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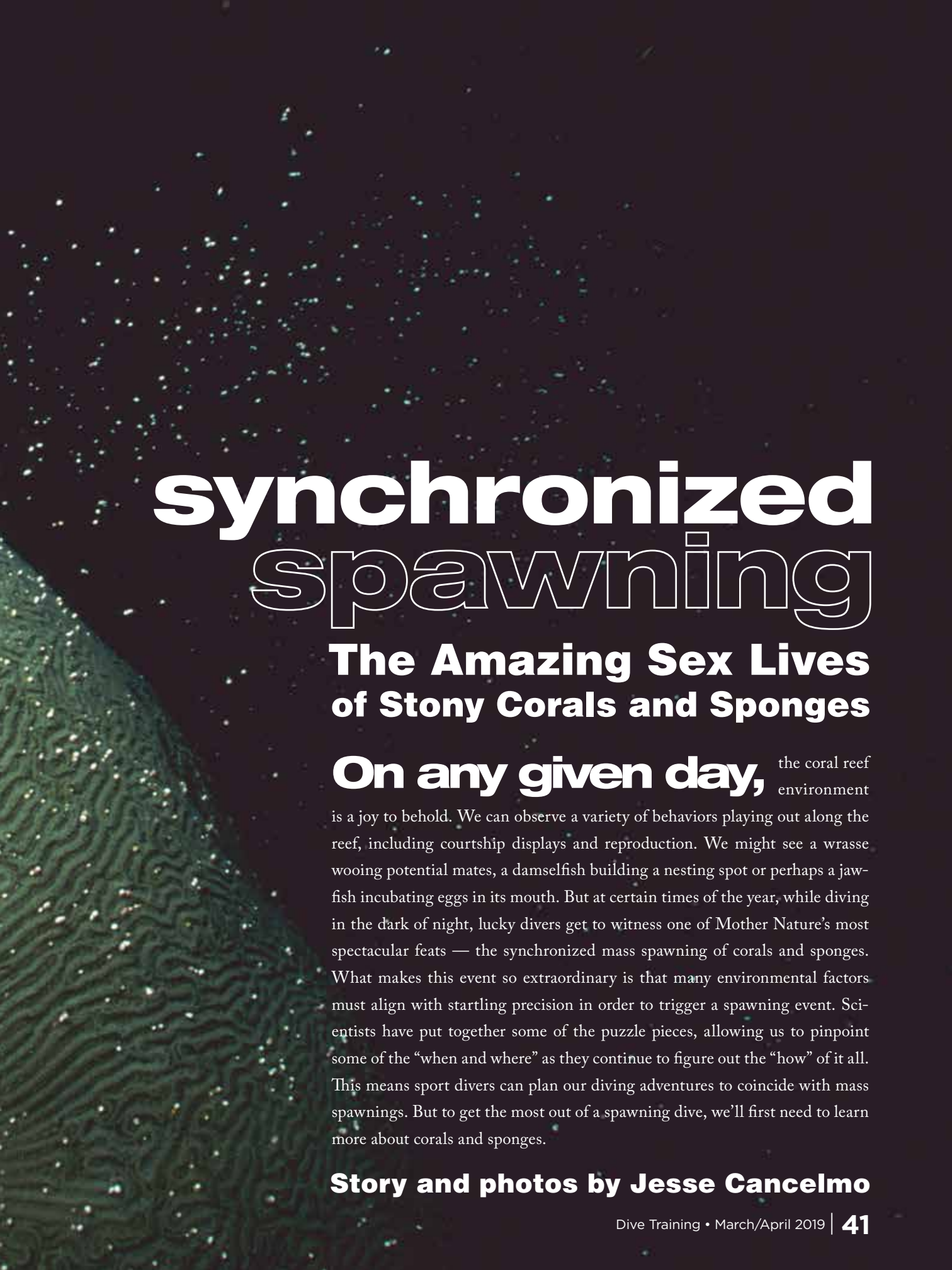
Thousands of white and sometime pinkish bundles containing both egg and sperm gametes spew from brain coral.

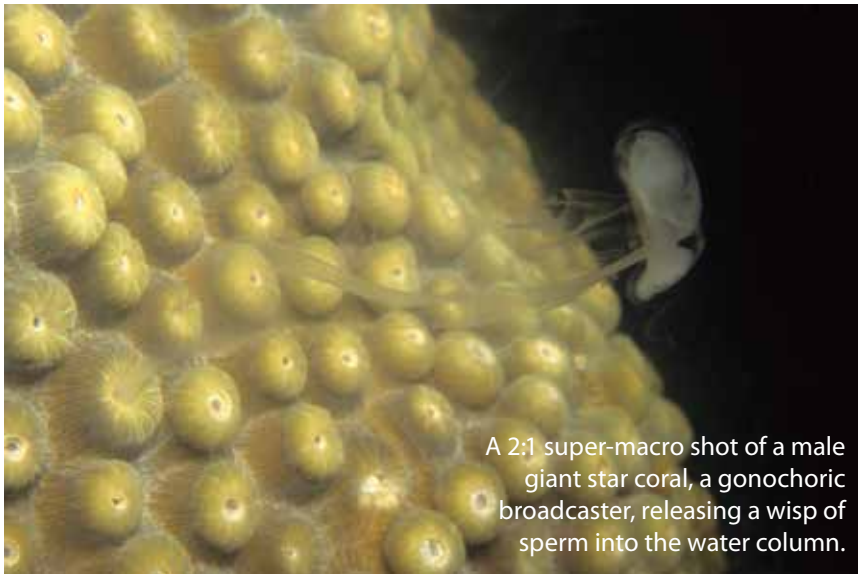


synchronized spawning

The Amazing Sex Lives of Stony Corals and Sponges

On any given day, the coral reef environment is a joy to behold. We can observe a variety of behaviors playing out along the reef, including courtship displays and reproduction. We might see a wrasse wooing potential mates, a damselfish building a nesting spot or perhaps a jawfish incubating eggs in its mouth. But at certain times of the year, while diving in the dark of night, lucky divers get to witness one of Mother Nature's most spectacular feats — the synchronized mass spawning of corals and sponges. What makes this event so extraordinary is that many environmental factors must align with startling precision in order to trigger a spawning event. Scientists have put together some of the puzzle pieces, allowing us to pinpoint some of the "when and where" as they continue to figure out the "how" of it all. This means sport divers can plan our diving adventures to coincide with mass spawnings. But to get the most out of a spawning dive, we'll first need to learn more about corals and sponges.

Story and photos by Jesse Cancelmo



A 2:1 super-macro shot of a male giant star coral, a gonochoric broadcaster, releasing a wisp of sperm into the water column.

Hard Facts About Stony Corals

Stony corals, also known as hard corals or Scleractinia and include reef-building corals, are in the Phylum Cnidaria and biologically related to sea anemones. Individual coral polyps have cylindrical bodies usually less than a half inch (1.5 cm) in diameter, are fringed on top with a crown of tentacles similar to anemones and are sessile, meaning they attach to the substrate. Most divers know a coral polyp is an animal and not a plant, yet coral polyps are actually not such small or simple animals. Their existence depends upon zooxanthellae, a plant commonly known as algae that live in the coral's tissues in a symbiotic relationship. Algae use sunlight to photosynthesize sugars and provide the coral polyps their main source of nutrition. Algae also give coral its coloration. Unlike sea anemones, beneath the tissue of a coral polyp is a hard skeletal cup-like structure of calcium carbonate that binds the polyps together to form colonies attached to the substrate. So, in a way, the make-up of stony corals includes animals, plants and minerals.

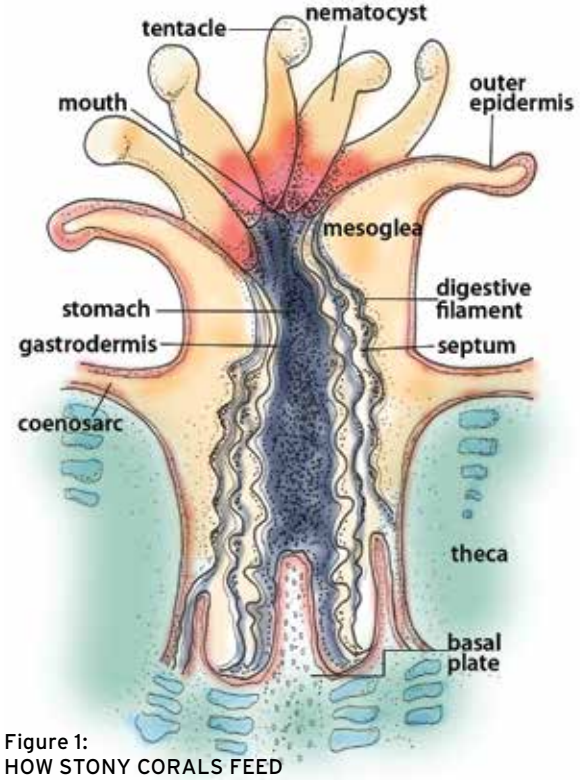


Figure 1:
HOW STONY CORALS FEED

Animal reproduction requires nutrition and to understand how stony corals feed, refer to Figure 1 and note the location of the mouth and stomach. The tentacles that surround the mouth have nematocysts, which are capsules that release venomous harpoon-like threads. The nematocysts and tentacles are used to stun zooplankton floating by and then direct the food to its mouth. This is also how the coral lives up to its part of the symbiotic bargain because byproducts of some of the captured food go to feed the algae in its protective home.

Stony Coral Reproduction

Stony corals can reproduce asexually but most reproduce sexually with eggs fertilized by sperm. Some hard corals are hermaphrodites meaning each polyp in a colony contains both male and female gametes. Other species have separate male and female colonies and are called gonochoric (single-sex) corals. Some hard corals that mate sexually fertilize internally, which is called brooding. For others, the fertilization process takes place externally in the water column in a "broadcasting" manner. It's the broadcasters that put on the annual mass coral spawning show — typically once a year, just after the full moon and at a certain time after sunset.

The majority of hard corals in the world are broadcasters and most are the hermaphroditic species that release bundles of eggs and sperm sheathed in mucus that are buoyant and rise to the surface where they rupture and release the gametes. The fertilization process often mixes eggs and sperm from different colonies of the same species or even from different species, allowing genetic diversity to strengthen the stock. Male colonies of the gonochoric broadcasters like the giant star coral (*Montastrea cavernosa*) and the blushing star coral (*Stephanocoenia intercepta*) release smoky white wisps of sperm followed by female colonies releasing tiny orbs containing eggs that mix while making their ascent to the surface.

Broadcasters create a distinctive sheen of floating gametes on the surface where the development of free-swimming larvae or planulae occurs. This all happens in the darkness of night — researchers suspect this is likely to minimize the impact from predators and maximize a successful

The larvae that develop from coral spawning drift in the current for days or weeks before settling to the bottom.

outcome. The larvae eventually settle on a substrate and usually develop into tiny polyps after several days, weeks or more by secreting skeletons from the underside of their skin.

Mass spawning occurs in a synchronized fashion with multiple colonies in the same area so that gametes from different colonies have the greatest chance of successfully contacting each other. The period between planulae formation and settlement is when their survival is at greatest risk. The massive amount of gametes in the water column and on the surface increases the chances for a successful outcome, as do other factors such as clear warm water, predator satiation, calm surface conditions and a nearby hard substrate for settlement.

As mentioned already, the hermaphroditic "brooders" reproduce internally and do so unnoticed by most scuba divers. But the male gonochoric brooders, like a lesser starlet coral *Siderastrea radians*, eject sperm like a "spawner" into the water column and the female colonies are somehow able to selectively capture the male gametes floating by and fertilize internally. Later the larvae are released into the water column and settle in short order. Brooders sow their wild oats several times a year, some on a monthly basis.

A few stony coral species not so showy about reproduction do so asexually by budding, fragmentation, fission or bailout. Budding occurs when polyps divide and begin new colonies after reaching a certain size. Fragmentation happens when pieces break off and form a new colony. Fission is when colonies split during early development stages and bailout is when a coral abandons its colony to settle on the substrate creating a new colony.

Marine scientists continue to better understand the cues that trigger the synchronized mass coral spawning events — the lunar cycle, water temperature, day length, light cues, wind speeds and possibly others, but more research is needed to fully understand how multiple colonies of the same species spawn at the same time. About 15 years ago an Israeli scientist conducting coral research in Australia confirmed that free-swimming coral planulae exhibit positive phototaxis which means they swim toward light, that being the surface moonlight. It's also been determined that settlement on a substrate is not entirely happenstance. Coral planulae are able to "select" the right spot from chemical cues and other factors to attach for a best outcome.

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Watching it Happen

Every year, usually beginning on the seventh night after the August full moon, hundreds upon hundreds of coral colonies spawn millions of gametes into the water column in synchronization at two tiny coral reefs off Texas in the northwestern Gulf of Mexico. Researchers and reef-watchers vie for a chance to witness this wondrous display of nature at the Flower Garden Banks National Marine Sanctuary (FGBNMS) where the make-up up of the reef cap is predominantly very large, healthy broadcast-spawning corals.

Before the 1980s, marine scientists thought that stony coral reproduced primarily by brooding. The mass-spawning phenomenon of broadcasting corals was first reported in a scientific journal in 1984 by researchers in Australia. Three years earlier, graduate students in Australia witnessed this phenomenon on the Great Barrier Reef. In the summer of 1990, divers in the Bahamas directed by coral biologist Dr. Alina Szmant, witnessed mass coral spawning of star corals and elkhorn corals (*Acropora palmata*) on three consecutive nights. Meanwhile, the same summer at the Flower Garden Banks, divers Jennifer Lang and Bill Moneyhon returning from a late afternoon dive reported coral heads "smoking." Later that evening one diver described her ascent like finning through a snowstorm. These were the first observations of mass coral spawning in the Gulf of Mexico. This prodigious spawning spectacle went unnoticed for such a long time because it happens in the hours after sunset.

The timing of the synchronous spawning varies in different parts of the world. In the northern Gulf of Mexico, the spawning window for broadcasting corals is seven to ten days after the August full moon. However, for a late August full moon, mass spawning can occur in the following month. Or, if there is an early full moon, spawning can occur twice, once in August and then again in September. Corals in other parts of the Caribbean spawn in mass after the August, September and October full moons. Reefs in the southern Caribbean typically spawn later in the year (see Sidebar 1). The timing of the mass spawns also coincides with the annual peak water temperatures and occurs during the period of the year having calmest seas and best visibility.

Just before dusk on the seventh night after the full moon at the FGBNMS, the giant star corals (*Montastrea cavernosa*) begin changing. The individual pea-sized polyps puff up like tiny bulbs ready to burst. Not long after sunset, the polyps begin to release white wisps of sperm into the water column. Soon after, the gonochoric female colonies start spewing tiny orbs of eggs like

see for yourself

There's nothing like witnessing a spawning event firsthand. It gives divers a deep understanding of how wondrous our coral reefs are. To get the most out of a spawning dive, you'll need to do three things: **1)** plan ahead so you can attempt to be in the right place at the right time; **2)** make sure your skills and equipment are appropriate for the conditions; **3)** dive into a few coral reef identification books that will help you identify the various corals and sponges you'll be targeting during spawning events.

Plan Your Trip

Stony corals in the Florida Keys, Bermuda, Bahamas, Gulf of Mexico and northern Caribbean normally spawn in mass after the August full moon and sometimes after the September full moon. Reefs farther south typically spawn a month later. The timing varies but the best bet for witnessing this spectacle is two to three hours after sunset, seven to ten nights after the full moon. When a full moon occurs early or late in the month, there can be a split-spawn for certain species like the boulder brain coral (Colpophyllia natans) where the spawning can happen in two separate months. Although in the western Atlantic and Caribbean region broadcasting spawns usually occur once a year in a time window several days long, stony corals in western Australia are known to have primary and secondary events, namely March/April and October/November. Contact a dive operation in your targeted locale to get specific dates for the predicted mass-spawning event in that region.

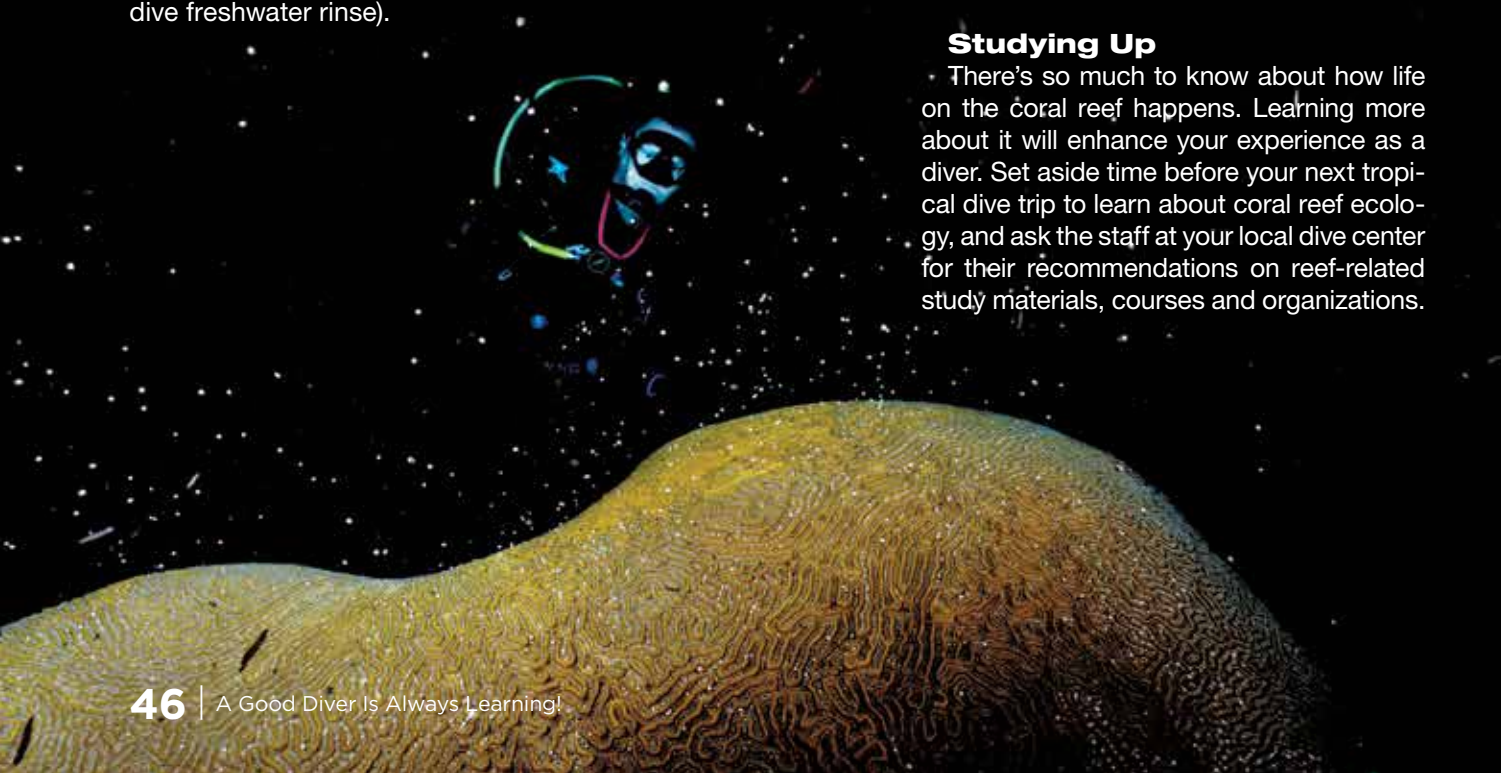
Months	Days After Full Moon	Location
March or April and Oct or Nov	7-10	Western Australia
August or September	3-5	Fla. Keys, Bahamas, N. Caribbean
August or September	7-10	Flower Garden Banks, Bermuda *
September, October, Nov	5-10	Central to S. Caribbean
October, November	1-6	Eastern Australia, Great Barrier Reef

***also after late July full moon**

Skills and Equipment

Your buoyancy control needs to be spot-on, so you can hover nearly motionless in the water column to witness the spawning while avoiding accidental contact with the reef. You'll also need to be comfortable using a dive light and diving at night. Consider taking a buoyancy control course and obtaining a Night Diver certification.

As far as equipment goes, you'll need a primary and backup light. Also, plan to wear exposure protection that covers your arms, legs and head. Even if you don't need a thick wet suit or hood for the tropics, you'll appreciate wearing a Lycra skin suit and hood to minimize your contact with spawn (this simplifies your post-dive freshwater rinse).



Studying Up

There's so much to know about how life on the coral reef happens. Learning more about it will enhance your experience as a diver. Set aside time before your next tropical dive trip to learn about coral reef ecology, and ask the staff at your local dive center for their recommendations on reef-related study materials, courses and organizations.

Corals aren't the only ones doing it. Here, a pair of red brittle stars is shown preparing to spawn.

derma rubicundum) eject their gametes. Perched with extended arms, the females release bright red eggs while the aggregation of males climb to the tops of coral heads and spew out red wisps of sperm. Christmas tree tubeworms, blue head wrasses, black durgeons and brown chromis sometimes join in the event. The mass spawning also occurs on the ninth and tenth nights after the August full moon but usually at lower levels. To date, scientists have observed seven of the twenty two reef-building coral species found at the FGBNMS participating in synchronized mass coral spawning.

During the height of the eruptions, the normally crystal-clear water around the coral heads resembles the inside popcorn poppers. About an hour or so later the hermaphroditic symmetrical brain star corals (*Pseudodiploria strigosa*) develop lines of tiny packets containing eggs and sperm that sit in the mouths of the polyps in their convoluted ridges. They gradually emerge and release into the water column. At near the same time, boulder star corals (*Orbicella franksi*), also hermaphrodites, release their bundles of eggs and sperm. They have been observed separating in rows, sequentially in a wave-like manner. On a celestial cue, hundreds of thousands of BB-sized packets of gametes break free from the coral colonies in a synchronized fashion. The following night is often even more dramatic with greater participation from the same species at the same times. Also, on the eighth night, and later at night around 10 pm, the mountainous star corals (*Orbicella faveolata*) participate in the synchronized mass spawning with their egg and sperm packets. The darkness of night provides protection from plankton-eating fish and other reef inhabitants also join in the sex spree. Ruby brittle stars (*Ophio-*

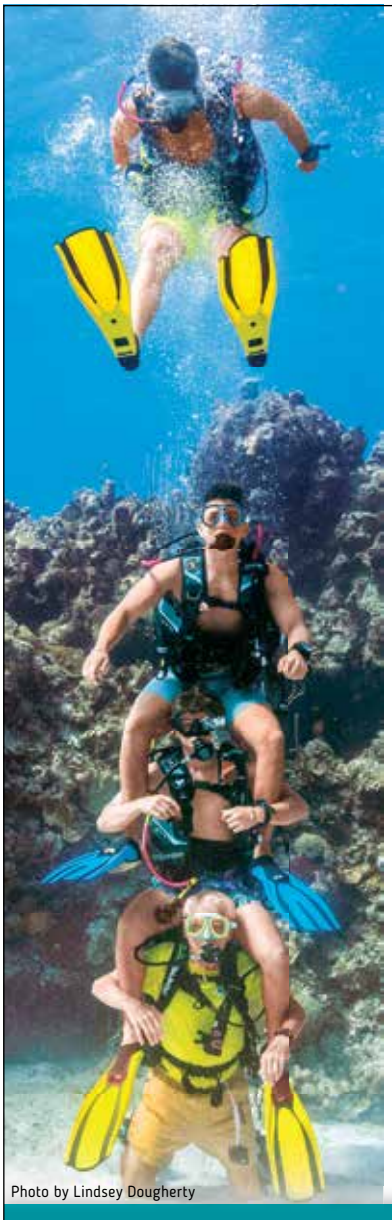
of a snow globe. But unlike snow, the tiny packets slowly rise to form a thick mat of biologically active gametes on the surface. The floating mat of spawn is where much of the fertilization occurs. Waves break apart the bundles of seeds, giving the ocean's surface a musky scent. The larvae that develop drift in the currents for days or perhaps weeks before eventually settling on the bottom. The mass coral-spawning phenomenon is a subject of great interest to marine scientists especially now, considering the numerous global and regional threats affecting coral reefs.

A Macro View of Reef-Building Stony Corals

Scientists estimate coral reefs have been around for about 240 million years and established coral reefs are between 5,000 and 10,000 years old. The age of a coral reef can be determined by taking core samples of the reef. Like cross sections of tree trunks, coral growth rings reveal the age and growth rates of individual coral colonies. Reef-building corals, the foundation for coral reefs, require the right temperature, salinity and water clarity for survival and so are limited to tropical and semi-tropical waters in both the Indo-Pacific and Atlantic Ocean regions of the world. Coral reefs cover less than one percent of the surface of our globe, yet marine scientists estimate coral reefs in our oceans host as many as 25 percent of all marine species. That's a big number when you consider 80 percent of all life forms on earth are present only in the ocean. The largest coral reef in the world, the Great Barrier Reef, spans 1,600 miles (2,600 km) off the east coast of Australia. Coral reefs are the "hot spots" of biodiversity in our oceans and, like rainforests, critical for the sustainability of planet earth. As animals go, corals are slow growers. In the Caribbean region, the fastest growing coral polyps are the branching and staghorn corals (*Acropora cervicornis*) that can grow as much as 6 to 8 inches (15 to 20 cm) per year but most of the massive coral formations grow only about 0.2 to 1 inch (0.5 to 2.5 cm) a year.

Is Spawning Sufficient?

Corals are making their best effort to survive but, unfortunately, many coral reefs in all oceans around the world continue to decline. The National Academies of Science estimates since the 1980s, on the average, 30 to 50 percent of coral reef cover has been lost. Some marine scientists predict a dire future and say coral reefs may be goners in the next 50 to 100 years while others are encouraged by new developments in coral reef restoration and intervention using methods like algae removal, coral larval enhancement to increase resilience, genetic engineering and coral out-planting.



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Reef-building corals in the shallow sub-tropical waters prefer water temperatures in the 70 to 85 degrees F (22 to 29 C) range. Healthy corals live long lives but they grow slowly and are vulnerable to numerous stresses both natural and man-made.

Coral bleaching occurs when overly high temperatures stress out the coral polyps and cause them to eject their zooxanthellae, putting their life at risk. Because the algae provide the corals both protection and color, the loss turns them white since the translucent tissue exposes their ivory skeleton. Since the zooxanthellae provide stony corals with their main source of food, if the high temperatures persist, the coral can starve or die. But if tolerable water conditions return before an extended period and the zooxanthellae return, the coral polyps will survive. As an example, in 2016, corals in the northwestern Gulf of Mexico at the FGBNMS experienced more than 40 percent bleaching but a mortality rate of only three percent. Coral also needs saltwater to survive and can be threatened by excessive outflows of fresh water from coastal areas. Coral diseases such as white band, white pox, yellow band and others continue to threaten coral reefs. Other threats include invasive species and storm damage. Man-made threats include overfishing, pollution and anchor damage, just to name a few. Perhaps the greatest threat is climate change — the large-scale warming of our oceans which subsequently causes an increase in CO_2 in the atmosphere and an increase in CO_2 in the ocean. This in turn lowers the pH of the seawater (ocean acidification), which weakens the coral skeleton and hampers its ability to reproduce.

Sponges and Sex

Sponges (phylum Porifera) are diverse multi-cellular animals that come in ranges of colors, shapes and sizes. Sponges have existed for more than 500 million years and there are more than 5,000 different species in the world. Like corals, sponges are sessile animals and attach themselves to hard substrates, natural or man-made. The typical structure of these somewhat primitive animals is an aggregation of cells on a glass-like frame consisting of small spikes called spicules. Their walls are lined with tiny pores called ostia and the open end of a sponge is called the osculum. The sponge pores allow water with nutrients and oxygen to flow into the wall, and also allow waste and carbon dioxide (CO_2) to flow out. They are strong animals

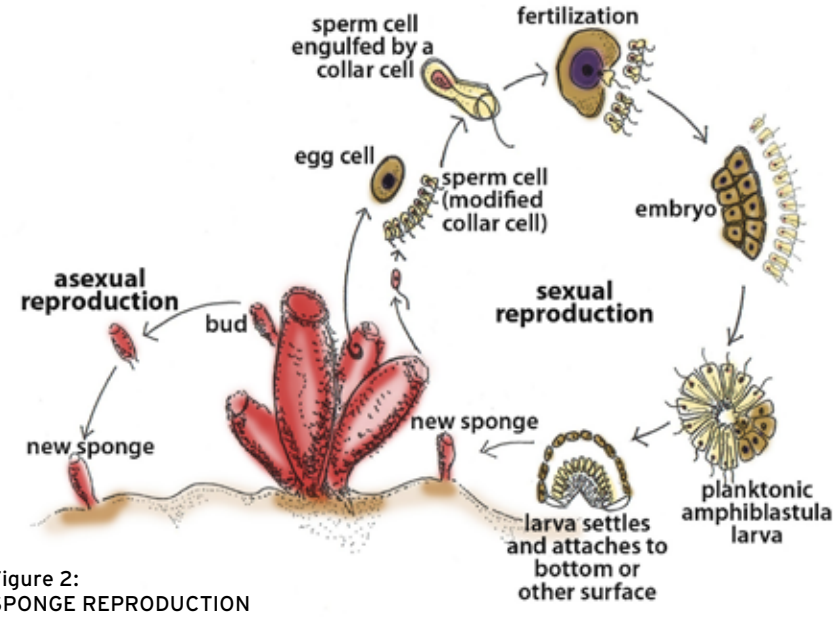

Figure 2:
SPONGE REPRODUCTION

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with dense skeletons and adapt well in varied environments.

Sponges are the "filter feeders" on coral reefs, filtering large quantities of water increasing water quality and helping control algae. When filtering the water, they collect bacteria that scientists believe extract nitrogen from the seawater — which nourishes the sponges and lowers nitrogen levels, thus maintaining the health of coral reefs. Many species also provide habitats for reef invertebrates and provide stability to the coral reef ecosystem.

How Sponges "Do It"

Like corals, sponges can reproduce both sexually and asexually and the sexual reproduction can be internal or external. Most sponges can be either male or female but only make one type of gamete at a time and are not able to self-fertilize. The male sponge releases sperm into the water that looks like drifting smoke. The sperm from one sponge makes its way in the water column and, as it passes near an egg-producing sponge, the sperm becomes trapped as it enters the female organism. Most sponges fertilize internally but the giant barrel sponge does so externally. In either case, the larva ends up in the water column where it floats around for a few days before attaching to a hard substrate where growth begins (Figure 2). Sponges can also reproduce asexually by a budding process that can be external or internal. External budding is when a small piece breaks off the sponge and is able to attach itself to the reef and begin increasing in size. Internal budding is done when buds called gemmules are formed internally and enclosed in a protective coating allowing survival of the organism in harsh conditions.

Giant barrel sponges (*Xestospongia muta*), known as the "redwoods of the reef," can reach sizes of 6 feet (1.8 m) across, and are known to spawn at least twice a year, usually in the spring and late summer. Divers have observed barrel sponges spawning in synchrony at the FGBNMS in August and September during the morning of the ninth night after the full moon. Female sponges release their eggs into the water column at the same time the male sponges release massive sperm clouds in a spawning event that lasts about an hour. This phenomenon has not been as predictable as the mass spawning of corals.

Having a better understanding of how stony corals and sponges reproduce gives us a richer experience of the coral reef environment. And the more we understand about our world's reefs, the better we can advocate for their protection.