

**ACCESS NUMBER: M04PC00033**  
**1435-01-04-CT-33137**

**STUDY TITLE:** Long-Term Monitoring at the East and West Flower Garden Banks

**REPORT TITLE:** Long-Term Monitoring at the East and West Flower Garden Banks: 2004-2008. Volume I: Technical Report and Volume II: Appendices

**CONTRACT NUMBERS:** 1435-01-04-CT-33137; M04PC00033

**SPONSORING OCS REGION:** Gulf of Mexico

**APPLICABLE PLANNING AREA:** Western

**FISCAL YEARS OF PROJECT FUNDING:** 2004-2008

**COMPLETION DATE OF REPORT:** December 2010

**COSTS:** FY 2004: \$244,559.00; FY 2005: \$255,291.00; FY 2006: \$199,976.00; FY 2007: \$269,672.00; FY 2008: \$240,520.51

**CUMULATIVE PROJECT COST:** \$1,210,018.50

**PROJECT MANAGER:** Don R. Deis

**AFFILIATION:** PBS&J

**ADDRESS:** 7406 Fullerton St. Suite 350 Jacksonville, FL 32256

**PRINCIPAL INVESTIGATORS\*:** W. Precht, R. Aronson, K.J.P Deslarzes, and L. Kaufman

**KEY WORDS:** Gulf of Mexico, ecology, biology, coral, reef, monitoring, survey, East Flower Garden Bank, West Flower Garden Bank, *Montastraea annularis* species complex

**BACKGROUND:** The Flower Garden Banks (FGB) are located in the northwestern Gulf of Mexico and form part of a discontinuous arc of reef environments along the outer continental shelf. These coral reef banks are the largest charted calcareous banks in the northwestern Gulf of Mexico and are the northernmost coral reefs on the continental shelf of North America. Although coral and non-coral dominated communities exist on neighboring banks (e.g., Sonnier Bank, Stetson Bank), the reefs at Cabo Rojo, Mexico are the closest developed coral reefs in the Gulf of Mexico.

The topographic features of the FGB were created by salt diapirs of Jurassic Louann origin and the consequent uplifting of sedimentary rocks. The caps of these salt domes extend into the photic zone in clear, oceanic water where conditions are ideal for colonization by coralline algae, hermatypic corals, invertebrates, and fish species typical of Caribbean basin coral reefs. Coral species richness is lower at the FGB than on

Caribbean reefs with just 31 species of scleractinian corals. The FGB also supports over 250 species of reef invertebrates, over 80 species of marine algae, and 177 species of tropical Atlantic fish. Oceanic salinity conditions prevail at the FGB and range from 28 to 38 ppt, with water temperatures ranging from 19°C (February/March) to ~ 31°C (August/September). Water clarity at the FGB is excellent, commonly 30 m or more, providing light to photosynthetic organisms.

Since 1973, the Minerals Management Service (MMS) has conducted a program of protective activities at the FGB. The topographic features stipulation was designed to protect sensitive biological resources in the northwestern Gulf of Mexico, especially the FGB, from the adverse effects of oil and gas activities. The stipulation defines a No Activity Zone (NAZ) around each of the Banks and no oil or gas structures, drilling rigs, pipelines, or anchoring are allowed within the NAZ. From 1988 to 1995, the MMS monitored the FGB coral reefs on an annual basis to detect any changes that may be caused by oil and gas activities, as well as other incipient changes. In addition to the protective measures provided by MMS, the FGB were designated as a United States National Marine Sanctuary in 1992. Beginning in 1996, the National Oceanic and Atmospheric Administration (NOAA), Flower Garden Banks National Marine Sanctuary (FGBNMS), and the MMS partnered to continue the long-term monitoring at the FGB.

**OBJECTIVE:** To monitor the East Flower Garden Bank (EFGB) and West Flower Garden Bank (WFGB) in accordance with the long-term monitoring protocol, ensuring that the protective measures established by MMS continue to be effective.

**DESCRIPTION:** For the 2004-2008 monitoring effort, cruises were conducted aboard the *M.V. Fling* or *M.V. Spree* in September and November 2004 (EFGB and WFGB, respectively), June 2005, June 2006, June 2007, August and September 2007 (EFGB and WFGB, respectively), and November 2008. The general locations of the study sites are marked by permanent mooring buoys: FGBNMS permanent mooring number 2 at the EFGB and mooring number 5 at the WFGB. Establishment of the perimeter and crosshairs subdivided each 100-m x 100-m study site into four quadrants. To estimate the areal coverage of benthic components, fourteen to sixteen 10-m long transect tapes were randomly positioned at each study site. Benthic coverage and the coverage of coral stressors were estimated from these transects using videography. Four coral cores were extracted from *Montastraea faveolata* colonies at each Bank in 2005 and 2007 to determine annual coral growth rates. Because *Diploria strigosa* is the second largest contributor to coral cover at the FGB, *D. strigosa* lateral growth margins were monitored and photographed to detect changes from year to year. In order to monitor changes in coral reef community structure repetitive 8-m<sup>2</sup> quadrats were photographed and analyzed for percent cover, coral condition, and growth or loss of coral tissue over time. Perimeter lines were videotaped each year to document change at known locations and to obtain a general sense of coral condition and fish populations each year. Physical and chemical characteristics of the seawater overlying the reef caps at the FGB were assessed by monitoring temperature, salinity, dissolved oxygen, pH, turbidity, photosynthetically active radiation, chlorophyll *a*, ammonia, nitrate, nitrite, TKN, and soluble reactive phosphorous. These water quality parameters were selected to

characterize the environmental background in which the FGB coral reef resources exist. Surveys of fish assemblages were conducted to determine relative abundance and diversity of fish species. Surveys of sea urchins and lobsters were performed at night to determine abundance and distribution of populations.

In addition to the annual monitoring protocol, Hurricane Ike impacts (Hurricane Rita impacts were reported in a previous document, [MMS 2008-019](#)), quantitative coral health surveys, and notable biological and oceanographic events were also reported. On September 12, 2008, the storm track of Hurricane Ike passed ~0.7 km (0.4 mi) from mooring buoy number 2 at the EFGB study site. Repetitive 8-m<sup>2</sup> quadrats and perimeter video collected in November 2008 were assessed for hurricane damage. Quantitative coral health surveys were conducted in June 2007 to assess the presence, types, and prevalence of coral diseases and other coral health issues at the FGB. Notable biological and oceanographic events, such as sponge spawning, *Acropora* discoveries, coral disease, and exotic/invasive species were qualitatively assessed and documented. Coral biodiversity and taxonomy at the FGB were also evaluated.

**SIGNIFICANT CONCLUSIONS:** The EFGB and WFGB coral reefs continue to thrive and remain the highest coral cover dominated reefs in the Caribbean and Gulf of Mexico. The reef communities have remained stable for the monitoring period 1988-2008, while other reefs in the region have declined. Continued monitoring of these reefs will document their long-term condition and be useful for studies focused on the dynamics of the robust benthic communities and the fish populations they support.

**STUDY RESULTS:** Total coral cover, recorded by random transect videography from 2004 through 2008, ranged from  $49.55 \pm 3.01\%$  to  $64.13 \pm 2.70\%$  at the EFGB and from  $54.41 \pm 3.13\%$  to  $60.41 \pm 2.94\%$  at the WFGB. The *Montastraea annularis* species complex was the predominant component of coral cover at both Banks in all years and ranged from  $26.80 \pm 4.09\%$  to  $33.58 \pm 4.52\%$  at the EFGB and  $31.70 \pm 2.70\%$  to  $40.13 \pm 3.29\%$  at the WFGB. From 2004-2008, macroalgae were typically less abundant than crustose coralline algae, fine turf algae, and bare rock (CTB), with the exception of the EFGB in 2005 and 2008. Sclerochronology was used to measure the accretionary growth rates of *Montastraea faveolata*. When compared to the past two coring events (2003 and 2005), the 2007 core data did not appear substantially different with respect to mean growth rates. However, the range of annual growth from the 2007 samples does not show the same magnitude as the 2003 and 2005 samples. In addition, a reduction in mean annual coral growth rates was observed in the 2007 cores, which was likely related to the large-scale bleaching event that occurred in 2005. Although growth at lateral growth stations showed some significant variations and interactions, net growth was positive over the period 2003-2007. The repetitive quadrat data showed that coral cover was consistently high during the period 2004-2008, ~64% for both Banks in all years. The coral assemblages remained stable at both Banks and dominant corals included *Montastraea annularis* species complex, *Diploria strigosa*, *Porites astreoides*, and *M. cavernosa*. Macroalgae and CTB cover showed reciprocal patterns and the incidences of bleaching, paling, and fish biting were low. There was no evidence of coral disease in the repetitive quadrats. Colonies of *M. annularis* species complex in repetitive quadrats (planimetry) showed overall positive growth from 2003-

2008. Coral cover was high at the deep repetitive quadrats (32-40 m or 105-131 ft) at the EFGB, averaging ~77% between 2004 and 2008. The *Montastraea annularis* species complex and *M. cavernosa* were the dominant species observed. The review of the 2004-2008 perimeter videos suggests that the coral communities displayed low levels of stress and high coral cover. Most distressed corals were affected by fish biting and there were few incidences of paling and bleaching. Though separate studies documented that bleaching affected up to 48% of corals in the fall of 2005, this study documented their recovery by the following spring. Fish surveys showed robust fish assemblages that were dominated by herbivorous fish and included healthy piscivore populations. Sea urchin surveys documented low densities of *Diadema antillarum* at both Banks from 2004-2008, except at the WFGB in 2004, 2007, and 2008; sea urchin density has not recovered to pre-1984 levels.

An estimated ~2.3 m<sup>2</sup> of coral was missing from the study-site repetitive quadrat stations between June 2007 and November 2008 at the EFGB and WFGB, most likely due to Hurricane Ike. The greatest loss in terms of both the number of missing coral colonies and the total loss in area of coral cover occurred at the EFGB. Quantitative coral health surveys revealed that the vast majority of colonies surveyed were healthy. The prevalence of all coral health issues (including predation, bleaching, ciliate infections, growth anomalies, and other miscellaneous health issues) was higher at the WFGB (9.96%) than at the EFGB (3.20%). The overall prevalence of all coral health issues at the community-wide level (EFGB and WFGB combined) was 6.78%.

**STUDY PRODUCTS:** Zimmer, B., L. Duncan, R.B. Aronson, K.J.P. Deslarzes, D. Deis, M. Robbart, W.F. Precht, L. Kaufman, B. Shank, E. Weil, J. Field, D.J. Evans, and L. Whaylen. 2010. Long-term monitoring at the East and West Flower Garden Banks, 2004-2008. Volume I: Technical report and Volume II: Appendices. U.S. Dept. of the Interior, Bureau of Ocean Management, Regulation and Enforcement, Gulf of Mexico OCS Region, New Orleans, Louisiana. OCS Study BOEMRE 2010-052. 340 pp and BOEMRE 2010-053. 4,392 pp (CD only).

Precht, W.F., R.B. Aronson, K.J.P. Deslarzes, M.L. Robbart, B. Zimmer, and L. Duncan. 2008. Post-hurricane assessment at the East Flower Garden Bank long-term monitoring site: November 2005. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, Louisiana. OCS Study MMS 2008-019. 39 pp. + appendices. Internet URL: <http://www.gomr.mms.gov/PI/PDFImages/ESPIS/4/4318.pdf>.

Precht, W.F., R.B. Aronson, K.J.P. Deslarzes, M.L. Robbart, D.J. Evans, B. Zimmer, and L. Duncan. 2008. Long-term monitoring at the East and West Flower Garden Banks, 2004-2005 - Interim report. Volume I: Technical report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, Louisiana. OCS Study MMS 2008-027. 123 pp. Internet URL: <http://www.gomr.mms.gov/PI/PDFImages/ESPIS/4/4322.pdf>.

Precht, W.F., R.B. Aronson, K.J.P. Deslarzes, M.L. Robbart, D.J. Evans, B. Zimmer, and L. Duncan. 2008. Long-term monitoring at the East and West Flower Garden Banks, 2004-2005 - Interim report. Volume II: Appendices. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, Louisiana. OCS Study MMS 2008-028. 1,330 pp. Internet URL: <http://www.gomr.mms.gov/PI/PDFImages/ESPIS/4/4323.pdf>.

Precht, W.F., R.B. Aronson, K.J.P. Deslarzes, L.S. Kaufman, M.L. Robbart, El. Hickerson, G.P. Schmahl and J. Sinclair. Long-Term Reef Monitoring at the Flower Garden Banks: Status, Stasis and Change. In, Ritchie, K.B. and Brian D. Keller, eds. 2008. A Scientific Forum on the Gulf of Mexico: The Islands in the Stream Concept. Marine Sanctuaries Conservation Series NMSP-08-04. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Sanctuary Program, Silver Spring, MD. 105 pp. Internet URL: <http://sanctuaries.noaa.gov/science/conservation/pdfs/gom.pdf>.

Precht, W.F., Deslarzes, K.J.P., Hickerson, E. Schmahl, G.P., Sinclair, J. and Aronson, R.B. 2008. Holocene reef development at the Flower Garden Banks: recent surprises. Abstracts 11th International Coral Reef Symposium, Ft. Lauderdale, FL, p.5. Internet URL: [http://www.nova.edu/ncri/11icrs/11icrs\\_abstractbook\\_final.pdf](http://www.nova.edu/ncri/11icrs/11icrs_abstractbook_final.pdf).

Schmahl, G.P., E.L. Hickerson and W.F. Precht, 2008. Biology and Ecology of Coral Reefs and Coral Communities in the Flower Garden Banks Region, Northwestern Gulf of Mexico. In, B.M. Riegl and R.E. Dodge, *Coral Reefs of the USA*, Springer Science, 2008.

Zimmer, B., W.B. Precht, E.L. Hickerson, and J. Sinclair. 2006. Discovery of *Acropora palmata* at the Flower Garden Banks National Marine Sanctuary, Northwestern Gulf of Mexico. *Coral Reefs* (2006) DOI 10.1007/s00338-005-0054-9.

Robbart, M., B. Zimmer, L. Duncan, D.R. Deis, R.B. Aronson, K.J.P. Deslarzes, W.F. Precht, J. Sinclair, E.L. Hickerson, G.P. Schmahl, G.S. Boland. 2008. Post-hurricane assessment and recovery at the East Flower Garden Bank. Page 417 in Abstracts (Poster 18.612), 11th International Coral Reef Symposium, 7-11 July 2008. Ft. Lauderdale, USA.

