STATUS OF THE FLOWER GARDEN BANKS OF THE NORTHWESTERN GULF OF MEXICO

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Introduction

The Flower Garden Banks are two prominent geological features on the edge of the outer continental shelf in the northwest Gulf of Mexico, approximately 192 km southeast of Galveston, Texas. Created by the uplift of underlying salt domes of Jurassic origin, they rise from surrounding water depths of over 100 m to within 17 m of the surface (Fig. 205). Stetson Bank, 48 km to the northwest of the Flower Gardern Banks, is a separate claystone/siltstone feature that harbors a low diversity coral community. Fishermen gave the Flower Garden Banks their name because they could see the bright colors of the reef from the surface and pulled the brightly colored corals and sponges up on their lines and in their nets.

These are the northernmost coral reefs on the continental shelf of North America, located between 27˚ 52' and 27˚ 56' North. They are isolated from other Caribbean and Gulf of Mexico reefs, being over 690 km from the nearest reefs of the Campeche Bank off the Mexican Yucatan Peninsula.

The East Flower Garden Bank, located at 27˚ 54.5' N, 93˚ 36.0' W, comprises about 65.8 km^2 and contains about 1.02 km^2 of coral reef. About 19.3 km to the west, the West Flower Garden Bank, (27˚ 52.5' N, 93˚ 49.0' W) comprises about 77.2 km^2, of which about 0.4 km^2 is coral reef (Gardner *et al*. 1998).

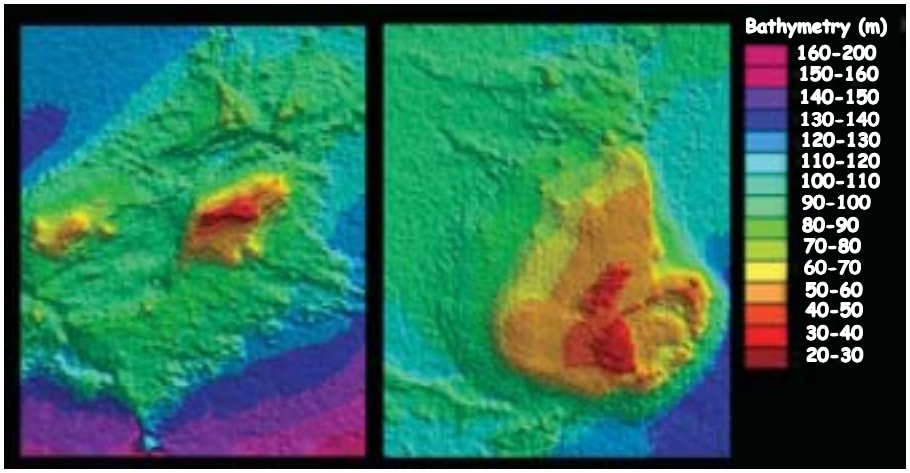
Structurally, the Flower Garden Banks coral reefs are composed of large, closely spaced heads up to three or more meters in diameter and height. Reef topography is relatively rough, with many vertical and inclined surfaces. If the relief of individual coral heads is ignored, the top of the reef is relatively flat between the reef surface and about 30 m. It slopes steeply between 30 m and the reef base. Between groups of coral heads, there are sand patches and channels from 1-100 m long. Sand areas are typically small patches or linear channels.

Probably due to its geographic isolation and other factors, there are only about 28 species of reef-building corals, a relatively low diversity. Interestingly, the Flower Garden Banks contain no elkhorn or staghorn corals and no shallow-water sea whips or sea fans (gorgonians) which are common in the Caribbean.

Coral growth is relatively uniform over the entire top of both banks, occupying the bank crests down to about 50 m. As the reef slopes in the deeper regions, corals grow flatter and individual heads can cover large areas.

The East and West Flower Garden Banks were designated as the Flower Garden Banks National Marine Sanctuary (the Sanctuary or FGBNMS) in January 1992. In 1996, Stetson Bank was added. The Sanctuary encompasses 145.8 km^2 and includes all of the shallow coral reef areas.

Figure 205. Bathymetry map of the East and West Flower Garden Banks (Credit: John Christensen).



Condition of the Coral Reefs

The Flower Garden Banks are two of the least disturbed coral reefs in the Caribbean and western

Atlantic and are among the few reefs anywhere that can be considered nearly pristine (Gittings and Hickerson 1998). The ocean water bathing the reefs is clear with visibility usually 25-30 m. Salinity and temperature variations are well within the range required for active coral growth. When first studied in the early 1970s, coral communities in the Flower Garden Banks appeared stable and in excellent general health and have remained so. Some isolated injury caused by anchoring vessels, illegal fishing gear, tow cables, and seismic arrays was observed.

Figure 206. Reefs at the Flower Garden Banks have high coral cover (Photo: Stephen Gittings).

Coral and Benthos – Gittings (1998) reviewed the data from all of the assessment and monitoring studies through 1995 (for specifics, refer to the below monitoring section within this report). Coral cover averaged 47.3% and has not significantly changed since initial studies in 1972 (Fig. 206). Similar consistency was observed in coral growth rates and other indicators of coral health. The most recently published results (Dokken *et al*. 1999) showed the trend had continued through 1997.

The current status provided by Dokken *et al*. (1999) is based on data from the 1996 and 1997 monitoring effort (Table 19). Live coral cover above 30 m averages 51.8% (53.8% on the East Bank and 49.8% on the West Bank). The coral heads are frequently very cavernous, showing evidence of substantial internal bioerosion (Fig. 207). Other prominent benthic components include coralline algae-covered rock (45.4%), leafy and filamentous algae (2.7%), sponge (1.5%), and patches of sand (less than 0.1%) may cover 10% of the bottom. Since sites were chosen to monitor reef habitat and avoid sand, sand channels and patches probably account for around 10% of the Bank benthos.

By percentage cover, the dominant coral species are the boulder star coral (*Montastrea annularis* complex, 28.8%), symmetrical brain coral (*Diploria strigosa*, 9%), mustard hill coral (*Porites astreoides*, 4.6%), and the great star coral (*Montastrea cavernosa*, 4.4%). Diversity (H´) averaged 1.727 for all monitoring years since 1992, and Evenness (E) averaged 0.853.

Coral bleaching is routinely observed most years when water temperatures exceed 30˚ C, but is generally low and does not result in significant mortality (Dokken *et al.* 1999). Based on repetitive quadrat photography, no bleaching was observed in 1996 at either the East or West Flower Garden Bank. In 1997, bleaching was observed in 1.9% of the coral colonies on the East Bank, and in 1.2% of the colonies on the West Bank. Bleaching during the summer of 1998 was slightly higher than previous years, but was still less than

Table 19. Mean percent cover (%) of corals, reef rock, algae, sponge, and sand on random transects sampled during 1996 and 1997 survey cruises at the East and West Flower Garden Banks.

PERCENT COVER				
Analyzed Components	**East Flower Garden Bank**		**West Flower Garden Bank**	
	1996	**1997**	**1996**	**1997**
Montastraea annularis	30.5	28.0	34.0	22.6
Diploria strigosa	6.8	9.4	11.6	8.4
Porites astreoides	5.9	6.6	2.6	3.2
Montastraea cavernosa	6.0	3.7	4.7	3.3
Colophyllia natans	1.0	3.1	1.7	1.2
Millepora alcicornis	2.3	0.8	1.5	0.9
Agaricia agaricites	1.0	0.2	0.3	0.4
Stephanocoenia intersepta	0.6	1.0	0.6	0.2
Madracis decactis	0.5	0.0	0.1	0.6
Siderastrea siderea	0.3	0.2	0.2	1.4
Mussa angulosa	0.0	0.0	0.0	0.2
Scolymia cubensis	0.0	0.0	0.0	0.0
Porites furcata	0.0	0.0	0.0	0.0
Madracis mirabilis	0.0	0.0	0.0	0.0
Total coral	**54.8**	**52.9**	**57.4**	**42.3**
Reef rock	41.8	48.6	39.8	51.5
Leafy algae	0.0	5.2	0.9	4.8
Sponge	1.4	2.8	1.0	0.7
Sand	0.0	0.0	0.0	0.2

5%, with mortality less than 1% (Q. Dokken pers. comm.).

Coral disease was relatively rare, with only 23 incidents of disease or other unexplained mortality observed in over 3700 colonies. Data from the 1998 and 1999 monitoring effort have been compiled and are now under review.

Predation of living coral by parrotfish (Bruckner *et al.* 2000) is commonly observed, but the long-term effect of this phenomenon is not known at this time (Fig. 208).

Algae – Only recently has the coral reef algal community been well documented. Crustose coralline and calcareous green algae are common. Collections obtained in 1999 show a community of at least 44 species of algae in depths above 30 m (S. Fredericq pers. comm.). Benthic macroalgae are a minor, yet important component of the reef community in terms of potential competitors for space (Fredericq *et al.* 2000), growing mostly in crevices and sandy interfaces. Solitary foliose algae are rarely encountered; most of the algal community is composed of turf species. Algae are a primary component of the deeper portions of the banks (below 30 m). The region between 46 and 88 m is known as the 'algal-sponge zone' (Rezak *et al*. 1985).

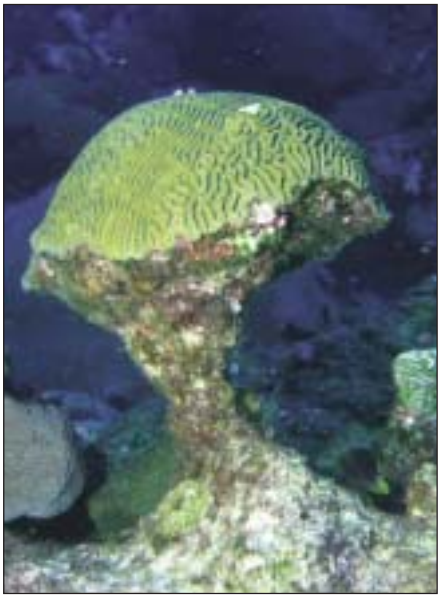


Figure 207. The mushroom-like shape of this brain coral is a product of bioerosion (Photo: Frank and Joyce Burek).

Algal populations have historically been low, with percent cover estimates generally less than 5% between 1989 and 1996. The algal community increased to over 13% after the long-spined sea urchin die-off in 1983-84, but returned to pre-dieoff levels after two years (Gittings and Bright 1986), perhaps due to an increase of other herbivores.

Blue-green algae are abundant and invading open space on coral heads (S. Fredericq pers. comm.). This could be in response to elevated nutrient levels, and therefore, may be an important indicator of water quality degradation and a potential concern for the condition of the entire ecosystem (S. Fredericq pers. comm.).

In 1997, a slight increase in a red or blue-green turf algal mat was observed on both banks, averaging about 5% cover (Dokken *et al.* 1999). Algal cover declined slightly to about 3.2% in 1998, but then underwent a dramatic increase in 1999 (27.6% on the East Bank, 20.7% on the West Bank) (Q. Dokken pers. comm.). This increase occurred as algae colonized the bare reef rock, and may signal that environmental factors are changing to favor algae.

Water Quality – In the vicinity of the Sanctuary, water quality is generally very good. Being on the outer edge of the Texas-Louisiana continental shelf, the Banks are directly influenced by the circulation patterns of the Gulf of Mexico. The most prominent current is the Loop Current which brings warm, clear water from the Caribbean through the Yucatan channel into the Gulf of Mexico basin, where it travels in a clockwise direction moving towards the western shelf of Florida. Moving inshore on the shelf, there is a significant onshore-offshore current component influenced by Loop Current rings and spin-off eddies. Close to shore there is a counter-clockwise (east to west) shelf current off western Louisiana and Texas. This current is strongest in

Figure 208. A stoplight parrotfish at the East Flower Garden Bank (Photo: Dick Zingula).

winter and almost absent in summer (Lugo-Fernandez 1998).

Water temperature near the Sanctuary varies seasonally and with depth. Average temperature over seven years varied at the reef surface at 24 m from a minimum of 19-20˚ C in February to a maximum of 29-30˚ C in July/August, with an annual range of 9-11˚ C (Lugo-Fernandez 1998). Interannual variations occur and temperatures over 30˚ C have been observed (Gittings *et al*. 1992), generally accompanied by varying levels of coral bleaching (Hagman and Gittings 1992). Salinity ranges between 35 and 36.5 ppt near the reef surface.

Visibility averages 25-30 m. Turbidity is generally very low, but periods of discoloration have been observed, primarily in June or July, and may be associated with the Mississippi and Atchafalaya River outflows and coastal waters moving onto the shelf (Deslarzes 1998). Surface waters are affected by freshwater flows when wind patterns reverse, changing nearshore currents.

Large Mobile Invertebrates – The Flower Garden Banks are home to at least 27 species of sponges, 20 species of polychaetes, 62 species of crustaceans, 667 species of mollusks, and 36 species of echinoderms. As in the case of mollusks, when invertebrate taxonomic experts inventory the biota of the Sanctuary, the total number of resident and transient species should increase substantially.

The Flower Garden Banks had an almost complete die-off of the long-spined sea urchin in 1983-84. There has been very little, if any, sustained recovery, even though individual sea urchins are found (Schmahl pers. comm.).

Fish – The Flower Garden Banks support a promi-

Figure 210 A manta ray at FGBNMS (Photo: Kaile Tsapis).

Figure 209. The golden-phase smooth trunk fish has only been reported on the Flower Gardens and Stetson Bank reefs (Photo credit: Frank and Joyce Burek).

nent reef fish population. Fish diversity is low compared with other Caribbean and South Atlantic reefs (266 species) and abundance is high (Pattengill-Semmens 1999). Based on abundance, planktivores and invertebrate feeders are the most dominant trophic groups (Pattengill *et al*. 1997).

Some of the most abundant species at all three banks were reef butterflyfish (*Chaetodon sedentarius*), Spanish hogfish (*Bodianus rufus*), bluehead wrasse (*Thalassoma bifasciatum*), brown chromis (*Chromis multilineata*), bicolor damselfish *(Stegastes partitus*), creolefish (*Paranthias furcifer*), and sharpnose puffer (*Canthigaster rostrata*). A unique gold color phase of the smooth trunkfish (*Lactophrys triqueter*) has been documented (Pattengill 1998, Fig. 209). Fish families and groups notably absent or only represented by one or few species in low numbers include grunts (Haemulidae), snappers (Lutjanidae), and hamlets (*Hypoplectrus* spp.). There is also evidence that these reefs may serve as an important spawning and aggregation area for certain species of grouper.

The banks are year-round habitat for devil rays and manta rays (*Mobula hypostoma* and *Manta birostris*, Fig. 210), and whale sharks (*Rhincodon typus*). They serve as a winter habitat for several species of schooling sharks, including hammerhead (*Sphyrna lewini*) and silky sharks (*Carcharhinus falciformis*), and spotted eagle rays (*Aetobatus narinari*) (J. Childs 2001).

Fishing pressure on the Sanctuary does not appear to be intense, but fishermen have used longline fishing gear in the vicinity of the banks and along the entire continental shelf since the late 1800s. Commercial snapper and grouper fishing occurs along the continental shelf edge, including the Flower Garden Banks. Target areas for this activity

are typically the deeper portions of the Bank structure, away from the shallower coral reefs. Anecdotal information suggests that snapper, jewfish, and other grouper populations have declined over time. These are present but do not occur in abundance. There is no data prior to the late 1970s.

Fish population estimates were not made at the same time as observations of algal populations, but by 1990, a significant increase in the abundance of queen and stoplight parrotfish (*Scarus vetula* and *Sparisoma viride*, respectively) was reported. Gittings *et al.* (1992) suggested that this increase may be due to greater availability of algae following the demise of long-spined sea urchins in the mid-1980s.

Other Marine Life – Juvenile loggerhead sea turtles (50-100 kg) are resident at the East and West Flower Garden Banks (Fig. 211). Based on satellite tracking studies, these turtles have a range of approximately 130 square kilometers, tightly centered on the Banks (Hickerson 2000).

Hawksbill and leatherback turtles (*Dermochelys coriacea*) have also been reported.

Atlantic spotted and pan-tropical spotted dolphins (*Stenella plagiodon* and *S. attenuatus* respectively), and bottlenose dolphins (*Tursiops truncatus*) are commonly seen. Recently an unidentified species of beaked whale was reported.

Coastal Populations and Reef Economics

Recreational SCUBA diving is popular and the demand appears to be increasing. There are currently three live-aboard charter dive vessels which can carry up to 35 divers each. In 1997, from a survey of charter dive operations, it was estimated that 2,350 divers annually visit the Flower Garden Banks. These divers spent $870,000 in Texas. About $636,000 was spent in the local economy of Free-port Texas where it generated $1.1 million in sales/output, $477,000 in income, and 24 full and part-time jobs. An additional $234,000 was spent in other areas of Texas with $559,000 in sales/output, $228 thousand in income, and 11 more jobs (Ditton and Thailing 2001).

Environmental Pressures on Coral Reefs

Human Pressures – Since they are relatively far from both Texas and Louisiana, the Flower Garden Banks are well buffered from urban pressures. There are four primary threats to these reefs: 1) physical injury from vessel anchoring, 2) potential water quality degradation, 3) impacts of fishing and fishing-related activities, and 4) impacts from oil and gas exploration and development.

Over the last 20 years, a number of large industry vessels, freighters, and fishing vessels have anchored at the Flower Garden Banks and caused significant damage (Gittings *et al*. 1992). Since 1994 there have been at least three large vessel-anchoring incidents. Foreign-flagged cargo vessels have occasionally anchored, unaware of the anchoring restrictions.

Figure 211. A loggerhead turtle (Photo: Frank and Joyce Burek).

Primary sources of potential degradation of water quality include coastal runoff, and river and effluent discharges from offshore activities such as oil/gas development and marine transportation (Deslarzes 1998). Oxygen-depleted (hypoxic) near-bottom waters have been found in a large area of the northern Gulf. Although relatively far from the Flower Garden Banks, there is concern that this area could grow and move, impacting the outer continental shelf. Often called the 'dead zone', this area has included up to 16,500 km^2 on the continental shelf from the Mississippi delta to the Texas coast.

General coastal runoff and degraded nearshore water quality can potentially impact the banks through cross-shelf transport processes, which brings turbid, nutrient-rich water offshore. Deslarzes (in press) postulates the fluorescent bands observed in the carbonate skeletons of some corals come from the seasonal transport of

nearshore water onto the Sanctuary, which may be tainted by urban, agricultural, and biological contaminants.

Research using nitrogen isotopes suggests a pathway for direct primary nitrogen input from coastal river sources a considerable distance away. Benthic algae from Stetson Bank have a distinct nitrogen isotope signature similar to plants found in coastal estuarine systems, suggesting coastal influences on water quality are reaching only as far as Stetson Bank. Nitrogen isotopes from the Flower Garden Banks have signatures of oceanic origin (K. Dunton pers. comm.).

The impacts of fishing and associated activities are not well known. At this time, only traditional hook and line fishing is allowed in the Sanctuary. However, illegal fishing by both commercial longliners and recreational spearfishers has been reported. Targeted fishing efforts, which are allowed under current regulations, could have a significant detrimental impact on snapper and grouper populations.

Lost and discarded fishing gear has been observed at both the Sanctuary and Stetson Banks (Fig. 212). These can cause localized physical injury to coral reefs and can entangle and injure loggerhead sea turtles and other animals.

Figure 213. The High Island 389A gas production platform within the Sanctuary (Photo: Frank and Joyce Burek).

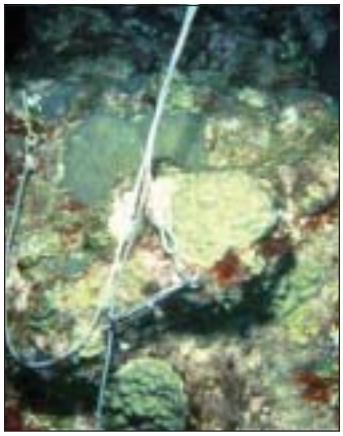


Figure 212. Hook-and-line fishing gear snagged on a coral (Photo: Frank and Joyce Burek).

The two primary groups using reef resources are fishers and SCUBA divers. Recreational hook-and-line fishers frequently use the area. Commercial snapper and grouper long-line fishers fish along the edges of the banks and sometimes illegally within the borders, or lose gear that drifts into the Sanctuary. However, these activities are typically in the deeper portions of the bank structure.

The northern Gulf of Mexico is one of the most active areas for oil and gas exploration and development. By the end of 1995, approximately 5,000 production platforms had been installed (approximately 1,000 were subsequently removed), 32,000 wells had been drilled and 80,000 km of pipeline installed (Deslarzes 1998, A. Alvarado pers. comm.). The Gulf of Mexico accounts for more than 72% of the oil and 97% of the natural gas produced in offshore U.S. waters.

Within a four-mile radius of the Flower Garden Banks, there are currently 10 production platforms and around 161 km of pipeline, half of which are dedicated oil pipelines (Deslarzes 1998). There is one gas production platform (High Island 389A) within the East Sanctuary boundary (Fig. 213).

Potential impacts from offshore oil and gas exploration and development include accidental spills, contamination by drilling related effluents and discharge, anchoring of vessels involved in placing pipelines, drilling rigs and production platforms, seismic exploration, use of dispersants in oil spill mitigation, and platform removal. In spite of the intense industrial activity, long-term monitoring studies indicate no significant detrimental impact to the coral reefs of the Sanctuary from nearby oil and gas development (Gittings 1998). Fortunately, there have been no major oil spills or impacts from these activities.

Climate Change and Bleaching – The location and depth of these coral reefs buffer them some-

what from the short-term effects of global warming and climate change. Even though the effects of coral bleaching are relatively low to date, some bleaching is routinely observed, mostly when the water temperature approaches 30˚ C. As global ocean temperatures increase, this will no doubt increase.

Current Conservation Management

Mapping – Using high-resolution multi-beam sonar coupled with an extremely accurate vehicle motion sensor and very precise navigation, the USGS, the University of New Brunswick, and C & C Technologies, Inc. mapped the East and West Flower Gardens and Stetson Banks (Gardner *et al.* 1998).

Monitoring, Assessments, and Research – Since 1989, there has been a consistent, long-term monitoring program at the East and West Flower Garden Banks. NOAA and the Minerals Management Service (MMS) share the funding for this program. While not all, much of the monitoring has been related to concerns about the potential impact of oil and gas development.

This program includes analysis of coral cover, relative abundance, diversity, and coral growth rates. Coral cover, abundance and vitality (disease, bleaching) are measured along random transects and at permanently marked, repeatedly sampled photo-quadrat stations. Coral growth data are collected using photography and growth-ring measurements from coral cores. Continuous-recording instruments have been installed to measure temperature and light at the reef surface.

Results of the long-term monitoring efforts are published periodically (Gittings *et al.* 1992, Continental Shelf Associates 1996, Dokken *et al.* 1999, Dokken *et al.* 2001). Prior to the development of the long-term monitoring program, there had been other quantitative studies of the benthic community at FGBNMS since 1972 (Bright and Pequegnat 1974, Viada 1980, Continental Shelf Associates 1985).

Additional studies include periodic reef fish censuses and trophic studies (Pattengill *et al.* 1997), elasmobranch surveys (sharks and rays), sea turtle tagging and tracking, coral recruitment research, annual observations and experiments relating to mass coral spawning (Fig. 214), and studies on historical water quality and paleoclimate (using coral cores). Enhanced water-quality instruments were installed in 2001, and are now collecting data on temperature, salinity, turbidity, dissolved oxygen, pH, and light intensity.

MPAs – The Flower Garden Banks were designated as a National Marine Sanctuary in January 1992, and are administered by NOAA. In cooperation with appropriate partners, the Sanctuary staff directs resource protection, education, research, and enforcement efforts. MMS provides additional protection through requirements imposed on industry operators in what is known as the 'Topographic Features Stipulation' for the Sanctuary.

Figure 214. Researchers from the University of Texas lay tiles out on a reef during a study of coral spawning (Photo credit: Ed Enns).

Government Policies, Laws, and Legislation

Regulations governing the Flower Garden Banks are authorized under the National Marine Sanctuaries Act, as amended, 16 U.S.C. 1431, and are contained within the Code of Federal Regulations 15 CFR 922, Subparts A, E, and L, and can be accessed on the web. They are designed to protect the sensitive coral reef and bank features of the Sanctuary. They prohibit all anchoring, mooring any vessel greater than 100 feet (30.5 m) in registered length on a Sanctuary mooring buoy, oil and gas exploration and development within a designated no activity zone (almost the entire sanctuary), injuring or taking coral and other marine organisms, using fishing gear other than traditional hook and line, discharging or depositing any substances or materials, altering the seabed, building or

abandoning any structures, and using explosives or electrical charges. To reduce damage, moring bouys have been installed (Fig. 215).

Effective June 1, 2001, the International Maritime Organization designated the Flower Garden Banks as the world's first international no-anchor zone.

Figure 215. Mooring buoys have been installed at FGBNMS to prevent anchor damage to corals (Photo: Joyce and Frank Burek).

Gaps in Current Monitoring and Conservation Capacity

The increased algal abundance highlights the need for more water quality monitoring. This needs to cover nutrient sampling and more detailed current and water circulation information. It also should be expanded to include specific studies on algae population dynamics, the incidence and etiology of coral disease, and the area of the coral reef community in the deeper parts of the Sanctuary. The frequency of the monitoring program should also be increased to capture the aspects of community ecology that undergo short-term and seasonal fluctuations (algal biomass, coral bleaching, herbivores, etc.).

The distance from shore hampers research and enforcement efforts. It also hampers monitoring human activity. While some data on visitor use can be acquired by a variety of remote methods such as overflights, satellite imagery, and remote radar systems, the Sanctuary needs on-site observation, management and enforcement. In May, 2001, the Sanctuary recently acquired its own vessel, an 82-foot cutter, but also relies on charter vessels.

Conclusions and Recommendations

Recent data indicating the Flower Garden Banks may be an important spawning area for several species of grouper highlights the importance of considering a marine reserve to protect the biodiversity of this area.