Chapter 1: Introduction and Background Information

1.1 GOALS

This project is a result of a collaboration between the National Centers for Coastal Ocean Science, Center for Coastal Monitoring and Assessment's Biogeography Branch (CCMA), and the Office of National Marine Sanctuaries' (ONMS) Flower Garden Banks National Marine Sanctuary (FGBNMS). The goal of this project was to provide FGBNMS staff with information on biogeographic patterns within the sanctuary critical to decision making. Specifically, this project focused on two explicit management goals of the sanctuary:

1) To develop a sampling design for monitoring benthic fish communities on the coral caps;
2) To obtain a spatial and quantitative characterization of those fish communities and their associated benthic habitats.

1.2 DESCRIPTION OF SANCTUARY

The FGBNMS is located in the northwestern Gulf of Mexico approximately 180 km south of Galveston, Texas (Figure 1.1). The distance of the banks from the coastline reduces direct coastal impacts on the resident coral population. In addition, their depth combined with local oceanographic processes may provide some shelter for resident species from thermal stresses and hurricanes. The healthy corals resident there support a high abundance of coral reef fishes and other associated marine organisms. Studies of the coral assemblages on the banks report live coral cover at nearly 50% (Gittings, 1998; Aronson et al., 2005), a value among the highest reported for coral reefs in the Caribbean (Pattengill-Semmens and Gittings, 2003). Despite the demise of other reefs in the region, this statistic has not changed significantly in the FGBNMS in over 30 years of monitoring (Bright and Pequegnat, 1974; Rezak, 1977; Gittings et al., 1992; Gittings, 1998; Precht et al., 2006).

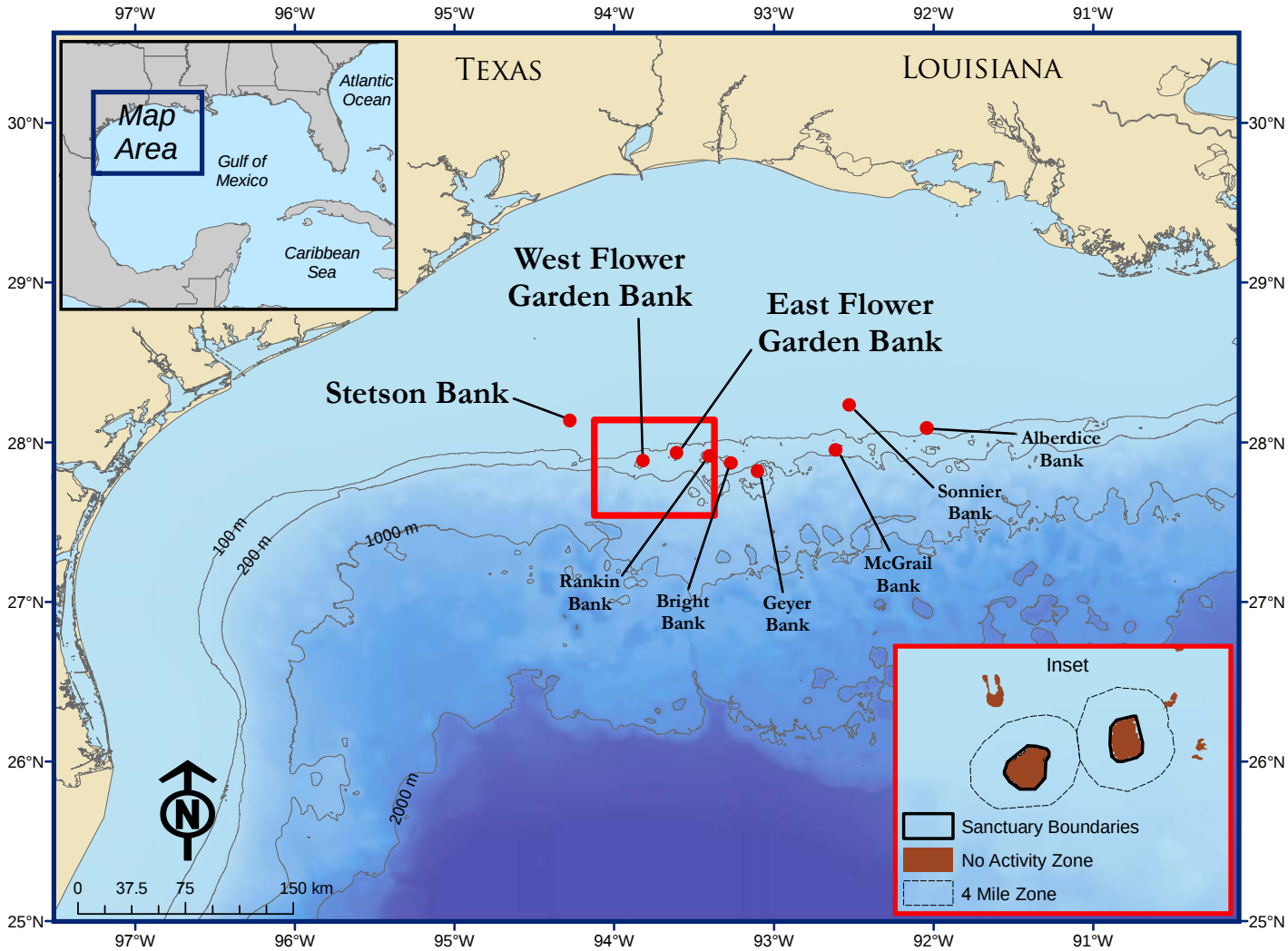


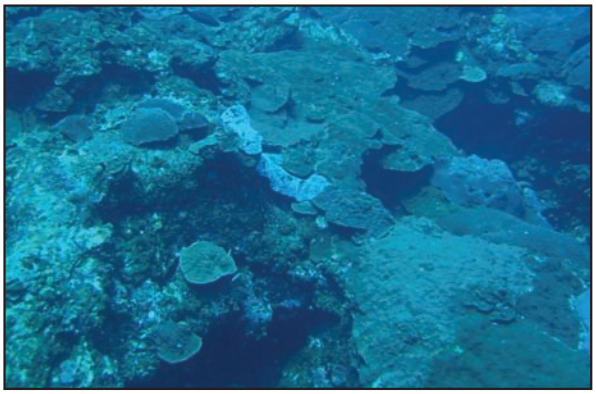
Figure 1.1 Map showing the location of the Flower Garden Banks National Marine Sanctuary in the northwestern Gulf of Mexico.

The FGBNMS is comprised of three underwater banks: East Flower Garden Bank (EB), West Flower Garden Bank (WB) and Stetson Bank that rise above a primarily soft bottom shelf habitat, (Parker and Curray, 1956). Located along the steep edge of the Sigsbee Escarpment, the banks originate from relic salt domes created by seafloor uplift and range in depth from 17-150 m (Shepard, 1937; Rezak et al., 1985). The EB is a younger, rejuvenated salt dome, while the WB has characteristics of a mature salt dome (Kennedy et al., 1983). Stetson Bank is a deeper bank that does not support the biological assemblages or diversity seen on either the EB or WB (Rezak et al., 1985).

Figure 1.2. Image of Madracis mirabilis *rubble covered with coralline algae (top) and polyps extended (bottom). (CCMA, E. Hickerson).*

McGrail (1982) classified the banks' benthic habitats into five major zones: 1) the upper coral caps ranging from 17-40 m depth (Rezak et al. [1985] define the upper limit as 15 m); 2) the lower algal-sponge dominated habitat between 40-90 m; 3) other shallow reef structures above 90 m; 4) the deep reef structures below 90 m; and 5) the soft bottom habitat below 90 m depth. The reef building corals that dominate the caps represent the northernmost coral reefs on the North American continental shelf. Coral assemblages on the caps can be divided into a shallower community (15-36 m) dominated by *Diploria, Montastraea* and *Porites* species; and a deeper community (down to 52 m) dominated by *Stephanocoenia* and *Millepora* species (Rezak et al., 1985). Along portions of the banks an area dominated by the ahermatypic yellow pencil coral (*Madracis mirabilis*) forms in between these two assemblages (Figure 1.2). Despite the similarities in species composition to Caribbean reefs, there is a noticeable lack of shallow water corals (e.g., *Acropora palmata, Porites astreoides*) and octocorals (Rezak et al., 1985; Aronson et al., 2005), although two small Acroporid colonies have been reported in recent years (Zimmer et al., 2006).

The region below the coral caps has been the subject of recent exploration efforts led by the FGBNMS staff, however, more comprehensive exploration and research is warranted. The deepwater benthic habitat is known to include: "algal sponge zones, honeycomb reefs, coralline algae reefs, highly eroded outcroppings, mud flats, mounds and mud volcanoes, and at least one brine seep" (FGBNMS, 2006). Researchers are currently investigating these deepwater environments using submersibles and remotely operated vehicles (ROVs) in an effort to understand connectivity between these habitats and the shallower water portions of the banks as well as to investigate linkages with the greater Gulf of Mexico region.



Coral assemblage (CCMA)

Dramatic oceanographic and climatological processes including storm fronts from the north, tropical cyclones as well as cyclonic and anticylconic gyres shape these habitats and their associated communities (Rezak et al., 1985; Lugo-Fernandez et al., 2001; Deslarzes and Lugo-Fernandez, 2007). On the surface, the major current affecting the banks is the Loop Current which originates in the Yucatan Channel and moves clockwise around the Gulf before exiting through the Florida Straits (McGrail et al., 1982). At deeper depths, McGrail (1982) discovered that bottom waters move around the individual banks rather than over them as originally hypothesized thus dispelling theories of regional upwelling. As a result, corals thrive in the warmer surface

waters while cold bottom waters remain below 100 m (Deslarzes and Lugo-Fernandez, 2007). The dynamic oceanographic patterns connect the otherwise isolated banks to the Gulf of Mexico basin and further link them biologically to the nearest tropical reefs in the Bay of Campeche, Mexico (Villalobos, 1971).

While the health of most of the sanctuary resources has been rated as either “good” or “good/fair” in a recent condition report, the sanctuary is still subject to both natural and anthropogenic impacts (ONMS, 2008). Biological impacts within the FGBNMS include pathogens, which virtually eliminated the *Diadema antillarum* population from the Atlantic basin (including the FGBNMS) in the early 1980s (Rezak et al., 1985). Fortunately, reports of coral disease in the FGBNMS have been minimal, despite the increased occurrence throughout neighboring Caribbean waters (Borneman and Wellington, 2005). In the past, limited bleaching events were reported within the FGBNMS and the coral demonstrated excellent recovery capabilities (Hagman and Gittings, 1992; Dokken et al., 2003; Pattengill-Semmens and Gittings, 2003). With increased sea surface temperatures throughout tropical waters, there has been an increase in the severity of coral bleaching events reported at the FGBNMS. While historically the corals have demonstrated high resilience, additional monitoring is necessary to investigate whether they are able to maintain this resistance to temperature stress (ONMS, 2008). Hurricanes also are capable of impacting the banks both directly through physical damage from water motion and from substantial land-based runoff of contaminated water which has been shown to reach the banks (ONMS, 2008).

Known anthropogenic impacts in the FGBNMS include anchoring, which has resulted in significant damage to coral structure, fishing activity, shipping and recreational diving (Gittings and Bright, 1986; ONMS, 2008). In addition to direct impacts, these activities collectively have resulted in the deposition of remnant marine debris, such as anchors, abandoned fishing nets, longlines and diving gear. Until they degrade, these anthropogenic remnants can be deleterious to benthic habitats as well as their associated communities for many years (Chiappone et al., 2005). With an increase in the number of annual visitors to the FGBNMS, there is concern regarding the cumulative impacts of these activities on the marine habitat and organisms. Oil and gas related activities, which began near the FGBNMS in the late 1970s, have also been identified as potential stressors to the biological communities (Hickerson et al., 2008; Figure 1.3). Studies examining the effects of drilling practices on resident coral communities have found no negative impacts to-date (Bright and Rezak, 1976; Hudson and Robbin, 1980; Shinn et al., 1980); however, it has been suggested that oil and gas structures may act as vectors in the spread of invasive and exotic species (Pattengill, 1998). Currently, there are 14 production platforms and more than 180 km of pipeline within a four mile radius of the FGBNMS boundaries (Hickerson et al., 2008). Proposed aquaculture facilities on oil and gas platforms as well as existing artificial reefs may also impact the sanctuary.

Figure 1.3. Image of oil rig topside (top) and underwater (bottom) in East Bank. (CCMA)

Recognizing the intrinsic value of the banks as well as the need for protection from the various activities occurring there, the FGBNMS was created in 1992. It currently encompasses the EB (27°54.5’N, 93°36.0’W; 65.86 km^2); WB (27°52.5 N, 93°49.0’ W; 77.54 km^2); and Stetson Bank (28’09.8’N, 94’17.9’W; 2.18 km^2). Stetson Bank was added to the sanctuary in 1996 and is located 48 km northwest of the WB.

A variety of regulations were put into place enabling the sanctuary to provide additional protections to the natural resources present (NOAA, 2001a). While fishing is permitted within the sanctuary it is restricted to conventional hook and line and take of other resources is generally prohibited. A “No Activity Zone” was established within the sanctuary by Minerals Management Service (MMS) where oil exploration and production are prohibited (MMS, 2004; Figure 1.1). In addition, within the sanctuary, the discharging of any pollutants or waste is prohibited and there is no permissible altering of the seabed, including from the placement of structure (e.g., oil transportation lines, fish traps, nets, and/or anchors; NOAA, 2001a). Within a four mile buffer zone surrounding sanctuary,

regulations require that drilling waste be discharged no more than 10 m from the seabed, thereby reducing the impact of sediment plumes on the coral community (MMS, 2004; Figure 1.1). In 1990, mooring buoys were installed on EB and WB to prevent anchor damage, but are restricted to boats <30.5 m (100 ft) long because boats of any larger capacity are considered a threat to the existing coral (NOAA, 2001a). In 2001 the International Maritime Organization designated the FGBNMS the first international no-anchoring zone and requires it be depicted as such on international charts (NOAA, 2001b).

1.3 DOCUMENT STRUCTURE

This document is organized around the two management goals provided by the sanctuary (see Section 1.1). Chapter 2 discusses sampling designs for characterizing and monitoring the reef fish community. It begins with a statement of objectives and identification of the data to be collected and population to be sampled. Following this, survey methods are discussed along with the potential benefits and difficulties associated with implementing them. This section is followed by an evaluation of candidate sampling designs including an analysis of covariance between the fish data collected and spatially explicit physical variables such as: habitat type, depth, gradient and bank location. Finally, data storage and distribution are discussed. As part of this project, a GIS tool was developed to assist with the implementation of the sampling design, including site selection. This tool and its user manual are both available from http://ccma.nos.noaa.gov/ecosystems/sanctuaries/fgb_nms.html.

Chapter 3 includes a comprehensive characterization of the biotic and abiotic benthic data collected at each survey station. Habitat structure including measures of percent cover of corals, sponges and algae are evaluated for the entire survey area, as well as compared among strata. Additionally, the level of coral bleaching is noted and spatial patterns are analyzed. A description of marine debris associated with the banks is also provided. Lastly, comparisons are made between the habitat data collected on the FGBNMS coral caps and study sites in the U.S. Caribbean.

Chapter 4 provides baseline data describing the fish communities along with a spatial and quantitative characterization of those communities. Analyses are conducted at the assemblage, trophic, family and individual species level. Estimates of abundance, biomass and size are provided sanctuary wide and comparisons are made between strata. As in Chapter 3, comparisons are made between FGBNMS study sites and those in the U.S. Caribbean.

Red hind (*Epinephelus guttatus*) (CCMA)

Field methods detailing the techniques utilized to collect both fish and associated habitat information are contained in Appendix A and B, respectively (Figure 1.4). Appendix C discusses the methods used to construct the benthic habitat map necessary for the creation of sampling strata. Finally, Appendix D presents a table with an example sample allocation and site selection.

Figure 1.4. Diver collecting benthic habitat data (left) and a diver collecting fish data (right). (CCMA)

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