# Mass Spawning by Reef Corals in the Gulf of Mexico and Caribbean Sea

## A Report on Project Reef Spawn '94

**A Report of the Flower Gardens Fund of the Gulf of Mexico Foundation**

Flower Gardens Fund Technical Series
Report No. 94-03

# Mass Spawning by Reef Corals in the Gulf of Mexico and Caribbean Sea

## A Report on Project Reef Spawn '94

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# *The Flower Gardens Fund*

The Flower Gardens Fund, established by the Gulf of Mexico Foundation in cooperation with the Flower Garden Banks National Marine Sanctuary, was created to enhance conservation efforts at the Flower Garden Banks through increased public and private sector involvement in research, monitoring, education, and communication. Among the goals of the Fund are to facilitate communication on Flower Gardens Sanctuary management and activities.

This is the third in a series of publications designed to inform and educate the general public, the scientific community, government entities, and others about activities taking place in the northwestern Gulf of Mexico. The series is intended to do this in a timely manner, and covers a broad range of research, education and management topics.

This document contains reports from Project Reef Spawn, a cooperative effort between volunteers and scientists to coordinate observations of coral spawning in 1994 at four sites in the Gulf of Mexico and Caribbean Sea. Project Reef Spawn was sponsored by Oceanographic Expeditions, the Flower Gardens Fund, and the National Oceanic & Atmospheric Administration's Flower Garden Banks National Marine Sanctuary, with additional support from Mobil Exploration and Producing U.S., Inc., and the University of Honduras. Because of its large scale and regional nature, the partnership between scientists and volunteer recreational divers was crucial to the success of this project.

We hope you enjoy reading about Project Reef Spawn.

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# Contents

# Love on the Rocks

Each year between 1990 and 1993, mass spawning by corals was witnessed on the reefs of the Flower Garden Banks, 100 miles south of the Texas-Louisiana border. Mass spawning is the synchronous release of gametes by more than one species. Some have described the event as looking like an upside-down, underwater snowstorm. The "snow" is a mixture of sperm and eggs, some combined in packets released by the parent colonies. When spawning is really active, the underwater visibility can decrease significantly for a period of an hour or so, and a blanket of floating gametes form a "slick" on the ocean surface.

Recreational divers were the first to see this spectacular occurrence at the Flower Gardens in 1990. Scientists from Texas A&M University and the National Oceanic & Atmospheric Administration's (NOAA) Flower Garden Banks National Marine Sanctuary have been documenting the affair ever since.

Each year's observation of spawning has revealed a surprisingly similar pattern. Eight evenings after the August full moon, between approximately 8:30 and 11:00 p.m., colonies of at least three coral species, two star corals and one brain coral, released buoyant packets of gametes into the water for external fertilization and larval development.

No one knows how corals sense that it is time to spawn, yet on one or two evenings a year, coral colonies fill the water column with eggs and sperm for a brief period of hours, only to see their newborns drift off into the wild blue yonder. (Photo Credit - Jesse Cancelmo)

# Ask Mother Nature

*Why synchronous spawning?* For coral sexual reproduction, timing is everything. The more synchronous, the better chance for fertilization of the coral eggs and the greater the chance for survival and proliferation. Also, the large number of eggs in the water make consumption of the entire lot by predators highly unlikely.

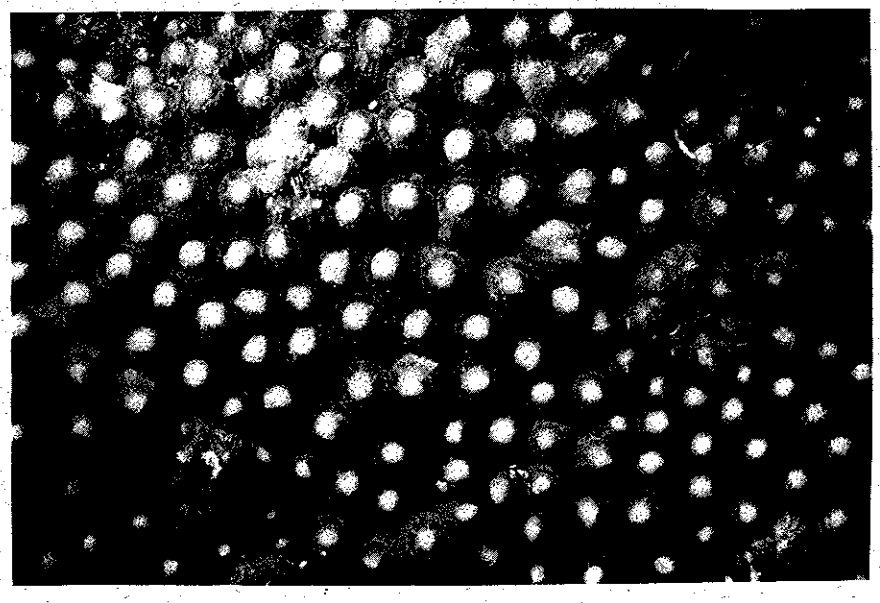
*Why eight evenings after a full moon?* Perhaps it's the neap tides, which occur during half moons, when tidal currents tend to be weak. This allows gametes (eggs and sperm) to remain close together, increasing the chances for successful fertilization.

*Why August?* Perhaps the warm water temperature increases the life of eggs and sperm, as well as the sperm's swimming ability. This would also increase the rate of fertilization and the number of fertilized eggs.

*Why nighttime?* Probably predator avoidance. The tasty little fat-filled eggs would be easy fodder during daylight hours. At night, very few predators are able to take advantage of this once-a-year smorgasbord.

So, good timing, receptive company, warmth, and darkness all increase successful mating. These areexamples of natural selective factors that have guided the evolution of corals that participate in mass spawning on modern coral reefs.

*But why mass spawning?* Why should more than one species spawn together? And does this occur on other Atlantic reefs? Does it happen on the same night on all reefs? What cues trigger the event? Are the same species active on all reefs? Do some species have different timing? And does the level of spawning in any way indicate the health of reef ecosystems? These are questions that are only now being investigated. The answers in most cases, however, require an enormous amount of effort, and eyes in many places at the same time.



Coral polyps in the "setting phase", ready to release egg/ sperm bundles. In this phase, the tentacles are retracted, and the egg and sperm are packaged together and bound by a mucus sheath. (Photo Credit - Greg Boland)

# Are Caribbean Corals Shy ?

## Blue Moon Baffles Forecasters

In 1993, an unusual astronomical event called a "blue moon" (two full moons in one month) forced the corals at the Flower Gardens to make a choice. Most spawned eight evenings after the second full moon, when water temperature reached its summer maximum. Yet the corals still spawned synchronously as they had in previous years, maximizing the numbers of developing gametes. While such events may make prediction of spawning dates difficult, they help scientists determine which environmental cues are most imporant as triggers for mass spawning.

Mass spawning has been observed and studied on Pacific reefs for over a decade. But few observations of spawning have been made in the Atlantic. For a number of years, Bermudans have reported surface slicks that were thought to have resulted from coral spawning, but it has only been in recent years that observations have confirmed corals spawning there. There have also been recent reports of coral mass spawning from the Netherlands Antilles, on Bonaire and Saba. Surprisingly, there were no known reports of coral spawning from the Florida Keys before 1993, yet in the Keys late summer night dives have been commonplace for decades.

It was a welcome surprise in 1990 to discover synchronous coral spawning at the Flower Gardens. This meant that the reefs had the capability to repopulate from within as a result of local coral spawning; they need not depend on larvae from the closest neighboring reefs hundreds of miles to the south. This was an extremely important finding for resource management. For one thing, in the event of a mass die-off of corals for any reason, not only could surviving corals enable natural recovery over time, but perhaps gametes from the reefs themselves could be collected, allowed to develop and grow, and then used for artificial restoration.

## *Project Reef Spawn*

Luckily, mass spawning lends itself to stunning photography and videography. This makes it easy for scientists to engage the many recreational divers interested in participating in environmental studies. It is this partnership that was the basis for regional spawning observations through Project Reef Spawn 1994.

In the late summer of 1994 Oceanographic Expeditions Executive Director, Jim Hart, arranged for groups of divers to visit four different sites simultaneously in the Caribbean and Gulf of Mexico. These were the Flower Garden Banks (northwest Gulf of Mexico), Molasses Reef (Key Largo, Florida Keys), Cozumel (Mexico), and Roatan (Honduras). The participants are listed in Appendix 1. At each site, divers would record observations on prepared data sheets at designated monitoring sites over several days around the predicted spawning dates (determined from previous years at the Flower Gardens). They would then communicate between groups to record and compare their findings of coral spawning, water and atmospheric conditions. This report summarizes those reports and includes information from other sites as well.

# Site Reports

## Flower Gardens

The five-day cruise to the Flower Gardens had a number of objectives. Because mass spawning occurs mainly at night, other projects could be conducted during the daytime. These included coring of coral colonies for studies of historical growth and water quality, conducting reef fish censuses, collecting data on coral populations in reef areas below 100 feet, and surveying manta ray and turtle populations (these are summarized in Appendix 2). At night, spawning observations and gamete and larvae collections were made. For all these efforts, the cruise had remarkable success. Volunteers proved to be the lifeblood in nearly all these activities.

August 27th

The first day of diving on the East Flower Garden Bank (Buoy #7) was August 27, that evening being the seventh following the full moon. During the day dives were conducted to census fish and collect coral cores for studies of historical growth rates and water quality.

During previous years, mass spawning episodes were preceded by late afternoon sperm release by male great star corals (*Montastrea cavernosa*). This was not reported by any divers on the 27th. So we did not expect that the evening would be as lively as it turned out to be.

*Star coral spawning a day early*

At 9:00 p.m. a small number of gamete bundles were seen floating on the surface. At 9:15 the density of bundles on the surface increased dramatically, and the first divers entered the water . The density of the spawn slick was surprising, considering that during prior years, spawning on the night before the predicted date had been less intense. Yet by 9:30, divers reported very high levels of activity among boulder star coral (*Montastrea annularis*) colonies. In addition, a number of symmetrical brain corals (*Diploria strigosa*) spawned, and one male and one female great star corals were seen releasing gametes. While the latter two observations were not unusual, the high level of star coral activity was not expected.

Samples of the gametes, primarily *M. annularis*, were collected using hand-crafted "butterfly nets". Divers used the nets to collect the gametes as they were released into the water column. After each sample was obtained it was placed into a gallon-sized Zip-Loc bag, sealed, and transported to the surface for processing.

Based on the nearby Mobil gas production platform HI-A389 in the Flower Garden Banks National Marine Sanctuary, Mr. Derek Hagman (University of Texas) conducted observations and studies on coral fertilization, development, and settlement. Mr. Russell Hooten (National Biological Survey) worked on toxicological studies using the larvae.

The U.S. Department of Interior, Minerals Management Service, has for the last two years provided a drifter for deployment during the mass spawning. The satellite-tracked unit drifts for a period of months while two satellites track its progress. Theoretically, the unit tells where the spawn slick moves. Over a period of several years, we may better understand the variability in ocean currents during the spawning period. This will also help us

determine the potential for coral reseeding of the Flower Gardens following gamete release, and tell us, for example, the likelihood of coral population recovery at the Flower Gardens following a mass mortality.

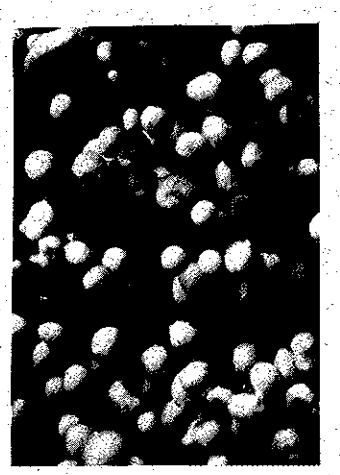
We decided to release the drifter buoy on the night of the 27th. Because of the high level of spawning on that night, we were uncertain whether this evening's activity represented the majority of spawning activity for the year - the so-called "main event". Following the 10:30 p.m. release, the buoy drifted WNW at 310°. Currents were from the ESE at less than 0.5 knots. Winds were 10-12 knots from the southeast. Seas were less than 2 feet.

Unfortunately, after two days, and having drifting only a short distance to the west of the bank, the drifter buoy failed for unknown reasons. In 1993, the drifter buoy headed to the south for over a day, then turned east and drifted for over a month toward an area south of the Mississippi River delta. The variation between the two years demonstrates the sort of variability coral larvae are subjected to in the region, and indicates that the likelihood of long-term survival for the corals is itself unpredictable and highly variable.

Spawning on the 27th ended at approximately 11:00 p.m., as it had in previous years, having lasted roughly two hours. A midnight dive confirmed that all activity had ceased.

August 28th

The low level of spawning by corals other than *M. annularis* on the 27th suggested that spawning was likely for those species on the 28th, the date earlier predicted to be the "main event". Considerable spawning did take place on the 28th, but the sequence of events was unusual in comparison to previous years.



Prior to 7:00 p.m. on the 28th, no divers reported spawning by male *M. cavernosa* colonies, as had been seen in prior years. But Chris Ostrom and Dr. Ann Bull noted an orange egg mass on a brown encrusting octopus sponge (*Ectyoplasia ferox*) at 2:30 in the afternoon. Dr. Bull also reported creole wrasse (*Clepticus parrai*) spawning "rushes" at dusk, in which fish swim rapidly upward to release eggs and sperm. A dusky damselfish (*Stegastes fuscus*) was seen and photographed by David Bull guarding its eggs. Black durgons (*Melichthys niger*) were also observed guarding nests. On August 26, brown chromis (*Chromis multilineata*) spawned in mass on one area of the East Flower Garden Bank in concentrations of over 30/m$^2$. Spawning by these species may coincide with mass coral spawning, as some had been witnessed at the same time in previous years.

Above -A star coral releases spherical gamete bundles. Right - A diver collects bundles using a net. The samples were transfered to the surface, where experiments could be conducted. (Photo Credits - Greg Boland)

# Flower Gardens Site Report (continued)

August 28th (continued)

At 7:55 p.m., a surge of coral gamete bundles rose to the surface near our ship, the M/V Spree. Slick samples were taken at 8:10. But at 8:20, the slick thinned, with comparatively little activity underwater until around 9:30. At 9:00, egg release by the ruby brittle star *Ophioderma rubicundum* was observed. Capt. Bud Shertleff, aboard another vessel, For The Good Times II, witnessed and filmed similar spawning activity at 9:45.

*A weaker "main event" than previous years*

Between 9:30 and 10:30, coral spawning activity increased and was dominated by brain corals *(D. strigosa)*. Two boulder star coral *(M. annularis)* colonies spawned at 10:10, and both male and female spawning by great star corals *(M. cavernosa)* was observed by divers on another vessel. At 10:30, an unusual gamete release by a *M. annularis* colony was observed. It appeared that its entire mass of gamete bundles was bound by mucus. Normally, these bundles are separate from one another. This observation remains to be explained. Also at 10:30, a Christmas tree worm (*Spirobranchus giganteus*) failed to retract its radioles (two whorls that extend out of the worm's tube) when touched by a diver. In prior years, spawning by this species had been witnessed on the same nights as the coral mass spawning. Though no gamete release by this species was observed in 1994, prior observations of this species have taught us that they are reluctant to retract the radioles when spawning. Thus, it is likely that the worm had recently released or was preparing to release either eggs or sperm.

At 11:00 p.m. Capt. Gary Rinn reported unusual activity by large fireworms (*Hermodice carunculata* ) (some nearly a foot long). He noted that they were orienting themselves upward ("standing up"). It is not known what this activity indicates, though spawning is suggested.

Spawning by corals continued at a fairly constant, though comparatively slow pace between 11:00 and 12:30 a.m. After 12:30, all activity ceased.

*Variety is the spice of life*

The four- to five-hour duration of spawning by the corals on the 28th was unprecedented at the Flower Gardens. In previous years, it had lasted no more than three hours, and most activity was limited to about two hours. During those years, spawning on the eighth evening after the full moon was also more intense than in 1994, though we suspect that a similar number of colonies probably spawned in each year (taking into consideration the number seen on the dives and the duration of the events). It is not known what significance this may have. And it may be nothing more than nature's way of trying something new to see how it works. After all, that's what enables evolution. Nevertheless, it teaches us that predicting the timing of spawning can be tricky when so littleis known about what drives the process.

August 29th

*Another species added to list of mass spawners*

A small amount of spawning was predicted on this night because it had been seen in previous years. Yet none was reported for any of the species that spawned on the prior nights. But a number of boulder brain coral colonies (*Colpophyllia natans*) were observed for the first time to broadcast gametes. Like the other brain coral at the Flower Gardens, *D. strigosa*, and like *M. annularis*, *C. natans* appears to release single bundles of gametes from each polyp. The bundles were remarkably large, measuring 0.5 to 0.7 cm in diameter. The release is fairly slow compared to *M. annularis*, and may even be somewhat slower than *D. strigosa*. This activity occurred between 8:40 and 9:40 p.m., with most occurring before 9:20.

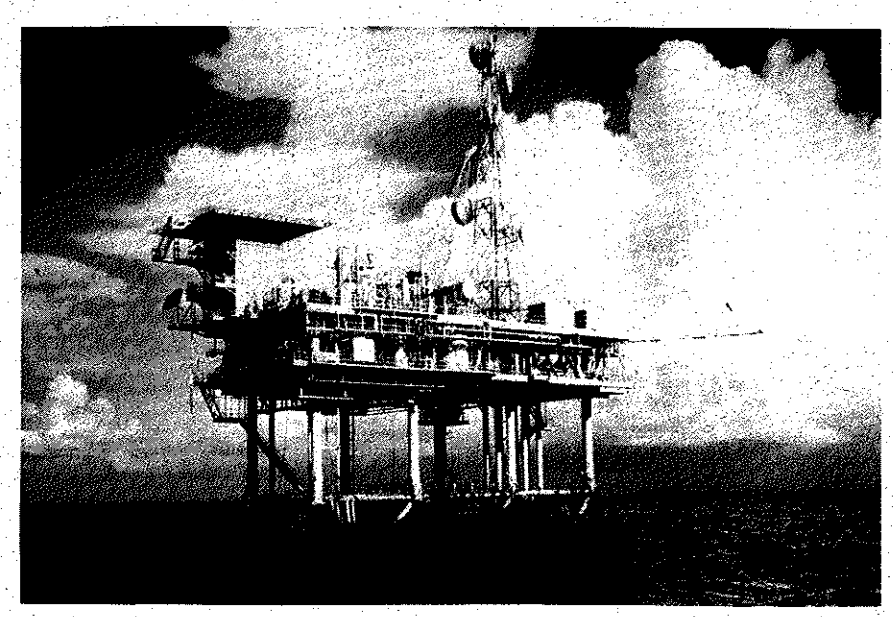
# Spawning Research

*Transplanting corals to restore reefs*

Some important areas of research can be pursued as a result of the predictability of mass spawning. Two of these areas are currently being investigated at the Flower Gardens by Mr. Derek Hagman, of the University of Texas at Austin, with support from NOAA, Seaspace, Mobil Exploration and Producing U.S., Inc., a grant to the Flower Gardens Fund by Texaco, and the National Fish and Wildlife Foundation. The work involves the biology of early development in corals and the potential for use of artificially reared corals for reef restoration. The coral biology studies include investigations of natural fertilization success, fertilization success of gametes in a laboratory setting, and development phases between embryo and settlement. The second area of research involves presenting larvae with settlement substrates in the lab so they can attach themselves. Following settlement, the plates are returned to the reefs to determine the success of the coral recruits. Approximately 50 concrete anchor bolts were installed in reef rock and tagged between August 25-27 around a small sand flat near Buoy 6 at the East Flower Garden Bank. These pins will be used to attach recruitment plates containing juvenile corals when they are returned to the Flower Gardens. This is a measure of the potential to use such a process to restore reefs that have been damaged or destroyed. If successful, the process could add a valuable tool to the arsenal available for coral reef management.

Immediately following sample collection by volunteer divers on August 27th, processing was conducted on the M/V Spree. Gametes from separate samples were crossed with those of others and stored in large container for transportation to the platform.

After 11:00 p.m., the samples were transported to the Mobil platform for microscopy observations and culturing experiments. No videomicroscopy was conducted, as had been in previous years, but photographs of various developmental stages were obtained. Fertilization rates for *M. annularis* were low (<20%) initially, but showed a dramatic increase (>60%) in several samples during later observations. Fertilization rates of both of the *D. strigosa* samples were over 80%. Observations were concluded around 5:30 a.m. on August 28th.



Research was conducted on Mobil 's gas production platform a little over a mile from the coral reef on the East Flower Garden Bank. Mobil frequently provides transportation, food, lodging and logistical support to research scientists. (Photo Credit - Greg Boland)

On August 28th, divers were instructed to collect only brain coral samples (*D. strigosa*). These were again processed on the M/V Spree prior to transport to the platform. Spawning activity was dominated by *D. strigosa* with a few isolated observations of *M. annularis* and *M. cavernosa*. At the platform, fertilization rates were determined for *D. strigosa*, both in self-fertilized (same colony) and cross-fertilized (mixed colonies) samples. In crossed samples, the rates were high (typically >90%), while in selfed samples rates varied (generally around 70%, with a couple of samples >90%). Larvae from samples with fertilization rates exceeding 90% were placed into four buckets containing conditioned quarry tiles (they had been left at the Flower Gardens for several weeks prior to the spawning). No *M. cavernosa* samples were obtained this year.

Following the return of the samples to the University of Texas, observations on survival and settlement were made. Compared with 1993, settlement rates and larval behavior appeared sluggish. This may be due to different handling of the samples following their development into planulae. Prior samples were not placed into buckets. This year's samples may have been affected by growth on the tiles.

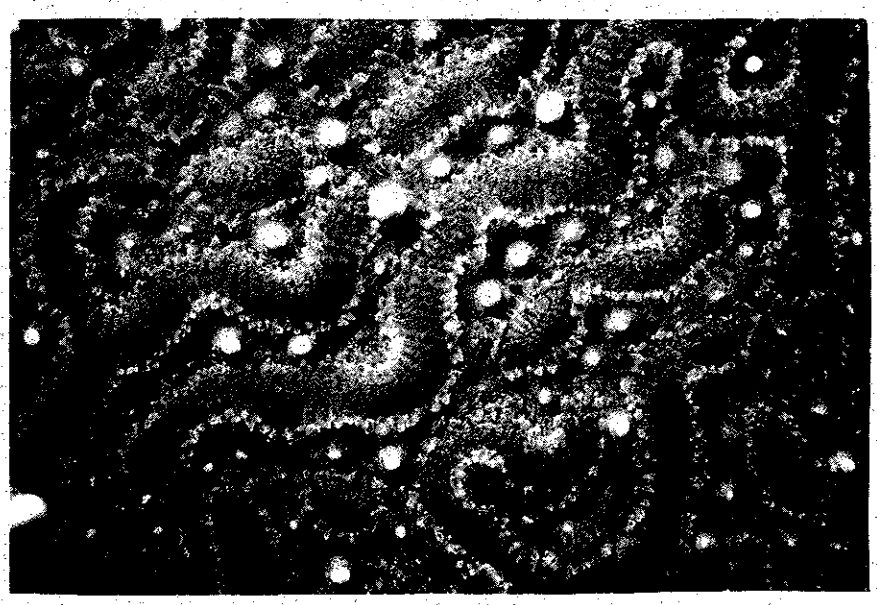
While coral larvae kept in vials survived and settlement occurred on both the tiles and in the vials, recruits in the four containers containing tiles did not survive. This is probably the result of fouling growth on the tiles and the subsequent stagnation of the water. Larvae that successfully settled in the vials will be used for field work to evaluate the potential for re-seeding of reefs with laboratory-reared corals. We will also attempt to design a better system for mass culture for 1995 field work.

# Key Largo, Florida

The longitude of Key Largo is 80°19'W. This is 12.85 degrees east of the Flower Garden Banks, which represents 51.4 minutes difference in "sun time" (15° = 1 hour time). Key Largo is located in the Eastern Time Zone - one hour earlier on a clock than the Flower Gardens. Any event referenced to sun time in Key Largo would be equivalent to only 8.6 minutes on local clocks after any reference event at the Flower Garden Banks. So sunsets occur at nearly equivalent clock times at both sites, and similar clock times for events at both sites would represent similar times after sunset (i.e. within 8.6 minutes).

The expedition to Key Largo was sponsored by the Baltimore Aquarium. The majority of reports from Oceanographic Expedition's team members were made from Molasses Reef, Buoy #10 at depths of 15 to 30 ft. Three different coral species were observed spawning on the nights of August 27 and 28, including both *Montastrea* species, (*M. cavernosa* and *M. annularis)*, and the brain coral, *D. strigosa*. Some spawning activity was witnessed by most divers, but a surface spawn slick was never observed.

The first observations on August 27 were at 8:17 p.m. Only male *M. cavernosa* heads spawned, typically releasing clouds of sperm from just three to five polyps at a time. One diver reported a time delay of one minute between subsequent groups of polyps releasing sperm. Also noted was the observation that the coral polyps contracted after the end of the sperm release. *M. cavernosa* activity was reported until 10:30 p.m.



A brain coral, *Diploria strigosa*, releases gamete bundles containing both eggs and sperm. One bundles is released by each polyp, through its mouth. (Photo Credit - Greg Boland)

Beginning at 8:30 p.m. on August 28, male *M. cavernosa* colonies were again seen releasing clouds of sperm. Successive divers reported sperm release until 9:05 p.m. One diver noted that a sperm release by one colony lasted 15 seconds, and the sperm dispersed within 30 seconds.

The first spawning report of the boulder star coral, *M. annularis* was made at 9:10 p.m on the 27th. One dive team noted that there was no mucus associated with the *M. annularis* egg bundle release, as had been observed on one occasion at the Flower Gardens. Numerous colonies released gamete bundles over an extended period until the dive team had to leave the area at 2:30 a.m. on August 28. At that time, some divers reported that many *M. annularis* heads continued to look like they were going to spawn (the so-called "setting phase", in which polyps appear swollen and tentacles are retracted). It was reported that the water visibility diminished drastically from approximately 60 feet to about 25 feet after the *M. annularis* spawning activity started. It was the opinion of the divers that the reduced visibility was associated with the release of gametes by the corals.

The activities of the brain coral *D. strigosa* on August 28 were apparently mixed. One dive team observed "polyps swollen with eggs" and later observed the gamete bundles over and around the colony. Another diver noted active feeding by *D. strigosa* heads on animals attracted by a dive light.

One other species may have spawned on the night of August 29, that being the boulder brain coral, *C. natans*. After hearing the description of spawning by *C. natans* at the Flower Gardens on August 29, a dive team in Key Largo described seeing similarly large gamete bundles floating in the water at approximately the same clock time (8:45 in Florida).

## Ancillary Observations

Several divers at the Molasses reef site reported seeing numerous reef squid during their night dives. The reports made special note of the squid's close proximity to divers and docile behavior.

# Roatan, Honduras

On the island of Roatan, Honduras, eight volunteers participated in Project Reef Spawn (Appendix 1). Roatan is located at a longitude of 86°35'W, or 7.04° east of the Flower Gardens. This is a difference of 28.1 minutes of sun time. Roatan is in the same time zone, but is one hour earlier on clocks because it does not recognize daylight savings time. The resulting reference sun time for comparison to the Flower Gardens is therefore -1:28.1. So, if an event occurred the same amount of time after sunset at both sites, and it was 9:00 p.m. at the Flower Gardens, it would occur at 7:32 p.m. in Roatan.

*Earliest spawning*

Spawning activity on Roatan was limited but occurred nonetheless, primarily on August 27 and 28. The earliest indirect observation was on August 26, one day earlier than any other site. Dive teams returning to the boat noted many white spheres about 2 mm in diameter near the surface at 9:00 p.m. This observation was the earliest of all sites, occurring six evenings after the full moon.

On August 27, at a dive site 35-40 ft deep called Mary's Front Porch, two divers witnessed simultaneous release of all gamete bundles on five *M. annularis* colonies. The first observations were at 7:55 p.m., 1:55 after local sunset (9:23 at the Flower Gardens). Spawning was observed until 8:10 local time. The gamete bundles floated up as groups joined by mucus. It was noted that the egg mass appeared to be attached to the coral colony and did not break loose for two to three minutes.

These five colonies were the only mass release of gamete bundles observed in Roatan. However, divers reported large numbers of *M. annularis* and *M. cavernosa* colonies full of bundles, apparently ready for release. Only one *M. cavernosa* colony, however, was seen spawning, this being a male releasing sperm in three sequences starting at 7:29 p.m. on August 28.

*Unexplained observation*

One remarkable observation was made on August 28 at 7:55 p.m. A coral plate of *M. annularis* was observed with a dense and opaque yellow/cream-colored cloud. On close inspection, no particles of any kind were seen in the cloud as it dispersed into the minimal current after about 15-20 seconds. Just after the dispersal of the first cloud, a second cloud was observed instantaneously above the *M. annularis* plate, also dispersing into the current after about 15 seconds.

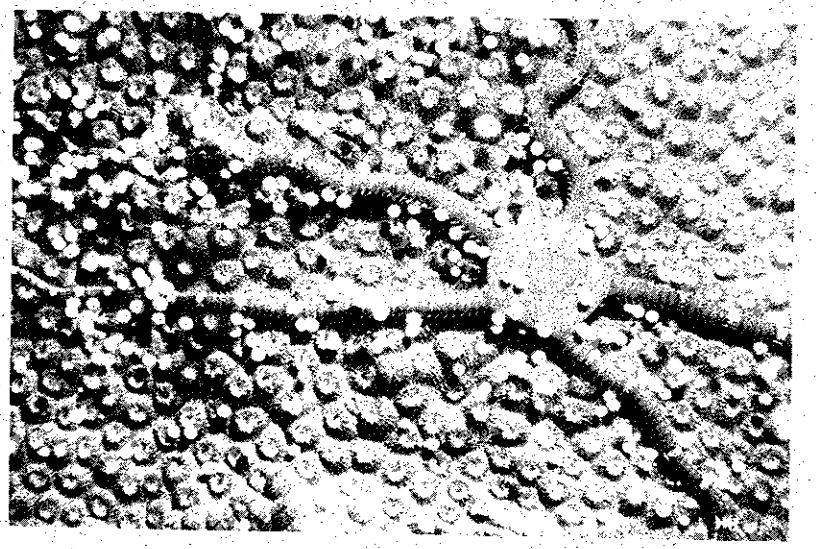
This observation is unusual because *M. annularis* is thought to be hermaphroditic, combining both male and female gametes within each coral colony. These observations suggest that some colonies of *M. annularis* may exhibit dioecious characteristics (similar to having separate male and female colonies, as in *M. cavernosa*). Observations of unusual spawning by one *M. annularis* colony at the Flower Gardens in 1993 supports this. The colony did not release typical gamete bundles, but released amorphous masses of white material from each polyp. These may have been what are called "pseudo-eggs", which are non-viable eggs sometimes released by colonies that are, functionally, males. The colonies release viable sperm, but non-viable eggs. Alternatively, the material from the colony in Roatan may have contained viable eggs from a female colony that released no sperm, or simply eggs and sperm from a hermaphroditic colony that did not "package" the gametes in a mucus sheath, as typically occurs in this species.

A team of Honduran divers were also participating in Project Reef Spawn on August 28. Diving on a site called John's spot at a depth of 42 ft., *M. cavernosa* was observed releasing sperm between 7:58 and 8:02 local time. This dive team also reported a *D. strigosa* colony releasing gametes at 8:10 p.m.

### Ancillary Observations

On the nights of August 26, 27 and 29, specific comments were made about the presence and lack of shyness of the red night shrimp, *Rhynchocinetes rigens*, which were exposed on coral substrate. The shrimp were exceptionally tolerant of dive lights and one moved under cover only after several close up photographs were taken. The same situation occurred with an octopus on the night of the 27th. It was much less timid than usual and even when touched, did not try to escape.

Red brittle stars were observed in the open on the nights of August 27 and 28. In both cases, they were sitting on the surface of corals and did not move away when lights were shined on them, as normally occurs.



Brittle stars are commonly seen on the tops of coral colonies near the time of mass spawning. Some seem to feed on the gamete bundles. But others have been seen spawning, with females releasing a ruby red egg mass, and males releasing sperm clouds. Females stand up on their arms and do a dramatic, twisting dance prior to releasing eggs. (Photo Credit - Lynn Kendall)

# Cozumel, Mexico

The island of Cozumel is at a longitude of 87°0'W, or 6.62° east of the Flower Gardens, and equal to a difference of 26.5 minutes of sun time. It is in the same time zone as Roatan and the Flower Gardens, but like Roatan is one hour earlier than the Flower Gardens on clocks because it does not recognize daylight savings time. The resulting reference sun time for comparison to the Flower Gardens is therefore -1:26.5. So, if an event occurred the same amount of time after sunset at both sites, and it was 9:00 p.m. at the Flower Gardens, it would occur at 7:33 p.m. in Cozumel.

Unfortunately, due to poor weather and closing of the harbor, the research team in Cozumel was unable to get onto the reef on the night of August 27. On August 28, a spawn slick was observed on the sea surface at 8:30 p.m. (10:03 equivalent Flower Gardens time). This was the only spawning observation made in Cozumel. Although limited, the information does indicate that corals in the unique Cozumel environment may participate in mass spawning. This observation also raises questions about why spawning may be limited or does not extend late into the night, as was seen in the Florida Keys.

# Dry Tortugas

*Third sighting of* Colpophyllia *spawning*

Walter Jaap, Jennifer Wheaton, and Leanne Miller (Florida Marine Research Institute) were on Bird Key Reef in the Dry Tortugas on August 28th. Conditions were rough, due to a low pressure system in the area. Nevertheless, spawning was witnessed between approximately 9:10 and 10:00 p.m. Divers at depths between 25 and 35 feet observed sperm release by male *M. cavernosa* colonies at around 9:10. This was followed by egg release by females colonies. They also saw large gamete bundles being released by *C. natans* colonies during this period. No spawning by *M. annularis* colonies was seen, although a number of colonies appeared to be in the setting phase, with polyps that appeared swollen with gametes. Spawning may have occurred later in the evening.

# French Cay, Turks and Caicos

*Flower coral spawning - more unexplained observations*

A single, yet very important observation of spawning was made by Anne Owen and David Wheeler in the Turks on Caicos (southern Bahamas). On August 28, at 9:00 p.m., a *Eusmilia fastigiata* smooth flower coral two feet across at 40 feet deep was seen releasing eggs into the water. They also reported there was no obvious feeding by other animals on the gametes, but noted that planktonic worms were very abundant that night (authors note: these could have been spawning as well).

As far as we know, this was the first observation of *Eusmilia* spawning. Even more important than the report, two slides of the spawning colony were sent. They show what appear to be at least some of each polyp's eggs migrating or floating up through the polyp's gastrovascular cavity into the tentacles. Some tentacles appeared enlarged. The eggs accumulated in the tips of the tentacles. The mechanism of release is not known, but in the slides, it is clear that eggs were in the water around the colony, and the observers reported that the eggs floated vertically upwards on release. Perhaps the eggs in the tentacles were trapped while others were released through the mouth of the polyp.

It does not appear that egg bundles are produced by the smooth flower coral, and no sperm is visible in the slides. Thus it is possible that the species is dioecious (sexes are separate). This cannot be confirmed, however, without more observations or tissue analysis. Whatever the case, this was an extremely important record and the photos of the activity are quite revealing.

This flower coral is spawning, but eggs seem to be trapped in many of its tentacles. It is not known whether these will later be released by the polyp, and if so, how. (Photo Credit - Ann Owen and David Wheeler)

# Lee Stocking Island, Bahamas

Dr. Bill Head, Former Director of the Caribbean Marine Research Center (CMRC), Kevin McAllister, Shelley Anthony and Jay Reichman witnessed coral spawning on Perry Reef, located on the windward side of the Lee Stocking Island, Bahamas (part of the Exuma chain). On the evening of August 25th, no spawning was observed. On the 26th, conditions did not allow diving. On the 27th, none was observed. On the 28th, some colonies of *M. annularis* released egg/sperm bundles, and a male *M. cavernosa* was seen releasing sperm. On the 29th, one large *M. annularis* spawned. Videos of the *M. annularis* spawning were reviewed and showed exactly the same behavior that has been witnessed at the Flower Gardens for this species.

One of the authors (Gittings) dove with Dr. George Dennis, Science Director for CMRC on September 27, exactly one month later. On a 45-minute dive starting at approximately 10:00 p.m., no spawning was observed, and all corals appeared to be acting normally (e.g. tentacles extended).

# Cayman Islands

Mr. Franklin Viola, a professional photographer, was in the Cayman Islands on the spawning dates. He had been on previous Flower Gardens cruises and had witnessed mass spawning there. He did not see spawning in the Caymans.

# Bermuda

Dr. Robbie Smith reported that islanders saw spawn slicks on the 27th and 28th of August. On the 29th, a small amount of spawning was observed, but no details were provided. He also noted that 1994 was a fairly intense coral bleaching year. Coral bleaching is a stress response sometimes caused by unusually high temperatures, and involves the loss of symbiotic algae that usually reside within coral tissues. Reproductive processes could be altered among colonies that bleach.

# Saba, Netherlands Antilles

Tom van't Hof (Saba Conservation Foundation) was on Ladder Labyrinth on August 28th when several *M. annularis* colonies spawned at 8:40, and between 10:00 and 10:40. Van't Hof noted that the release of gamete bundles was slow. He also witnessed *E. fastigiata* bearing "white tips on polyps" (this would appear to be similar to the observations made in the Turks and Caicos). On that night aggregations of Ruby brittle stars (*Ophioderma rubicundum*) were quite significant. Rainald Framheim and Christophe Leroux who were also diving at Ladder Labyrinth between 9:00 and 9:35 saw brittle stars preying on gamete bundles expelled by two *M. annularis* colonies. The actual spawning of the Ruby brittle star was seen by Leanne Fernandes from 8:50-8:55. Free-swimming and spawning worms were observed in the water column. On the 29th, van't Hof saw very few brittle stars at Ladder Labyrinth (9:05-10:50). He did however document two *M. cavernosa* colonies slowly extruding a "worm-shaped" substance. Tiny white spheres were also observed floating around these colonies, but were not seen coming out of the *M. cavernosa* colonies.

# Summary Comments

*Value of volunteers*

The primary objective of Oceanographic Expeditions' effort was to stage research teams in four locations to document the possibility of simultaneous spawning of certain coral species. In this regard, a tremendous step was made in the coordinated observation of coral reefs in widely separated locations. These were unprecedented observations for this region of the world.

There were remarkable similarities between the sites as well as differences (Table 1). The Flower Garden Banks had been expected to be the most predictable location to observe this spectacular event as it had been the setting for the original discovery of mass spawning in the Gulf of Mexico and had been studied each year since 1990. Yet the timing at the Flower Gardens in 1994 was not as it had been in previous years. A considerable amount of spawning occurred on the night prior to the predicted date. Nevertheless, all sites witnessed spawning on the 28th of August, which had been predicted to be the "main event."

For *M. annularis*, a dominant Caribbean reef coral, spawning was observed on three nights in the region (Table 1). *M. cavernosa* spawned on two nights, the 27th and 28th, as did the brain coral *D. strigosa*. *C. natans* also spawned on two nights, but these were the 28th and 29th. *E. fastigiata* was observed spawning on only one night, the 28th, and at only one site.

The earliest sighting of mass spawning was at sunset, the latest over six hours later. In previous years, however, male *M. cavernosa* colonies had been seen releasing sperm before sunset. This was not seen in 1994.

*Future dive planning*

Generally speaking, divers who care to witness this event should plan their excursion between seven and nine days after the August full moon and should dive between dusk and midnight. The majority of activity appears to take place on the seventh or eighth evening after full moon and between one and three hours after sunset.

The list of other animals spawning at about the same time as the corals continues to grow. In 1994 alone, divers witnessed possible mating activities for four fish species, and invertebrates representing five phyla. One sponge, two polychaetes, an echinoderm, a crustacean, and a mollusk all participated in activities that suggest they spawn at the same time of year as the corals (see Table 1). Though it is possible that spawning by one group of animals triggers spawning in other groups, it is not know whether this happens. Alternatively, a response to similar environmental cues could trigger the activity in different groups. Only future observations can resolve linkeages between these events.

Based on data collected since 1990, it appears that the timing of mass spawning might be more restricted and predictable at the Flower Gardens than at other sites. This may have to do with annual temperature cycles. The northwestern Gulf of Mexico has the most extreme temperature variation of any location on Earth at the same latitude. Corals at the Flower Gardens, partly as a result of this, experience a larger range of temperatures every year than corals elsewhere. The range is from 19°C to over 30°C (66-86°F). Coral reefs do not exist where water temperatures dip below 18°C (64°F) or exceed 31°C (88°F) for

extended periods. Due to the large range of water temperature at the Flower Gardens, spawning may have to occur during a very limited portion of the year to be effective. Fortunately for divers hoping to witness mass spawning, the temperature cycle varies only slightly from year to year. The maximum summer temperature occurs over a short period of time, generally in mid-August. Corals, in effect, are not therefore "confused" by the long periods of warm water during the summer that many other reefs experience. On those reefs, spawning could take place over an extended period and still be effective, but as a result would be less likely to occur as a reef-wide mass spawning event. This would account for the fewer reports of mass spawning from reefs at lower latitudes.

To date, five of the estimated 65 Caribbean reef-building coral species have been observed participating in mass spawning events. A sixth, the blushing star coral *Stephanocoenia michelini*, is thought to participate at the Flower Gardens, but has not been confirmed. Project Reef Spawn, a coordinated, volunteer multi-national data collection effort, was instrumental in adding a new species to the list of known mass spawners, *C. natans* and a report by recreational divers in the Turks and Caicos added a second, *E. fastigiata*. This information will undoubtedly lead to continuing research in new directions.

Oceanographic Expeditions is now planning for Project Reef Spawn '95. At least four sites will be studied in '95 and may include Bonaire, Netherlands Antilles.

# The Future

The future is promising for detailed studies on coral reproduction. Research should address such topics as environmental (chemical, physical and biological) cues that trigger mass spawning, the effects of environmental alteration on reproduction, the feasibility of raising colonies in the laboratory for restoration purposes, dispersal mechanisms, larval settlement cues, the effects of changes in water quality on larval and juvenile survival, and many other questions related to human use and management of the marine environment. Yet with all the scientific potential that derives from the fact that some corals spawn in synchrony, it is critical that future studies continue to focus on documenting when and how organisms spawn during this and other times of the year. For in reproduction is the perpetuation of life. And that is an essential component in the maintenance of healthy and resilient reef ecosystems.

# Table 1

Coral reef spawning activity observed in 1994 in the Caribbean Province. Flower Gardens, Florida Keys, Roatan, and Cozumel observations were made during Project Reef Spawn '94. Information from the other sites is based on personal accounts. Times indicated are hours:minures after local sunset. [(#) = dates of observation; LT=local time].

| REEF ORGANISMS | Flower Garden Banks<br>93°36'W<br>East Bank Buoy #7<br>60-65 ft<br>Sunset: 19:56 | Cozumel (Mexico)<br>87°0'W<br>Palancar Deep<br>Sea surface<br>Sunset: 18:02 | Roatan (Honduras)<br>86°35"W<br>Mary's Porch/John's Spot<br>35-42 ft<br>Sunset: 18:00 | Dry Tortugas<br>82°56'W<br>Bird Key Reef<br>25-35 ft<br>Sunset:20:32 | Florida Keys<br>80°19'W<br>Molasses Reef<br>Buoy 10, 15-30 ft<br>Sunset: 19:52 | Lee Stocking Is., (Bahamas)<br>76°60'W<br>Perry Reef | Turks & Caicos<br>72°0'W<br>French Cay<br>40 ft | Bermuda<br>64°50'W<br>Surface | Saba, NA<br>63°14'W<br>Ladder-Labyrinth |
|---|---|---|---|---|---|---|---|---|---|
| *Montastrea annularis*<br>(Boulder star coral) | 1:19 to 3:04<br>(27, 28) | - | 1:55-2:10<br>(27, 28) | - | 1:18 to 6:38<br>(27, 28) | Yes<br>(28, 29) | - | - | 8:40-10:40 LT<br>(28) |
| *Montastrea cavernosa*<br>(Great star coral) | 1:19 to 3:04<br>(27, 28) | - | 1:29-2:02<br>(27?, 28) | 0:38-1:28<br>(28) | 0:25 to 3:01<br>(27, 28) | Yes<br>(28) | - | - | 10:05-10:50 LT<br>(29) |
| *Diploria strigosa*<br>(Symmetrical brain coral) | -0:01 to 4:34<br>(27, 28) | - | 2:10<br>(28) | - | Recorded time? | - | - | - | - |
| *Colpophyllia natans*<br>(Boulder brain coral) | 0:44 to 1:44<br>(29) | - | - | 0:38-1:28<br>(28) | 0:53<br>(29) | - | - | - | - |
| *Eusmilia fastigiata*<br>(Smooth flower coral) | - | - | - | - | - | - | 9:00 LT<br>(28) | - | - |
| **SPAWN SLICK** | Yes<br>(27, 28, 29 in water) | Yes<br>(28) | Yes<br>(26, in water) | - | No | - | - | Yes<br>(27, 28) | - |
| **SPAWN INDICATORS** | | | | | | | | | |
| *Clepticus parrai*<br>(Creole wrasse) | dusk<br>(28) | - | - | - | - | - | - | - | - |
| *Chromis multilineata*<br>(Brown chromis) | afternoon<br>(26 | - | - | - | - | - | - | - | - |
| *Melichthys niger*<br>(Black durgon) | ?<br>(28) | - | - | - | - | - | - | - | - |
| *Stegastes fuscus*<br>(Dusky damselfish) | ?<br>(28) | - | - | - | - | - | - | - | - |
| *Ectyoplasia ferox*<br>(Brown encrusting octopus sponge) | 1:04 to 1:49<br>(28) | - | - | - | - | - | - | - | - |
| *Ophioderma rubicundum*<br>(Ruby brittle star) | 1:04<br>(28) | - | Yes<br>(27, 28) | - | - | - | - | - | 8:00-9:35 LT<br>(28) |
| *Spirobranchus giganteus*<br>(Christmas tree worm) | 2:34<br>(28) | - | - | - | - | - | - | - | - |
| *Hermodice carunculata*<br>(Bearded fireworm) | 3:04<br>(28) | - | - | - | - | - | - | - | - |
| *Rhynchocinetes rigens*<br>(Red night shrimp) | - | - | Yes<br>(26, 27, 29) | - | - | - | - | - | - |
| Octopus | - | - | Yes<br>(27) | - | - | - | - | - | - |
| *Eunice* spp.?<br>(West Indian Palolo) | - | - | - | - | - | - | - | - | 8:20-10:40 LT<br>(28) |

# Appendix 1
## Project Reef Spawn '94 Participants

| Participants at the Flower Gardens Site | Affiliation | Function |
|---|---|---|
| Montie Ballantyne | Texas Scuba - Houston | EMT |
| Gene Baugher | Gulf Reef Envt'l. Action Team | Dive Officer |
| Carl Beaver | TAMU - Corpus Christi | Scientist on HI 389 Platform |
| Greg Boland | Texas A&M/Oceanographic Expeditions | Oceanographer |
| Jim Bouton | Oceanographic Expeditions | Team Member |
| Ann Bull | Minerals Management Service | Fish Censusing |
| David Bull | Audubon Institute - New Orleans | Photographer |
| Greg Bunch | Oceanographic Expeditions | Fish Censusing |
| Jesse Cancelmo | Independent - Houston | Photographer |
| Jeff Childs | Texas A&M University | Scientist on HI 389 Platform |
| Ron Corbett | Oceanographic Expeditions | Team Member |
| Susan Cox | TAMU - Corpus Christi | Scientist on HI 389 Platform |
| Quenton Dokken | TAMU - Corpus Christi | Scientist on HI 389 Platform |
| Jan Edwards | Texas Parks & Wildlife Magazine | Writer |
| Paul Fitzgerald | Texas A&M at Galveston | Fish Censusing |
| Steve Gittings | NOAA/Flower Gardens Sanctuary | Scientist |
| Marty Gittings | Independent - College Station | Science Help |
| David Gray | TAMU - Corpus Christi | Scientist on HI 389 Platform |
| Derek Hagman | University of Texas | Scientist on HI 389 Platform |
| Emma Hickerson | Texas A&M University | Fish Censusing |
| Darrell Hollister | Oceanographic Expeditions | Team Member |
| Russell Hooten | National Biological Survey | Scientist on HI 389 Platform |
| David Hornack | KFDM-TV - Beaumont, TX | Television |
| David Kobrin | KFDM-TV - Beaumont, TX | Television |
| Charles Lewis | Oceanographic Expeditions | Team Member |
| Stephan Meyers | Texas Parks & Wildlife Magazine | Photographer on HI 389 Platform |
| Vicki Nichols | Save Our Shores - Monterey, CA | Science Help |
| Chuck Noe | Independent-League City, TX | Dive Master |
| Alex Odell | Oceanographic Expeditions | Team Member |
| Chris Ostrom | NOAA/Sanctuaries & Reserves | Science Help |
| Christy Pattengill | Texas A&M University | Fish Censusing |
| Doug Perrine | Independent - Miami | Photographer |
| Matt Richards | M&M Scuba - Clute | Science Help |
| Tiffany Richards | M&M Scuba - Clute | Science Help |
| Paul Salop | NOAA/Sanctuaries & Reserves | Science Help |
| Terry Schaff | Joint Oceanographic Inst. | Science Help |
| Tony Sebastian | Oceanographic Expeditions | Fish Censusing |
| Brice Semmens | Texas A&M University | Fish Censusing |
| Charles Sheaver | Oceanographic Expeditions | Team Member |
| Marty Snyderman | Independent - San Diego | Photographer |
| Chris Upham | Oceanographic Expeditions | Team Member |
| Ken Young | Kenlee's Dive Shop - Houston | Science Help |
| Dick Zingula | Houston Underwater Club | Dive Officer |

## Florida Keys

| Participants at the Florida Keys Site | Affiliation | Function |
|---|---|---|
| Laddie Akins | R.E.E.F. | Team Member |
| Paul Billeter | Oceanographic Expeditions | Lecturer |
| Mary Casey | Oceanographic Expeditions | Team Member |
| Chris Dummit | Palm Beach Post | Journalist |
| Lisa Gills | Oceanographic Expeditions | Team Member |
| Perry Hampton | Baltimore Aquarium | Dive Officer |
| Jim Hart | Oceanographic Expeditions, Director | Expedition Leader |
| Robin Huff | Oceanographic Expeditions | Team Member |
| Rosemary Krussman | Baltimore Aquarium | Conservation Coordinator |
| John O'Neil | Oceanographic Expeditions | Team Member |
| Ryan Pugh | Oceanographic Expeditions | Team Member |
| Todd Richard | Oceanographic Expeditions | $H_2O$ Production-Videography |
| Kathryn Von Rueden | Oceanographic Expeditions | Team Member |
| Tom Schottle | Oceanographic Expeditions | Team Member |
| Spencer Slate | Atlantis Dive Center, Key Largo | Captain |
| Jennifer Smith | Oceanographic Expeditions | Team Member |
| Greg Stewart | Oceanographic Expeditions | Team Member |
| Ned Sullivan | Oceanographic Expeditions | Team Member |
| Dr. Alina Szmant | University of Miami | Science Advisor |
| Ed Truter | Oceanographic Expeditions | Team Member |
| Janice Wagner | Oceanographic Expeditions | Team Member |
| Rob Zimmerman | TAMU/Oceanographic Expeditions | Oceanographer |

## Roatan

| Participants at the Roatan Site | Affiliation | Function |
|---|---|---|
| Lynn Depas | Oceanographic Expeditions | Team Member |
| Leah Hennigh | Oceanographic Expeditions | Team Member |
| Dr. James Kendall | Metairie, LA | Expedition Leader/Dive Officer |
| Lynn Kendall | Metairie, LA | Team Member |
| Dr. Chris Merritt | Oceanographic Expeditions | Scientist/Data Coordinator |
| Ingrid Merritt | Oceanographic Expeditions | Team Member |
| Nathan Reiskin | Oceanographic Expeditions | Videographer |
| Romeo Sylvestri | Oceanographic Expeditions | Romeo's Resort |
| Janet Welch | Oceanographic Expeditions | Team Member |

## Cozumel

| Participants at the Cozumel Site | Affiliation | Function |
|---|---|---|
| Vickie Baker | Oceanographic Expeditions | Team Member |
| Dr. Thomas Bright | Texas A&M University | Oceanographer |
| Ted Herbert | Oceanographic Expeditions | Videographer |
| Juan Leca | Dive House, Cozumel | Captain/Dive Officer |
| Danny Lyons | Oceanographic Expeditions | Expedition Leader |
| Eduardo Schutte | Oceanographic Expeditions | Fiesta Americana Hotel |

# Appendix 2
## Ancillary Studies at the Flower Gardens

Below are summaries of studies conducted by scientists in cooperation with members of the Oceanographic Expeditions dive team during the Flower Gardens spawning cruise.

### *Cutting Through Time*

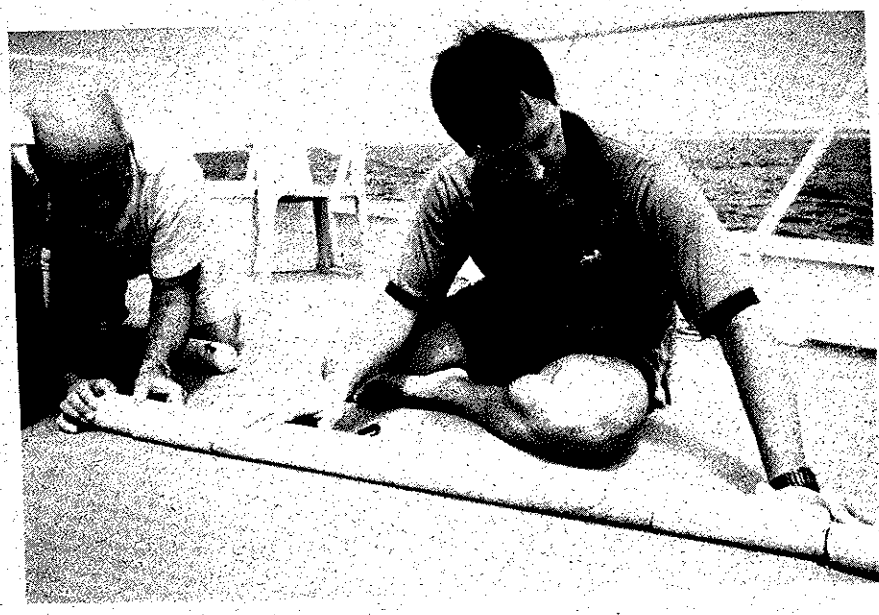
During the Flower Garden cruise, cores were taken from five coral colonies by alternating teams of volunteer divers using an hydraulic drilling system. Four cores were taken from the East Flower Garden Bank, two from the boulder star coral *M. annularis* and two from the massive starlet coral *Siderastrea siderea*. One core was taken from a *M. annularis* colony on the West Bank.

In all cases, the cores measured nearly five feet in length and should each provide data on over 250 years of growth and historical water temperature, salinity, and climate. Very few cores of this length have been taken for these types of studies. Dr. Niall Slowey, of Texas A&M University in College Station (TAMU) is currently studying the cores under grants from the National Science Foundation and the Texas Institute of Oceanography.

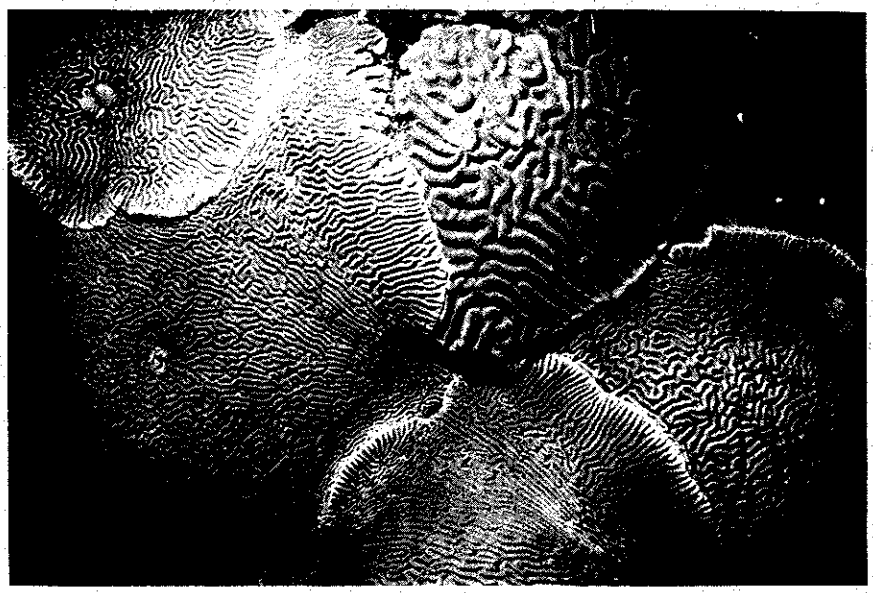
### *Visual Fishing*

*Fish censuses*

Ms. Christy Pattengill (TAMU, College Station) coordinated fish censuses and conducted surveys on the East and West Flower Garden Banks and Stetson Bank. Her study is providing an enormous service to the Sanctuary's efforts to increase the involvement of the diving public in scientific endeavors. The study is also providing valuable information to the monitoring database that is used to assess the condition of the resources of the Sanctuary. Christy's work is funded by the National Fish and Wildlife Foundation, with additional support from the Gulf Reef Environmental Action Team, the Flower Gardens Fund, and Oceanographic Expeditions.



Steve Gittings and Dick Zingula reassemble a five-foot long coral core taken from a star coral at the Flower Gardens. The core will be analyzed to asess historical climate changes in North America. (Photo Credit - Greg Boland)



Coral cover at the Flower Gardens increases with depth, down to around 100 feet or so. Competition for space at these depths is intense. Corals tend to be flatter so they can more efficiently capture light, which is necessary for the growth of symbiotic algae in their tissues. (Photo Credit - Steve Gittings

## *Deep Thoughts*

Video surveys were conducted by Greg Boland and Steve Gittings between 100 and 120 feet on the East Flower Garden Bank. These were taken during swimming surveys using a hand-held, Hi-8 video camera. Video footage will be analyzed using some recently developed computer imaging techniques to determine the percent cover and species composition at depths below which most recreational divers on the Banks venture. The reason for the interest is that no accurate estimates of coral cover have been made below 80 feet at the Flower Gardens. Anyone who dives to 90 or 100 feet can see that coral cover appears extremely high in some places. Data analysis is being funded by the Flower Gardens Fund.

## *Thinking Big*

*Sharks, mantas, and turtles*

Mr. Jeff Childs and Ms. Emma Hickerson, both of TAMU, conducted surveys of manta rays and sea turtles, respectively. Jeff is studying mantas to determine their population levels, migration patterns, behaviors, and other life history mysteries. He briefed the cruise participants and provided data forms that were completed after each manta sighting. Divers recorded sizes, dorsal and ventral markings, behaviors, and where possible, sex of these magnificent creatures. A surprise greeted Jeff during the cruise while reviewing tapes that Gary Rinn had made on Stetson Bank. He confirmed the existence of the ray *Mobula* on the bank. This ray looks like a *Manta*, but has a mouth that is under the body (termed sub-terminal), not at the anterior edge.

Jeff also conducts periodic surveys of whale sharks in the vicinity of the Flower Gardens. He spent some time during the cruise in a helicopter provided by Mobil and spotted three

whale sharks, dolphins, jacks and other animals in single aggregation about five miles south of the West Flower Garden Bank. One possibility is that the aggregation was feeding on coral and other larvae contained in the spawn slick as it drifted from the bank. The curious behavior is only one example of how these banks continue to intrigue scientists and awe recreational divers as they slowly give up their secrets.

Emma is studying sea turtles to answer similar questions. Sightings over the last year have confirmed that turtles can occur in quite high numbers at the Flower Gardens. Yet we know virtually nothing about their residence times, migration routes, sex ratios, activities while on the banks, or feeding habits. With information gained from recreational divers and her own observations, Emma is designing a study of the turtles at the Flower Gardens. Visitors to the Sanctuary are encouraged to fill out the data forms provided on the charter boats and pass them on to Emma.

## *Sick Thinking*

Mr. Rob Zimmerman (TAMU, College Station), who was representing Oceanographic Expeditions in Florida spawning during this effort, is studying coral diseases at the Flower Gardens. He is also interested in the effects of damselfish gardens on coral health. He makes observations of damselfish territories and looks for evidence that coral tissue death results from the fishes' activities. He is also trying to determine whether diseased areas are later occupied by damselfish for the purpose of cultivating gardens. He is essentially trying to answer the chicken or the egg question for damselfish gardens and diseases. What initiates the tissue loss, the garden or the disease?

*Coral diseases*

Rob is also starting to study what are called hyperplasms, those bumps on some brain corals that have the appearance of tumors. On this cruise, surveys were conducted on each bank to determine the abundance and size frequency of hyperplasms. All data were taken from the brain coral *D. strigosa*. One swimming survey was conducted on each bank, consisting of approximately 200 m transects and measurements of all hyperplasms encountered. On each bank, roughly 30 hyperplasms were noted, ranging in size from less than an inch to nearly 10 inches in diameter. And on many colonies, where one existed, others did. This suggests that there may be some genetic basis for hyperplasms. This remains to be determined, as well as the effect on corals of having these tumors, and the implications. Rob's work is funded by NOAA, Seaspace, a grant to the Flower Gardens Fund by Texaco, and the National Fish and Wildlife Foundation.

# Appendix 3.

## Partial List of Mass Spawning and Related Research Literature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## Appendix 3 (continued)


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