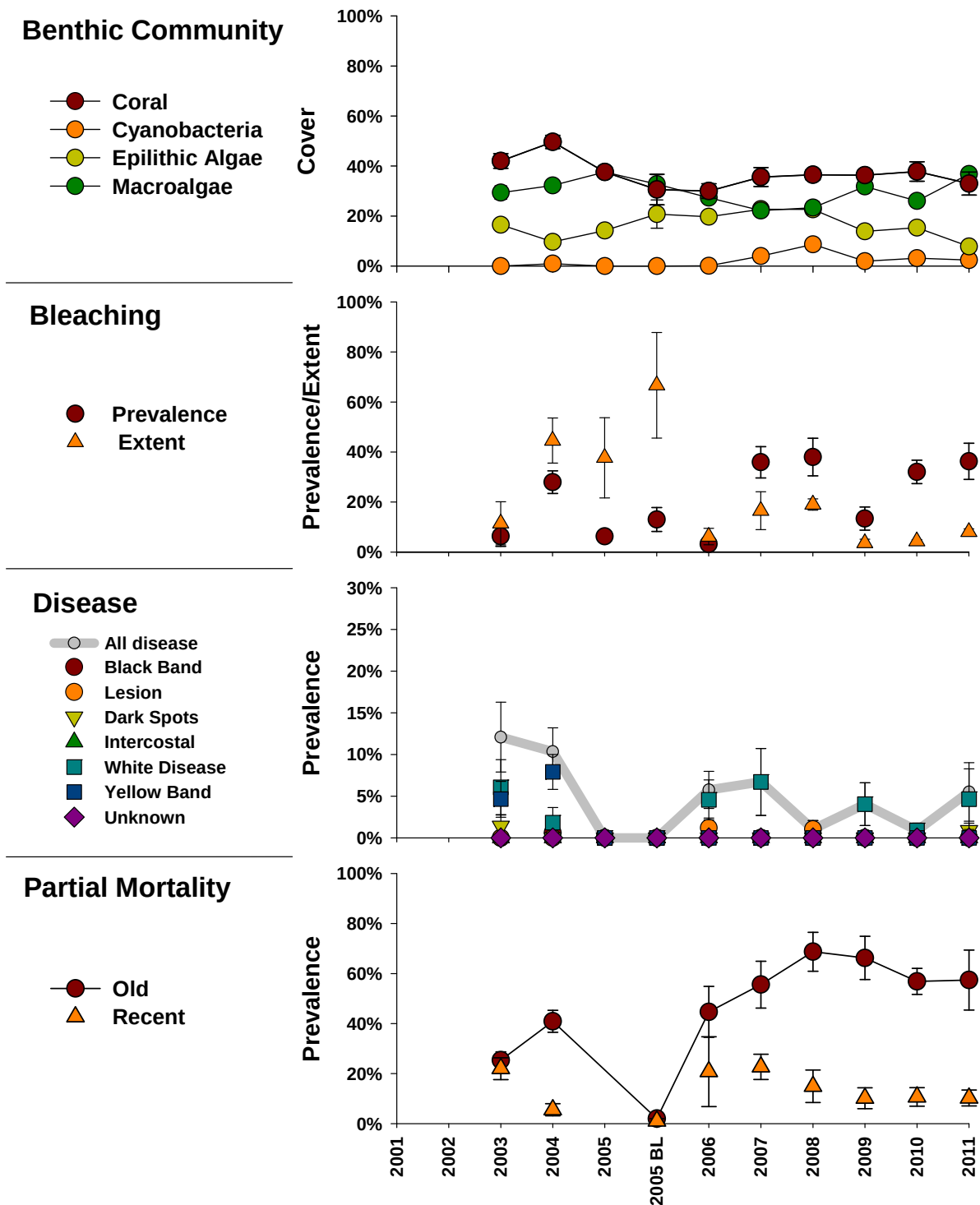


Figure 139. Grammanik Tiger benthic cover and coral health through time (mean  $\pm$  SE).

## SITE SUMMARIES

**Fish Community.** The Grammanik Tiger site supports less herbivores and a greater number of piscivores than the more shallow sites in the TCRMP. It is within the staging area and near the spawning site of an aggregation of several species of grouper and snapper. Given the range of spawning species encountered, surveys often coincide with the occurrence of aggregations, particularly in those species with protracted spawning seasons (e.g., cubera and schoolmaster snapper). This drives up the relative piscivore biomass; however, on the Grammanik Bank there also commonly occur members of the pelagic jack family (Carangidae) as well as occasional other large non-spawning grouper and snapper that are rarely or never found on the near and offshore reefs. Nassau, yellowfin, yellowmouth and tiger grouper are present during non-spawning periods. This reef is protected from traps year round, and from all fishing gear from March through May. Creole wrasse dominate the invertivores and adult stoplight parrotfish dominates herbivores. Juvenile parrotfish and doctorfish are relatively uncommon on this and all mesophotic sites. Yellowhead and bluehead wrasse are also notably much less common on the Grammanik Bank than other sites. In recent years the invasive Indo-Pacific lionfish (*Pterois volitans*) has become very common, with tens of individual commonly observed on any given dive.

# GRAMMANIK TIGER

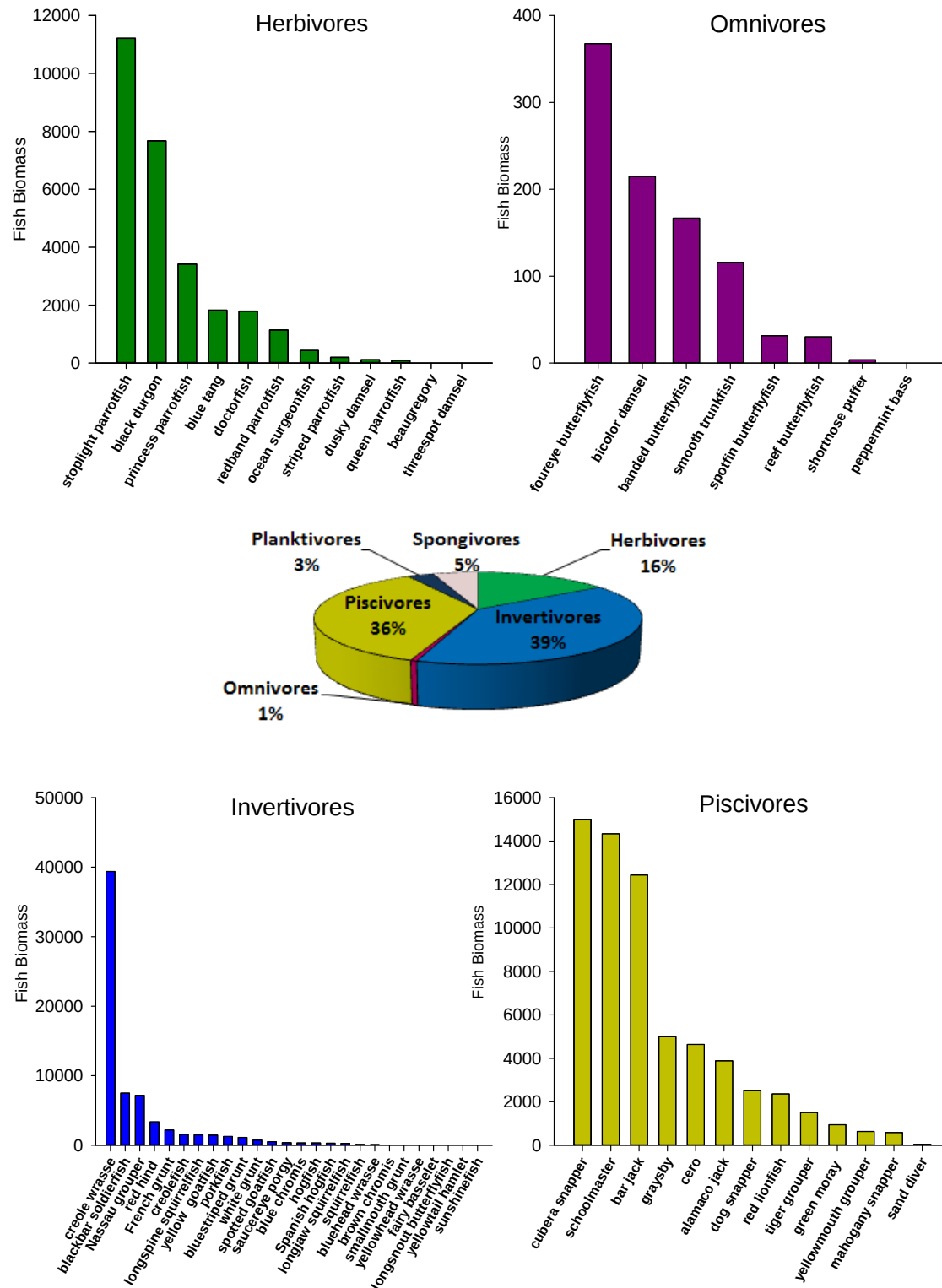


Figure 140. The Grammanik Tiger fish community by absolute and relative biomass.

# SITE SUMMARIES

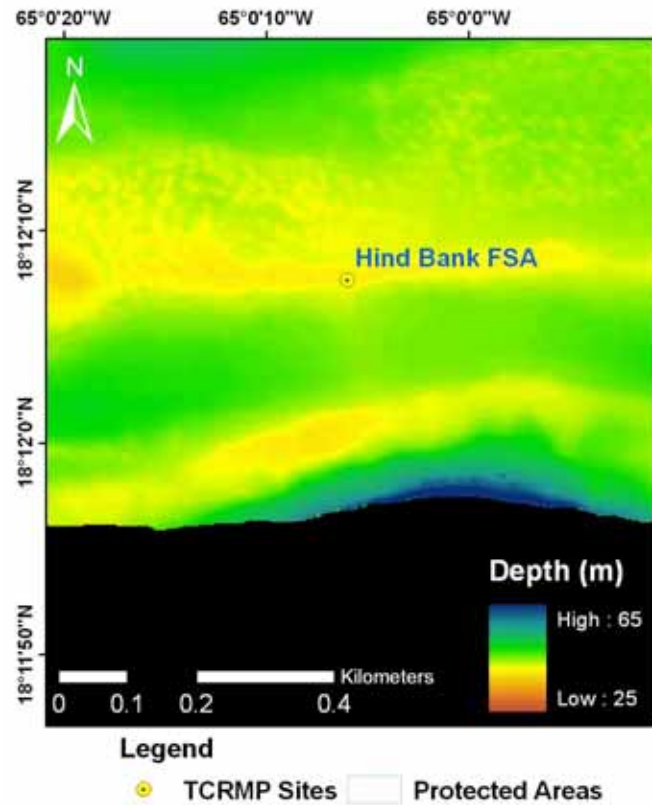
## HIND BANK

**Description.** The Hind Bank is a mesophotic tertiary bank in depths of 38 – 42 m. The reef is part of a patchy complex of boulder star coral (*Montastraea annularis* spp.) dominated reefs that stretch across the eastern Red Hind Marine Conservation District. The Hind Bank has been monitored since 2003, with permanent benthic transects installed in 2007.

**Outstanding Feature.** The Hind Bank is within a no-take marine reserve and fish populations are recovering and robust. The Hind Bank monitoring site hosts a multispecies spawning aggregation, including a recovering mating population of the commercially important red hind grouper (*Epinephelus guttatus*).

**Threats.** The Hind Bank and surrounding dense reefs are somewhat buffered from high thermal stress, but they are susceptible to chronic coral white diseases. Periodic disease outbreaks follow high thermal stress. The Indo-Pacific lionfish (*Pterois volitans*) has formed dense populations within the study area and may be affecting native fish populations.

**Figure 141.** Hind Bank (top) Location. (right) A representative photo of the reef.



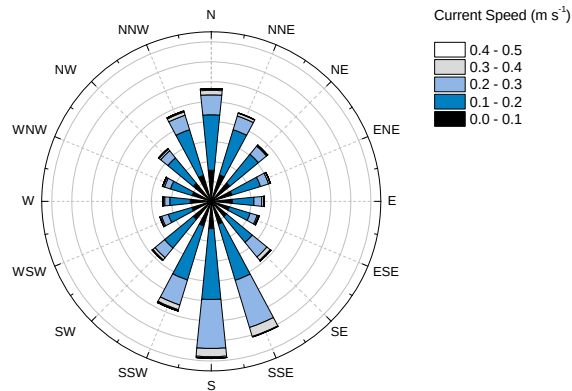
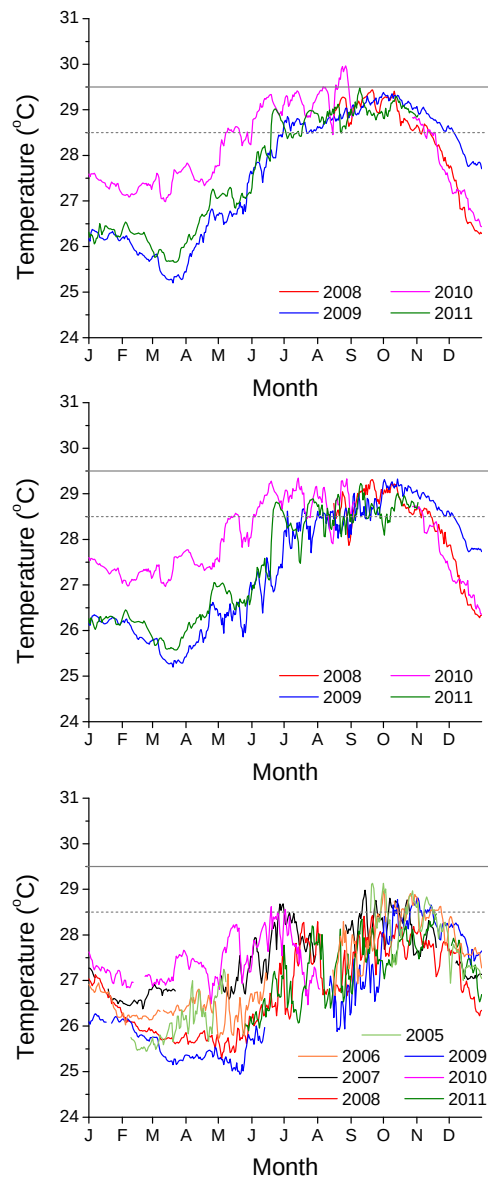


**Figure 142. Hind Bank benthic current speed (40m depth). Benthic temperature record at 20, 30, and 40 m depth.**

## Physical Characteristics.

**Current.** Hind Bank has moderately strong unidirectional near-benthic currents that are dominated by a north to south components. Currents can be moderate to strong ( $>20\text{cm s}^{-1}$ ). Current speeds are based on near-continuous ADCP deployments from February 2005 to May 2012, with measurements at 30 or 60 min. intervals. Oscillatory currents are not known from the Hind Bank.

**Temperature.** Benthic temperatures at the Hind Bank were augmented with a subsurface buoyed thermistor string carrying thermistors at 20 and 30m depth. Benthic temperatures show strong inter-annual variability, but were much cooler than temperatures in the mixed layer at 20m depth. This was particularly evident in 2010, when temperatures were warmest at 20m in late August during coral bleaching, temperatures were unseasonably cool on the bottom. The 30m thermistor was intermediate, with warming to near the bleaching threshold in 2010, but not surpassing the threshold like the 20m depth. One caveat for the accuracy of the 20 and 30m thermistors is that they can change depth to some degree by bowing of the buoy line by currents.



# SITE SUMMARIES

**Benthic Community.** The Hind Bank site is dominated by boulder star corals (*Montastraea annularis* spp. complex), but also has a high abundance of lettuce corals (*Agaricia* spp.). The Hind Bank site lost 21.8% of its coral cover in the 2005 bleaching event, but had regained 71.4% of this cover by 2011. The algal community is co-dominated by epilithic algae and the macroalga *Lobophora variegata*. There is also high representation of crustose coralline algae and other unidentified macroalgal species.

**Coral Health.** Bleaching during the 2005 event was nearly indistinguishable from background levels of bleaching in both prevalence and extent. The prevalence of bleaching was actually higher during the 2010 coral bleaching event. In later years the high prevalence of moderate prevalence, low colony extent bleaching was often associated with granular bleaching. This bleaching pattern shows pigmented spots surrounded by bleached tissue. Coral diseases are common at the Hind Bank and may be increasing. White disease was the dominant disease, and 2011 showed a peak of disease signs. In 2009 there was a high prevalence of intercostal mortality syndrome, which is only known from mesophotic coral reefs (Smith et al. 2010b). Old partial mortality increased after the 2005 bleaching event and the high prevalence was not reduced until 2011. Recent partial mortality prevalence is often high and reflects the impacts of disease and predation.

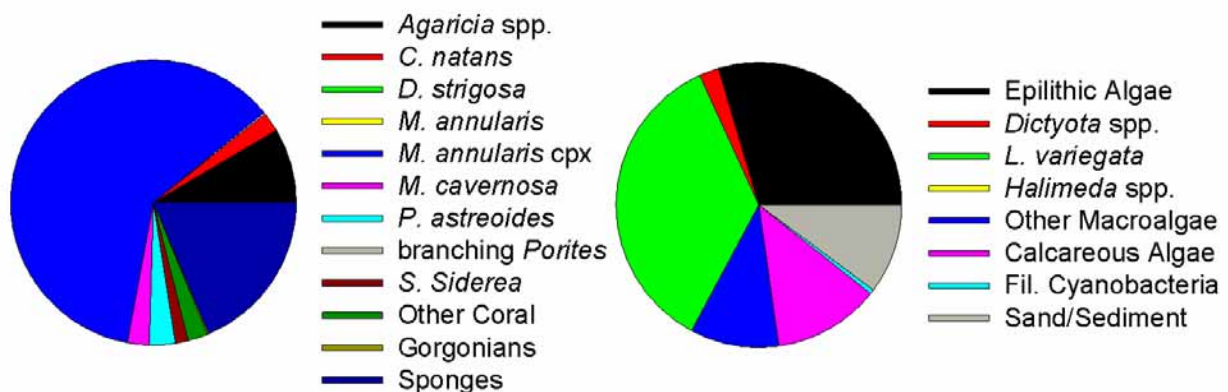


Figure 143. Hind Bank. (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

# HIND BANK

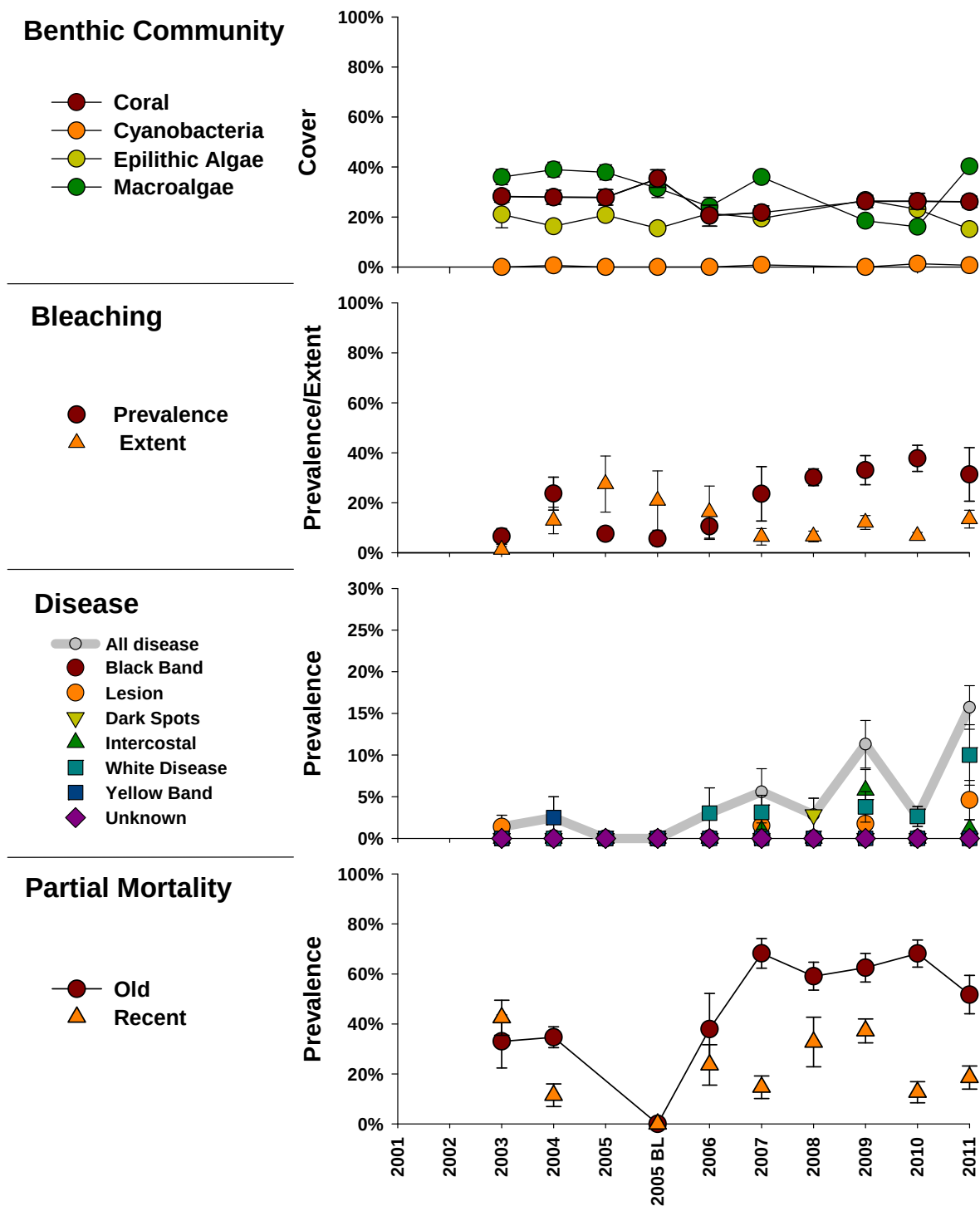


Figure 144. Hind Bank benthic cover and coral health through time (mean  $\pm$  SE).

**Fish Community.** The Hind Bank is characterized by a high number of piscivorous fish. The site is within the Marine Conservation District (MCD) and is protected year round from all fishing, except surface trolling. It is the spawning site for several species including red hind, mutton snapper, tiger grouper and schoolmaster snapper. Surveys often coincide with the occurrence of schoolmaster snapper. This drives up the relative piscivore biomass; however, there also commonly occurs members of the pelagic jack family (Carangidae) and large barracuda. Invertivores are dominated by goatfish as the likely results of the proximity of sand areas around reefs. Creole wrasse are not nearly as dominant as on other mesophotic sites. Herbivores are less common than on nearshore sites and are dominated by adult or semi-adult princess parrotfish. Juvenile parrotfish and doctorfish are uncommon, as on all mesophotic sites. Yellowhead wrasse are fairly common on the Hind Bank, however bluehead wrasse are not.

# HIND BANK

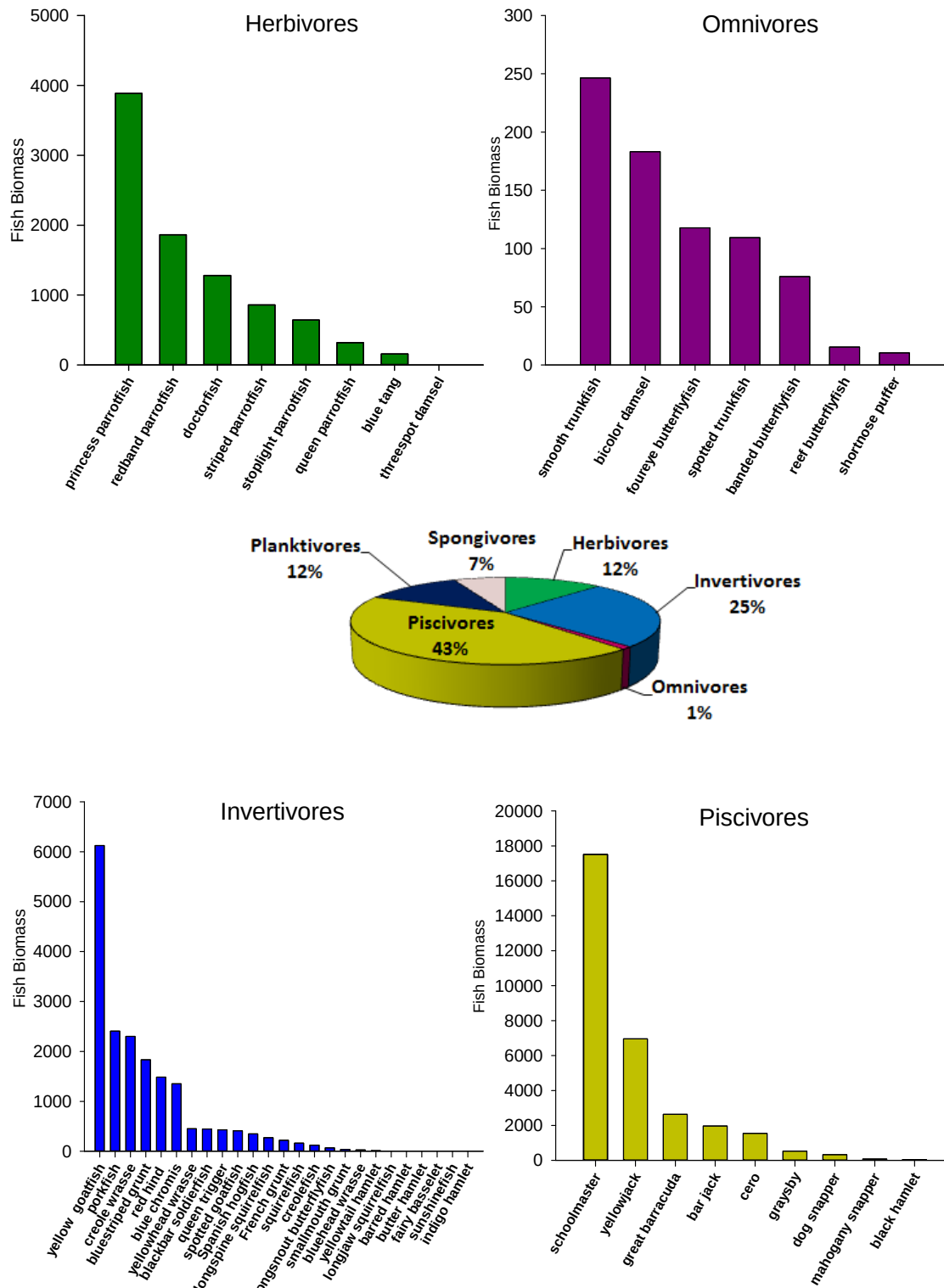


Figure 145. The Hind Bank East fish community by absolute and relative biomass.

# SITE SUMMARIES

## LITTLE SAINT JAMES

**Description.** The Little St. James site is a midshelf hardbottom reef in depths of 16-22m. The reef is a patch reef surrounded by sand/rhodolith plain. Little St. James has been monitored since 2005, with permanent benthic transects installed in 2007.

**Outstanding Feature.** The Little St. James site is just outside the St. Thomas East End Reserve and supports occasionally high densities of snappers, grunts, and queen trigger.

**Threats.** Commercial fisherman target the Little St. James site and active and derelict fish traps are in high abundance. The site is down-current of development on Little St. James Island and is potentially threatened by land-based source of pollution.

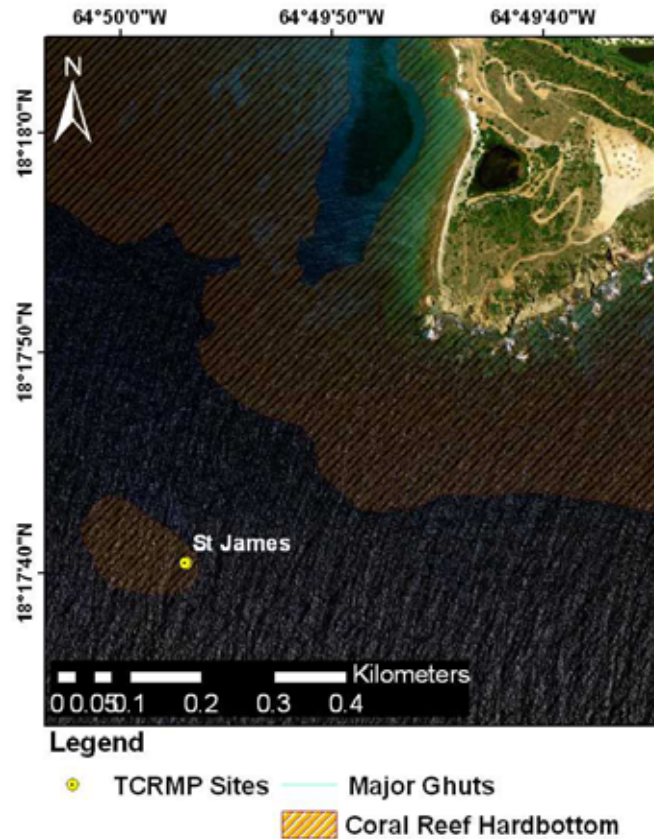


Figure 146. Little St. James. (top) Location. (right) A representative photo of the reef.



# LITTLE SAINT JAMES

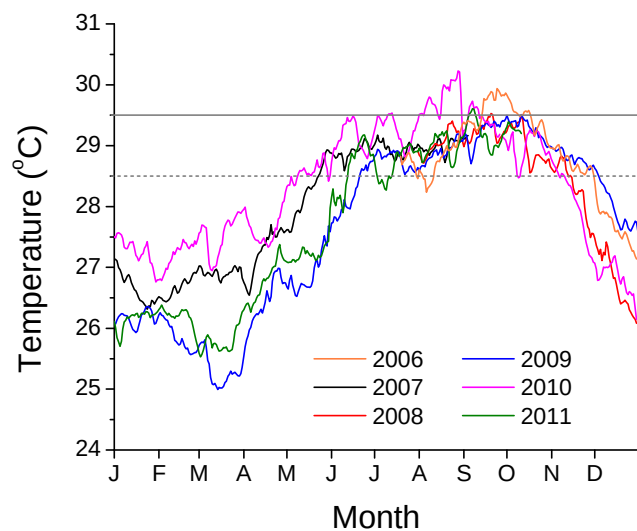


Figure 147. Little St. James benthic temperature record (19m depth).

## Physical Characteristics.

**Current.** Currents have not been directly measured at St. James. Unidirectional benthic currents have only been weak during monitoring. Strong wave-driven oscillatory currents may take place, as evidenced by the high proportion of gorgonians and *Sargassum* spp. at the site.

**Temperature.** Benthic temperatures at St. James can be high during warm years, such as 2010.

# SITE SUMMARIES

**Benthic Community.** The sparse coral community of the Little St. James site is diverse. There is a high proportion of rare species, such as *Eusmilia fastigiatum*, *Madracis* spp., and *Mycetophyllia*. The site lost 16.5% of coral cover in the 2005 bleaching event but had apparently regained 376.2% of this loss by 2011. This large increase above bleaching losses may be explained by the fact that transects were not made permanent until 2007. The sessile epibenthic community overall is largely composed of sponges and gorgonians. The algal community is dominated by the macroalgae *Dictyota* spp. and the *Sargassum* spp. *Lobophora variegata* and epilithic algae are also in high proportional abundance.

**Coral Health.** The coral community at Little St. James was highly affected by the 2005 coral bleaching event, with all corals assessed completely bleached. Half the corals were affected by low extent bleaching in 2010. Low-level bleaching is a common feature of the site. Diseases are less common, with the exception of a white disease outbreak that preceded the coral bleaching event in June 2005. Dark spots disease can also be common. Old partial mortality increased rapidly after the 2005 bleaching event. Recent partial mortality is not very prominent.

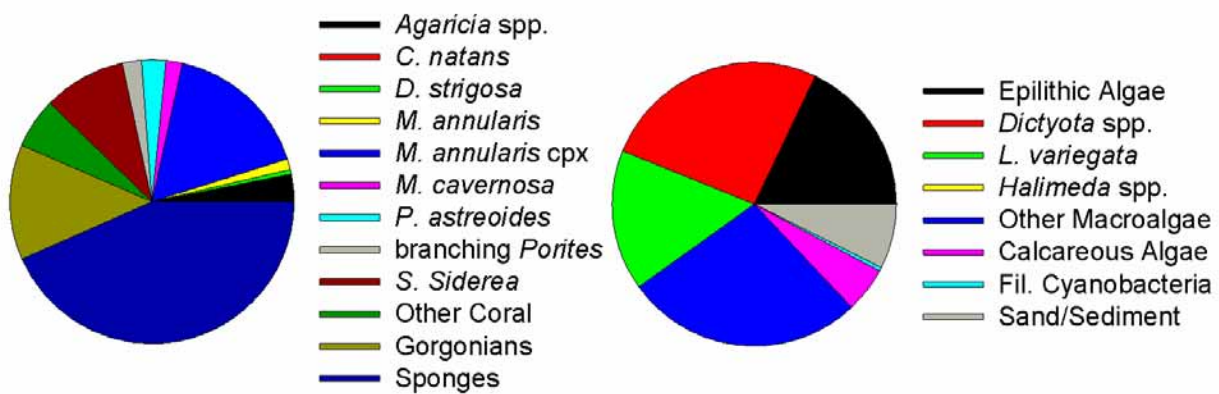


Figure 148. Little St. James. (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

# LITTLE SAINT JAMES

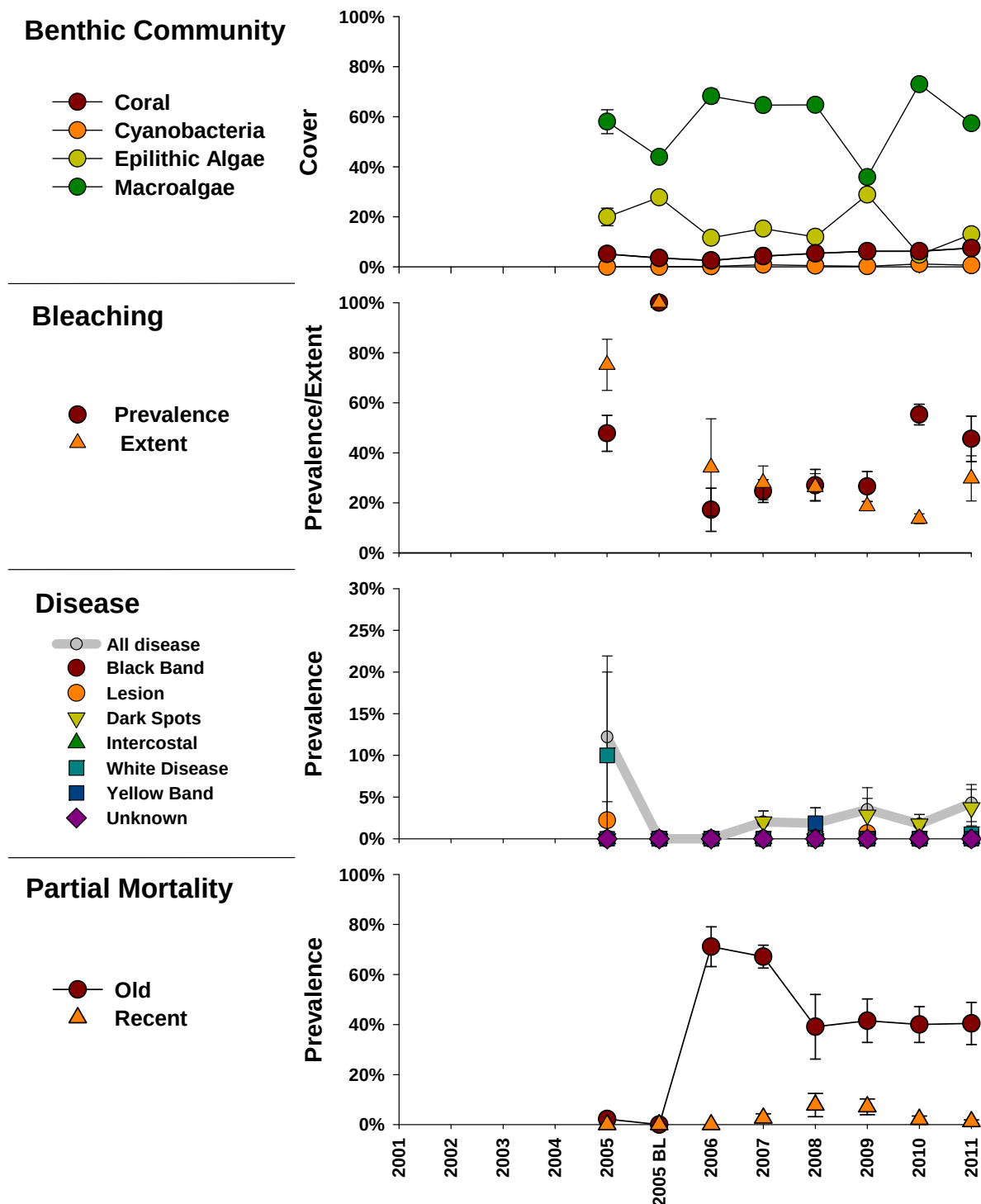


Figure 149. Little St. James benthic cover and coral health through time (mean  $\pm$  SE).

# SITE SUMMARIES

## MAGENS BAY

**Description.** The Magens Bay site is a nearshore fringing reef located along Peterborg Point in depths of 4 – 14 m. The reef has a sharp break in slope leading to a steep escarpment that terminates in a sand/sediment plain at the reef base. Magens Bay has been monitored since 2001.

**Outstanding Feature.** The Magens Bay site is well protected northside reef near one of the most popular tourist beaches in the Caribbean.

**Threats.** Magens Bay is in a highly enclosed embayment receiving a very large and developed watershed. Sediment run-off is high and deposition on reefs is favored by slow current speeds. In addition, leaky septic systems may impair bay waters. Recreational/artisanal fishers frequently fish this site with hand line and spear.

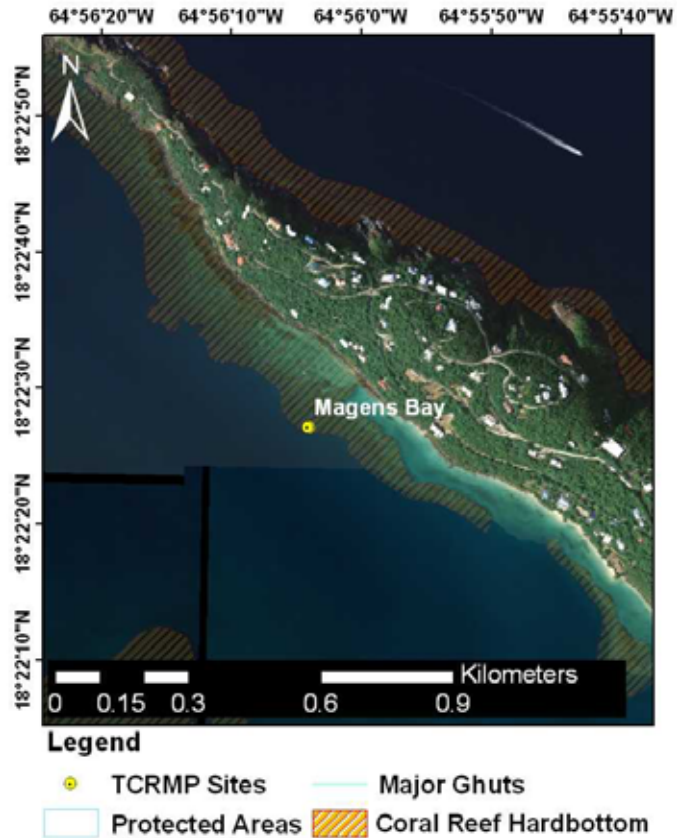


Figure 150. Magens Bay. (top) Location. (right) A representative photo of the reef.

# MAGENS BAY

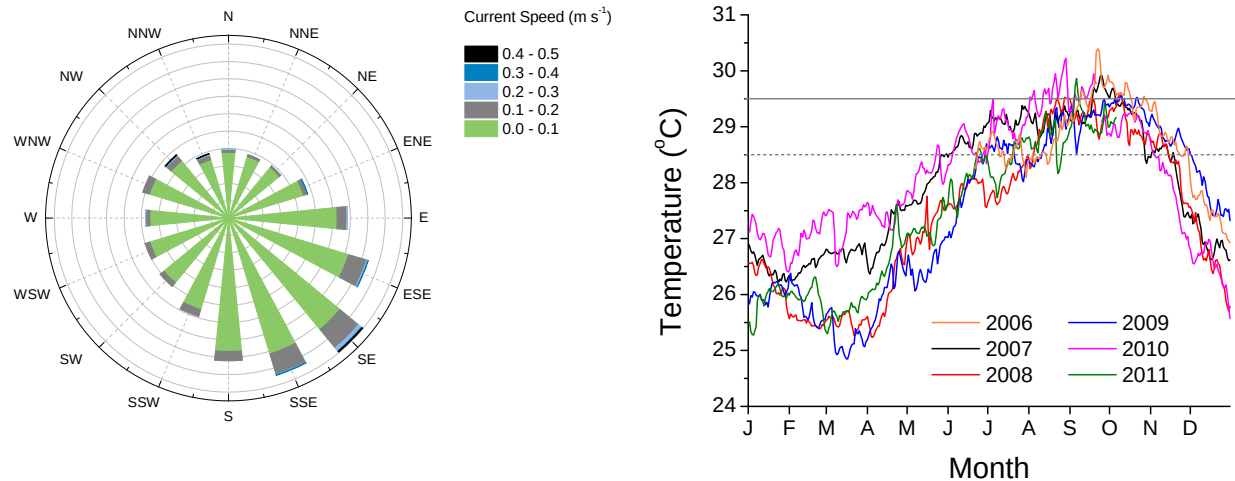


Figure 151. Magens Bay current speed and benthic temperature record (9 m depth).

**Physical Characteristics. Current.** Magens Bay has restricted water flow dominated by weak currents running counter or orthogonally to the left of the dominant wind direction. This may indicate that there is a counter flowing eddy. Current data are based on average data from Dec. 2006-Oct. 2007 7.5 m above the sensor head. **Temperature.** Black Point has low circulation, but temperatures are kept cooler by exposure to the Atlantic. **Chlorophyll & Turbidity.** Magens Bay is susceptible to very high chlorophyll and turbidity values indicating very high productivity that is likely fueled by terrestrial run-off. By blocking light this shallows the depth limits for coral growth and water column productivity favors heterotrophic organisms, such as sponges and gorgonians.

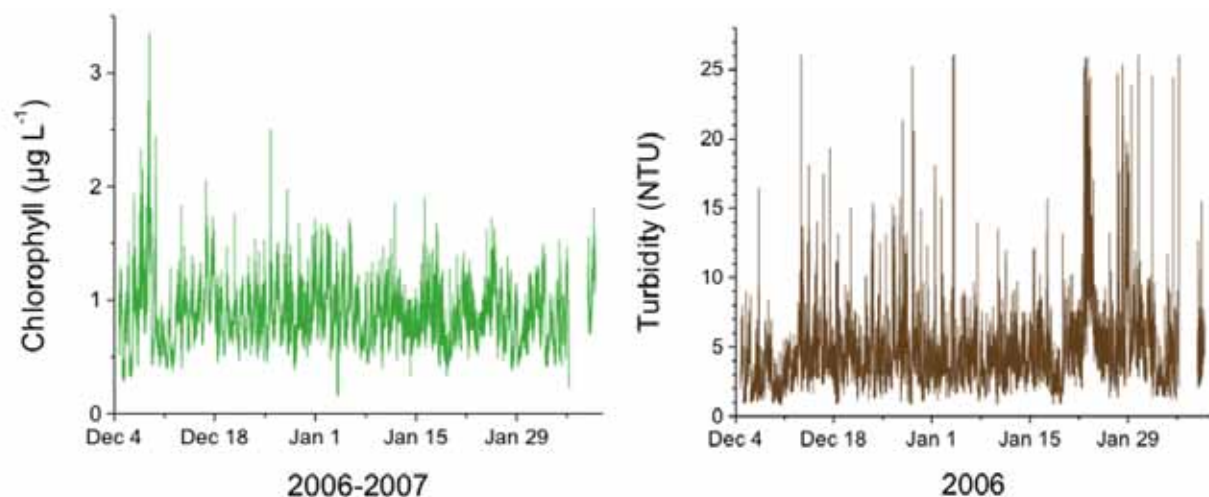


Figure 152. Magens Bay chlorophyll (left) and turbidity (right) record (16 m depth).

# SITE SUMMARIES

**Benthic Community.** The sparse coral community at Magens Bay is very diverse, with no real dominance by any one species. The site lost 12.4% of its coral cover in the 2005 bleaching and has continued to lose coral, with a cover loss of 33.1% from 2005 pre-bleaching to 2011. Gorgonians and then sponges dominate the sessile epibenthic community. Epilithic algae and the macroalga *Dictyota* spp. dominate the algal community. Filamentous cyanobacteria are also common. There is a high proportion of sand/sediment around corals at the Magens Bay site.

**Coral Health.** Corals were highly affected by the 2005 bleaching event, with about 80% of corals 80% affected across the colony surface. This site also showed a strong response to the 2010 bleaching event with about 60% of corals bleached at a low extent. Diseases can be high and are dominated by dark spots disease. Old partial mortality increased after the 2005 bleaching event and then declined, with a slight increase from 2009 to 2011. Recent partial mortality is common at the Magens Bay site, largely as the result of biting by territorial damselfish (*Stegastes* spp.; data not shown).

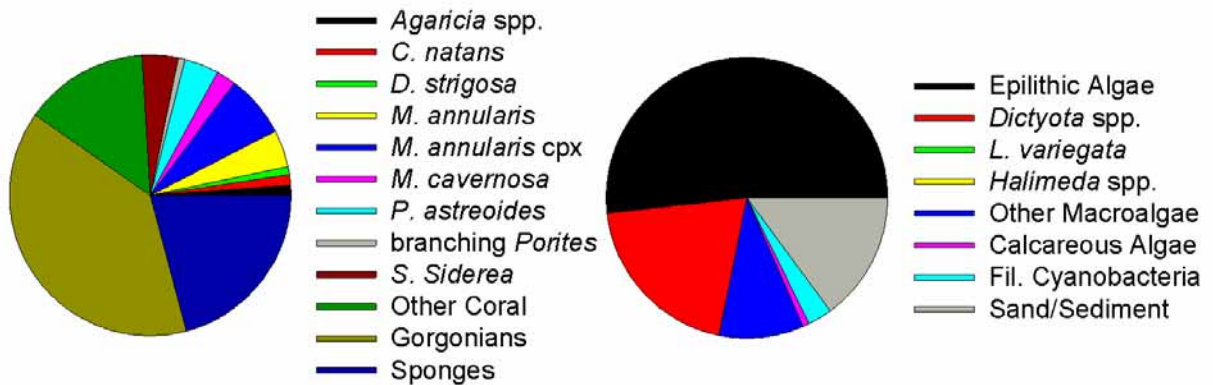
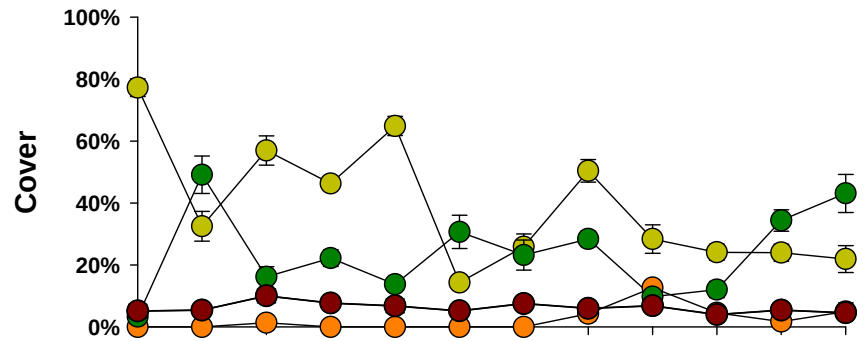


Figure 153. Magens Bay. (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

# MAGENS BAY

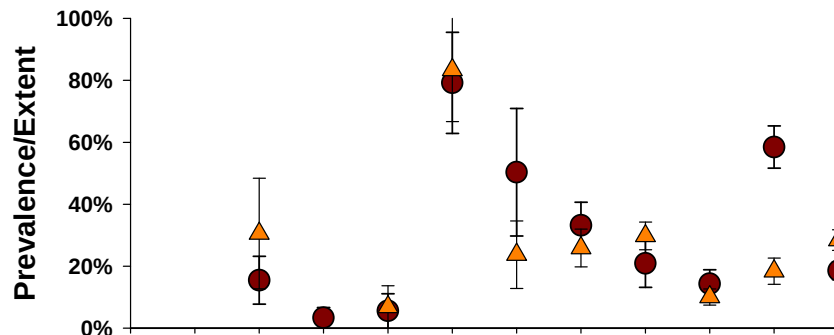
## Benthic Community

- Coral
- Cyanobacteria
- Epilithic Algae
- Macroalgae



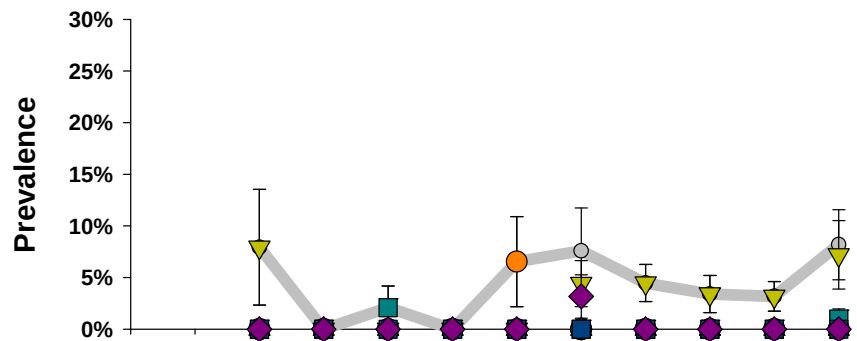
## Bleaching

- Prevalence
- ▲ Extent



## Disease

- All disease
- Black Band
- Lesion
- ▼ Dark Spots
- ▲ Intercostal
- White Disease
- Yellow Band
- ◆ Unknown



## Partial Mortality

- Old
- ▲ Recent

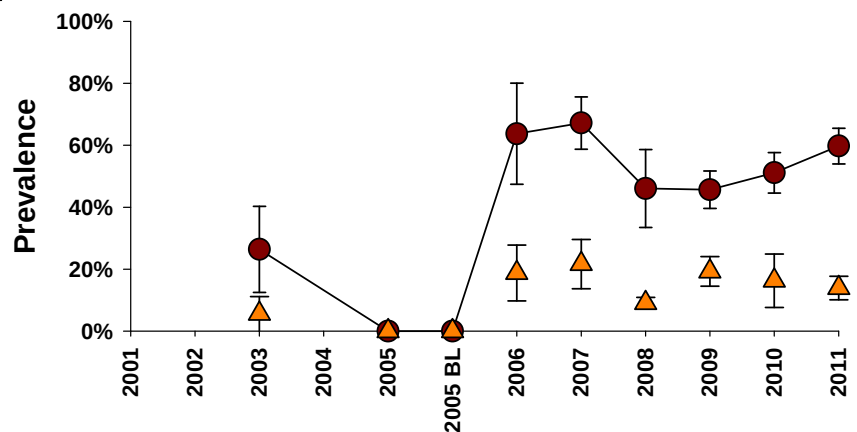


Figure 154. Magens Bay benthic cover and coral health through time (mean  $\pm$  SE).

# SITE SUMMARIES

## SAVANA ISLAND

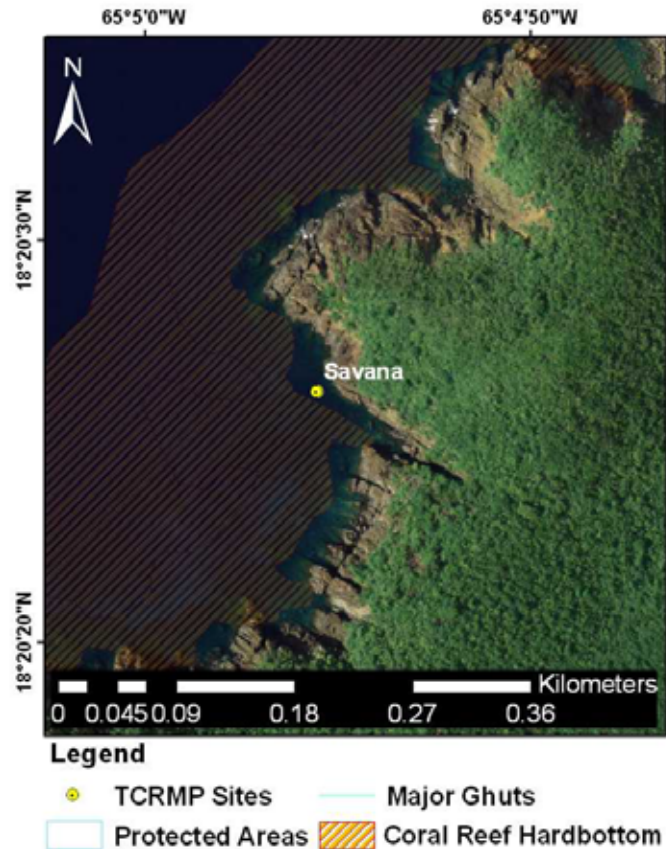
**Description.** The Savana Island site is a midshelf fringing reef facing the Atlantic Ocean to the northwest in depths of 5 – 17 m. The reef is a well-developed coral community atop bedrock, with some insipient carbonate accumulation. Savana has been monitored since 2003, with permanent benthic transects installed in 2007.

**Outstanding Feature.** Savana harbors behemoth colonies of boulder star coral (*Montastraea faveolata*) and a diverse and abundant fish community.

**Threats.** Savana is threatened by warming ocean temperatures, as *M. faveolata* can be susceptible to bleaching, disease, and partial mortality.

The area is also open to fishing and the occasional accumulation of debris can be seen.

**Figure 155. Savana.** (top) Location. (right) A representative photo of the reef during the 2005 coral bleaching event. The dog snapper *Lutjanus jocu* is approximately 50cm in length.



# SAVANA ISLAND

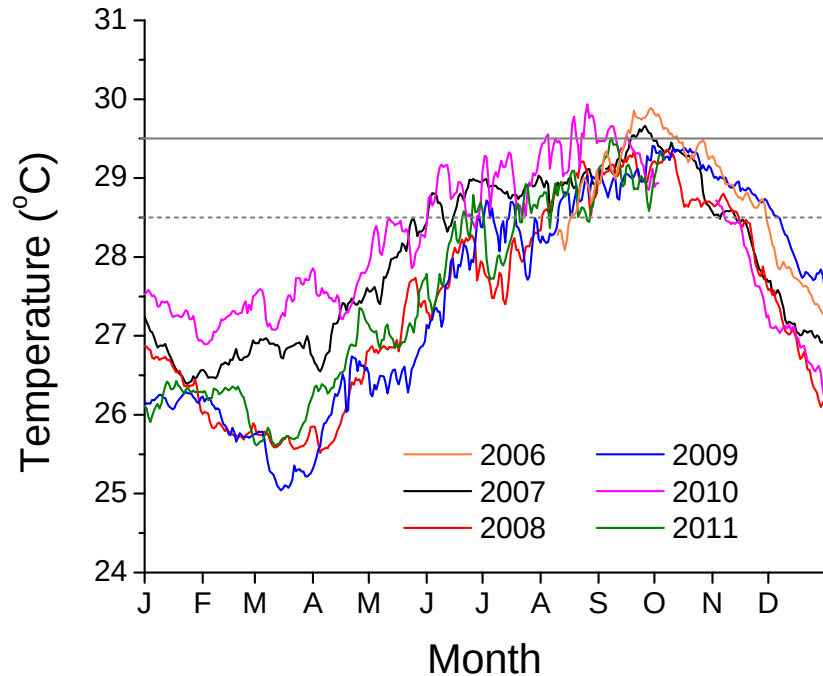


Figure 156. Savana benthic temperature record (10m depth).

## Physical Characteristics.

**Current.** Currents have not been measured directly at Savana. Strong unidirectional currents can influence the surface near the site. Wave-driven oscillatory currents are common and occasionally strong.

**Temperature.** Savana has temperatures cooler than other shallow sites, likely due to the proximity of the open Atlantic Ocean.

# SITE SUMMARIES

**Benthic Community.** Boulder star corals, predominately large (>2m wide) colonies of *Montastraea faveolata*, dominate the coral community at the Savana monitoring site. The site lost a 45.2% of its coral cover in the 2005 bleaching event. Some of the largest losses occurred between 2010 and 2011, but there was no indication of the cause, since the site bleached moderately and no disease outbreaks were noted. Gorgonians and sponges are also prominent components of the sessile epibenthic animal community.

**Coral Health.** The coral community at Savana was highly affected in the 2005 bleaching event, with 80% of corals affected on almost 90% of the colony surface. Bleaching was also very prominent in 2006, but at a lower extent. Bleaching was moderate during the 2010 bleaching event, with over 50% of colonies bleached at a low extent. Coral diseases can reach high prevalence and are diversely represented. Particularly noticeable is the dramatic outbreak of white disease in 2006. Dark spots disease has also affected a high proportion of corals from 2008 onwards. Old partial mortality increased markedly after the 2005 coral bleaching event and has declined only slightly. Recent partial mortality after the 2005 coral bleaching event was unprecedented for any site. Recent mortality has also been common after 2007 and is largely caused by bites from territorial damselfish (*Stegastes* spp.).

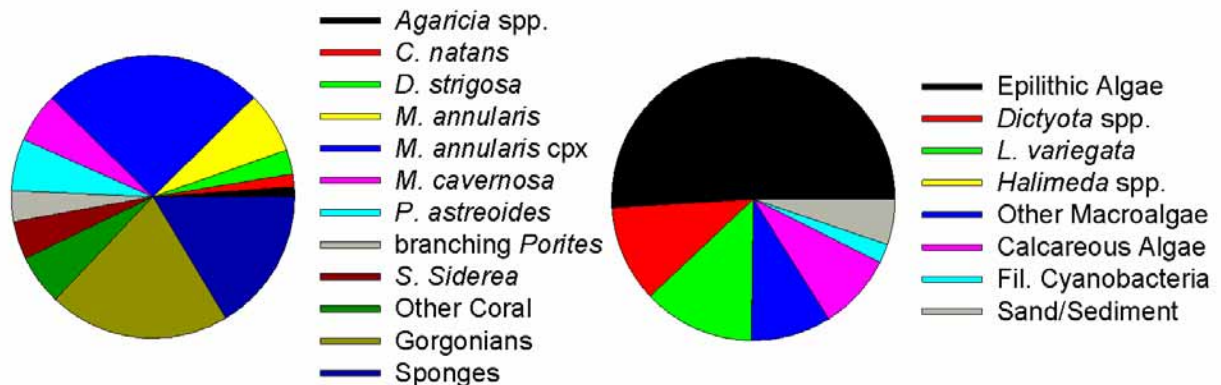


Figure 157. Savana Island. (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

# SAVANA ISLAND

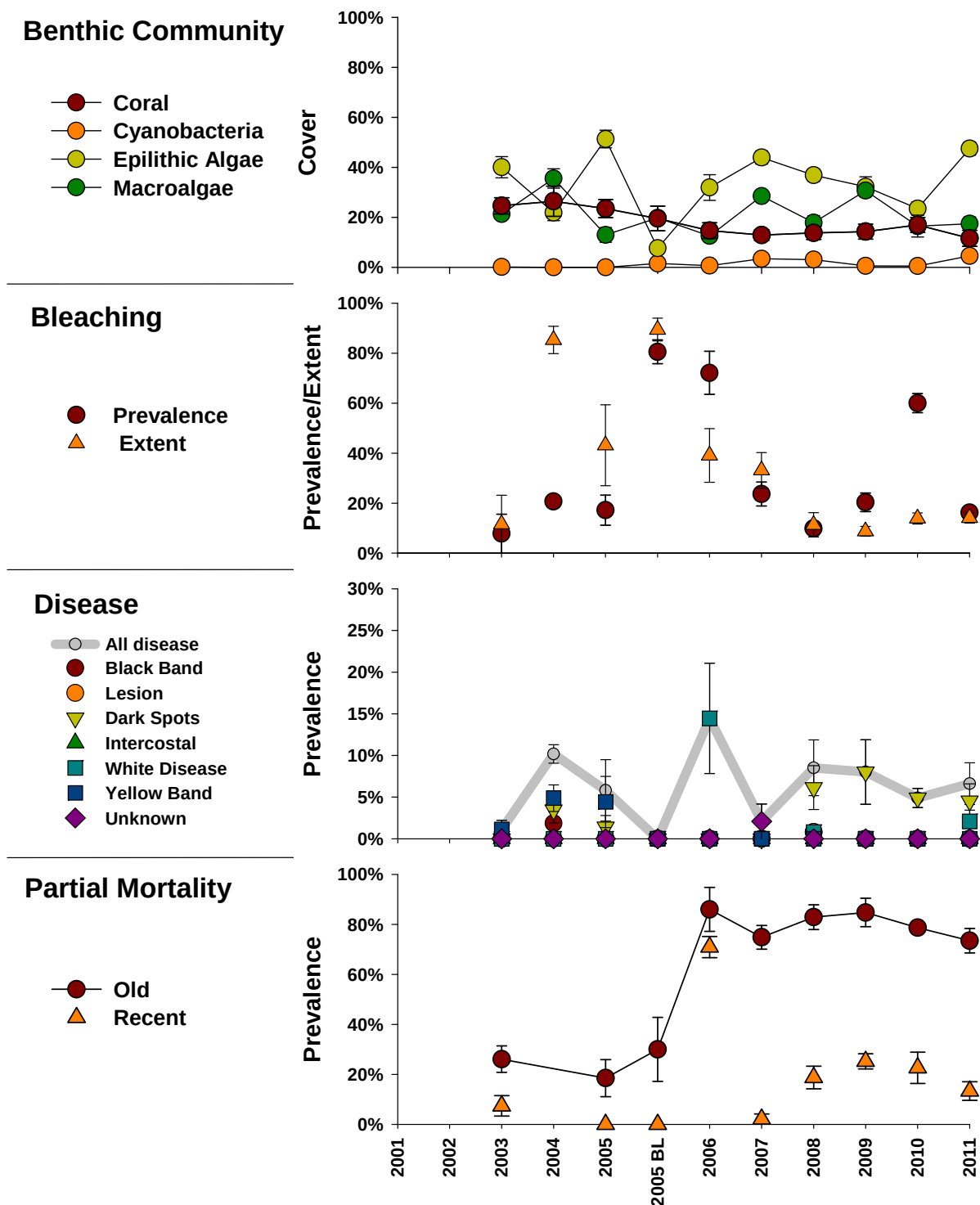


Figure 158. Savana Island benthic cover and coral health through time (mean  $\pm$  SE).

# SITE SUMMARIES

## SEAHORSE COTTAGE SHOAL

**Description.** The Seahorse Cottage Shoal site is a large patch reef surrounded by sand and rhodolith in depths of 17 – 23m. The isolated reef is flat topped and dominated by the *Montastraea annularis* spp. complex. Seahorse has been monitored since 2003, with permanent benthic transects installed in 2007. A ciguatera study with monthly sampling has been ongoing since 2009.

**Outstanding Feature.** Seahorse supports a diverse and abundant coral and fish community adjacent to the St. Thomas East End Reserve.

**Threats.** Seahorse is buffered from land-based sources of pollution. The site is a targeted site in the St Thomas trap fishery and trap strings have been observed over and adjacent to the site.

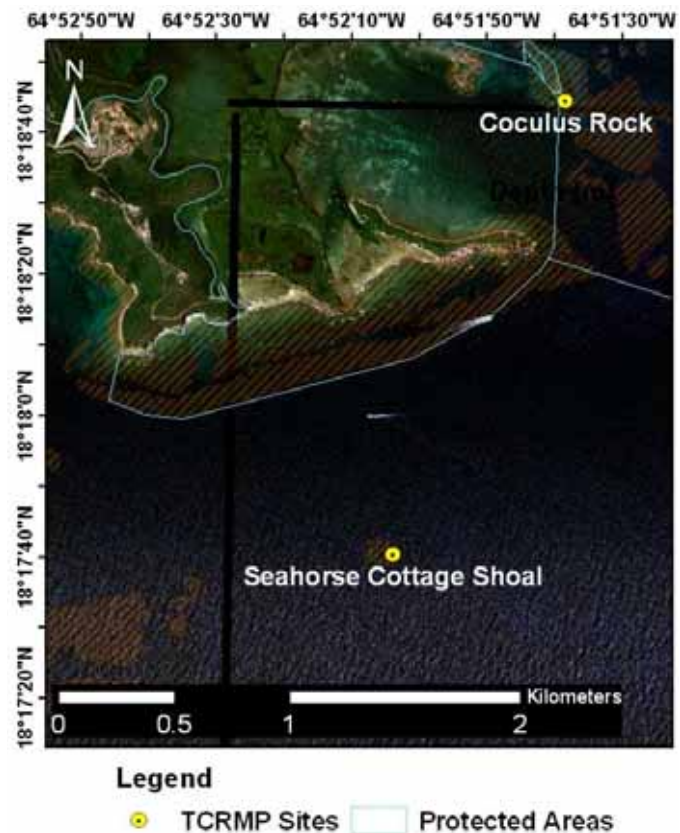


Figure 159. Seahorse Cottage Shoal. (top) Location. (right) A representative photo of the reef.



# SEAHORSE COTTAGE SHOAL

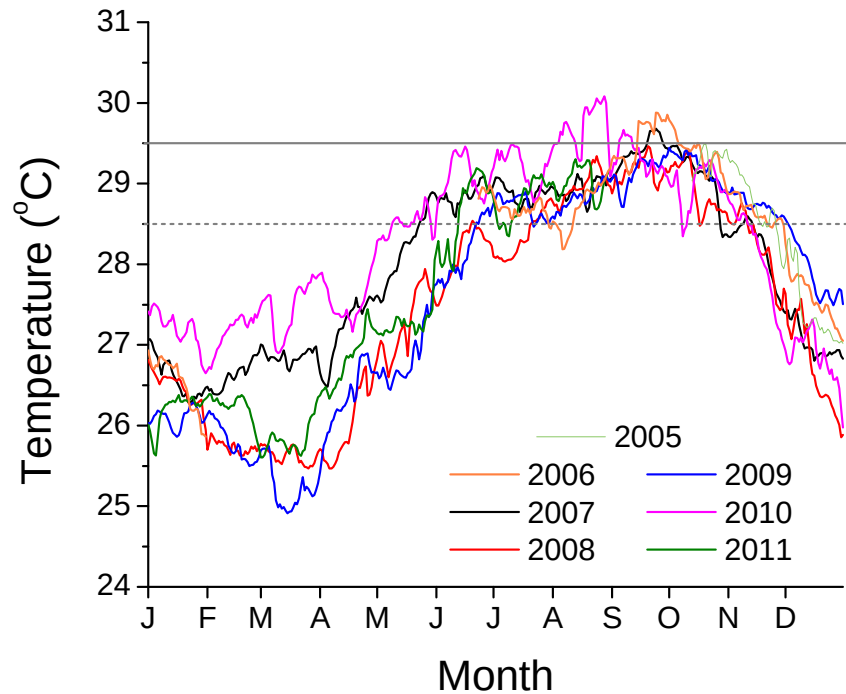


Figure 160. Seahorse benthic temperature record (21m depth).

## Physical Characteristics.

**Current.** Currents have not been directly measured at Seahorse Cottage Shoal.

Unidirectional benthic currents tend to be slow and wave-driven oscillatory currents only occur during heavy storm activity.

**Temperature.** Benthic temperatures are moderate to high during warming events.

# SITE SUMMARIES

**Benthic Community.** The coral community of the Seahorse site is dominated by the boulder star coral (*Montastraea annularis* spp. complex), but hosts a high diversity of other coral species. The site lost 46.6% of its cover in the 2005 bleaching event and had only regained 4.7% of this loss by 2011. Gorgonians and sponges are also common components of the sessile epibenthic animal community. The algal community is co-dominated by epilithic algae and the macroalgae *Lobophora variegata* and *Dictyota* spp..

**Coral Health.** The coral community bleached severely in the 2005 bleaching event with nearly 100% of corals bleaching over about 100% of their surface. Bleaching prevalence after 2005 was slow to decline due to delayed recovery in large *M. annularis* spp. complex colonies. The site also had a high prevalence of bleaching in the 2010 event, but at a low extent on colonies. Bleaching was also moderately prevalent in 2011. Coral diseases are common and diverse at Seahorse. White disease was also prevalent in 2004, which is rare for a site at this depth. Dark spots disease is also ubiquitous. Old partial mortality increased to a very high prevalence after the 2005 bleaching event, but had declined to 2011.

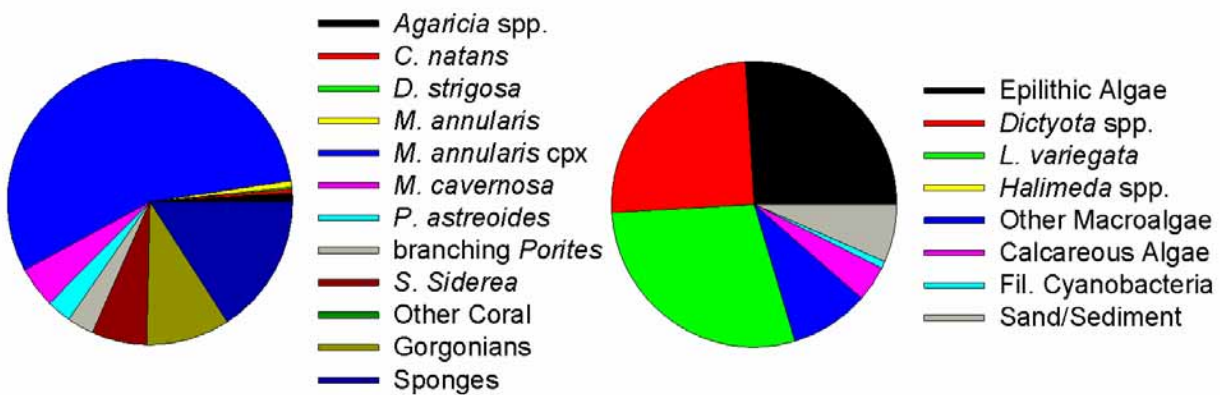


Figure 161. Seahorse Cottage Shoal. (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

# SEAHORSE COTTAGE SHOAL

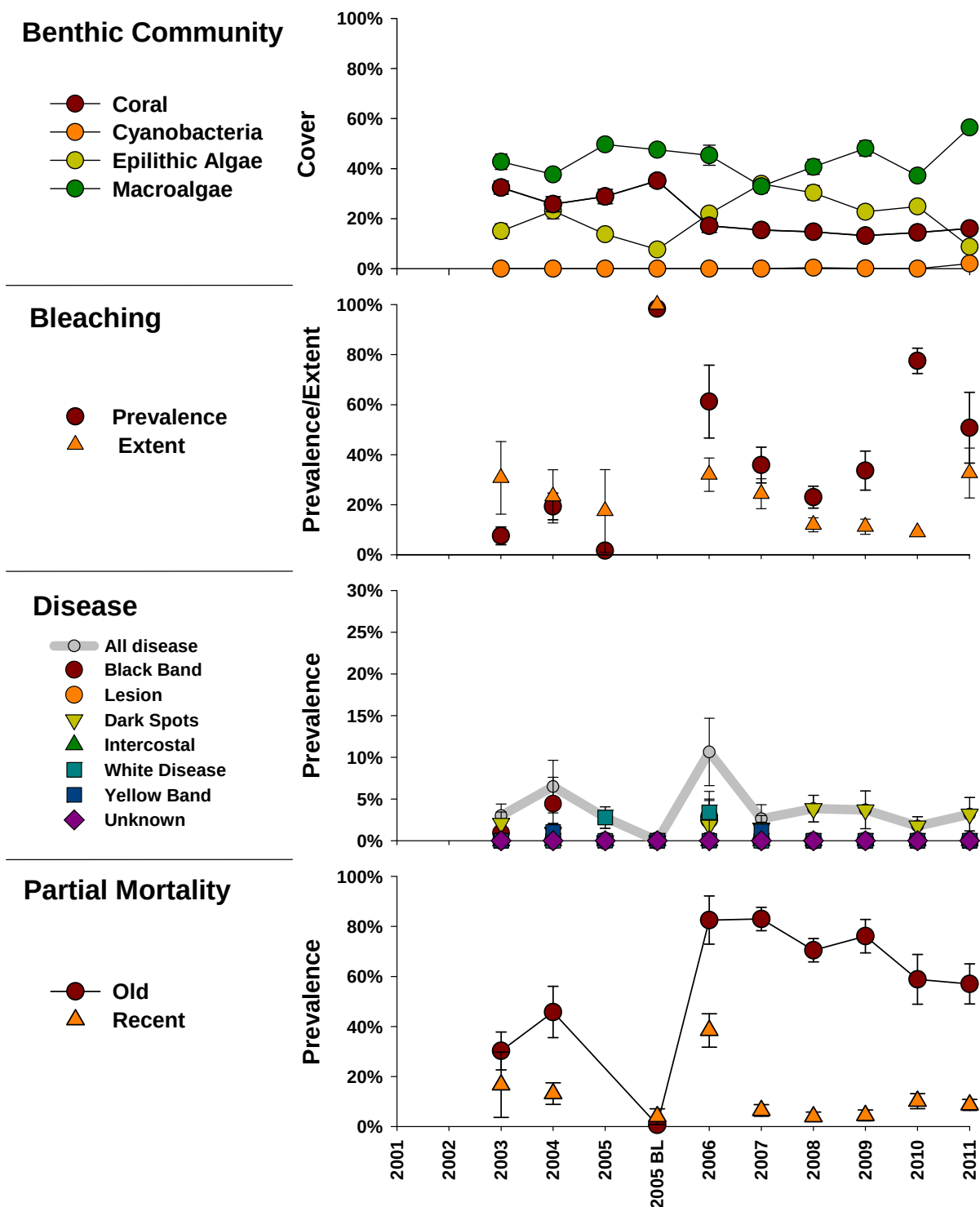


Figure 162. Seahorse Cottage Shoal benthic cover and coral health through time (mean  $\pm$  SE).

**Fish Community.** Seahorse Cottage Shoal supports a large variety of reef fish and hosts spawning aggregations of gray snapper and lane snapper during the summer months. The trophic guilds on the offshore reef are split relatively evenly between herbivores, invertivores, and piscivores. This reflects the heterogeneity of reef substrates and the availability of unconsolidated sand and rhodolith habitat surrounding the reef. Mutton snapper and queen triggerfish are relatively common. Adult stoplight and redband parrotfish dominate herbivores, although most of the larger parrotfish species do occur, including the juvenile phase. Glasseye snapper and graysby dominate piscivores. Large groupers are never seen on the reef. Seahorse Cottage Shoal is well known to fishermen and fairly heavily fished. Traps on the reef are common during surveys. However, schoolmaster, lane, gray and mahogany snapper are all common. This may reflect the proximity to nursery habitats in the St. Thomas East End Reserve. Planktivores are limited nearly entirely to yellowtail snapper.

# SEAHORSE COTTAGE SHOAL

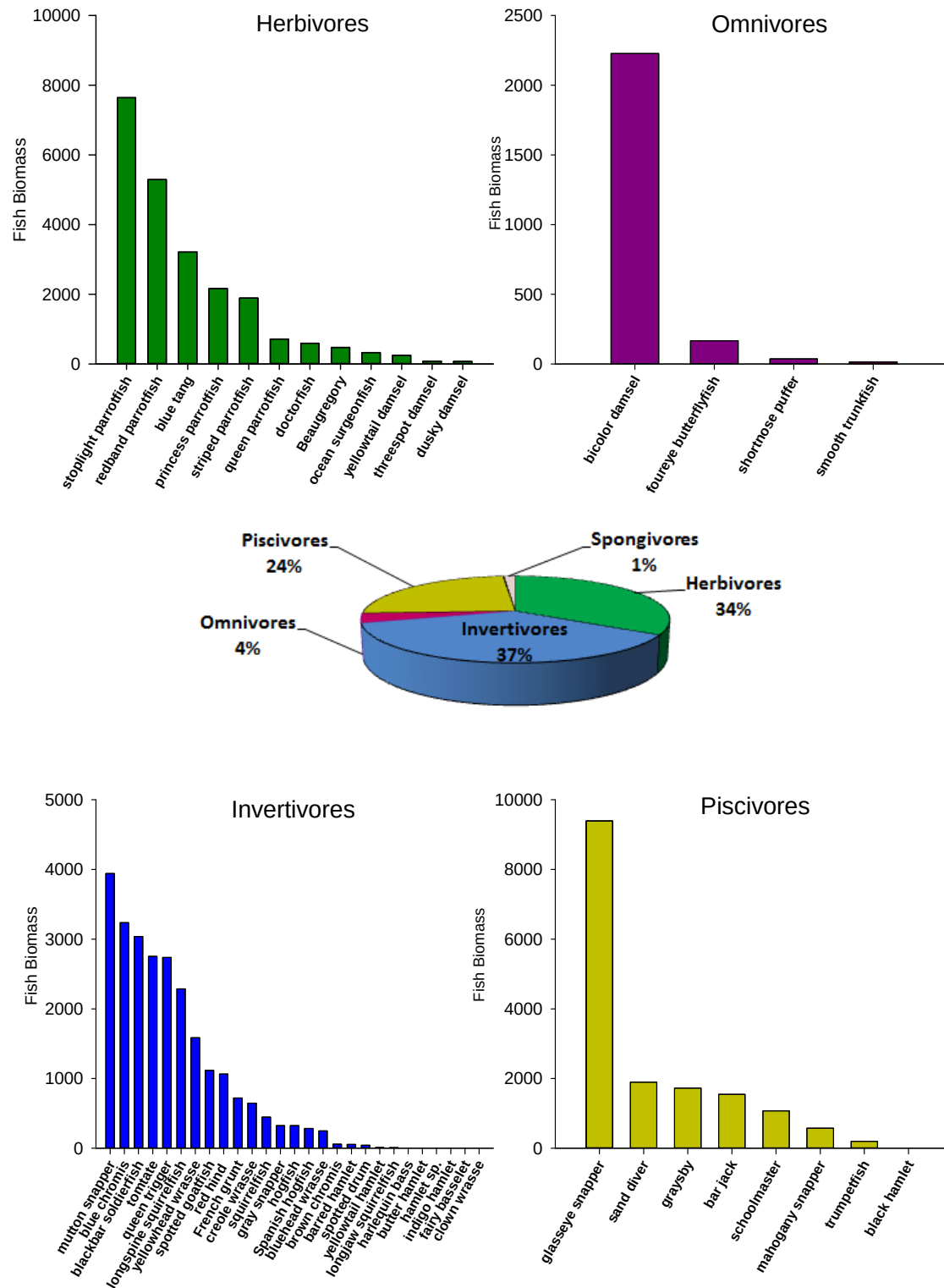


Figure 163. The Seahorse Cottage Shoal fish community by absolute and relative biomass.

# SITE SUMMARIES

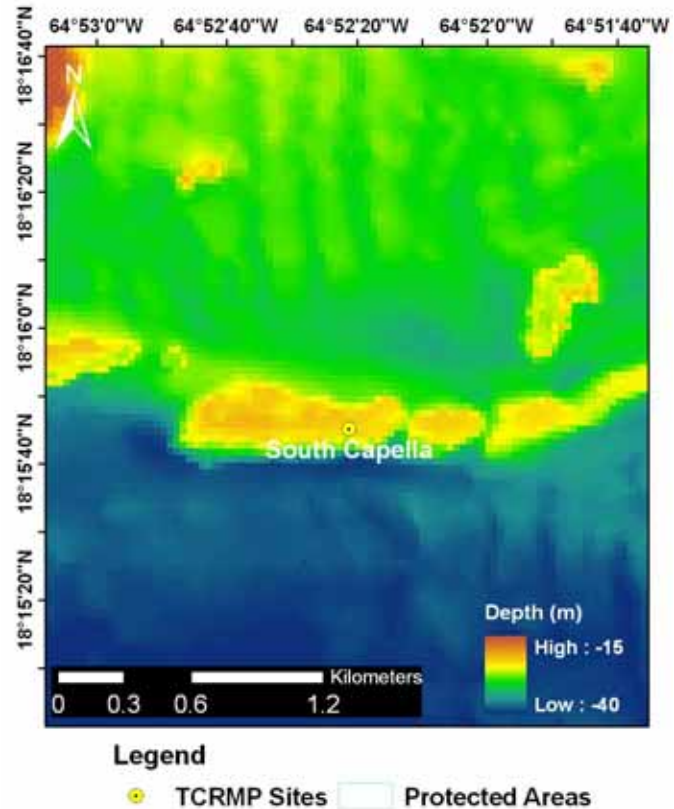
## SOUTH CAPELLA

**Description.** The South Capella site is located on a rise of the St. Thomas-St. John midshelf reef complex in depths of 16 - 25m. The reef is made of rolling ridges of coral and pavement interspersed with sand grooves. South Capella has been monitored since 2003, with permanent benthic transects installed in 2007.

**Outstanding Feature.** The South Capella site is part of an outstanding shallow water midshelf reef system that is essential fish habitat.

**Threats.** The St. Thomas trap fishery heavily targets South Capella. Active and derelict trap strings crisscross the site and a derelict trap appeared in permanent transect 1 in 2008 and has been degrading there since. The trap was still fully intact as of 2012. The reef was also highly affected by the 2005 coral bleaching event, suggesting a susceptibility to rising sea surface temperatures.

**Figure 164. South Capella.** (top) Location. (right) A representative photo of the reef.



# SOUTH CAPELLA

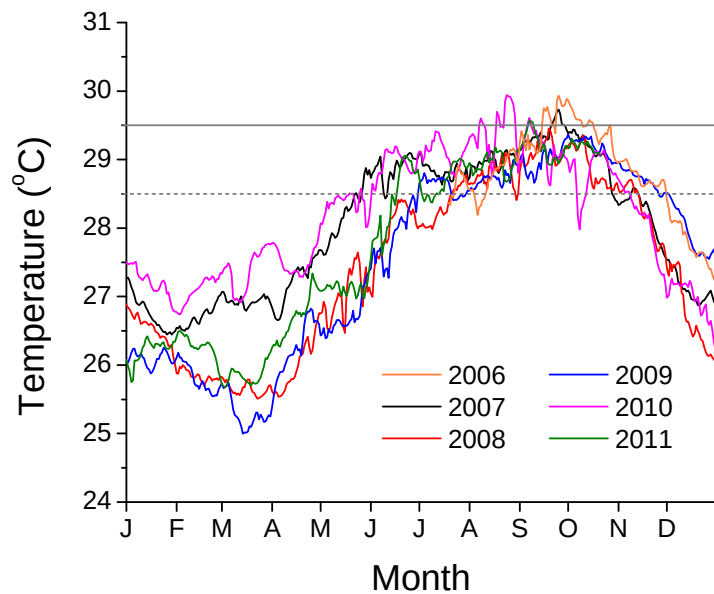


Figure 165. South Capella benthic temperature record (24m depth).

## Physical Characteristics.

**Current.** Currents have not yet been directly measured at South Capella. Wave-driven oscillatory currents have not been experienced but are likely during swells and storms. Unidirectional benthic currents are usually weak, but strong currents can develop from the surface to midwater.

**Temperature.** South Capella has relatively cool benthic temperatures for a shallow site during warm years, which may be a reflection of its moderately deep depth and proximity to deep water to the south.

# SITE SUMMARIES

**Benthic Community.** Boulder star corals (*Montastraea annularis* spp. complex) dominate the coral community at South Capella. These corals were very heavily affected by mortality due to the 2005 coral bleaching event, and the site lost 56.4% of its cover and had not regained any cover by 2011 (-3.7% recovery). Gorgonians and sponges are also common components of the sessile epibenthic animal community. The macroalga *Lobophora variegata* dominates the algal community, with epilithic algae and *Dictyota* spp. comprising the second largest shares. There was also a high abundance of crustose coralline algae and filamentous cyanobacteria.

**Coral Health.** Corals were moderately-heavily affected by the 2005 bleaching event, with a prevalence of 80%, but an extent on colonies of only about 50%. Bleaching prevalence also increased during the 2010 bleaching event, but at a low extent. Bleaching is moderately prevalent at this site even in years without notable thermal stress. Coral diseases are common and diverse at South Capella. White disease was prevalent after the 2005 bleaching event in 2006, and then again in 2009 and 2011. Black band disease was found in 2002, which is unusual for a site at these depths. Dark spots disease was also typically present in most years. Old partial mortality increased after the 2005 bleaching event and has declined to 2011. Recent partial mortality was prevalent in most years of monitoring, particularly in 2006. In years not following thermal stress the highest identifiable source of recent partial mortality was biting from territorial damselfish (*Stegastes* spp.).

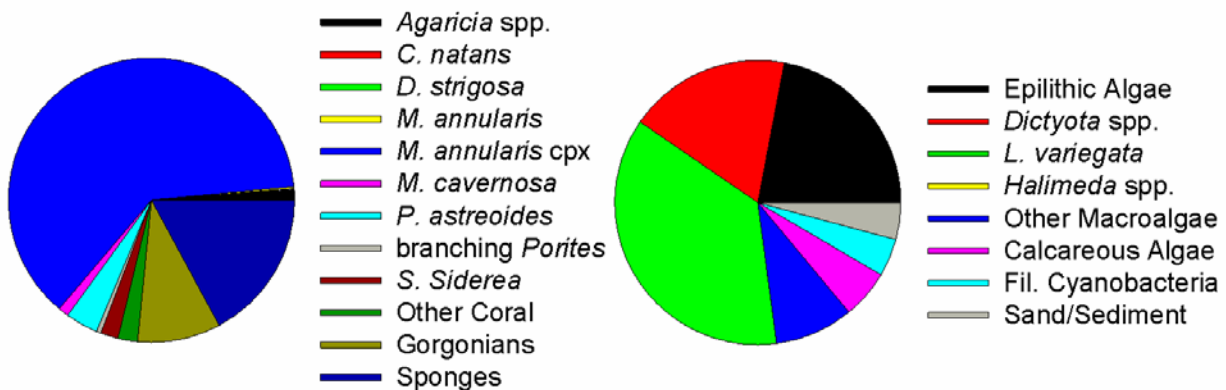
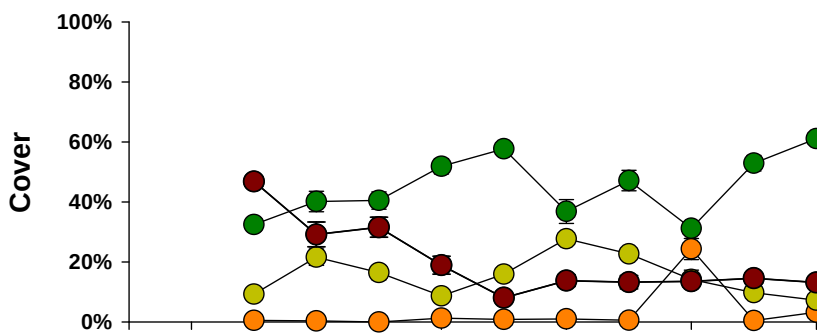


Figure 166. South Capella. (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

# SOUTH CAPELLA

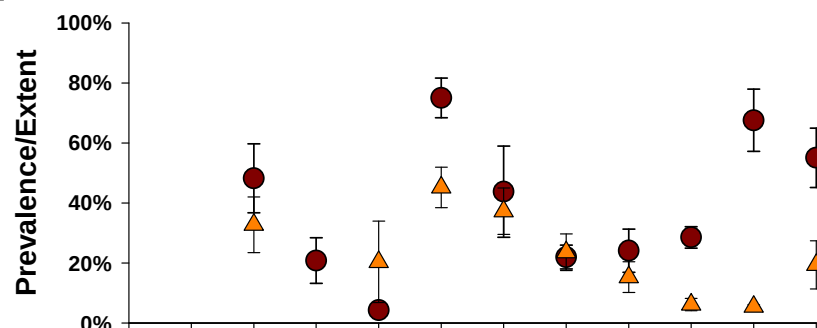
## Benthic Community

- Coral
- Cyanobacteria
- Epilithic Algae
- Macroalgae



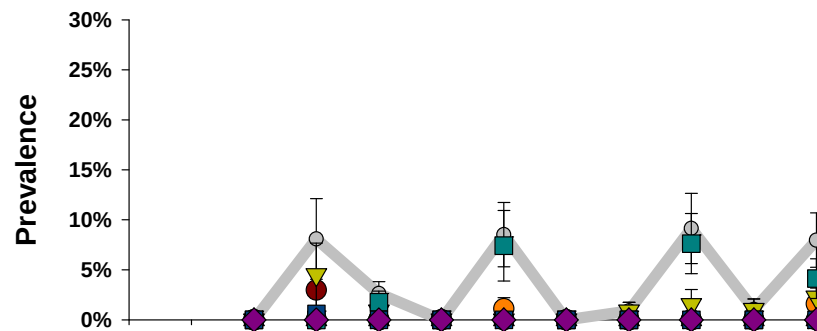
## Bleaching

- Prevalence
- ▲ Extent



## Disease

- All disease
- Black Band
- Lesion
- ▼ Dark Spots
- ▲ Intercostal
- White Disease
- Yellow Band
- ◆ Unknown



## Partial Mortality

- Old
- ▲ Recent

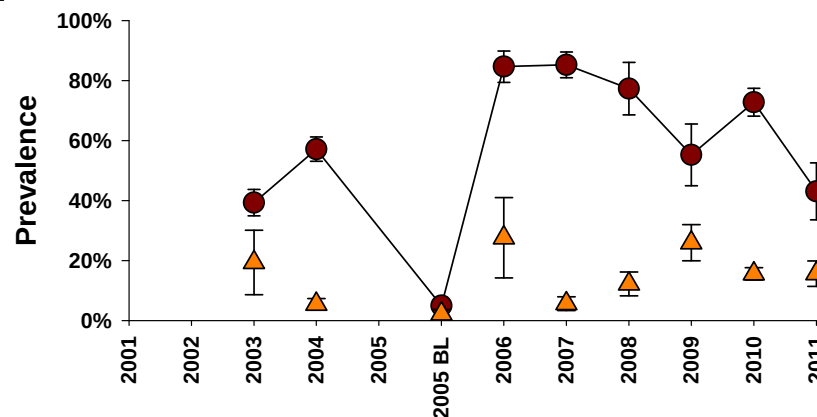


Figure 167. South Capella benthic cover and coral health through time (mean  $\pm$  SE).

## SITE SUMMARIES

**Fish Community.** South Capella is characterized by a fairly diverse fish community that is usually fairly well split between trophic levels. In 2011 a large school of schoolmaster snapper skewed this balance toward piscivores; however, this was probably a spawning event, and not typical of the daily fish community. The reef is spur and groove with complex reef edge and sand channels that supports a large number of invertivores and variety of omnivores. Planktivores are limited nearly entirely to yellowtail snapper. Herbivores are dominated in biomass by stoplight parrotfish and black surgeon. The South Capella reef is highly fished and traps are commonly seen during our survey events. The complex reef is noticeably bare of large snappers and groupers. Lionfish are more common than on other sites.

# SOUTH CAPELLA

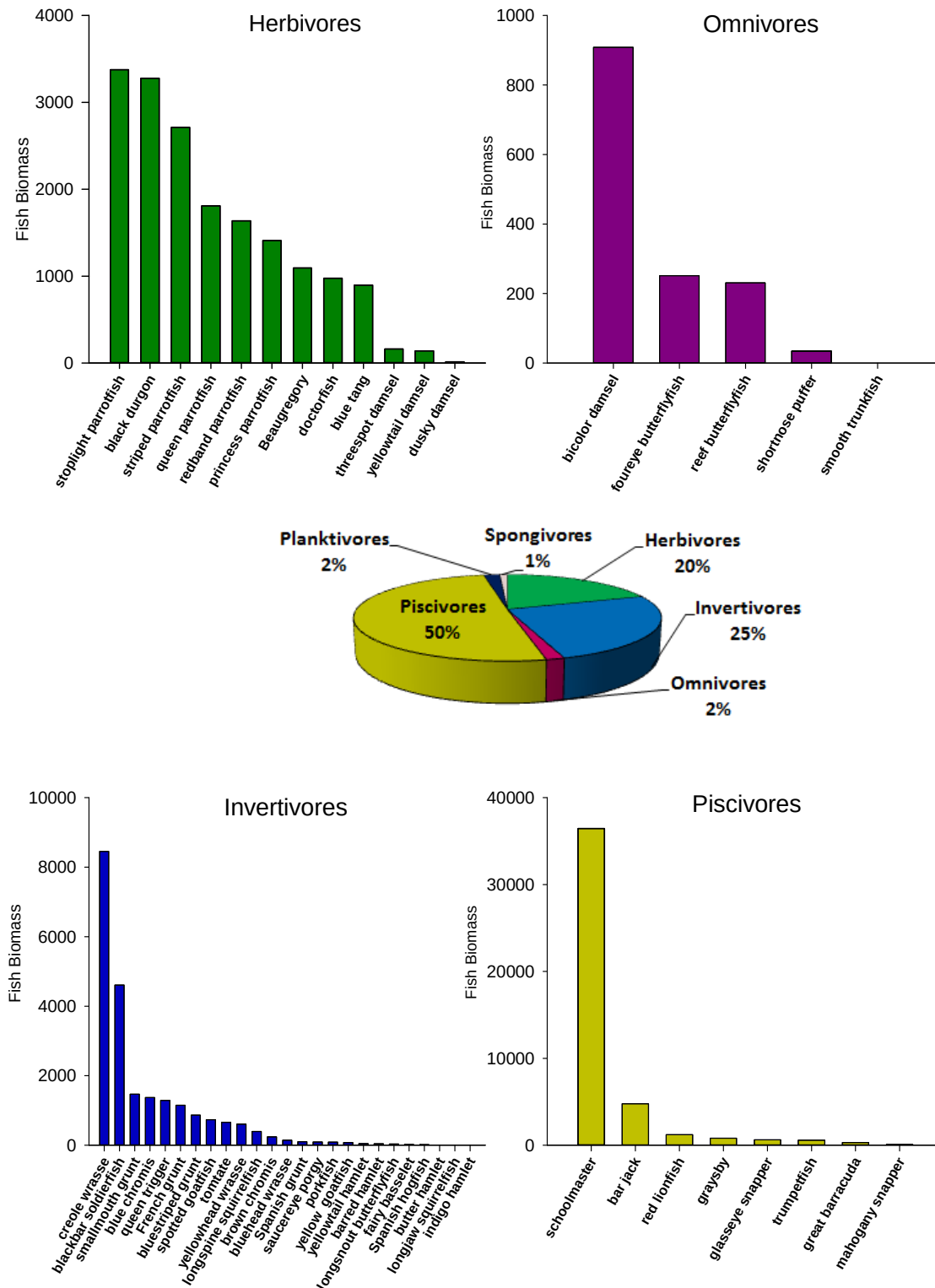


Figure 168. The South Capella fish community by absolute and relative biomass.

# SITE SUMMARIES

## SOUTH WATER

**Description.** South Water is a hardbottom coral community along the sharp break of a midshelf reef complex in depths of 20 – 28m. The reef has a sharp break in slope leading to a steep escarpment that terminates in a sand/sediment plain at the reef base. South Water has been monitored since 2005, with permanent benthic transects installed in 2007.

**Outstanding Feature.** South Water is a commercially important fishing ground for reef fishes and spiny lobster.

**Threats.** South Water is primarily threatened by fishing and strings of fish and lobster traps are common over the site.

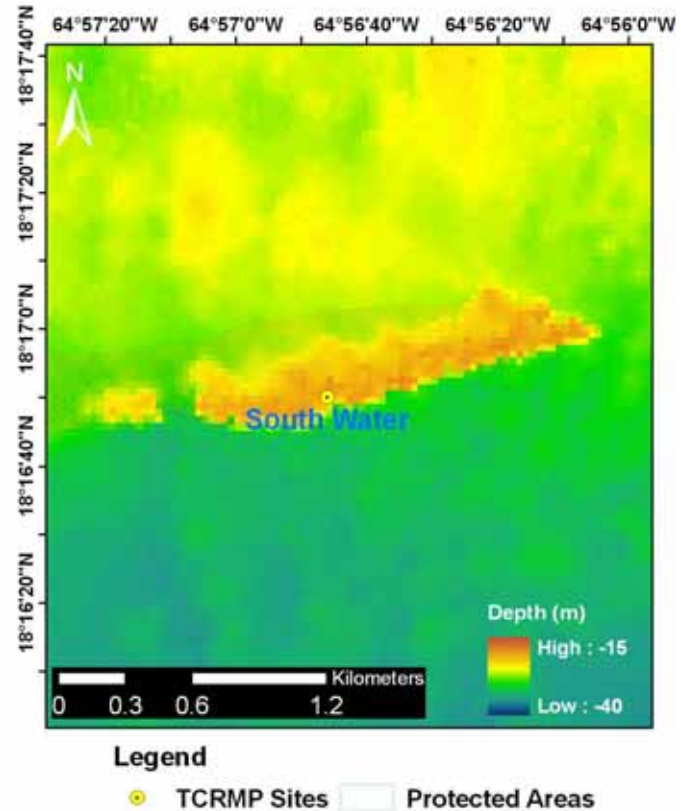


Figure 169. South Water. (top) Location. (right) A representative photo of the reef.



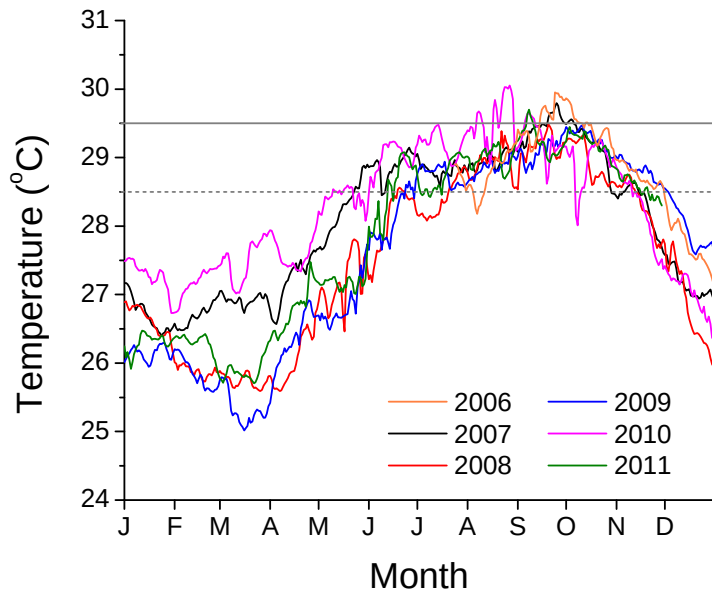


Figure 170. South Water benthic temperature record (24m depth)

## Physical Characteristics.

**Current.** Current measurements have not been taken at the South Water site.

Unidirectional benthic currents can be moderate on the hardbottom reef top and strong from the surface to midwater. Wave-driven oscillatory currents are likely to be felt on the reef top during swells and storms.

**Temperature.** South Water has relatively moderate temperatures compared with other shallow water sites during warm years. This may be due to the deeper depths of the site and the proximity of deep water.

# SITE SUMMARIES

**Benthic Community.** The sparse coral community at South Water is very diverse. Coral cover increased by 21.3% over the 2005 bleaching event and had increased by 42.6% between 2005 and 2011. However, permanent transects were not installed until 2007 and the low coral cover means that small variations in detection of corals can lead to large apparent year-to-year differences in cover. Sponges and gorgonians dominate the sessile epibenthic animal community. The algal community is nearly equally divided between *Lobophora variegata*, *Dictyota* spp., and epilithic algae. Crustose coralline algae and filamentous cyanobacteria are also very common.

**Coral Health.** Corals were severely affected by the 2005 coral bleaching event, with over 80% of corals bleaching over nearly the entire coral surface. Corals were moderately affected in the 2010 bleaching event, with just less than 50% of corals bleaching at a low extent. Bleaching tends to be moderately prevalent even in non-thermal stress years. Coral diseases are not common, although there is a trend of increasing dark spots disease. Old partial mortality increased in prevalence after the 2005 bleaching event, but at a prevalence lower than most other sites. Recent partial mortality is rare.

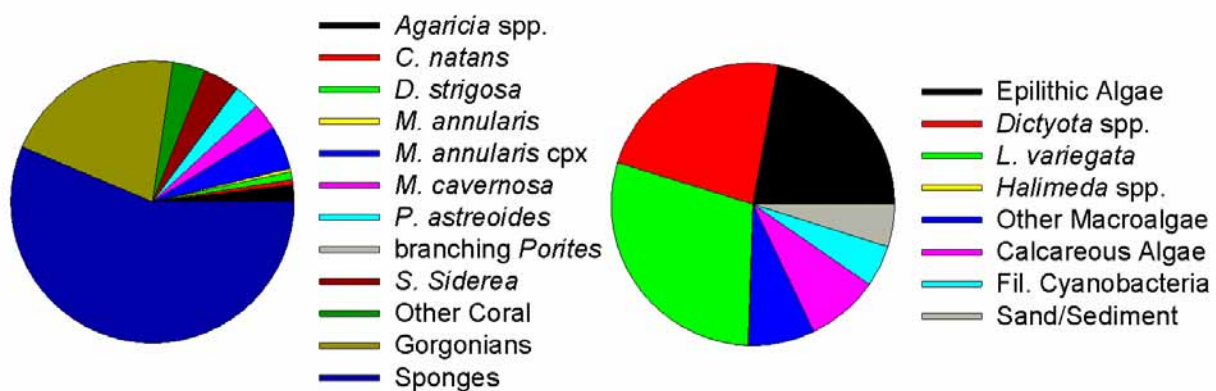


Figure 171. South Water. (left) Relative composition of the sessile epibenthic animal community. (right) Relative composition of the algal community and unconsolidated sediment.

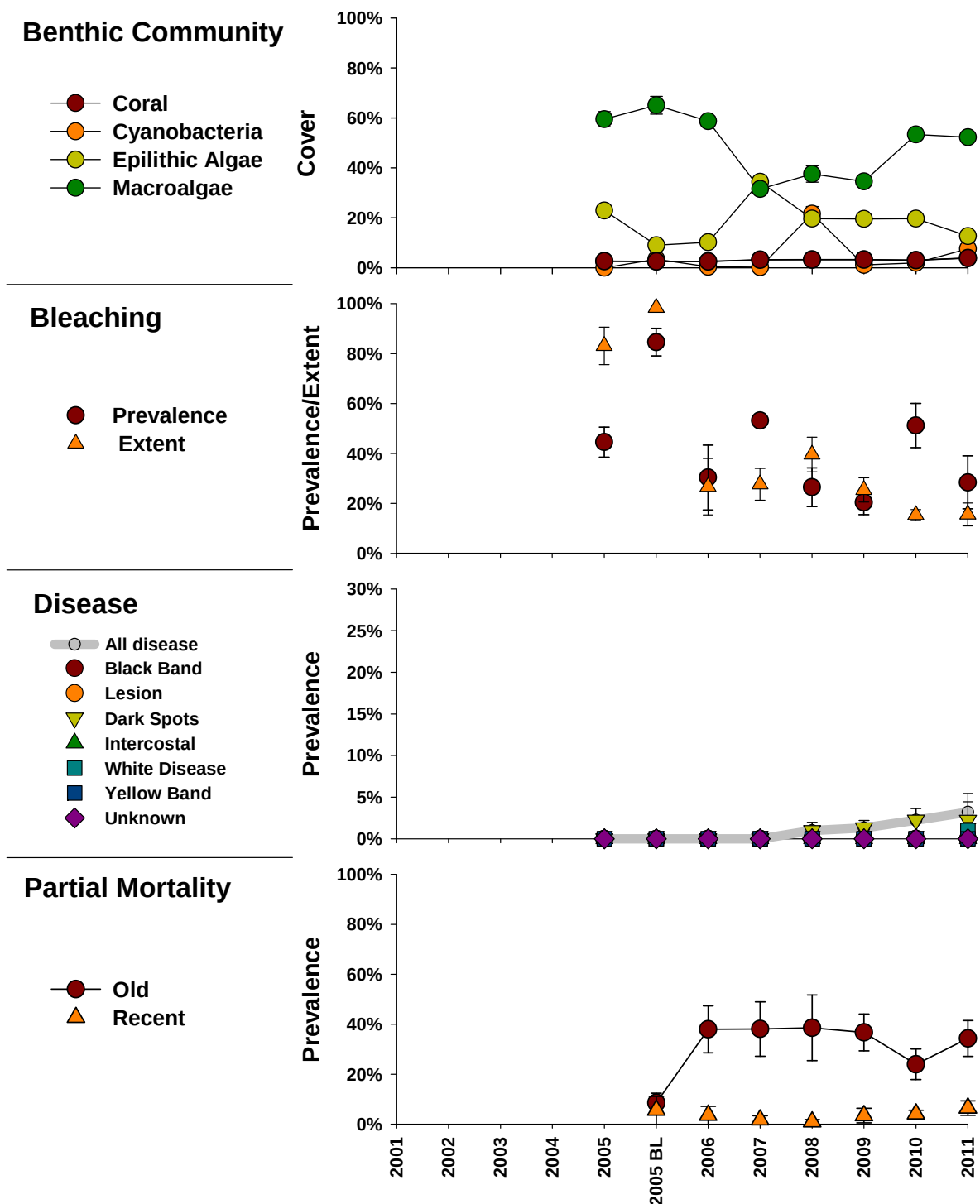


Figure 172. South Water benthic cover and coral health through time (mean  $\pm$  SE).

## SITE SUMMARIES

**Fish Community.** South Water Island is a low lying reef with hard bottom that supports primarily invertivores. Fish biomass is lower on this site than other offshore St. Thomas sites. Invertivore biomass is dominated by queen trigger and red hind. Mutton snapper are occasional. Stoplight and princess parrotfish dominate herbivores, and many juvenile and sub-adults of these species occur on the site. Piscivores make up only 5% of the biomass on the South Water Island site, and is primarily composed of the graysby. South Water Island is highly fished and traps are commonly seen during our survey events. Except for mutton, the reef is bare of large snappers and groupers. Lionfish (*Pterois volitans*) are more common on this site.

# SOUTH WATER

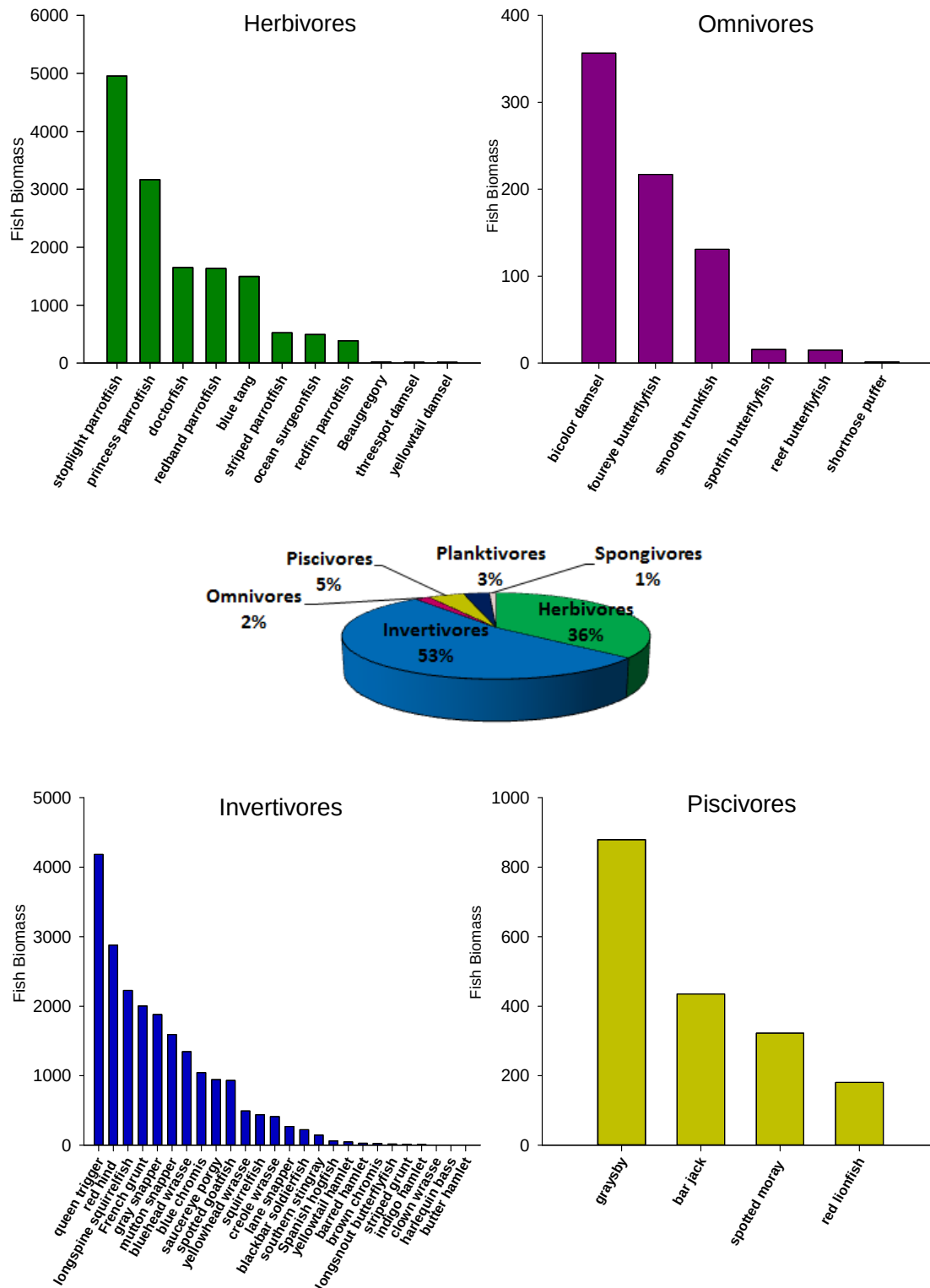


Figure 173. The South Water fish community by absolute and relative biomass.

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