Field Guide to the Corals of Nauru

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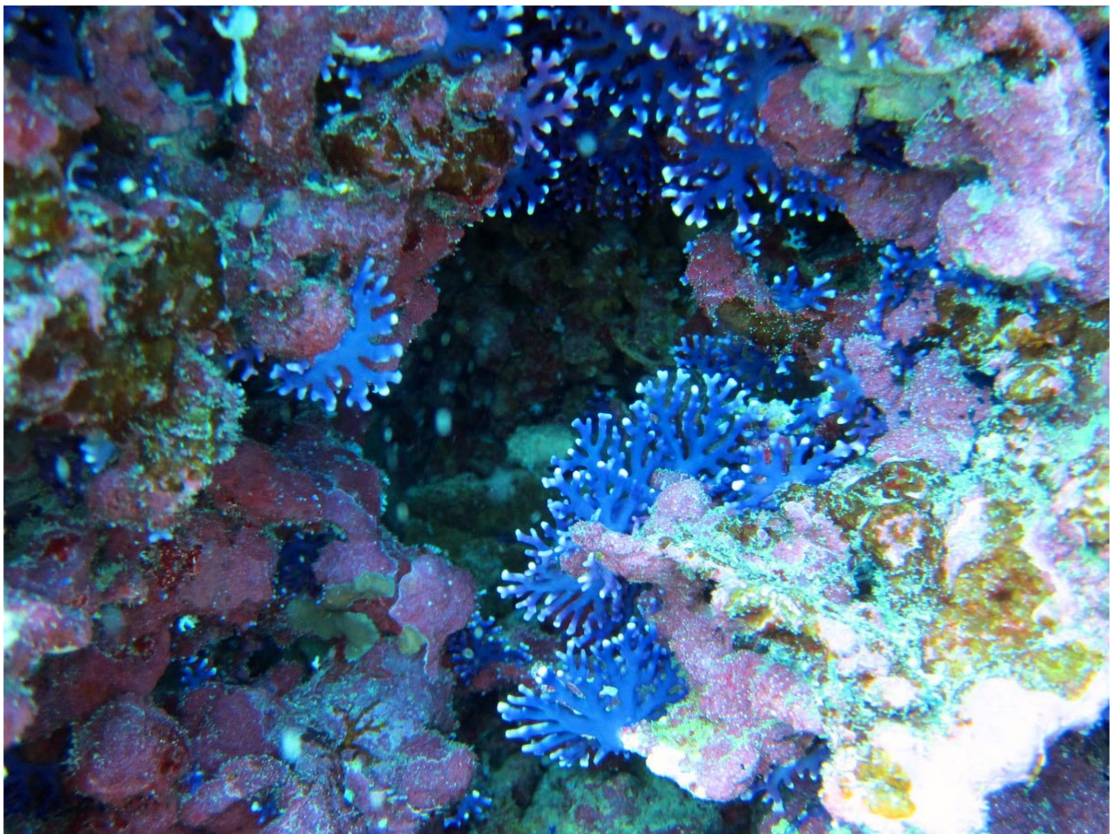
A guide to the underwater identification of 48 species of living reef corals in 19 genera that secrete hard skeletons in Nauru.



Colonies of *Distichopora violacea*, Nauru.

All photographs were taken in Nauru by the author, unless stated otherwise. Parts of the text are the same as in other guides by the author.

To: J.E.N. "Charlie" Veron, for all you do for the study of corals and reefs and their conservation.

Other field guides by the same author:

Fenner, D. 2022. Corals of Hawai'I, 2nd Edition. Field Guide, Coral Diseases, Coral Biology, Coral Reef Ecology, Hawaiian Reefs. Mutual Publishing, Honolulu. 400 pages.

Fenner, D. 2022. Field Guide to the Corals of the Marshall Islands. MIMRA.

Fenner, D. 2005. Corals of Hawai'i, A Field Guide to the Hard, Black and Soft Corals of Hawai'i and the Northwest Hawaiian Islands, including Midway. Mutual Publishing, Honolulu. 143 pages.

Sheppard, C., Fenner, D., and Sheppard, A. 2017. Coralpedia for the Chagos Archipelago, Indian Ocean. http://chagosinformationportal.org/corals

Fenner, D. 2018. Field Guide to the Corals of American Samoa. Pdf.

Fenner, D. 2018. Field Guide to the Corals of the Marshall Islands. Pdf.

Fenner, D. 2019. Field Guide to the Corals of the Federated States of Micronesia. Pdf.

Fenner, D. 2019. Field Guide to the Corals of Saipan. Pdf.

Fenner, D. 2019. Field Guide to the Corals of Palau. Pdf.

Fenner, D. 2019. Field Guide to the Corals of Tonga. Pdf.

Fenner, D. 2019. Field Guide to the Corals of Fiji. Pdf.

Fenner, D. 2019. Field Guide to the Corals of Wallis. Pdf.

Fenner, D. 2020. Field Guide to the Corals of Wake Atoll. Pdf.

Fenner, D. 2020. Field Guide to the Corals of the Northern Mariana Islands. Pdf.

Fenner, D. 2021. Field Guide to the Corals of the Marianas. Pdf.

Fenner, D. 2022. Field Guide to the Corals of New Caledonia. Pdf.

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Corals are presented in the conventional taxonomic order, because it puts corals that are morphologically similar together, which facilitates learning to distinguish them. A few modifications of that order have been introduced to help put similar looking species closer together. The classification based on DNA-sequencing data is presented below this contents listing.

Corals by the New Systematics: DNA-sequencing (PCR) Phylogeny

Here, families are listed alphabetically, genera within each family are listed alphabetically, and species with each genus are listed alphabetically. The species names used are those of the new taxonomy, based on DNA sequencing. There are quite a few changes in which genera species are in and which families genera are in. The old families were based completely on morphology, and morphology had little to base families on. It was impossible to visually identify families. So it is not surprising that DNA sequencing has indicated new groupings of genera into families. What is surprising is that several genera are indicated by the DNA sequencing to be in families that are morphologically very different. So for instance, *Alveopora* which has polyps almost identical to *Goniopora*, is moved from the Poritidae to the Acroporidae to join *Acropora*, *Montipora*, *Astreopora*, *Isopora*, and *Anacropora*, none of which have polyps or skeleton like *Alveopora*. However, under the electron microscope, *Alveopora* is seen to have minute scales on its skeleton like all the other genera in Acroporidae (and a few other species in other genera and families). And, that result has now been replicated using a method that uses much more DNA. Also, the Faviidae in the Pacific and Pectinidae are no more, species in those genera have been moved into the Merulinidae. The faviids, pectinids, and merulinids are all quite different morphologically but all are now in the Merulinidae. The former *Favia* in the Pacific have been renamed *Dipsastrea*, except *Favia stelligera*, which was moved into *Goniastrea*. *Diploastrea* and *Plesiastrea* get their own families. *Montastraea* in the Pacific was divided into *Astrea*, *Phymastrea*, and *Paramontastrea*, which is not surprising, Veron has commented that it seemed to be a collection of different things. The families Mussidae and Echinophyllidae are no more, their species have been moved into a new family, the Lobophyllidae. The morphology of the species in Muissidae and Echinophylliidae are quite different. The genus *Symphyllia* is no more, all the species in *Symphyllia* have been moved into *Lobophyllia*. *Psammocora explanata* and *Coscinaraea wellsi* have been placed in *Cycloseris*, which they don't remotely resemble. *Fungia concinna* and *Fungia repanda* are moved out of *Fungia* which they closely resemble, into the genus *Lithophyllon*, which they don't remotely resemble. Several species in *Fungia* have been moved into *Pleuractis*, and several others into *Danafungia*, and one into *Lobactis*. Only one species remains in *Fungia*, *Fungia fungites*.

Learning to identify corals is less difficult when similar species are compared, and the old taxonomy based on morphology tended to group corals together that had more similar morphology. So the order that corals are presented in this guide is more similar to the old taxonomy than the new systematics. The order of families, genera, and species in the new systematics as shown below is derived from Montgomery et al (2019) which was based on WoRMS (World Register of Marine Species, marinespecies.org). It is said that convergent evolution has produced similar appearances in species that are not closely related, but so far there is no independent evidence for that for most cases with coral taxonomy.

Introduction

This field identification guide was written to help identify corals in Nauru. All the photos were taken in the Nauru, so the photos look like the corals there. Corals look different from each other on a wide range of scales from near to each other to different reefs to different archipelagoes close together to archipelagos very far apart. No species are included in this guide that are not present in the Nauru, so you don't have to pick your way through many species that aren't in the Nauru. This is a first version of this guide and there may be a few more corals that are in Nauru which are not yet in this guide, but with additional visits by the author more species could be added. Additional searching will find additional corals, but the majority of corals are probably already in this guide. The order in which genera are presented is one that has been commonly used in the past (e.g., Veron, 2000) because it tends to put species together that look similar, which hopefully aids learning to distinguish them. The order of genera and species has been modified slightly here to try to put similar-looking species close together in the order, to assist identification.

Nauru

Nauru is a single small island that is an independent nation, located in the Western Pacific, 50 km south of the equator. Nauru is a raised atoll with only 21 km^2 area, and is very isolated. The closest island or reef is Banaba Island (Ocean Island) about 290 km east of Nauru, which is a very small (6 km^2), raised atoll like Nauru and is part of Kiribati. Kiribati is the closest archipelago, about 702 km east of Nauru. The Marshall Islands are about 972 km northeast of Nauru, Nauru (Micronesia) is about 783 km northwest of Nauru, and the Solomon Islands are about 1000 km southwest of Nauru.

Nauru is oval and about 6 km long in its longest dimension. It is a coral reef carbonate cap on top of a volcanic seamount. Most of the human population lives on a nearly flat, narrow, low lying coastal plain around the island. The interior rises steeply from the outer coastal plain to a height of about 15 m. The interior is depressed below that rim, and in one small spot reaches sea level and is occupied by a small lake. The interior from the rim inward is composed of reef carbonate which has a jagged surface called "karst" that resulted from rainwater dissolution of the carbonate when it was above sea level. The jagged karst surface was filled with phosphate deposits with a tropical forest growing on it. Much of the phosphate deposits have been mined, leaving the jagged karst surface. An effort is underway to smooth the karst surface in mined areas and revegetate it. The origin of the phosphate is not known for certain, though seabird colony guano has been suggested as the origin. Coral reefs, which surely formed the carbonate, do not form phosphate, which would dissolve in the water. The fact that the phosphate is on top of the karst and conforms to its surface indicates it was deposited after the karst was formed. Although the limestone of the karst was formed under water by the corals, the karst shape was formed when it was exposed to air later, as rainwater dissolved some of the carbonate. Thus, the phosphate had to be deposited on top of the karst while the karst was exposed to the air. In addition, Nauru is ideally located in the middle of a very large area of ocean with no predators on the island before human arrival, an ideal place for seabirds to nest and fly out into a huge area of sea to feed. People on Nauru eat seabirds, which are easy to catch when they fly onto the island in the evening. Seabird populations are declining and face local extinction son at present rates of exploitation.

The age of the limestone cap and the volcano that underlies it are unknown and the thickness of the cap is unknown. The limestone cap is clearly a raised atoll since it has a raised rim surrounding a depressed center. It takes about 12 million years for an atoll to form on a slowly subsiding volcano. The volcano was built when it was active, but after it stopped being active the part of it above the sea surface was eroded by rain over several million years. The volcano sits on the Pacific Plate, which moves about 7 cm a year westward. The plate is formed from hot lava in the southeast Pacific. When the plate is initially formed it is thick and hot. Slowly it cools and contracts, making it denser. Because it is denser, it slowly sinks deeper. So the sea floor in the southeast Pacific is shallower than in the rest of the Pacific, and it very gradually gets deeper going west from where it is formed. All islands in the Pacific sit on the plate, and all sink very slowly as the plate carries them towards the west. Meantime, coral reefs grow along the shore of the volcano. As the volcano sinks the coral reefs grow upward in place. The volcanic island in the center slowly becomes smaller as it sinks with less and less of the mountain top protruding above water. As a result, a gap forms between the coral reef ringing the island and the sinking, shrinking island. The reef originally was a “fringing reef” when it was right along the shore. When a gap appears between the reef and the shore and grows large, the reef is then called a “barrier reef” and the water-filled gap between the island and the reef is called a “lagoon.” Finally, when the volcanic mountain sinks out of sight in the center of the lagoon, the reef is called an “atoll.” This sequence was first theorized by Charles Darwin, and in modern times was tested by drilling an atoll, which found volcanic rock under the carbonate reef rock, showing he was correct. Atolls are typically some sort of ring shape, and reflect the shape of the outline of the original volcano’s shoreline. There are many atolls in the Pacific. A few have been dated, and have turned out to be about 40-60 million years old. The coral reef continues to grow upward as the volcano underneath it slowly sinks. Reefs can grow upward much faster than the plate and the volcanoes on it sink. Nauru went through all of these stages, and one of the last stage was when the plate underneath the mountain went over a small bump, raising the mountain and the atoll reef on top of it up about 15 m to the present height of the rim. There are a few other raised atolls around the Pacific, such as Banaba Island, the nearest island to Nauru, and Niue Island south of American Samoa, but not many. The bump that is under Nauru may be under Banaba Island as well, if so it is vastly wider than it is tall, over 300 km wide but only about 15 m tall.

Nauru is surrounded by reef flats which are just above the level of the lowest tides. It appears that the reef flat current level is due to rainwater dissolution of a layer of carbonate over it that was several meters thick. This is indicated by the presence in some areas of eroded carbonate pinnacles, which reach a maximum height of several meters. They appear to be the last remaining bits of a layer of limestone that was dissolved by rainwater, first becoming riddled with holes and so would be called “karst” and then almost completely gone, leaving only a few pillars. It seems likely that the present level of the reef flat was produced by the limit of freshwater dissolution, which can only happen above low tide level.

Beyond the reef flats, the coral reefs descend at about a 45 degree angle, without terraces, and below the reefs the slopes continue at a similar slope.

The climate at Nauru is tropical, humid with about 2 m annual rainfall, though this is highly variable, and seasons are minimal. Because it is so close to the equator, there are no cyclones, however there are other storms that can produce significant wave action. The island reef limestone is extremely porous, the rainwater drains into the holes and there are no surface streams or runoff. Fresh water reaches the sea in submarine vents or seeps, and is likely to have little if any sediment in it.

The reef flats are almost completely barren of corals, but do have algae on them. The reef flats are completely exposed at low tides, exposing any corals that might grow there to air and thus killing them. The reef slopes have a high abundance and cover of corals, but low coral diversity. The uppermost slope has low coral cover and strong wave surge. The upper slope has *Pocillopora* colonies on it and encrusting and/or plate *Montipora* colonies on it. The reef slope below that has high coral cover that is heavily dominated by one species, *Porites rus*. The second most abundant coral is *Distichopora violacea*, which forms small colonies and thus is much less obvious than *Porites rus*. Coral cover diminishes below about 20 m deep with few corals below about 35 m. An older report from a visit by the Cousteau team indicated that the reef slopes back then were not dominated by *Porites rus*, had a fair bit of *Pocillopora*, and didn't have such high coral cover. Thus, the coral community has apparently changed considerably over time.

The high coral cover of Nauru indicates a healthy coral community. In addition, there is a very low abundance and diversity of coral diseases. Only a few examples of two types of coral disease were found. The water is clear and there is essentially no terrestrial sediment on the reef. Nutrient levels are probably low, as algae was not abundant. No major damage was found. The only significant impact of people is probably from fishing. The coral assemblage on Nauru has relatively few species and can be said to have relatively low diversity. Nauru is surrounded by archipelagoes that have much higher diversity than Nauru. This appears to be puzzling. The explanation is likely to be that it is a very small and very isolated island. It is hard for coral larvae to survive long enough in the ocean to get there, and the small area of the reef means that coral species that are not abundant have small populations and reare species have very small populations. Small populations in small areas are vulnerable to local extinction. The diversity is a result of the balance between the supply of new corals and the rate of extinction. The rate of supply of new corals is low because of the great isolation, and the rate of extinction is high because of the very small reef area. Together they produce low diversity. So Nauru has unusually healthy reefs with unusually low coral diversity.

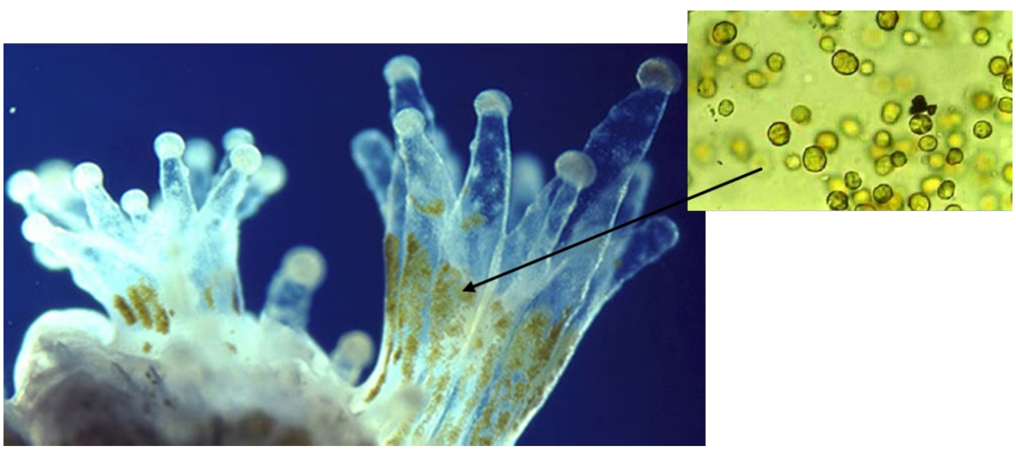
For more background information on marine environments in Nauru and on coral reef ecosystems and habitats in Nauru, see Wells, S., 1978; PROCFish/C and CoFish Team, 2005; McKenna et al, 2015; and Fenner (2019). For more information on coral reefs and corals in general, see Veron (1995; 2000), Wallace (1999), Goldberg (2013), Sheppard et al (2018), Sheppard (2021) and Fenner (2022).

Coral Anatomy and Biology: what are corals? Corals 101.

Corals are animals made up of units or modules called “polyps.” A polyp is a bag full of seawater, with a thin wall made of 3 layers, an outer layer of cells called the “epidermis,” a middle layer of connective tissue called the “mesoglea.” and an inner layer of cells called the “gastroderm.” The opening of the bag is the mouth, and it is actually turned inside the opening of the bag. There is a ring of tentacles around the mouth. Each tentacle is a hollow tube much like the finger on a glove, filled with water that is continuous with the water inside of the polyp. The water-filled space inside the polyp is called the “gastrovascular cavity” because it serves the function of both a digestive cavity and a circulatory system. Polyps are very simple and lack organs like a heart, blood vessels, and a brain. The gastrovascular cavity has only one opening, the mouth, unlike the tube digestive systems of higher animals, which have two openings and can digest things in a sequence like an assembly line. Anything that is indigestible has to be spat out the mouth. The inner two layers of the body wall project in a series of curtains called “mesenteries” that extend into the gastrovasuclar cavity. Hard corals have ether six mesenteries or multiples of six, and they have as many tentacles as mesenteries. Usually they have multiples of six. Coral polyps vary in size between species, ranging from less than 1mm diameter up to as much as 30 cm diameter.

Corals and their relatives are carnivores, sit and wait predators. They have a remarkable and unique type of stinger in their tentacles, called a “nematocyst.” Nematocysts are actually sub-cellular structures inside cells, secreted by the cell, and not alive. They are oval capsules, with a coiled thin tube inside them. The opening of the tube connects to the end of the capsule which touches the cell surface that is exposed to the water. When an animal touches the trigger on the surface of the cell, it provides a chemical that is only found in animals, a short polypeptide. In addition, the movement of the animal provides a mechanical stimulus. Both chemical and movement are necessary to trigger the nematocysts off. Corals and their relatives eat animals. When the nematocyst is triggered, water from the cell moves into the capsule, but the capsule is rigid and does not stretch. So the pressure goes up very high, about that of a scuba tank, the highest in any organism. There are 3 spines inside the tube which are attached to the tube and their sharp points are against the capsule where the capsule touches the cell surface that is exposed to the outside water. The pressure pushes the spines through the capsule wall, releasing the pressure, which then pushes the tube inside out, and outside the capsule and pushes the spines into the prey. The tube has many tiny spines attached inside it, initially pointing inward. As the tube turns inside out like a sock, the tiny spines are thrust out the end where the tube is being turned inside out, and stick into the prey. As the tube turns inside out, then they stick into the prey backwards, holding the tube in the prey. The spines poke into the prey and anchor the tube in the prey, and pull the tube into the prey. The tiny tube is very long, vastly longer than the capsule in which it was tightly wound up. Thus it can go well into the prey. The capsule is filled with a wide variety of nasty venoms, which attack nerve cells, blood and body cells. The end of the tube is open, so it serves as a hypodermic needle, invented by evolution probably over 500 million years ago. The prey is then pushed into the mouth and on into the gastrovasucular cavity by the tentacles. The layers of cells in the body wall have muscle cells in it which can cause the tentacles or body wall to contract. Once in the gastrovacular cavity, the food item is surrounded by the edges of the mesentery curtains, which have cells on the edge which secrete enzymes that digest the prey. The digested juice of the prey leaks out from between the mesentery edges into the gastrovascular cavity and diffuses through it, sped by body wall contractions that move the water inside it, so the juice reaches cells throughout the body wall and tentacles and feeds them.

The gastrodermis also has single algae cells in it, living inside the coral animal cells. They are called "zooxanthellae" which simply means "colored algae cells that live in animal cells." The zooxanthellae are in a group of single cells called "dinoflagellates" which when they are in water, have two flagella (hairs) that beat, one on the end of the cell, and one in a groove around the equator of the cell. When they beat, the cell swims and spins. The cells have chloroplasts in them that have chlorophyll, and can do photosynthesis in light. They also have other pigments that are red, orange or yellow, and together with green chlorophyll they always look brown. When they build glucose sugar in photosynthesis, some of it leaks out into the coral cell and feeds it. Thus, corals have two sources of food, animals they eat, and sugar from photosynthesis. The sugar is high in energy and low in nutrients, and supplies much of the coral's energy needs. The animals that corals eat are mostly small, and called "zooplankton." They provide the nutrients like nitrogen and phosphorus the coral animal cells need. The algae living inside the animal cell gets the waste products of the animal which are nutrients, fertilizer for plants. Plus, it gets a very well defended, stable spot in the sun. This is a mutualistic symbiosis, two different organisms living together, both benefitting, and it produces tight recycling of nutrients in low-nutrient water. The polyps are all connected by continuous tissue, and the gastrovascular cavities are all connected. The nervous system consists of nerve cells connected together like a net, with no brain or ganglion to control it. All the polyps behave as one connected individual coral organism. In addition, the polyps are all genetically identical and all the same sex. Thus, the colony is the individual, not the polyp. Polyps are modules within an individual.



Coral polyps on the left have tentacles. The white on the end of the tentacles and white bumps on the sides of tentacles are large cells called "nematocyst batteries" because they have many nematocysts. (Image: ocean.si.edu) The brownish green spots are zooxanthellae, seen in a microscope photo on the right. (Image: www.captivereefs.com).

Sexual maturity comes when the colony reaches a certain size, not when polyps reach full size. Eggs and sperm are produced by groups of cells which form gonads on the sides of the mesenteries. In a majority of species, the eggs and sperm are released into the water in what is called "broadcast spawning", where sperm from other colonies of the same species fertilize the eggs. The eggs and sperm are released together in egg-sperm bundles, which float to the surface and then break apart. Once the eggs are fertilized, they begin to divide and it takes about a week for them to divide enough to form a little larva, about the size of the head of a pin, called a "planula' larva. It is then capable of settling if it can find a suitable surface. If not, it can continue to float in the water. Over time, if they don't find a substrate, more and more die, and the last ones may live up to 100 days or so. In some places like the Great Barrier Reef, most coral species all spawn on the same night every year. The floating eggs are so numerous there they can form slicks on the surface so large they can be seen by aircraft. Most larvae probably don't go very far, with fewer and fewer going farther and farther with the currents. In other coral species the eggs are retained in the parent and sperm released, and sperm enter through the mouth to fertilize the eggs inside the parent. Then the egg divides and develops into a larva inside the parent, before being released. These are called "brooded larvae." Brooded larvae are able to settle immediately after being released, or they can float with the currents like other larvae. Some brooders release a few larvae every night, with more during some moon phases and times of the year. In addition, a majority of coral species are hermaphroditic, producing both eggs and sperm in one colony. A minority of species have separate sexes. Broadcast spawning and brooding are types of sexual reproduction.

When a coral planula larva settles, it then metamorphoses into a coral polyp of the same, tiny, size. The polyp then grows until it reaches a mature size. The mature size of polyps differs between species. Once the founding polyp reaches the mature size, it starts to divide. It can divide equally into two new polyps. It divides by the two polyps slowly growing and pulling away from each other. But they don't finish the job of dividing, they continue to stay attached to each other by a thin connection. So all corals start out as one tiny polyp which then grows to a mature size and divides into two. As those two grow, they reach the mature size and then they divide into 4. Then 4 into 8, 8 into 16, and so on until there may be hundreds, thousands, or millions of polyps.

Corals also can reproduce asexually, mainly by fragmentation. If something breaks a coral colony, the pieces can survive and grow if they are stable on a hard surface which they can attach to. In some relatively fragile branching species, this is the primary way they reproduce. In other, sturdier colonies, asexual reproduction by fragmentation is rare. Colonies can also have partial colony mortality which may leave islands of tissue living. In that case, as the islands of living tissue grow, they may reach each other and fuse. Only genetically identical tissue will fuse, when different colonies grow until they touch, they do not fuse. All fragments broken off of one colony are genetically identical and can be called "clone mates." Some species like staghorns form extensive thickets of these clones and are called "clonal." Branching corals like staghorns grow fast at the tip and slow on the sides. At the tip, only thin walls are secreted between corallites so the skeleton is highly porous and weak. Then with time the tissue keeps adding calcium to thicken the walls, until low on the branch not only is the branch thicker but it is nearly solid and very strong. If you think about it, leverage means that pressure near the end of the branch produces much more breaking force low on the branch than near the tip. The fact that the low part of the branch is thicker and more solid and thus much stronger, guards against breakage at the base. Thus, it appears that evolution has actually selected branching corals to resist breakage. That is probably because many fragments do not get stabilized on hard substrate and do not survive. Asexual reproduction by fragmentation can come at a high price. Mushroom corals have a few additional variations on these asexual fragmentation themes. When the larva of a mushroom coral settles, the polyp it forms, grows larger and then taller, and then the top surface with the corallte and septa starts widening beyond the stem-shaped part of the corallite. Then the tissue dissolves a crack in the skeleton under the wide top of the polyp. Then only the tissue holds the top on, and something like wave surge breaks the tissue and it falls off. That top that falls off is the shape of a mushroom coral, and grows much larger without ever attaching to anything. In the two species of "*Diaseris*" mushroom corals, the mature corallite dissolves a crack in its skeleton across the disc, and then the two halves are held together only by tissue. Something breaks the tissue and now there are two, half-disc mushroom corals which proceed to regenerate the other half and then dissolve another crack to do it all over again. As a result, those species can form large numbers of clone mate mushroom corals.

Coral polyps are very similar to sea anemone polyps, but reef building corals are usually colonial with several to many polyps, while anemones are solitary with single polyps that can, in some species, grow quite large. Reef building corals can grow large and have many polyps, and they almost always have zooxanthellae. Other corals are usually small, often solitary, don't have zooxanthellae, and live often in the dark, often in deeper water, and those that live in deep water are in very cold water and a few species live in cold polar waters. Reef building corals live only in warm, shallow water and usually live in clear water. Thus, coral reefs are all in warm, shallow water. All corals build what we call a skeleton, made of calcium carbonate. Calcium and carbonate are abundant in sea water, and actually have a higher concentration than needed to precipitate (but precipitate slowly). Corals take calcium carbonate out of the water and secrete it beneath themselves in a single structure that is external, underneath the living polyps, and not alive. So it is different from our skeleton, which have many separate pieces which are inside and have cells in them and are alive (and our skeletons are made of a complex phosphate compound, "hydroxyapatite"). Calcium carbonate can exist in at least two solid forms, one called "calcite" which forms thick crystals, and another called "aragonite" which forms long thin fiber-like crystals. Corals only build aragonite skeletons. After the larva settles on a surface, it secretes skeleton that is cemented to the substrate. Most coral species are firmly attached to hard substrate, but a few are not. Because the skeleton is not alive, it doesn't matter if other organisms like sponges burrow in the skeleton. As long as it doesn't break, it makes no difference to the living coral which is only on the surface of the skeleton. Each polyp sits in a cup in the skeleton called a "corallite." The inside surface of the cup has walls of skeleton that project into the cup and are called "sclerosepta" with "sclero" meaning hard and "septa" means walls. The corallite shape fits very closely to the polyp and reflects all the fine details of the polyp size and shape. The skeleton is much more permanent than the polyp and can retain its shape indefinitely out of water in a museum, and so is used for identification and taxonomy. All the taxonomy with only one exception is based on the skeleton shape. The irony is that a species is a group of living organisms, but we define coral species based on their skeletons, which are not alive. Both the shapes of colonies and the fine details of the corallites and other details of the skeleton, usually observed under a microscope, are used to separate species. Identification of living corals is not definitive, it requires confirmation by examining skeleton. Living corals in the water have some advantages for studying species, since you can see the whole colonies instead of pieces in a museum, and you can see large numbers of colonies, and it is non-destructive. Skeletons in a museum have the advantage that living tissues are not in the way of you seeing the skeleton details, and you can use a microscope, and you can see the same skeletons other people see.

There are a few general things about coral morphology that may be of help to you as you go along. The main unit in coral morphology is the polyp, and the corresponding cup in the skeleton which a polyp sits in. The cup in which a polyp sits is called a “corallite” and includes both the inside and the outside surfaces of the cup. The inside of the cup is called a “calice.” There are walls that extend from the inside wall of a corallite into the central space of the corallite, which are called “septa.” Each corallite has at least six septa. Septa come in sets, the first set having six septa, the second set also having six which are between the first set of six and usually smaller than the first set of six. The third set is 12 and is in between the existing 12 septa, the next set is 24, etc. In the center of the corallite there is a small structure called a “columella” which may be a single solid column or more often many small columns, or curving, twisted columns. The septa commonly extend up over the rim of the corallite and down the outside surface of the corallite, where they are called costae (costa is singular). Septa and costae may have teeth or granules on the edge and granules on their sides. Corallites can come in many different sizes and shapes. They range in size from about 0.5 mm to about 30 cm diameter. Some are circular, others oval, some quite elongated. Each elongated corallite corresponds to an elongated polyp which has several or many mouths but shares a single gastrovascular cavity. The corallite walls in that case are elongated and usually meander, forming a “meandroid” coral, commonly called a “brain coral.” There are many other details.

Coral Identification

Coral species are notoriously difficult to identify. Coral identification and taxonomy are not for the faint hearted. You need all the help you can get. We all do. The purpose of this identification guide is to help you to learn to identify coral species you see in the Nauru. This is a preliminary version of the guide, as the author gets more time underwater and finds and photographs more corals, more species will be added. The goal is to present photographs of the corals taken in Nauru, and have clear and helpful text that points out the features of the corals that can help in identification and how each species differs from others. One of the advantages of a pdf is that it can easily be updated as often as desired. Another is that photographs can fill the whole screen. The larger the photographs, the better you can see the corals that you are trying to identify. This guide attempts to show both pictures of the whole colony shape, and of close-ups of the corals, and some of the variation between corals. There are valuable identification clues in both the colony shapes and in the features of the corallites and areas in between corallites. You need to be able to see as many of these features as possible to help you identify the corals you see.

At any one reef, only a portion of the world's coral fauna will be present, and an even smaller portion of that fauna will be common enough that you encounter it frequently. The more often you see a coral, the more chance you have to practice your identification skills. The author recommends looking at the guide as often as possible, including before you get in the water. Then it is good to look again after you get out of the water. Going between the guide and looking underwater, back and forth, is one of the best ways to learn coral species. You will see corals in the water that don't fit well with the species in this guide. You will also see things in the guide that you won't initially see in the water, but with more and more time in the water you will see more and more of them. The author is doing the same thing, finding more species with time spent underwater in more places, and using pictures taken to add to the guide. But a local guide has several advantages over a guide that presents all species from all over the world (such as Veron's "Corals of the World"). For one thing, many of the species in a worldwide guide aren't at your location. That means you have to look through many photos of all sorts of things that aren't on your reef. For another, not all coral species look the same everywhere. Some can look quite different in different parts of the world or on different archipelagoes. Some look virtually identical, but others don't. Most or even all of the pictures taken in a worldwide guide weren't taken in Nauru, and so many of them may look quite different than corals in Nauru. This guide helps you by only showing you coral species that are in Nauru, and only showing you photos of corals in Nauru, so the photos look as much as possible like the corals you see.

Unfortunately, there are only a few common names that have been applied to coral species consistently, and most of those apply to groups of corals. So some corals are called "staghorns" and others "table corals" and others "brain corals." But there are several staghorn species and several table coral species. In this guide, similar looking species are presented together as far as possible. Genera are presented in a traditional order, which tends to put corals that look similar together. In addition, within genera corals that appear similar are put together, so all the "staghorn corals" are together, and all the "table corals" are together, and so on. But the species are all labelled with the scientific (Latinized) names, because only those names correspond (as far as possible) to the actual biological species.

Common names in widespread use are also given, but usually there are several species that have the same common name. So there is no easy way around using the scientific names.

There are two major reasons that corals are difficult to identify. The first is a naming problem, and the second is a problem of figuring out what group of organisms is the species you are studying. Names are arbitrary human inventions, while the group of organisms is something that exists in nature whether we give it a name or not. We need species names in order to be able to communicate to each other what we are talking about, but the name itself is arbitrary, any name would do, and everybody has a different idea of what name they would like to call it. The solution is a set of rules invented by Carl Linnaeus. You probably know some of the rules. One of the most important is that the first name correctly applied to a species is the one that is correct. This is called "priority." A second rule is that species names must have two words, the first is the genus and is capitalized, the second is the species and is not capitalized, and both are in italics. Any words can be used, from any language, but the words must be Latinized, making them look like Latin. So the word in English, "bushy", taken from a reef in the Great Barrier Reef where a coral was first discovered, was converted to Latin and became "bushyensis" and the species was named "*Acropora bushyensis*". Another rule is that the name and a description of the species must be published. The rule book does not specify where the name must be published. There are other rules, which are contained in a rulebook, "The International Code of Zoological Nomenclature" (which is available online open-access). This is in effect the rulebook for a game played by taxonomists, that is, naming species. There are a variety of problems with this, but one of the worst come from the publications that commonly are used for new species. Very few people are interested in the original descriptions of new species, mostly just other taxonomists that work on the same group of animals, and usually there are only a few of those in the whole world. No widely read journal that publishes papers that many people think are important will publish original descriptions of new species, because almost no one will be interested and read it. So almost all descriptions of new species are published in obscure little journals that almost no one reads, and almost no libraries subscribe to them, since almost no one uses them. One result is that most coral taxonomists have not read most original descriptions, primarily because they can't find copies of them. So many taxonomists have described as new species, species that were described before, sometimes many times. These are called "synonyms", when two names refer to the same species. Taxonomists occasionally write "revisions" of groups of organisms, in which they give new descriptions, and they list all the names that have been previously applied to what is now all considered one species. This requires considerable taxonomic knowledge and skill, because you have to look at lots of old descriptions to figure out which are all the same species. Yet a single species varies between individuals and locations, so original descriptions from different places are often a little different even though it is the same species, and everyone uses different words and sentences, making this a difficult task.

In addition, the rules do not specify which language must be used in original descriptions. At first, most were written in Latin, because that was the scholarly language of the time in Europe where taxonomy originated. Then they were written mostly in a variety of European modern languages, and now most are written in English. Even in English, the language has changed over time, particularly in coral taxonomy. Older publications in English use terms that they didn't define, and which we don't use now. That makes it harder even in English. I have seen an original description of a coral species that consisted of two sentences in Latin. Your Latin better be very good, the whole definition could hang on the meaning of one word in Latin.

Originally there were no samples of the new species, or photographs (photography had not been invented!) or even drawings of the new species. Then people started including drawings in their new species descriptions. The drawings were often made from a particular piece of the species, and slowly those pieces, in a museum, were taken to be "type specimens" that helped define new species. In time, photographs were added. In 2000, the rules were revised to require the description of a new species to include designating a type specimen (usually in a museum). Type specimens are extremely helpful, because if an original description leaves out something that you now think is important, you can look at the type specimen and find out what that is. Further, it is often difficult to imagine what a species looks like from a description. The saying goes that "a picture is worth a thousand words." Of course, we are handicapped by the fact that for the species that were named long ago, there are no type specimens. Another problem is that some old type specimens are in terrible shape. One that Veron has a picture of on his website (Corals of the World) looks like it was dragged behind a car on beach for a couple miles, all the surface is worn off. You can't even tell what genus it is in. This may not be quite as bad a problem as that, most type specimens are not in bad condition. Another problem is that the type specimen doesn't have to be typical of the species, and the original description doesn't either. That's in part because a wide range of samples of a species are almost never available when a new species is being described, and a large collection of samples is needed to determine the variation within the species and what is typical. At this time, for most coral species, we still don't know the range of variation over the geographical range of the species. No one can go to everywhere there are corals and sample many colonies from every site of every species. But we know they vary from site to site. So some or many type specimens may not be typical, and for most species we don't even know whether they are typical or not.

It has been said that the main job of 20th Century taxonomists was to try to clean up the mess left to them by earlier taxonomists. Much of that comes from the arbitrary naming rules, but some comes from the variability in the organisms themselves.

The second great hurdle for recognizing coral species and doing taxonomy on them, is the question of what group of individual organisms comprise a species. This is an empirical question. With some species, it is easy. For *Homo sapiens*, we have the advantage that no other human species is alive today. Our nearest living relatives, chimpanzees and bonobos, are so different from us no one would ever confuse one with a human, and many people don't believe we're related at all. If Neanderthals were alive, it would be much more difficult.

Almost all species ever named and described were named and described based on their morphology and anatomy alone. Originally, only morphology was known and could be included. Plus, morphology until recently has been the quickest and easiest thing to use to describe species. And it makes it possible to identify species in the field. About 1-2 million species of all types of life on earth have been described, but it is estimated that there are 10-30 million species on earth (and other estimates that run from 3 million to a billion; nobody really knows). After about 250 years, we may have only named and described about 10% of the organisms on earth, and we have little prospect of speeding that up substantially. It is not immediately obvious how large the anatomical differences need to be between individuals for them to be different species. There is lots of variation within some species, so something that is different might be a new species or just a variation within a species. How do you tell? Not easy. One thing is that it is helpful to have at least two different features that are different between two species, and that the two go together. So species 1 has features A and B, and species 2 has features a and b. and individuals that have A and b or a and B are rare or can't be found. Another rule of thumb is that in a single feature that has variation between individuals within a species as well as between species, the distribution of that feature (such as length or body weight) has two modes (one for each species) and at least a small gap in between with no individuals. Of course these things require a lot of knowledge about many individuals within a species. That sort of information is very rarely available when describing a new species, but sometimes is available later on when much more is known about the species. Describing new species remains a fairly intuitive thing.

For corals, the morphology that is used in coral taxonomy is the morphology of the skeleton. Originally, the only thing available to taxonomists was the skeleton. Long sailing voyages of creaky old wooden European sailboats went long distances, sometimes around the world. Along the way the crew would pick up all kinds of curiosities, sometimes including corals. Months or even years later, the ship would return to Europe, and by then the coral had long had all the tissue rot off, and only the skeleton was left. If the taxonomist was lucky, the skeleton had not been broken into many pieces or ground against other pieces as the ship rocked. In time, deliberate collecting voyages were organized, financed, and crewed with people whose purpose was to collect. Corals were usually collected by dredging, pulling a dredge behind a boat which broke many corals and gathered many broken pieces of coral. But only within the lifetime of older people living now, has it become possible to dive into the water with scuba gear and view living corals in their natural state. Pieces of coral in museums are exactly that, they are almost always just pieces, and the overall colony shapes usually can't be seen. Further, it is possible now to see large numbers of living, whole colonies underwater, many more than can be seen in museums. Plus viewing corals is non-destructive. I know one coral taxonomist who has collected over 30,000 coral specimens in his lifetime. That is still tiny compared to the hundreds of millions of colonies destroyed by a single, natural, hurricane. But still it is significant. The colony shape of corals is one of the more useful cues that can be used to identify species, but it is usually only available when they are viewed alive on a reef. So viewing corals alive on a reef has its advantages for identifying coral. One disadvantage is that viewing a living coral is ephemeral and in and of itself you usually can't show it to a variety of colleagues. Now, underwater photography fills that gap, and it is possible to show pictures of whole living colonies and close-ups of smaller features to as many people as you wish. Another disadvantage with living corals is that the skeleton on which the taxonomy and secure identification rests, cannot be seen directly, usually, because it is covered with living tissue. The living tissue obscures many of the features you need to use in identification, such as skeletal septa, spines, etc. Further, underwater you can't use a dissecting microscope, your mask fogs up, waves or currents throw you around, you have to do a lot of other things to stay safe like watch your buddy and check your dive computer and air gauge, all the while you are trying not to break coral and to handle the camera and perhaps collecting tools. So there are advantages to working on a piece of skeleton in a lab or museum as well. But it is good to remember that an identification of a coral in the water is a hypothesis, and firm identification requires examination of skeletal samples under a microscope. The present guide is not yet backed up with examination of skeleton under a microscope by the author, but that is planned for the future. Identification of living corals is guesswork, hopefully well educated guesses, which can be checked against skeleton.

Discovering or studying species requires some idea of what a species is. Darwin wrote that many scientists differ in how they define what a species is, they have an intuitive feel for what it is. By now, about 30 different definitions of species have been offered. What I was describing in the previous paragraph is something like a definition of a species based on morphology, which has been called a "morphospecies." Another famous definition is what is called the "biological species". That defines a species as a group of organisms that interbreed within the group, but not with other groups. Reproductive isolation from other species is the hallmark of a "biological species." Reproductive isolation makes sense of some major problem cases for the morphological definition of species. For instance, dogs have enormous morphological variation. The differences between many dog breeds is far greater than that between many wild species. Yet we are sure all dogs are one species. Why? Because they can interbreed freely. Humans also have lots of variation, yet all modern humans are the same species, we can all interbreed. Another problem with morphospecies is illustrated by parrotfish. There are parrotfish that were described as different species because they are different sizes and have different color patterns. But subsequently, they were seen to be interbreeding, they were different sexes of the same species. Many (but not all) species are dimorphic to some degree, with different morphology in males and females. Sexual dimorphism is an example of polymorphism. There are some species, such as some butterflies, that have multiple morphs that look different, but interbreed freely, they are the same species. So the reproductive isolation definition of species handles these problems well. Intuitively we know that reproductive isolation is a better definition of species than morphology alone. However, one problem with reproductive isolation is that it takes a LOT more time and effort to gather the information needed to define species this way than by morphology alone, and we have millions of species left to describe so we don't have the luxury of testing reproductive isolation with each new species (or most of the old species).

There are at least two other major problems with the reproductive isolation definition of species. One is that a majority of all species are extinct and we know them only through fossils. Yet we can't record in fossils which organisms interbreed with each other and which don't. All we have is morphology. Second, there are some species that don't interbreed at all. Rotifers are entirely unisexual and do not interbreed, and have not been interbreeding for about 200 million years, it is thought. Some microorganisms don't interbreed. Bacteria exchange genetic material, but that's not interbreeding in the sense we mean, and bacteria can easily exchange DNA between different species. So interbreeding isn't much help there. In zooxanthellae, interbreeding has never been observed except in the original description of *Symbiodinium*. So it is in some cases not possible to use the reproductive isolation, and in most or almost all cases it is impractical. There is one study with about 20 species of *Acropora* which spawn all on the same night on the Great Barrier Reef, where reproductive isolation was studied. All possible crosses of these species were made, and whether the crosses would produce fertilized eggs. Several were able to cross, including at least one pair of species that had nearly as high frequency of fertilization success and within species. But most did not cross, and most that did cross had fairly low fertilization success.

The newest challenger is of course genetics. It is possible now to quickly get DNA sequencing data from large numbers of samples. One problem is simply handling the enormous volume of information when more than just single genes or small stretches of DNA are sequenced. Interpretation of the results in some cases is not always clear. For many types of animals, there is a relatively small stretch of DNA that is highly variable between species. The DNA sequence in that locus is unique for each species. This is the technique called "DNA finger printing" or "bar coding." If you define a species by morphology and then sequence this locus in the DNA, then you can sequence that locus in many individuals blindly and the results are "fingerprints" or "bar codes" that can identify the species for you. Thus, for the first time, large volumes of samples and species can be separated into species groups without the laborious task of identifying based on morphology. It is easy to sequence large numbers of individuals and use the fingerprints to divide the samples into species. Then matching to databases of known species sequences, you can identify species. You can only get a species name if a taxonomist has identified a species and it has had its DNA sequence fingerprint taken. Further, you have to sample each individual you want to identify, which would be impractical for some types of ecological surveys or monitoring. For most corals, the problem is that there is not enough variation in these markers to separate species (though it may work for genera), and no one has yet found a new stretch of DNA that works. Markers that do work for species have been found for *Pocillopora* and the Agariciids. So genetic fingerprinting doesn't work with all corals at this time, but it does for some. Note that if you compare a DNA sequence pppfor an individual coral with a database, you have to assume that the specimen for which the sequence appears in the database was correctly identified. That assumption may not be warranted for corals, people without significant training in coral ID may get ID's wrong.

The main problem with morphology for corals, is that corals are so highly variable in morphology within species. There is variation at every possible level. Variation between spines in a single corallite. Variation between neighboring corallites on a single colony. Variation between regions (like top and side) of a single colony. Variations between adjacent colonies (in the same environment). Variation between colonies in different zones of the same reef. Variations between reefs, between islands within the same archipelago, between adjacent archipelagoes and between distant archipelagoes. When you're trying to tell two species apart, they both have variations at all these levels, with all the different morphological features they have, all at the same time and perhaps independently. The variation within species is large, and often the variation between species is small. Some studies have quantitatively measured many features in the same individual coral, on the order of 30 or more features, on several corallites or locations of each coral. Do that on more than a few colonies and the work quickly becomes enormous, do it on all the archipelagoes within a species range and it has never been done and may never be done because the work is way out of proportion to the value of the end product, it is too inefficient.

For more on the results of DNA sequencing of corals, see the section after "Contents" on "Corals by the New Systematics: DNA-sequencing (PCR) Phylogeny' and Kitahara et al (2016). For more on the conflict between DNA sequencing and morphology, see Losos et al (2012). For more on the problems of morphological taxonomy with corals, see Veron (1995; 2000) and Veron et al (2022).

Yet we still very much need to be able to identify corals to species , for studies of ecology, monitoring, and conservation. So we struggle along, doing the best we can. My suggestion is to concentrate on enjoying the feeling of accomplishment each time you learn to identify one more species. Don't dwell on the fact that there are many to go, enjoy learning to identify coral species as you progress.

There are a few general things about coral morphology that may be of help to you as you go along. The main unit in coral morphology is the polyp, and the corresponding cup in the skeleton which a polyp sits in. The cup in which a polyp sits is called a "corallite" and includes both the inside and the outside surfaces of the cup. The inside of the cup is called a "calice." There are walls that extend from the inside wall of a corallite into the central space of the corallite, which are called "septa." Each corallite has at least six septa. Septa come in sets, the first set having six septa, the second set also having six which are between the first set of six and usually smaller than the first set of six. The third set is 12 and is in between the existing 12 septa, the next set is 24, etc. In the center of the corallite there is a small structure called a "columella" which may be a single solid column or more often many small columns, or curving, twisted columns. The septa commonly extend up over the rim of the corallite and down the outside surface of the corallite, where they are called costae (costa is singular). Septa and costae may have teeth or granules on the edge and granules on their sides. Corallites can come in many different sizes and shapes. Some are circular, others oval, some quite elongated. Each elongated corallite corresponds to an elongated polyp which has several or many mouths but shares a single gastrovascular cavity. The corallite walls in that case are elongated and usually meander, forming a "meandroid" coral, commonly called a "brain coral." There are many other details.

Corals are difficult to identify, primarily because they are highly variable. Coral identification and taxonomy is based on the skeleton. In most living corals the tissue layer, which is on the outside of the skeleton, is thin, and so the larger features of the skeleton can be seen underwater some of the time. Major aspects of the skeleton used for identification include the colony shape and size, the shape, size, and microscopic features of the "polyp cups" (corallites) where the polyps are located, and a variety of spines, ridges, and bumps on the coral between the corallites. The corallites are usually raised cups, with a raised edge surrounding a central depression that extends deeper than the surface of the coral. The whole cup is called a "corallite" and the inside is called a "calice" which is a word that means "cup" and rhymes with "chalice." Inside the calice there are a number of radiating ridges or walls called "septa." There are usually six or a multiple of six of these septa, but if the number is large it is often not a multiple of six. A coral larvae swims in the water and then attaches to the substrate, and starts to grow as a single polyp. Then it begins to lay down skeleton underneath it. The skeleton is made of calcium carbonate which the coral tissue gets out of the water. First it lays down six septa in the calice. Then it begins laying down a smaller set of septa, with each septa between the existing six septa. This produces two sets of six septa each, six large and six smaller. If it continues laying down septa, it will now lay down smaller septa in between all of the 12 existing septa, so a new set of 12 smaller septa. If it continues it would next lay down a new set of 24 septa between the existing 24 septa, and so on. Many corals, particularly those with small corallites, only put down 12 or 24 septa, and a few put down only six. All these details are used in the taxonomy and species identification, but the septa can't be seen in most species, only in those with the largest corallites. The largest corallites are in the "mushroom corals" and a single polyp on a single corallite in a mushroom coral can reach as much as 30 cm (a foot) in diameter. The septa are easy to see in large mushroom corals. Several kinds of corals have tiny corallites, about 1 mm diameter and sometimes even less, while many kinds have intermediate size corallies. Corallites can be seen in virtually all corrals.

Because coral identification is difficult and uncertain, you need all the help you can get. The present guide will provide a short guide to the most common corals, and then a visual index to help you find the different genera of coral. Learning corals in Nauru is much easier than elsewhere in the Pacific because there are relatively few species. This helps both because there are fewer species to learn and also because for many of the species in Nauru, there are no other species that are extremely similar to them and thus are hard to learn to distinguish.

Coral taxonomy and identification are based on skeletal features. At the time of writing, the author has not yet been able to collect skeleton samples to confirm identifications, so species identifications are somewhat tentative. Some corals are different in different archipelagoes or on different islands, making it harder to identify them and making identifications less certain until skeleton samples can be examined for confirmation.

Useful Terms

The descriptions often refer to "corallites." These are the skeleton cups that the polyps sit in. The word "corallite" refers to both the inside of the cup and the outside.

The descriptions also commonly refer to several different colony shapes. Here are some of the shapes:

Massive = dome shaped or hemispherical colonies without deep cracks.

Branching = having branches that have side branches and can go in any direction.

Columnar = having near vertical columns that don't branch much.

Encrusting = forming a thin crust over the substrate and attached to it, with no space under the coral. Much like paint though not usually as thin as paint.

Foliose = Plate = a relatively thin, nearly flat structure that is thin and has two sides like a plate. Plates are commonly near horizontal but sometimes can be vertical.

Mushroom coral = resembles the overturned cap of a mushroom.

Staghorn = branching, with branches that look like deer antlers (always in genus *Acropora*)

Table = a flat top surface held up by a pedestal which is usually under the center of the table (always in genus *Acropora*)

Digitate = branches look like fingers, without any side branches, not very long, and usually parallel, extending upward from an encrusting base (always in genus *Acropora*).

Corymbose = similar to digitate, but thinner branches, which are often growing up from larger horizontal branches (always in genus *Acropora*).

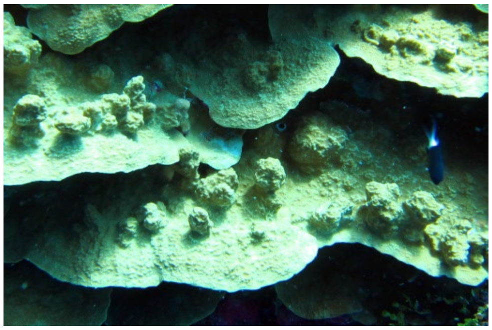
Hispidose = in the shape of a bottlebrush, with short thin branchlets radiating from a central larger branch (always in genus *Acropora*).

The identifications in this guide are primarily based on Veron (2000); Veron et al (2020); Wallace (1999); Wallace et al (2012); Hoeksema (1989), Randall and Cheng (1984) and references therein.

The words in **bold red** on the same line as the species name are the categories for endangered species. Some coral species have been listed as "threatened" under the U.S. ESA (Endangered Species Act), and some listed as "vulnerable" under the IUCN (International Union for the Conservation of Nature) Red List, (www.iucnredlist.org), and some both.

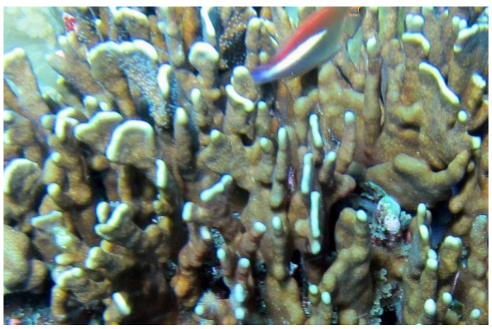
The Most Common Corals

You can learn to identify most of the corals in Nauru by just learning to identify one species, *Porites rus*!! Other common corals include the blue coral *Heliopora coerulea*, *Distichopora violacea*, *Pocillopora eydouxi*, and *Montipora* cf. *grisea*.

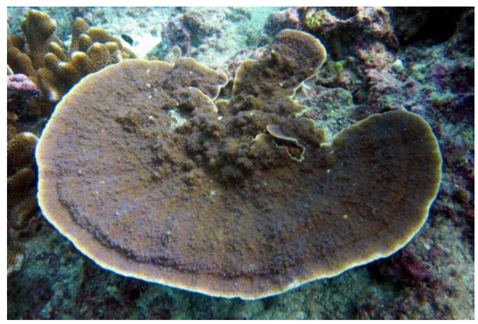


Porites rus, p. 58

Pocillopora grandis, p. 32



Heliopora coerulea, p. 114



Montipora cf. *grisea,* p. 34

Distichopora violacea, p. 120

The Corals

Phylum Cnidaria

This phylum contains animals that have a very simple sack-like body with three layers of cells and no organs. It has a mouth that leads to a water-filled gastrovascular cavity, but the mouth is the only opening to the cavity. It has a ring of hollow tentacles around the mouth, which are extensions of the body wall. The body shape can be a polyp which has an upward facing mouth and the downward end of the body is attached to a surface, or a medusa, which is a jellyfish which is free swimming. In some classes, polyps and jellyfish (= medusa) alternate, in one (Anthozoa), only polyps are present.

Subphylum Anthozoa

This class contains animals that have only a polyp stage (no jellyfish = medusa stage). It has two main groups in it, those with exactly 8 tentacles (Octocorals: soft corals, gorgonians, and sea pens), and those with multiples of six tentacles (Hexacorals).

Class Zoantharia or Hexacorals

This subclass contains animals that have six tentacles or multiples thereof: sea anemones, Scleractinia (hard corals), black corals, ceranthid anemones, zoanthids, and coralimorphs.

Order Scleractinia

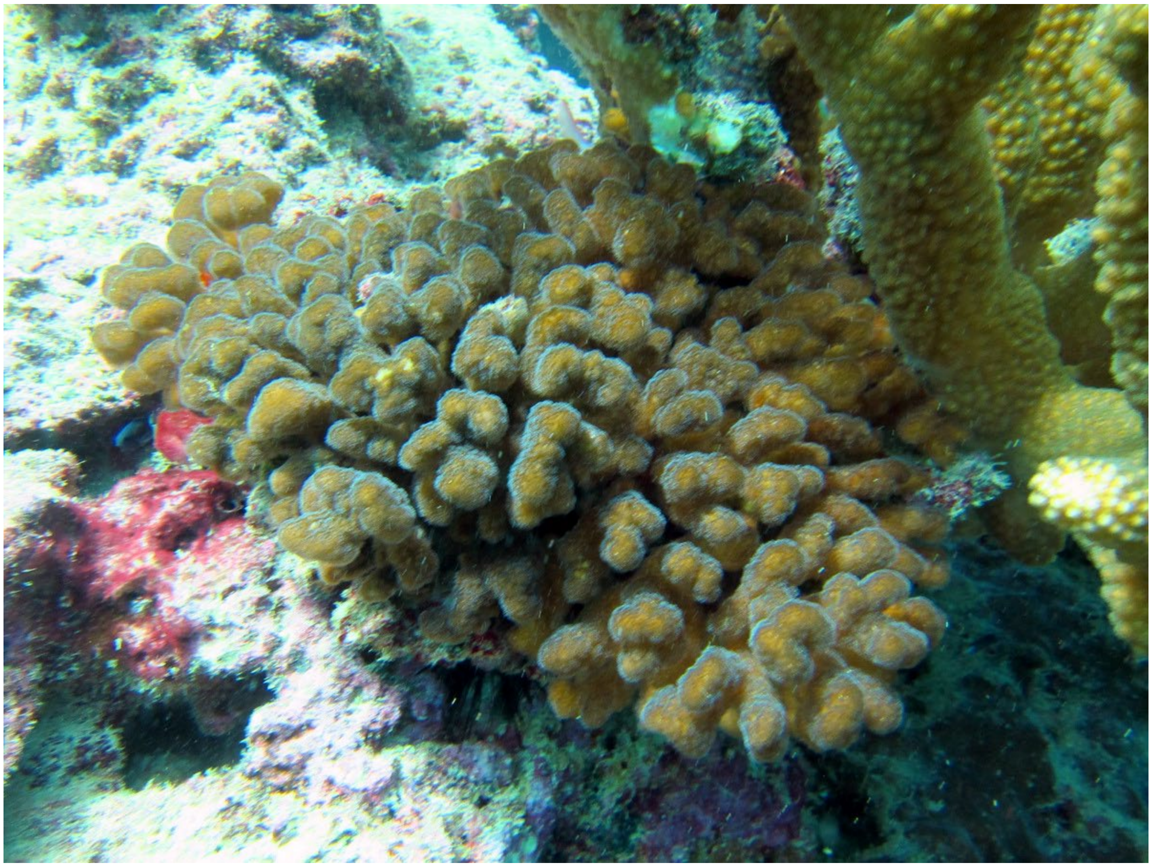
This order contains animals that build calcium carbonate (aragonite) skeletons underneath themselves, and in the corallites ("polyp cups") that polyps sit in, there are "sclerosepta" that are thin walls made of skeleton that project into the calice (the inside of the corallite). This includes almost all of the reef-building hard or stony corals. The reef-building corals have zooxanthellae (single-celled algae inside the coral cells), though there are almost as many scleractinian corals that don't have zooxanthellae and live in deep, dark, and/or cold water or a few that live in shady locations on reefs. Those that have zooxanthellae are called "zooxanthellate" and those that don't are called "azooxanthellate." Most azooxanthellate species are small, many have only one polyp, but a couple of species that live on reefs are large enough to be reef builders). Most Scleractinia are attached to a hard surface, but a few like most of the mushroom corals are not attached. Most reef-building Scleractinia have multiple to many polyps and corallites, but a few are solitary, with only one polyp. For those that have many polyps, the colony is the individual, and polyps are modules not individuals. In a sense a polyp could be considered an individual, but the polyps in a colony are all connected together with continuous tissue. Further, all polyps are the same sex in a colony, all are genetically identical, and their digestive systems and nervous systems are connected. They reach sexual maturity when the colony reaches a minimum size, not when polyps reach a minimum size. They function and behave as a single individual with modular units, from which a piece can break off and regrow. Polyps vary greatly in size between species from less than 1 mm diameter to as large as 30 cm diameter, and they vary greatly in shape and other details. Colonies also vary greatly in shape and size, which is helpful in identification.

Pocillopora

This genus forms branching colonies covered with tiny bumps (verrucae) about 3 mm diameter and tall. The branches and the bumps are covered with tiny corallites where the polyps are, which are about 1 mm diameter.

Pocillopora aliciae very rare

This species forms branching colonies with branches that taper irregularly and have rounded ends. Unlike other species of *Pocillopora* this species has no small bumps (verrucae). This species is very rare in Nauru.



A colony of *Pocillopora aliciae*.

Pocillopora meandrina uncommon

This species had branches with laterally flattened ends which may also be curved. It is the same size as *Pocillopora verrucosa*, which has cylindrical branches, and smaller than *Pocillopora grandis*, which can have either flattened or cylindrical branches.

A colony of *Pocillopora meandrina*.

Pocillopora verrucosa uncommon

Colonies of this species are branching and usually 30 cm or less in diameter. Like all *Pocillopora*, the branches are covered with little bumps. The branches are about 3-4 cm in diameter, and the bumps are only about 2-3 mm diameter. Most of the branches are cylindrical or nearly so. It is present at most sites and is usually uncommon. It is usually brown but sometimes green. *Pocillopora meandrina* has flattened and/or curved branch ends, and *Pocillopora grandis* has larger branches. Branches on *Pocillopora setchelli* are closer together.

A brown colony of *Pocillopora verrucosa*.

A green colony of *Pocillopora verrucosa*.

Pocillopora setchelli uncommon

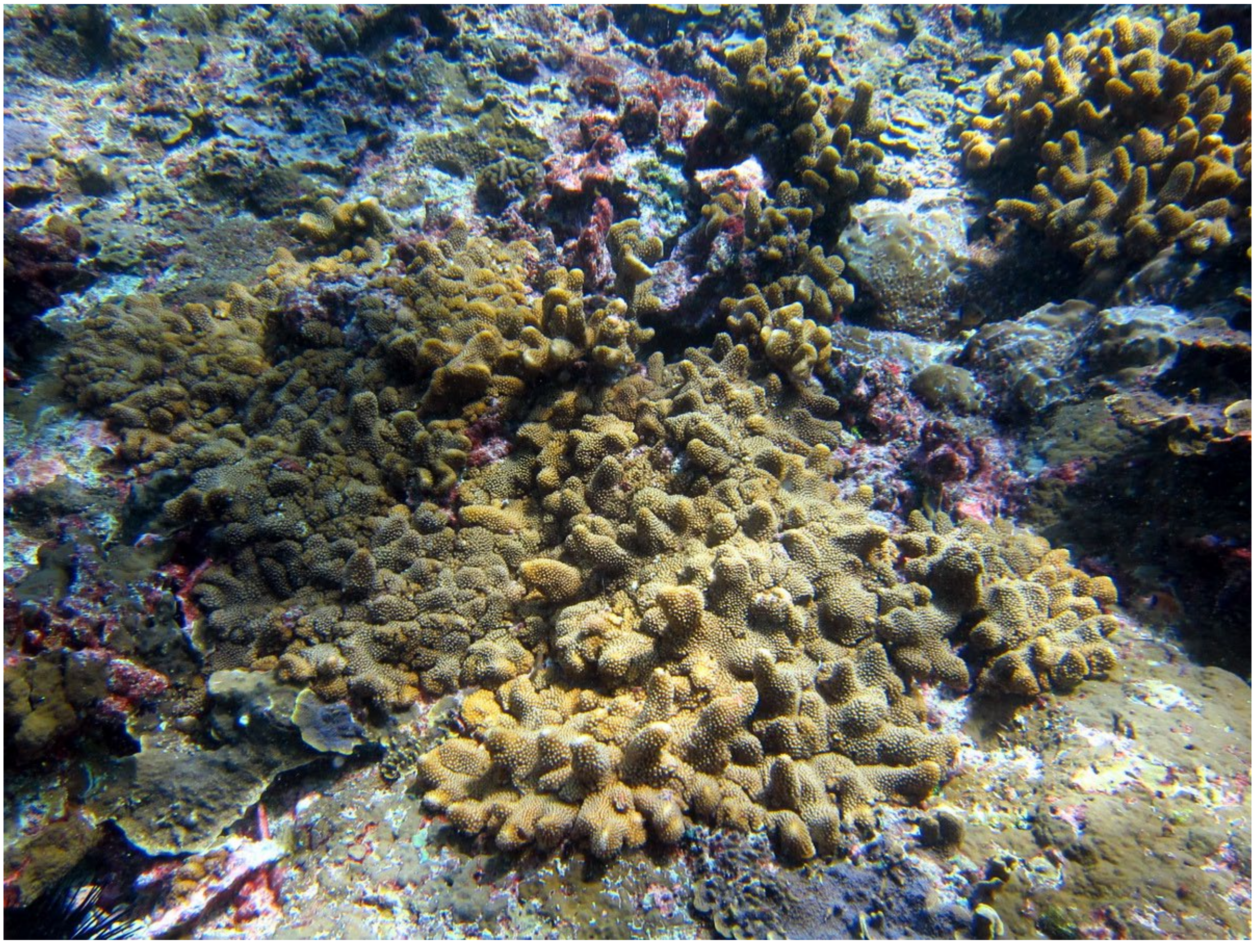
This species forms small branching colonies with cylindrical branches much like *Pocillopora verrucosa*, but with the branches very close together. Other colonies have some laterally flattened branches more like *Pocillopora meandrina*, but again the branches are close together.

This colony of *Pocillopora setchelli* has branches very close together.

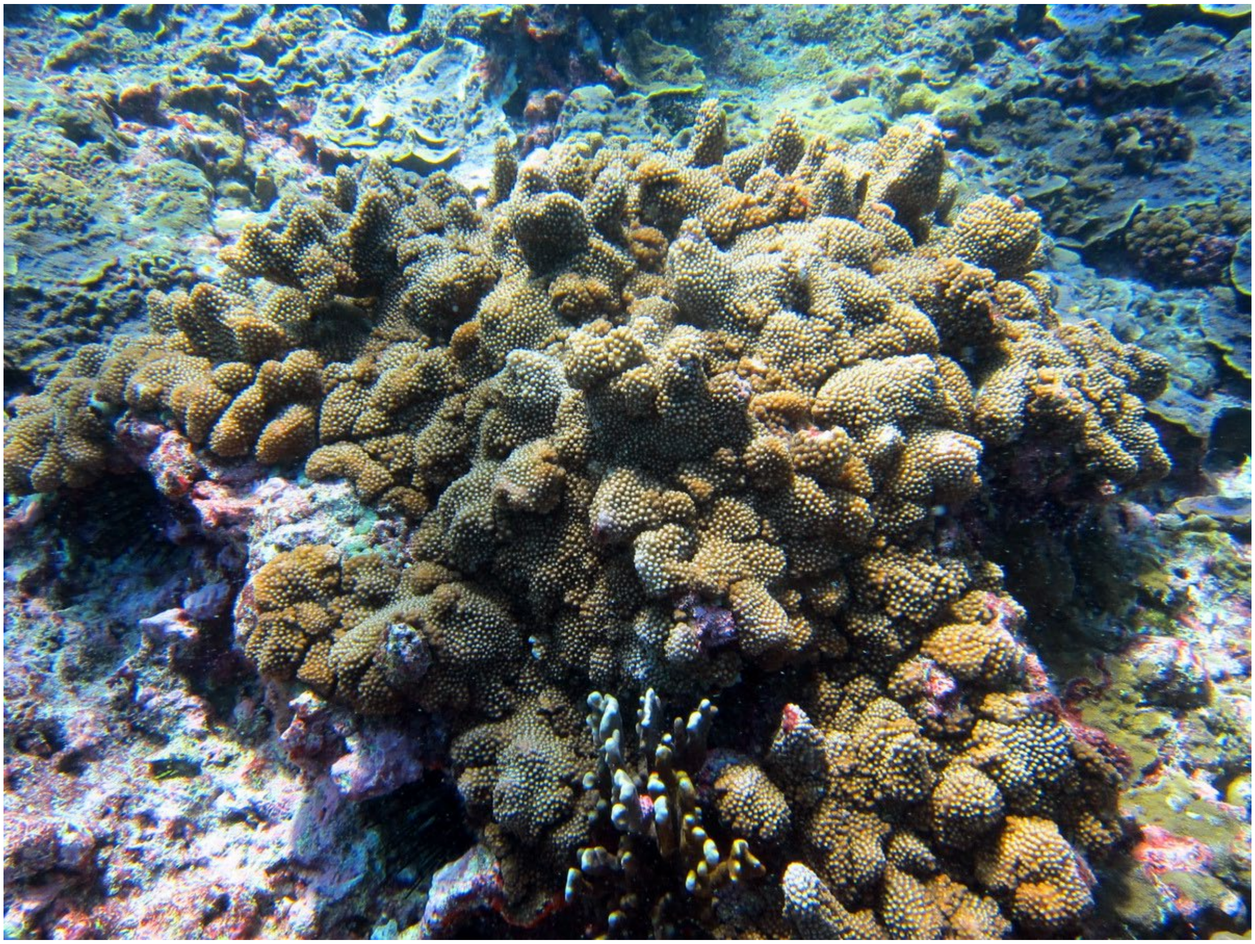
This colony of *Pocillopora setchelli* has some slightly laterally flattened branches. Branches are close together.

Pocillopora fungiformis uncommon Endangered (Red List), EDGE

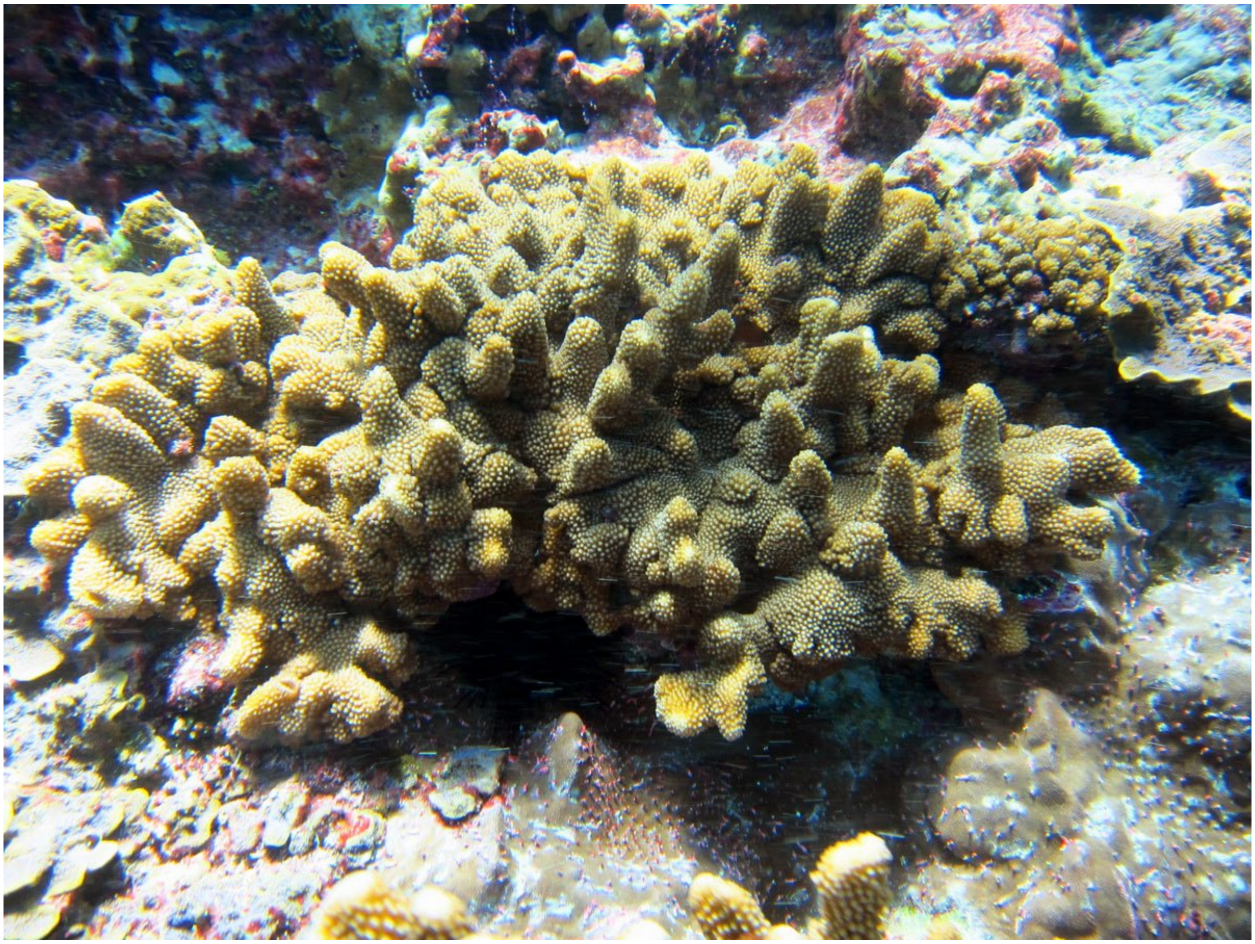
Colonies are encrusting, with bumps and/or short, rounded irregular branches. There are often cracks in the colony. This is a rarely reported species. Branches are shorter than in all other *Pocillopora* species.



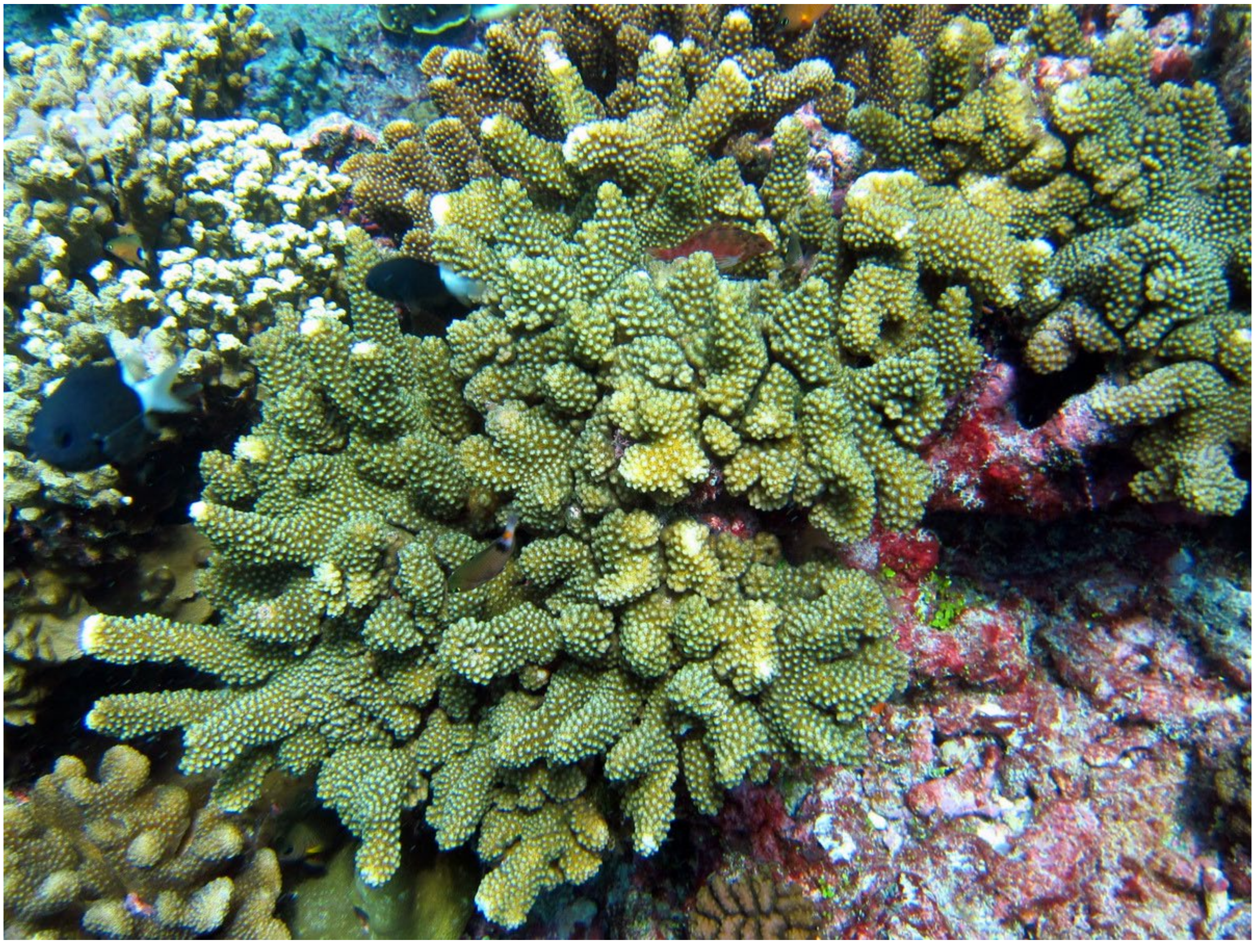
An encrusting colony of *Pocillopora fungiformis* with bumps and short irregular branches.



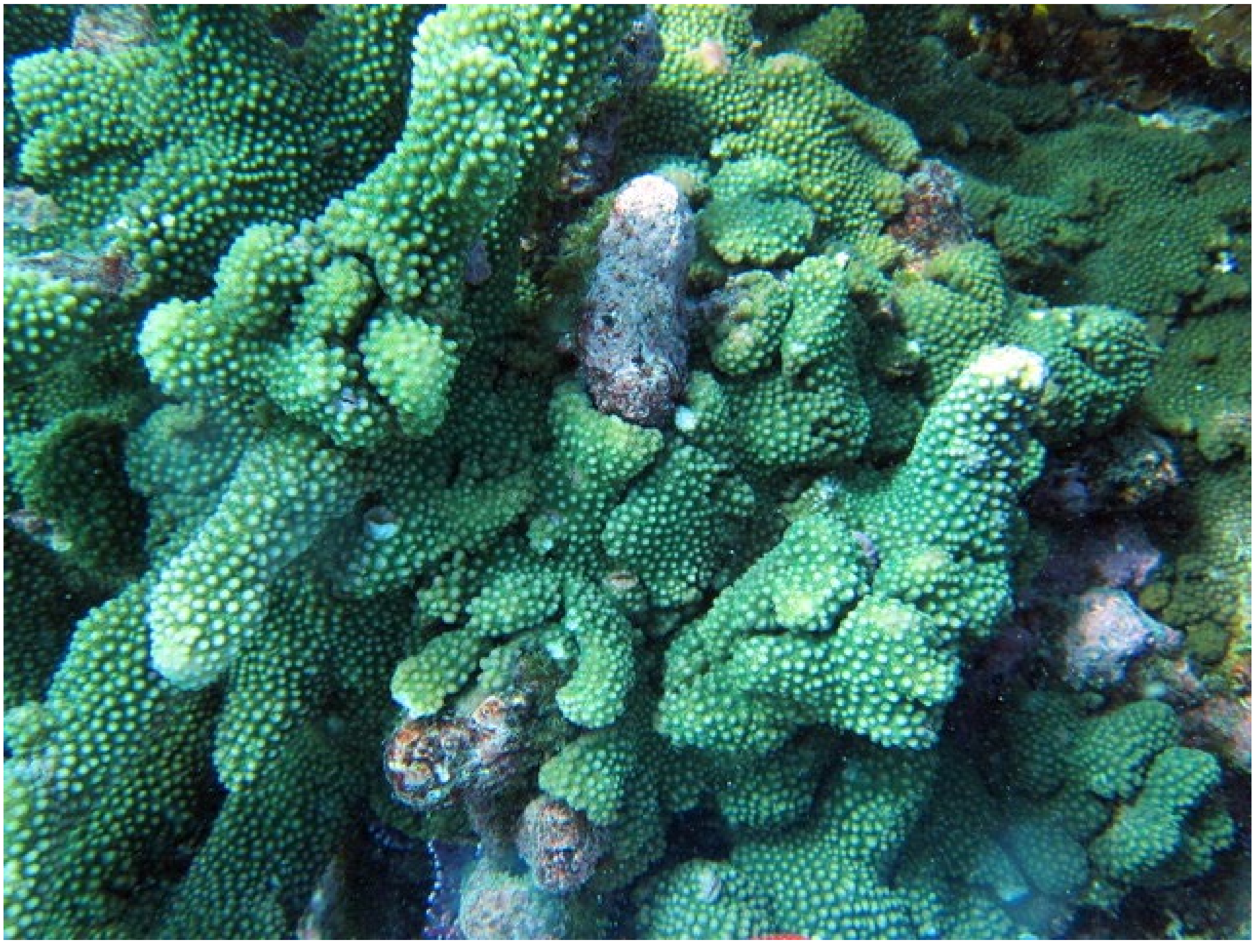
This is a lumpy colony of *Pocillopora fungiformis* with some short irregular branches.



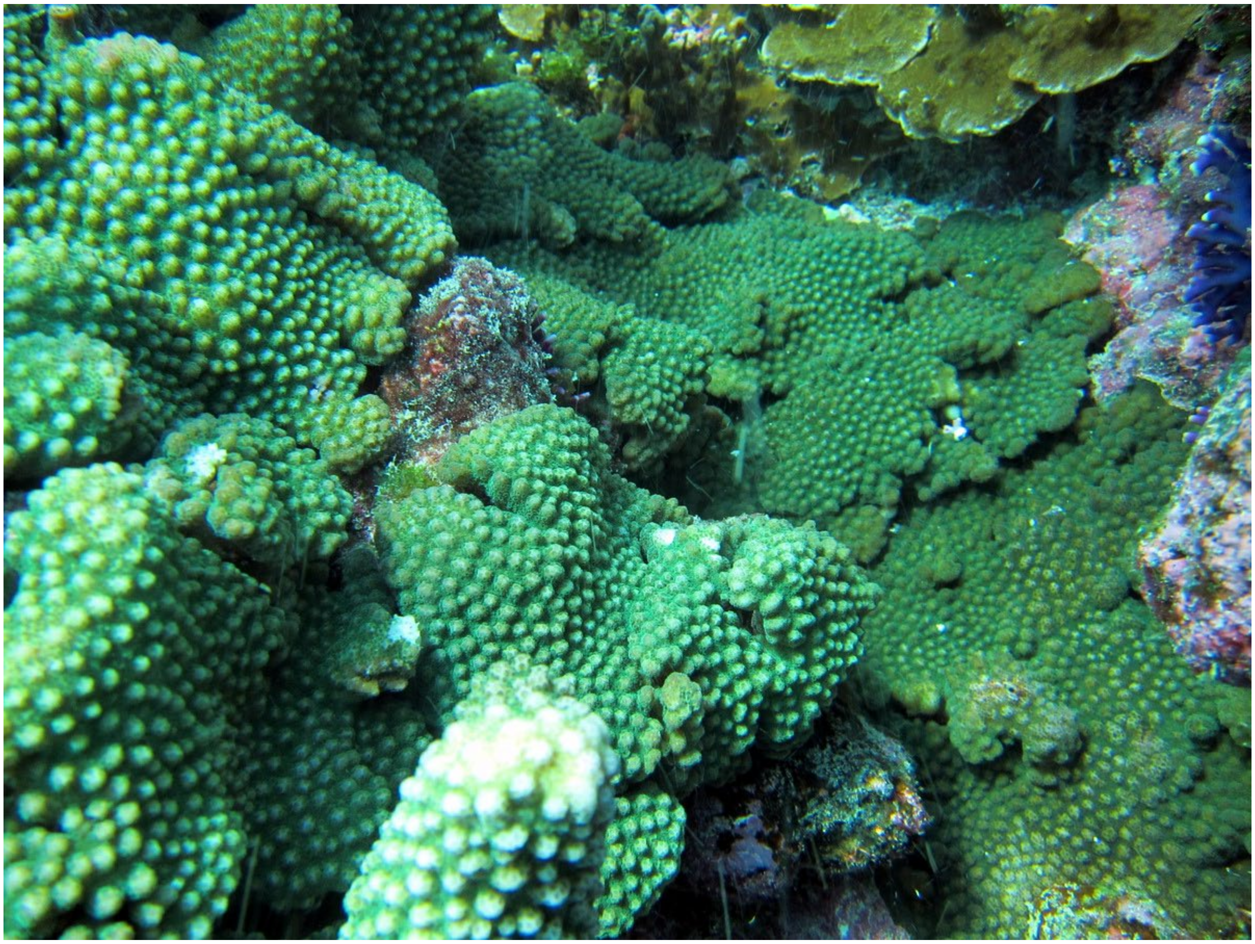
A colony of *Pocillopora fungiformis* with slightly taller and more regular branches, which are well spaced out.



A green colony of *Pocillopora fungiformis*, with some longer branches. Cracks in the colony can be seen.



A closer photo of a colony of *Pocillopora fungiformis* showing cracks and irregular branches.

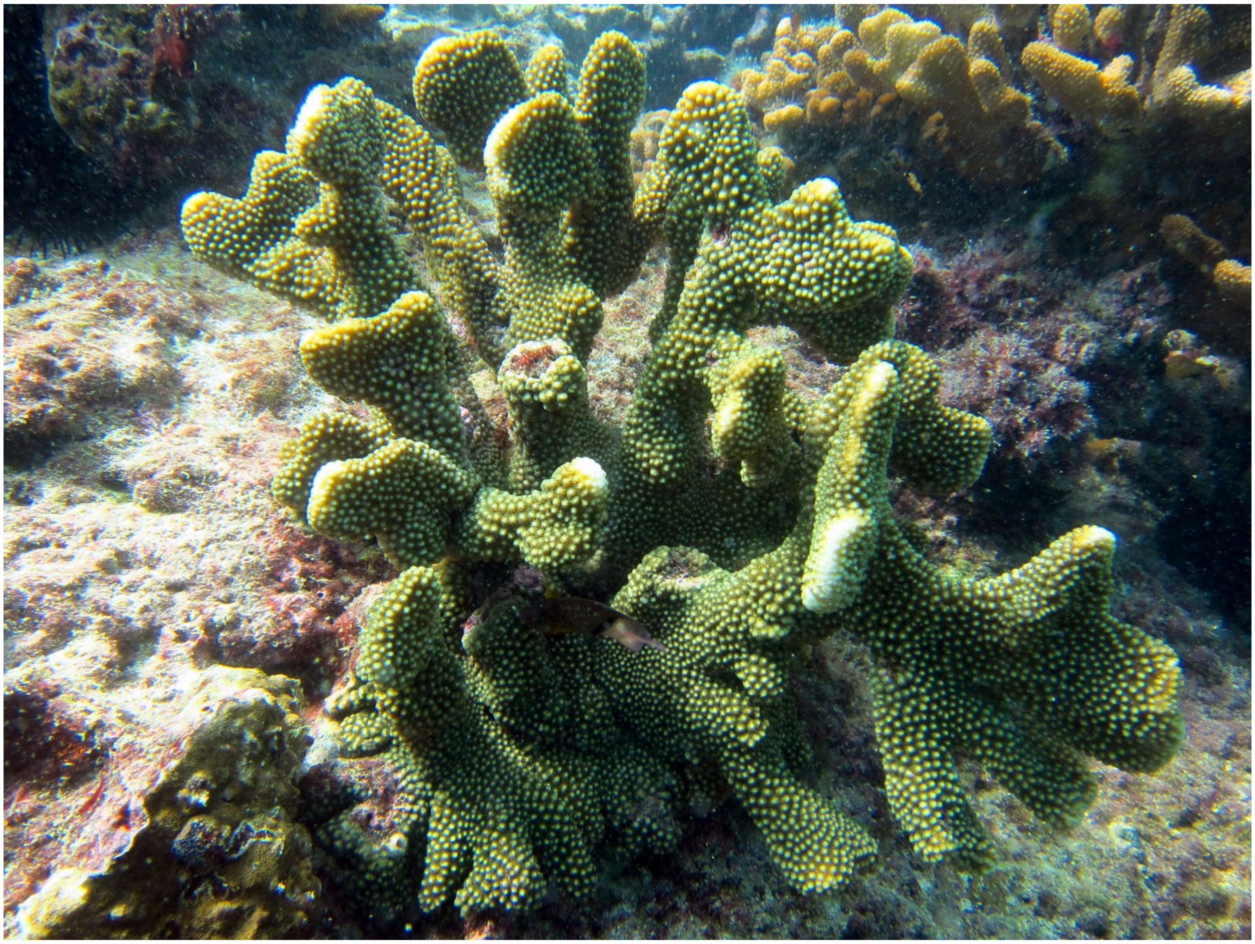


A close-up photo of a colony of *Pocillopora fungiformis*, showing encrusting areas and some cracks.

Pocillopora grandis *common* *This used to be called Pocillopora eydouxi*

This species forms larger colonies with larger branches that are more widely spaced than on *Pocillopora meandrina* or *Pocillopora verrucosa*. Usually branches are flattened sideways and may be curved, but sometimes they are cylindrical. Many colonies look like larger versions of *Pocillopora meandrina*.

A colony of *Pocillopora grandis* with cylindrical branches.



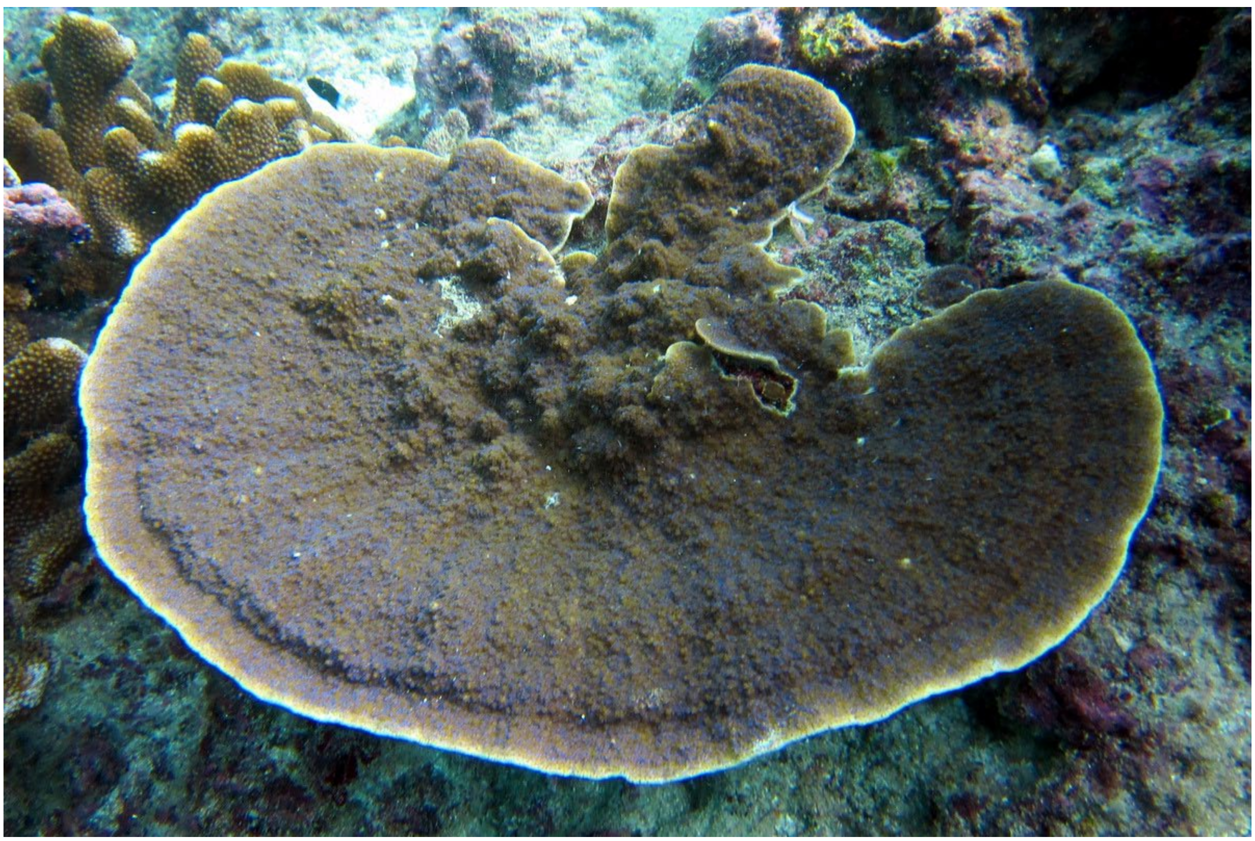
A colony of *Pocillopora grandis* with large, flattened, widely separated branches.

Montipora

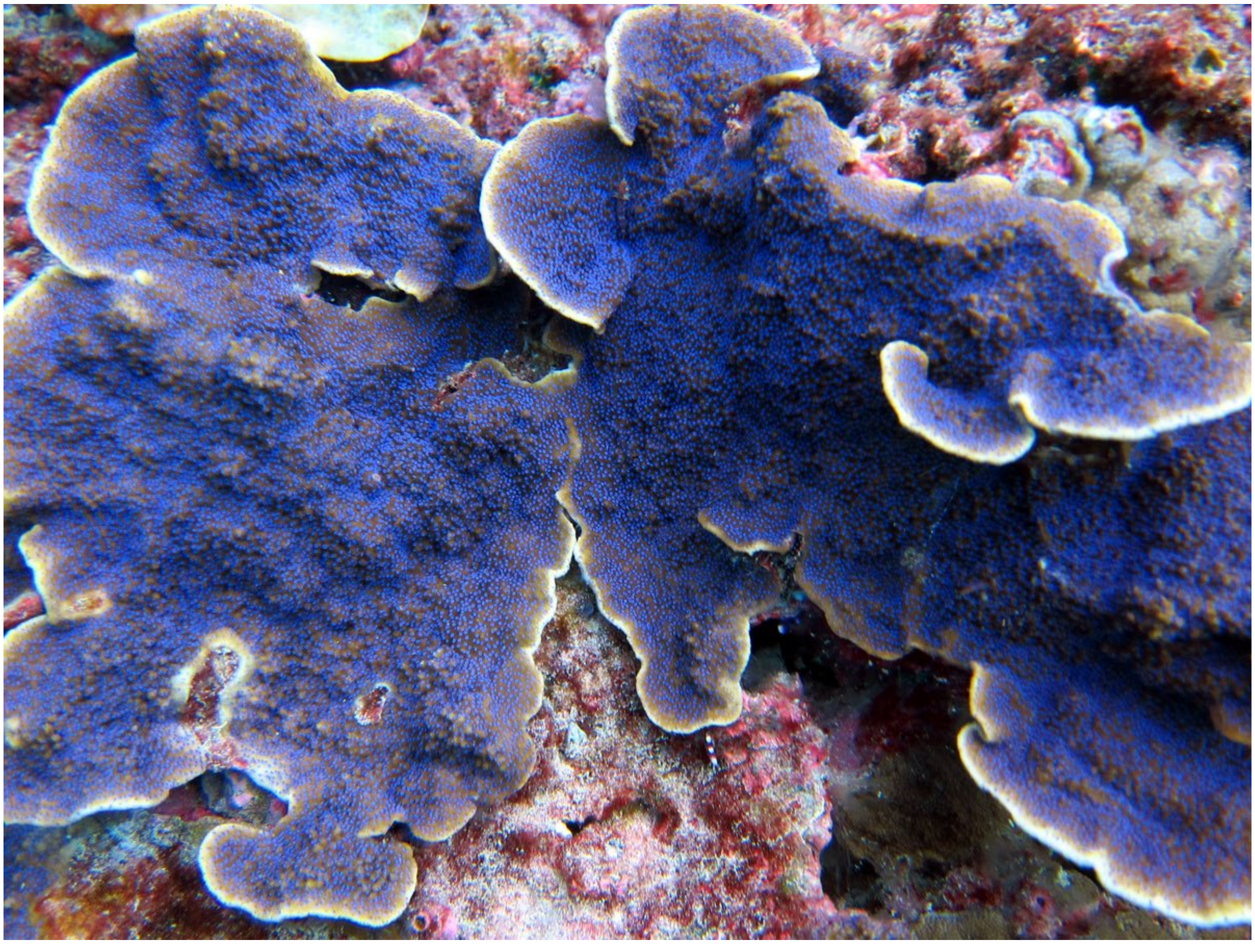
This genus forms corals in a variety of shapes, with encrusting and plate colonies among the more common shapes. Most species have tiny or small bumps, spines, or ridges on them, as well as corallites that are about 1 mm diameter.

Montipora cf. grisea common

This species grows as thin plates, with a central encrusting area that is attached to the substrate. The corallites are tiny as is typical of *Montipora*, and may project from the surface, but there are no ridges or bumps. There are tiny spines on the surface, though they are small enough they are difficult to see. Colonies are usually brown but may have purple polyps. This species lives on the upper reef slope down to about 5 m depth. *Montipora nodosa* is encrusting and nodular. *Montipora tuberculosa* has larger spines.



This is a thin plate colony of *Montipora* cf. *grisea*.

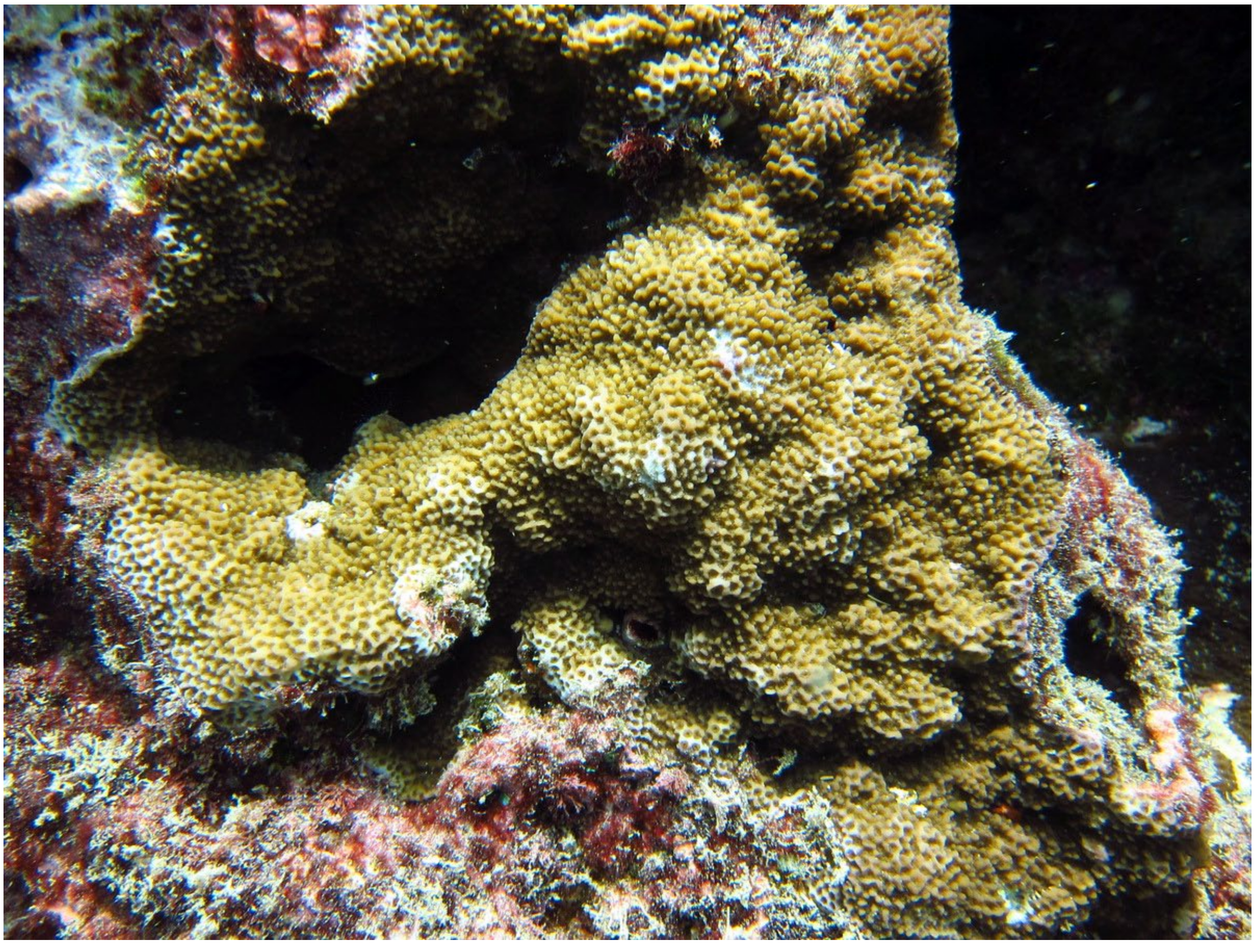


This colony of *Montipora* cf. *grisea* is partly encrusting and partly thin plate edges. The purple spots are the polyps.

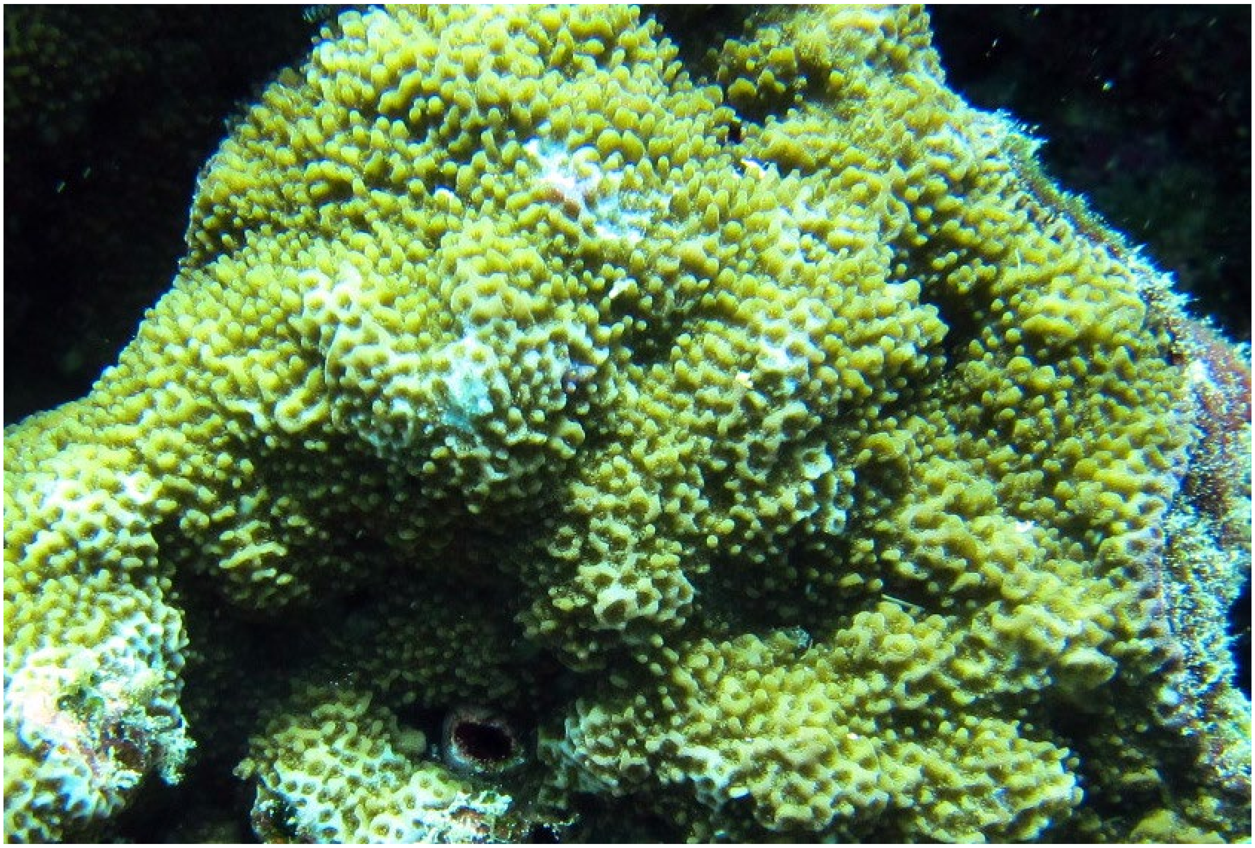
This is a close up photo of a plate colony of *Montipora* cf. *grisea*. On this colony, some of the corallites project upward from the rest of the colony.

Montipora tuberculosa uncommon

This encrusting species has tiny columns or bumps on its surface, about the same diameter as the corallites, about 1 mm diameter. They are uniform in shape and size, except in some areas they fuse together and surround corallites, which are as a result, recessed. Colonies are usually light brown or green. *Montipora grisea* and *Montipora nodosa* have smaller spines.



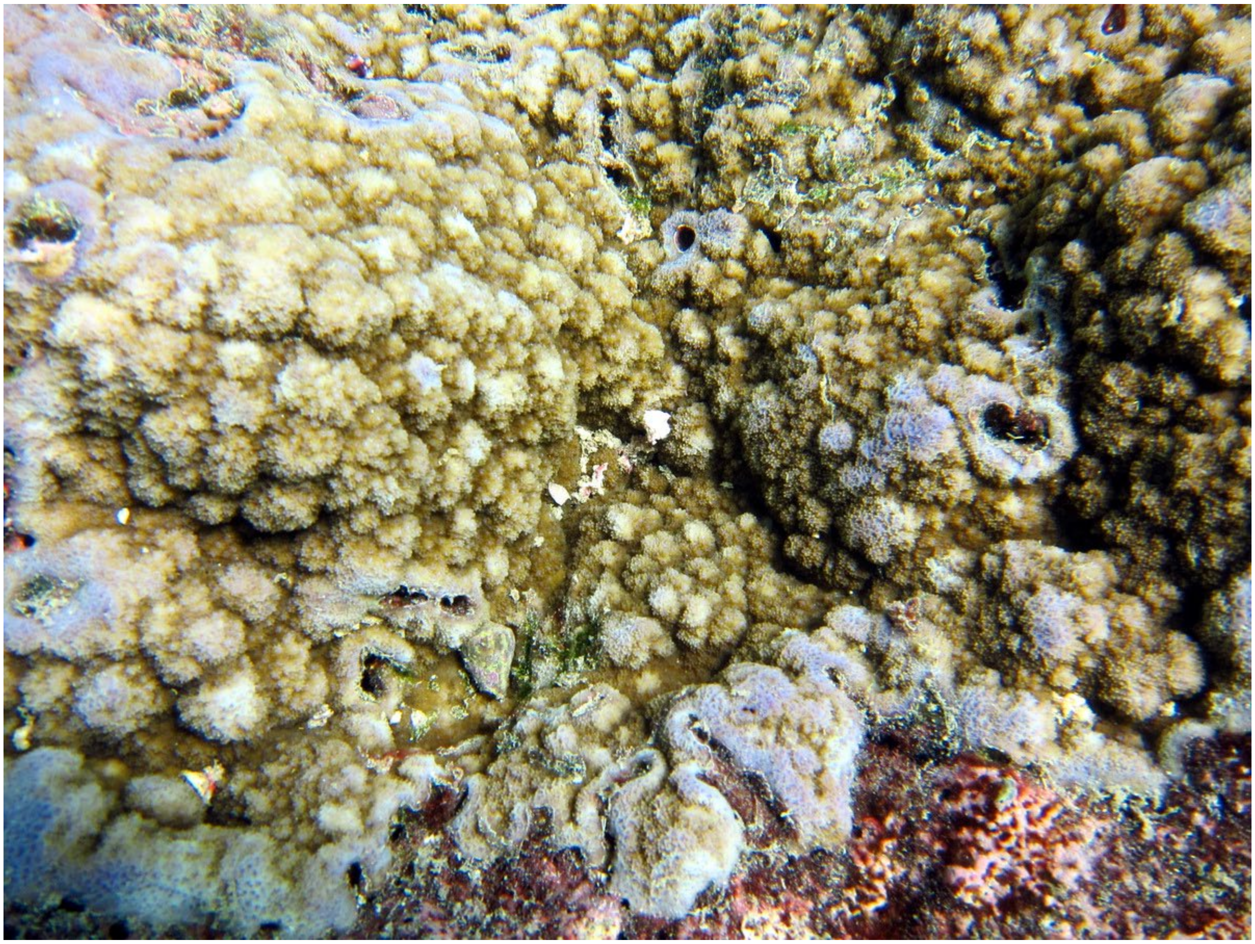
A colony of *Montipora tuberculosa*, which is encrusting and has tiny peg-shaped projections. In some areas these fuse to surround corallites which are then recessed.



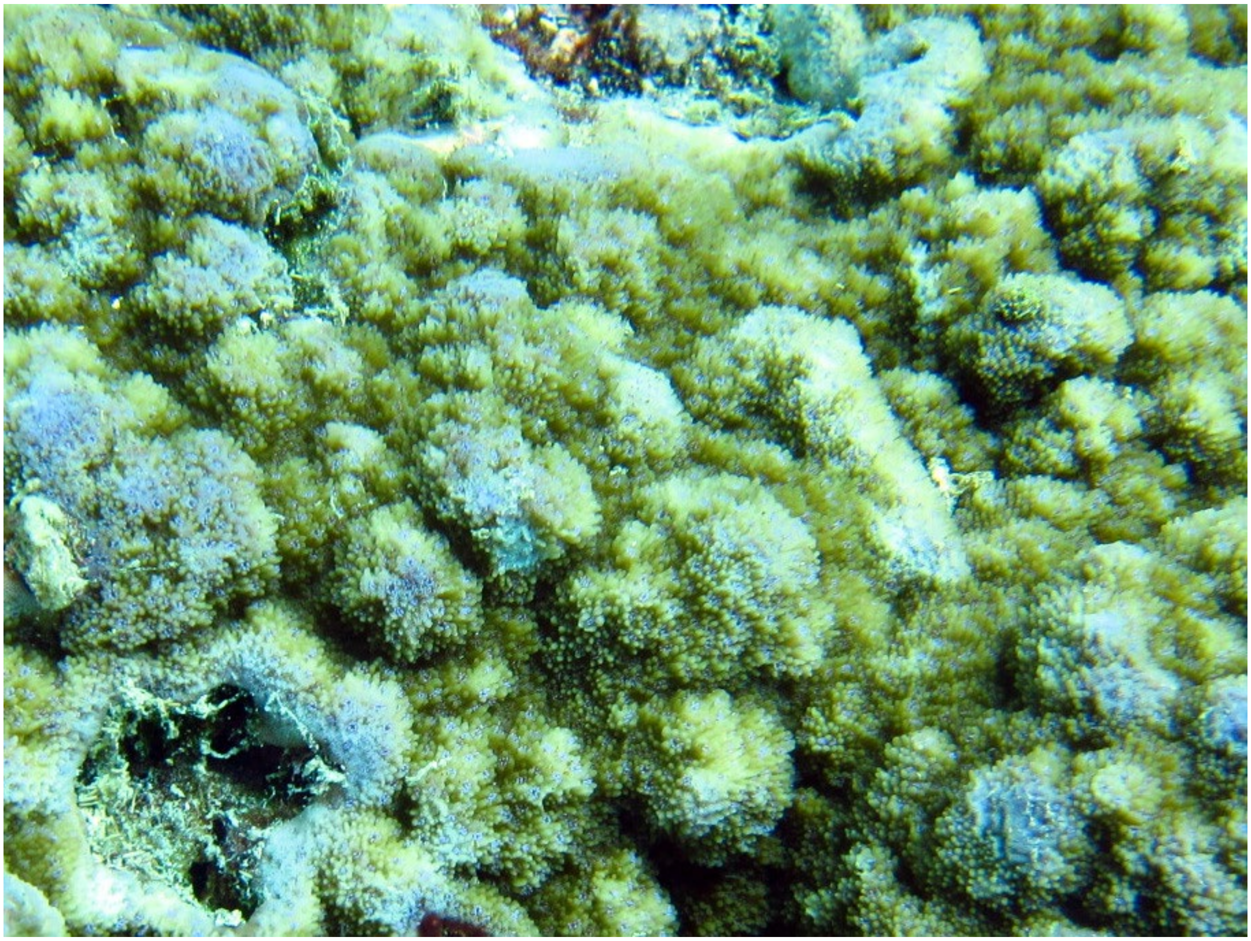
A magnified photo of a greenish colony of *Montipora tuberculosa*.

Montipora nodosa rare

This species is encrusting and has many rounded bumps or nodules on it. In addition, there are tiny spines on the nodules and in between them. Colonies are brown or green. *Montipora* cf. *grisea* is not nodular, *Montipora tuberculosa* has larger spines.



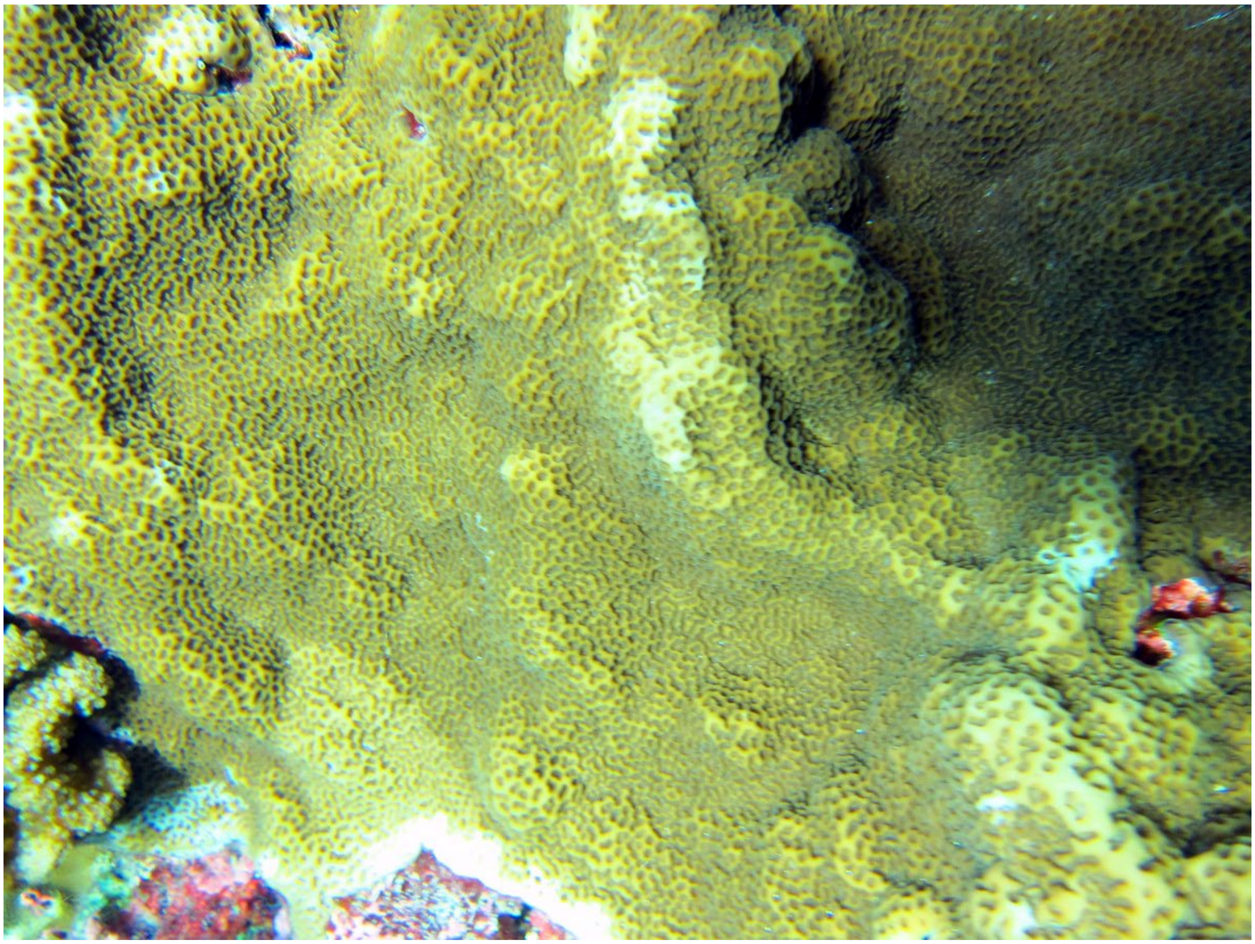
This colony of *Montipora nodosa* has many nodules on it of various sizes.



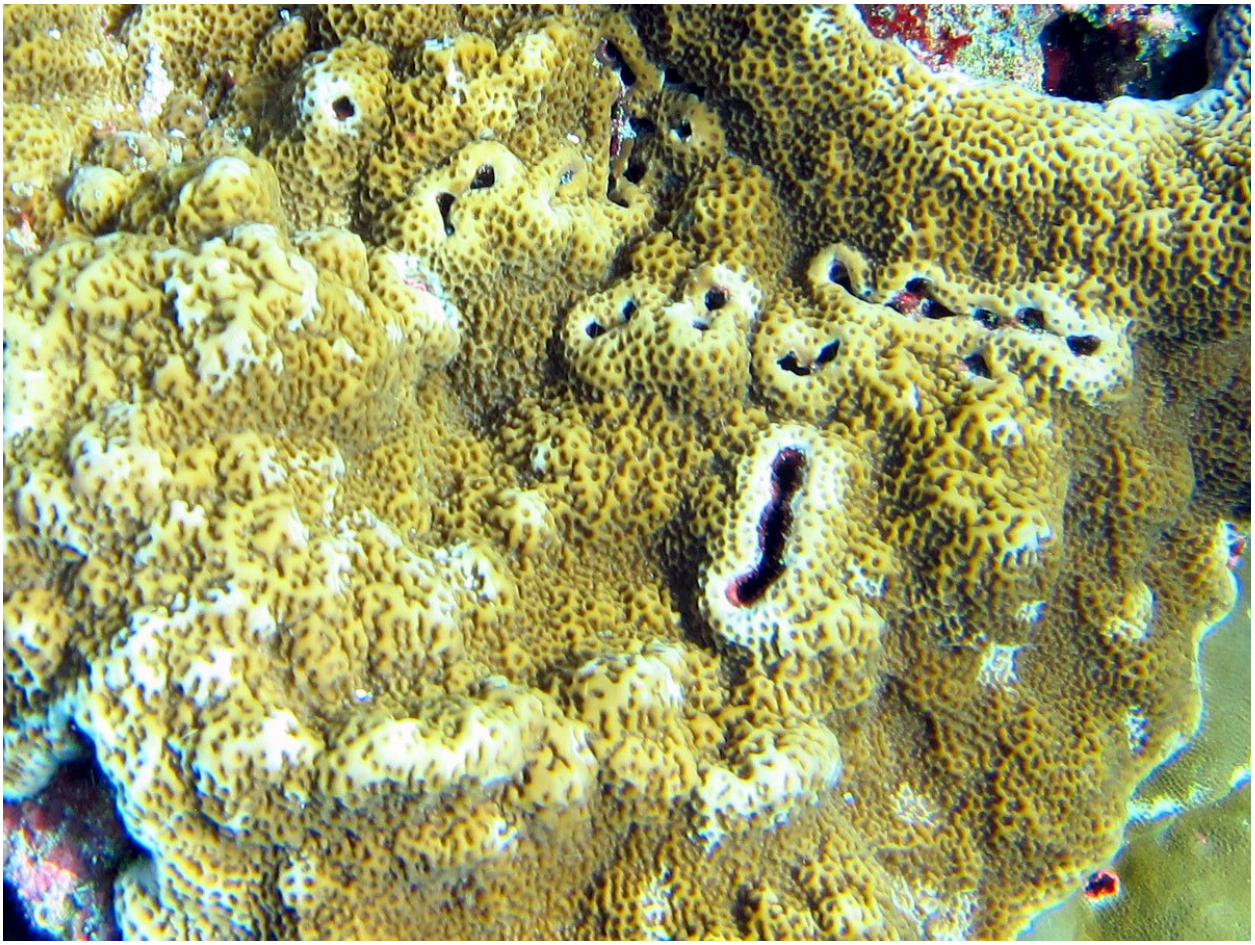
This is a magnified photo of a green colony of *Montipora nodosa*, in which tiny spines can be seen both on and between nodules.

Montipora venosa rare

This species forms encrusting colonies which have corallites recessed into their surface. The corallites look like they are deep in the surface of the colony. There are no spines or peg-like bumps. Colonies are green-brown or brown. Most *Montipora* do not have recessed corallites. *Montipora foveolata* has more deeply recessed corallites.



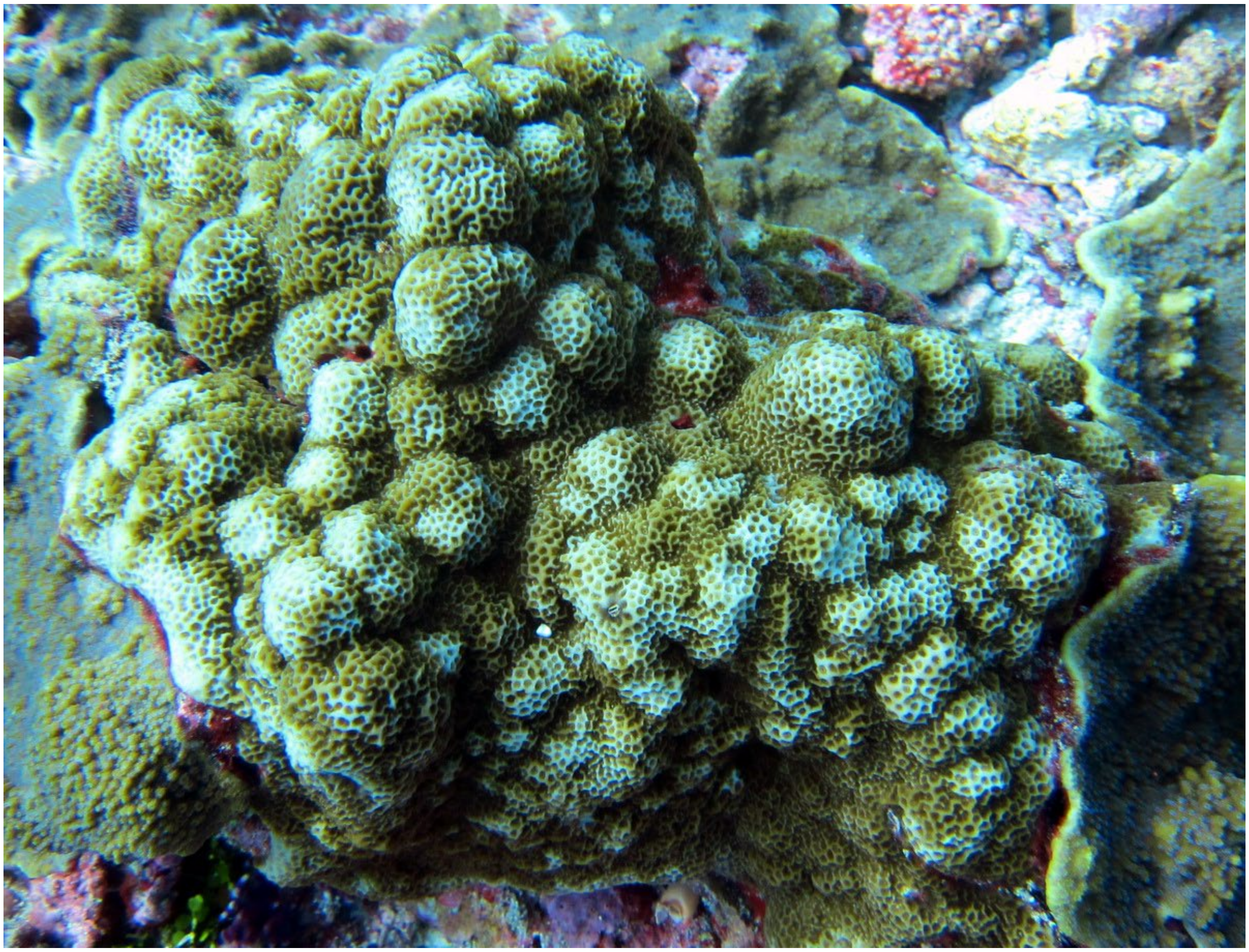
This colony of *Montipora venosa* has corallites recessed into the surface.



This colony of *Montipora venosa* also has recessed corallites, however, in some areas the recessed corallites are in rows in grooves, and in other areas the surface between corallites is wide and smooth. This may be another, similar species.

Montipora foveolata

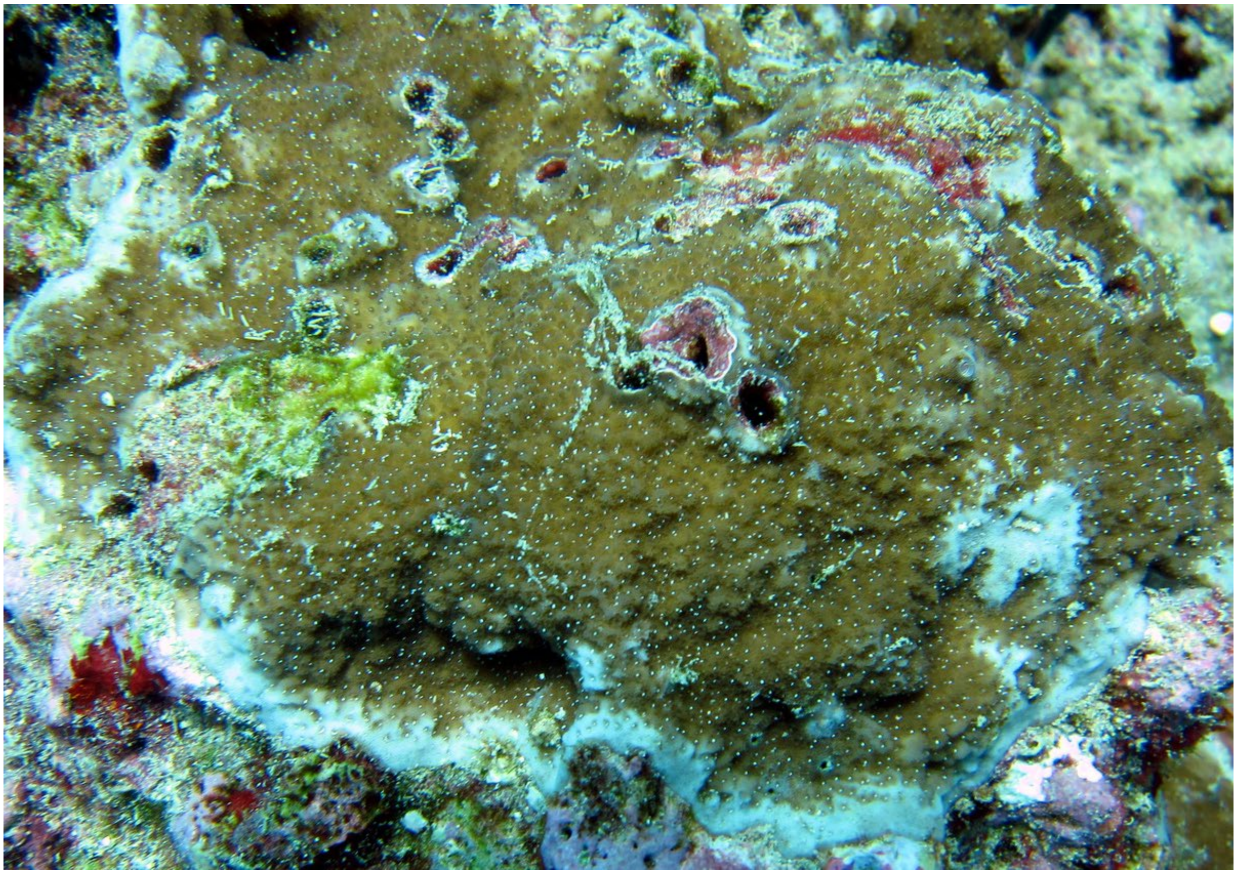
This species forms encrusting or dome-like colonies. The corallites are deeply recessed between thin ridges and there are no spines or bumps. This species has the most deeply recessed corallites of any *Montipora* species.



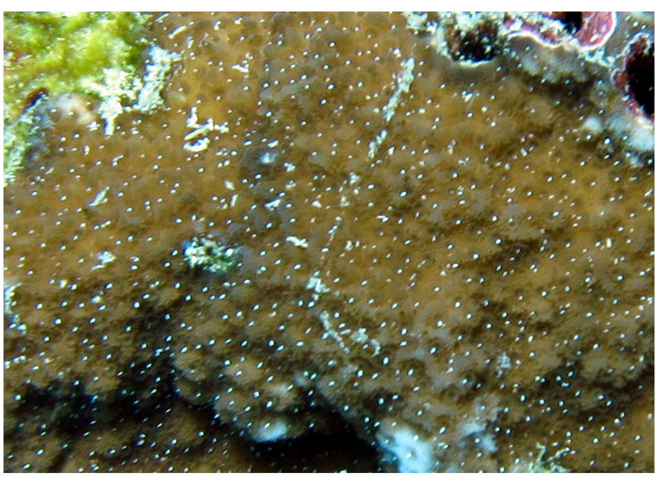
This colony of *Montipora foveolata* has deeply recessed corallites that are surrounded by a thin ridge that separates corallites.

Montipora floweri very rare

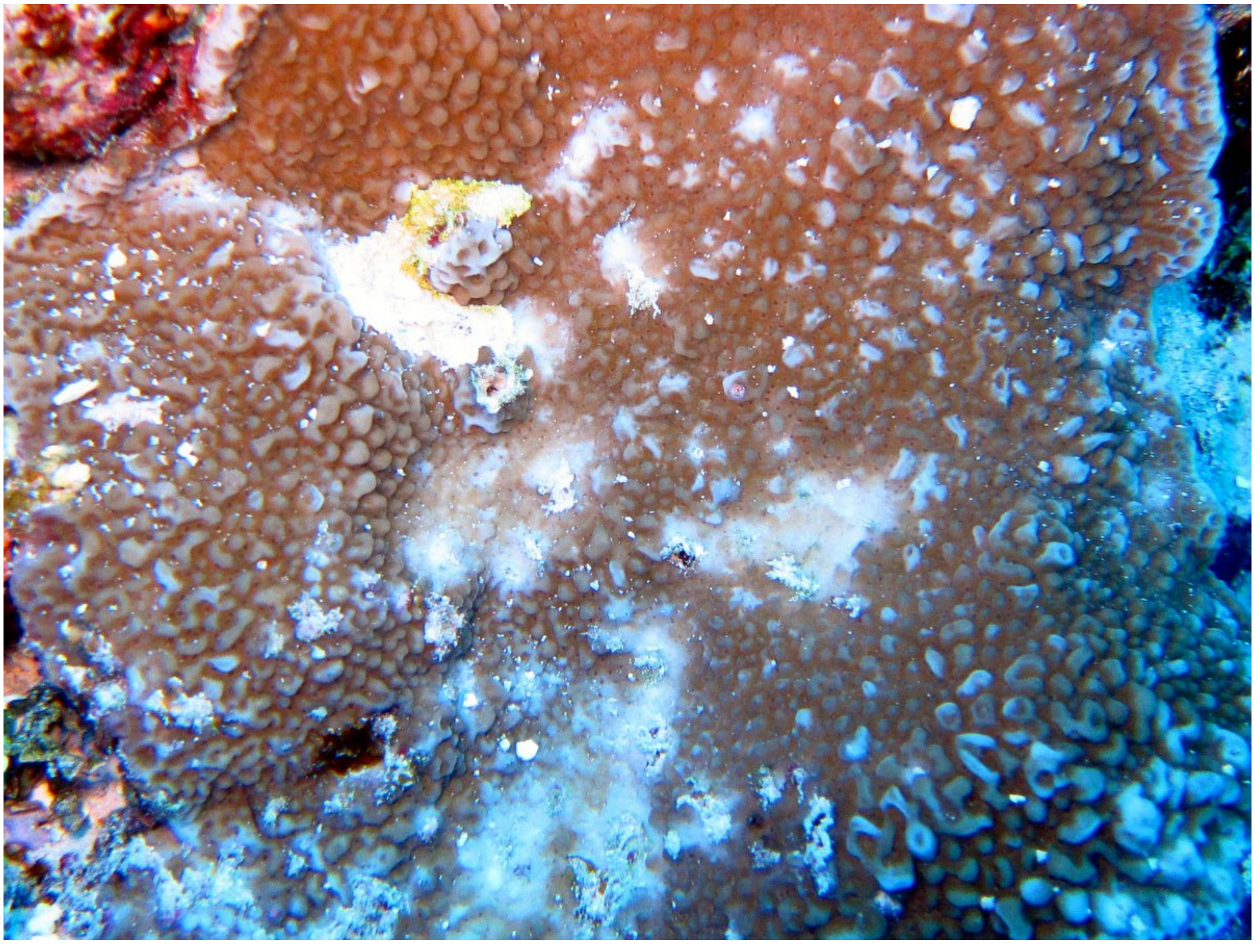
This encrusting species has small rounded lumps and corallites are both between lumps and on them. Colonies are brown. This species does not have spines like most *Montipora*.



This colony of *Montipora floweri* has corallites (white dots) both on and between the small lumps.



This is a slightly magnified view of the bumps and the corallites.



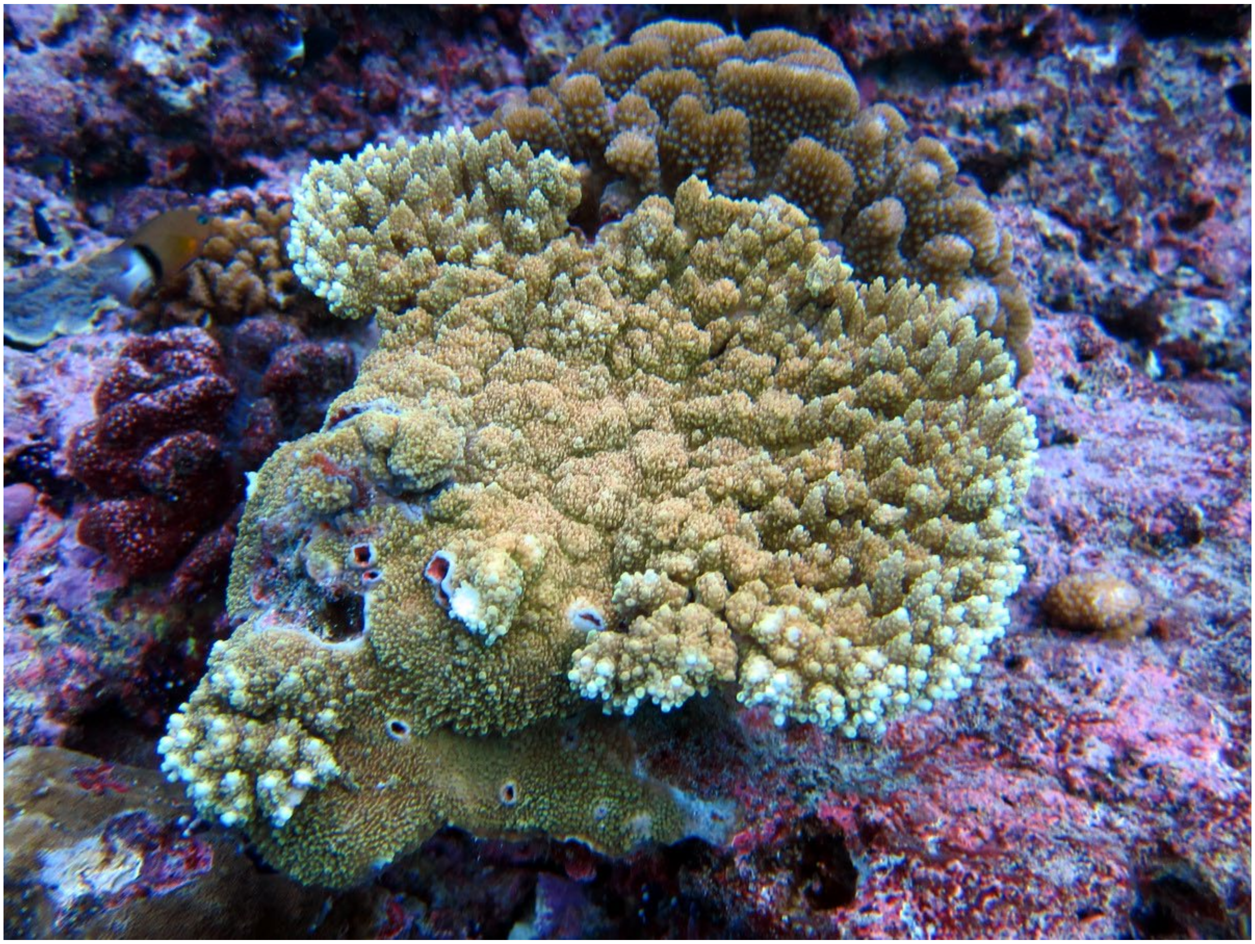
This is another colony of *Montipora floweri*, with lumps that have corallites on them as well as between them.

Acropora

This genus forms branching colonies, with one corallite on the end of each branch, and many corallites on the sides of branches. The corallite on the end of the branch is often different from the ones on the sides of the branches. No other coral genus has those features. *Acropora* comes in several major colony shapes. Some species have cylindrical tapering branches that look like deer horns, and so are called “staghorns.” Others called “digitate” are encrusting with finger-sized and shaped branches growing upward, which have few side branches. Others called “table corals” produce table-like colonies with a central column holding up a flat table top like structure. This is the largest genus of corals, with at least 165 species known presently, almost all in the Indo-Pacific. In addition to being the most diverse coral genus, it also is often abundant or dominant on reefs, making it very important for the ecology of reefs. Some species are fast-growing, able to add up to 10 cm on the ends of branches per year. However, they are among the most subject to hurricanes, high temperature bleaching, disease, and crown-of-thorns starfish.

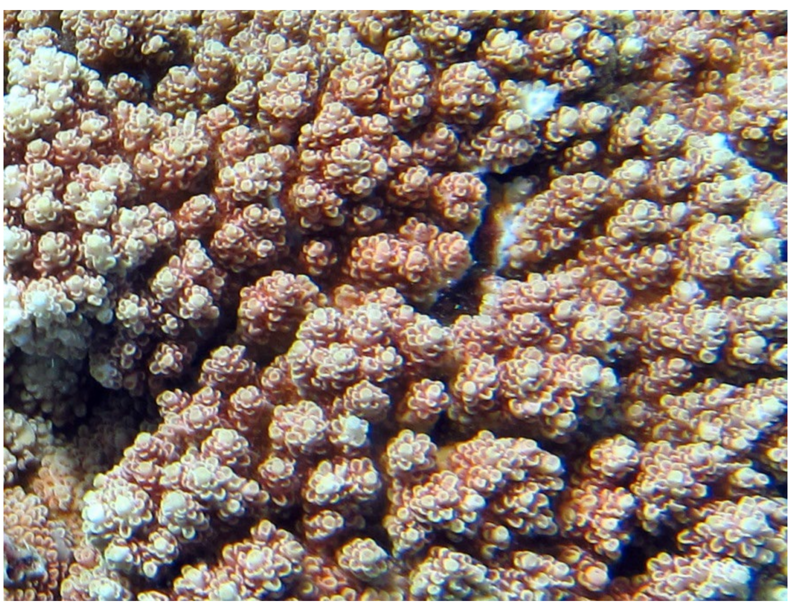
Acropora hyacinthus rare

This species forms “table” corals. As a very young colony grows by division of the first polyp into two and then subsequent divisions of polyps produce more and more polyps, it spreads out as an encrusting colony. When it reaches a size of around 10-30 cm diameter, then the center of the colony begins growing upward, forming a stalk. When it reaches a height of about 10 cm, it stops growing upward and starts to grow outward at the upper edge. The outward growing upper edge forms a nearly flat, thin table top as it grows. Large colonies can reach several meters in diameter and sometimes have one or two smaller tables grow upward from their surface. At the time the team was there, only three young colonies were observed, but one larger table was reported on the upper reef slope near the harbor entrance. The upper surface of colonies are covered with small, vertically pointing branchlets. The branchlets taper near their tip, and the sides of the branchlets are rough with polyp cups (corallites). This is the only table-forming species yet found in Nauru.



A young *Acropora hyacinthus* colony. Part of the encrusting base can be seen on the lower left.

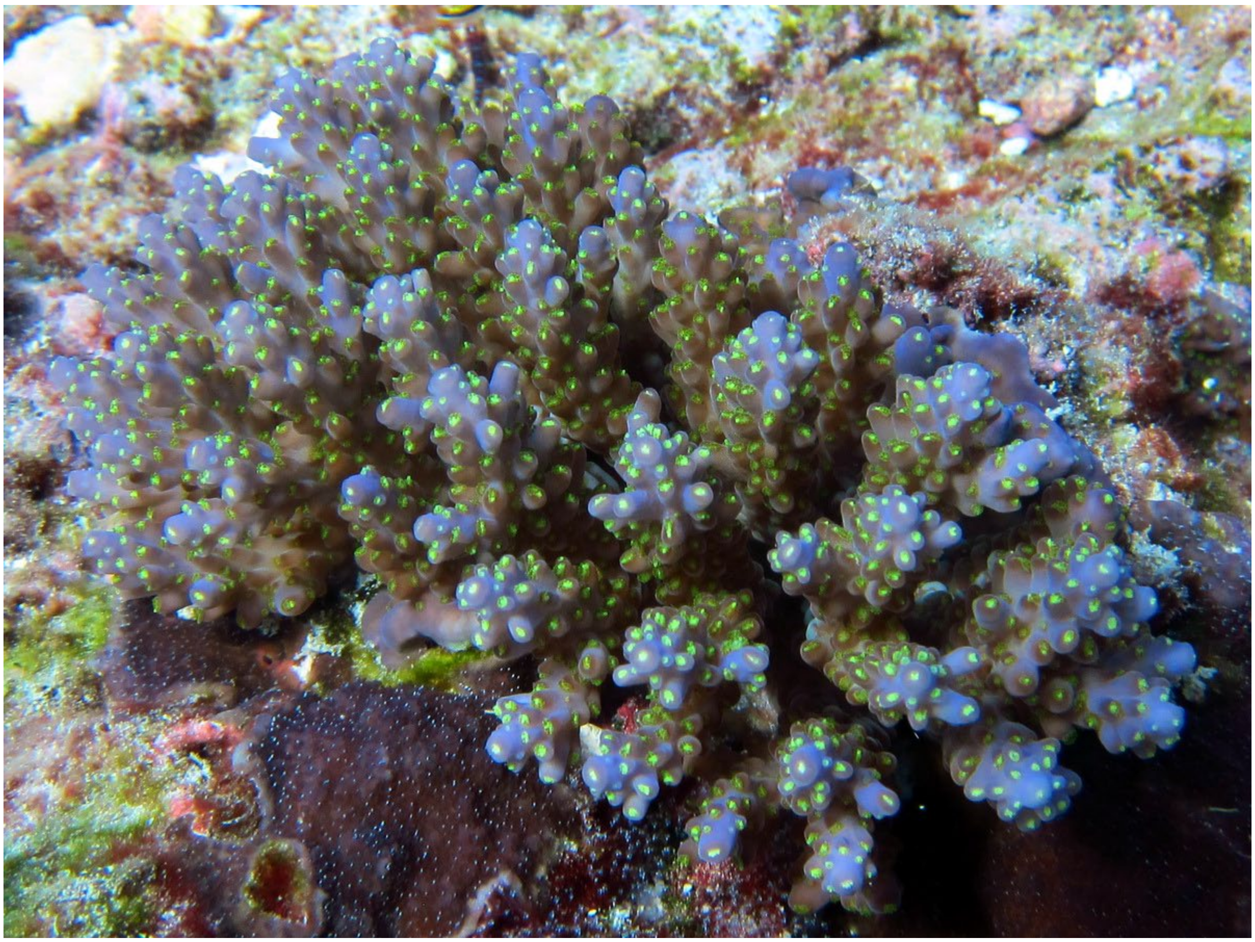
Another small *Acropora hyacinthus* colony.



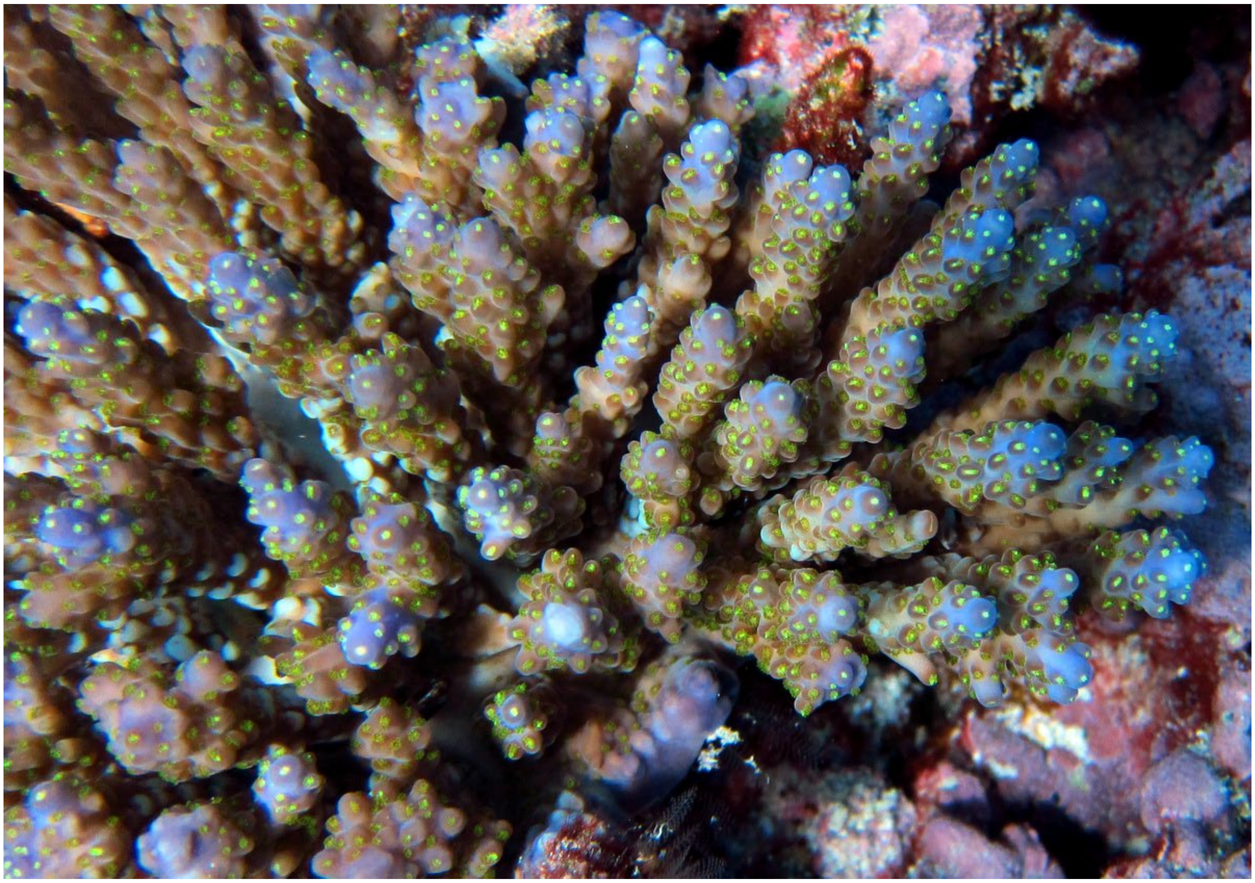
In this magnified view, the branchlets can be seen with the corallites on their sides.

Acropora valida rare

This species forms small bushes composed of small radiating branches. The polyp cups (corallites) on the sides vary from strongly inclined towards the branch end and fused to the branch to longer tubes radiating irregular lengths from near the tip of the branch. The corallite on the end of the branch is tubular and not large. At Nauru this species is usually purple with yellow green in the center of corallites. Corallites on the sides of the branches of *Acropora nana* diverge more from the branch. This is the only branching species in Nauru with purple branch tips.



This is a small colony of *Acropora valida*.

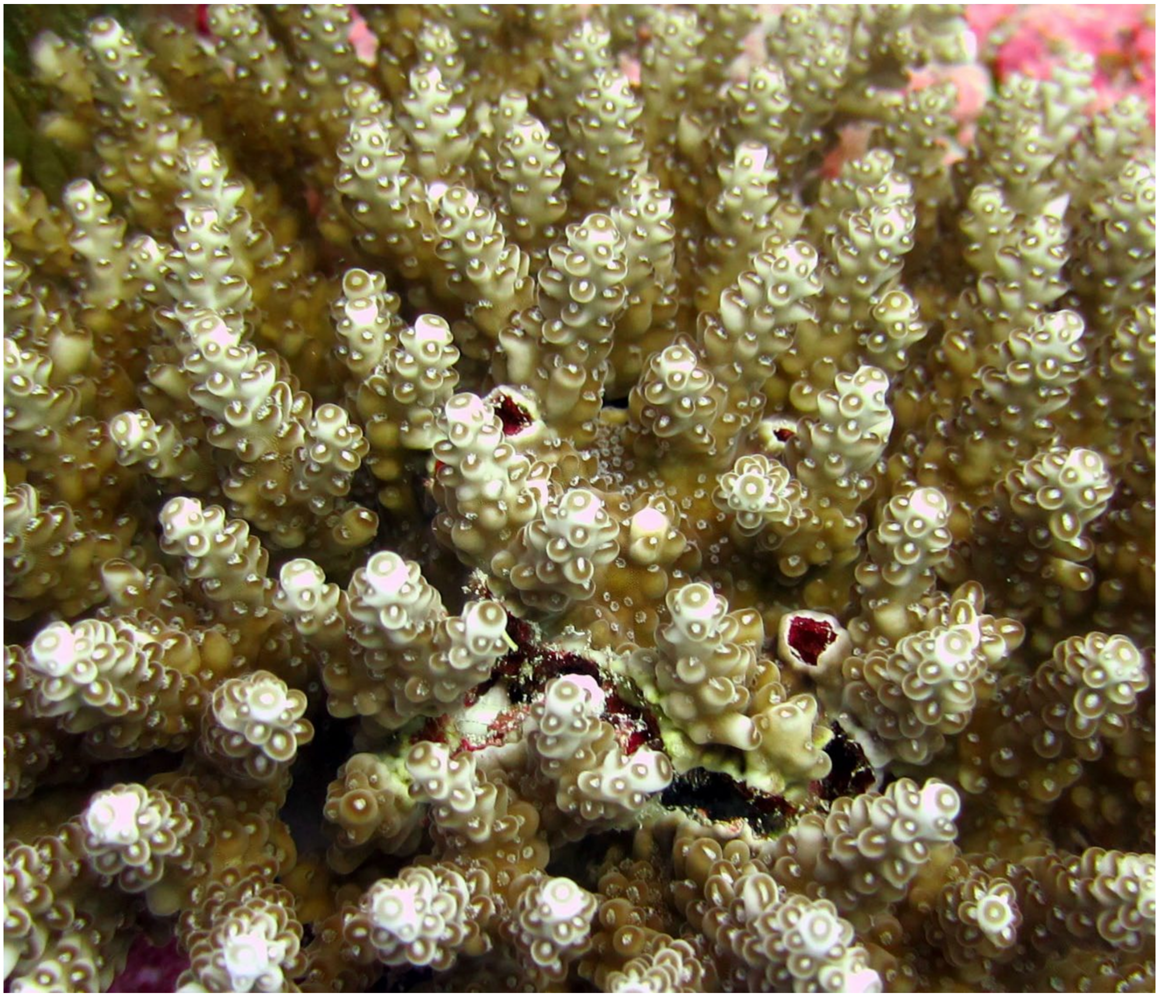


This colony of *Acropora valida* has slightly larger axial corallites (on the ends of branches), very few tubular radials (on sides of branches) and mostly small, uniform radial corallites.

Acropora cf. quelchi

This species forms small colonies with radiating uniform branches with few if any side branches. Branches are about the diameter of a pencil or small finger. Branches do not taper and are straight. The corallites on the tips of branches are short and have fairly thick walls. The corallites on the sides of branches are short and a bit shelf-like. They have thick walls. Colonies have a distinctive coloration, with a white center of each polyp with a brown ring around it. No other species in Nauru has that coloration. This is a rare species found on the upper reef slope. This species has a white spot in the center of each corallite (which is the polyp) surrounded by a brown ring, which no other species has.

A colony of *Acropora* cf. *quelchi*.

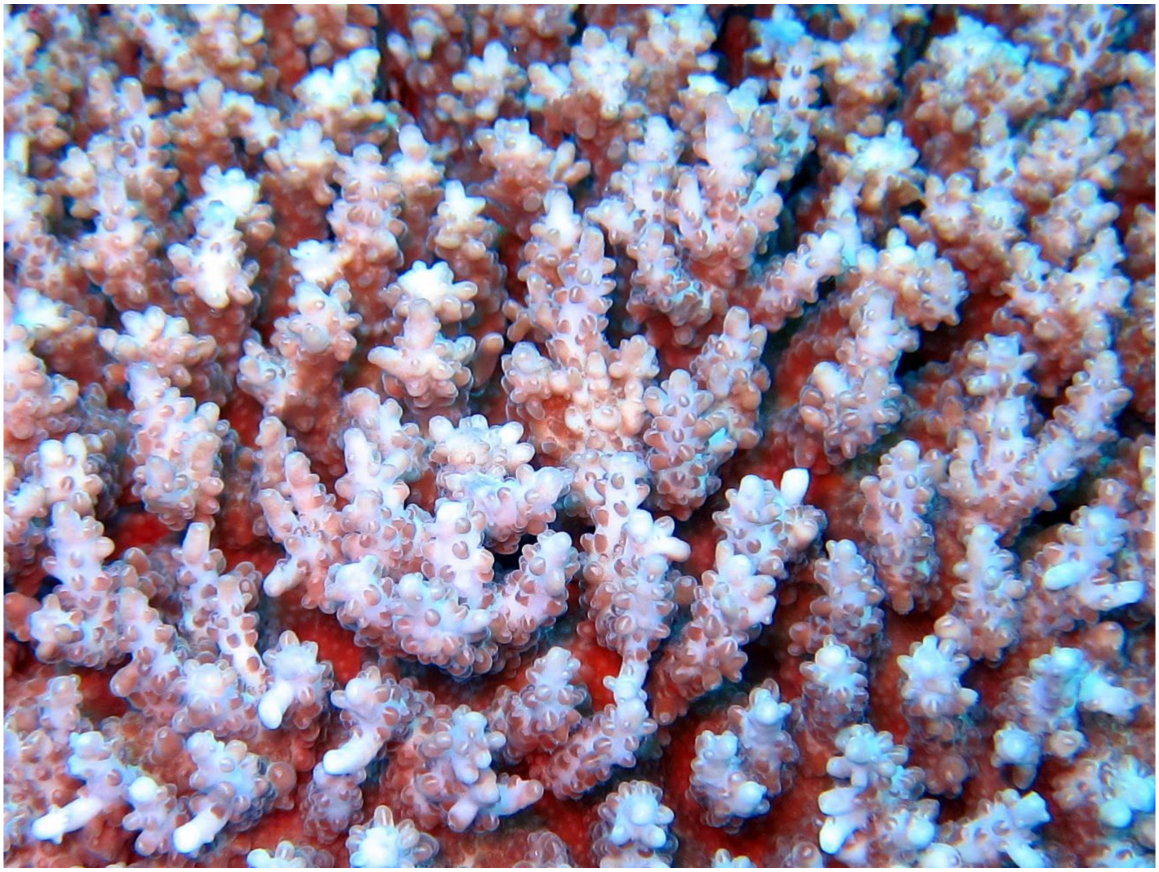


A close-up photo of *Acropora* cf. *quelchi*.

Acropora cf. insignis rare

This species forms small colonies with small non-tapering branches that mostly point upwards but radiate at the edges. There is some irregularity and small side branches. The branches are white and the corallites on the sides of branches are brown, giving the branches a spotted look. The corallites on the sides of branches are white in the center. The corallites on the ends of branches are tubular and white. Rare, reef slopes. This is the only species of *Acropora* with brown corallites on the sides of white branches.

A colony of *Acropora* cf. *insignis*.



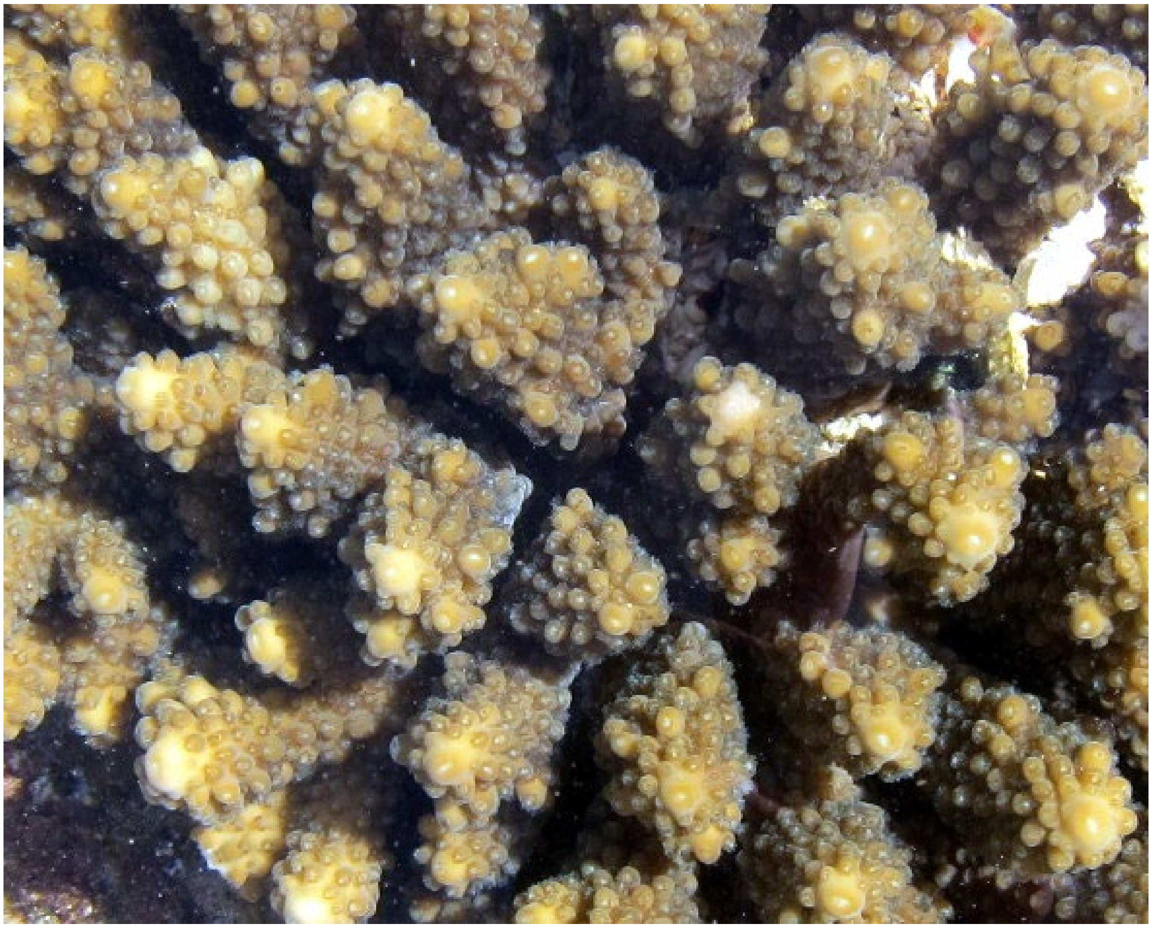
A close-up photo of a colony of *Acropora* cf. *insignis*. The brown corallites on the sides of branches can be seen against the white background of the branches.

Acropora cf. *retusa* Threatened Vulnerable

This coral forms small colonies with sturdy radiating branches. Branches are the thickness of a finger or thumb. The branches are a bit irregular, with a few side bumps that are the beginnings of growing side branches. The corallite at the end of a branch is fairly large. Corallites on the sides of branches are tubular, thick walled, and somewhat variable in size. The colonies are uniform brown except for the corallite at the end of the branch which is a little lighter. Rare, found in a tide pool under the cantilevers. This species has rougher, bumpier branches than other *Acropora* with finger shaped branches.

A colony of *Acropora* cf. *retusa*.

A close

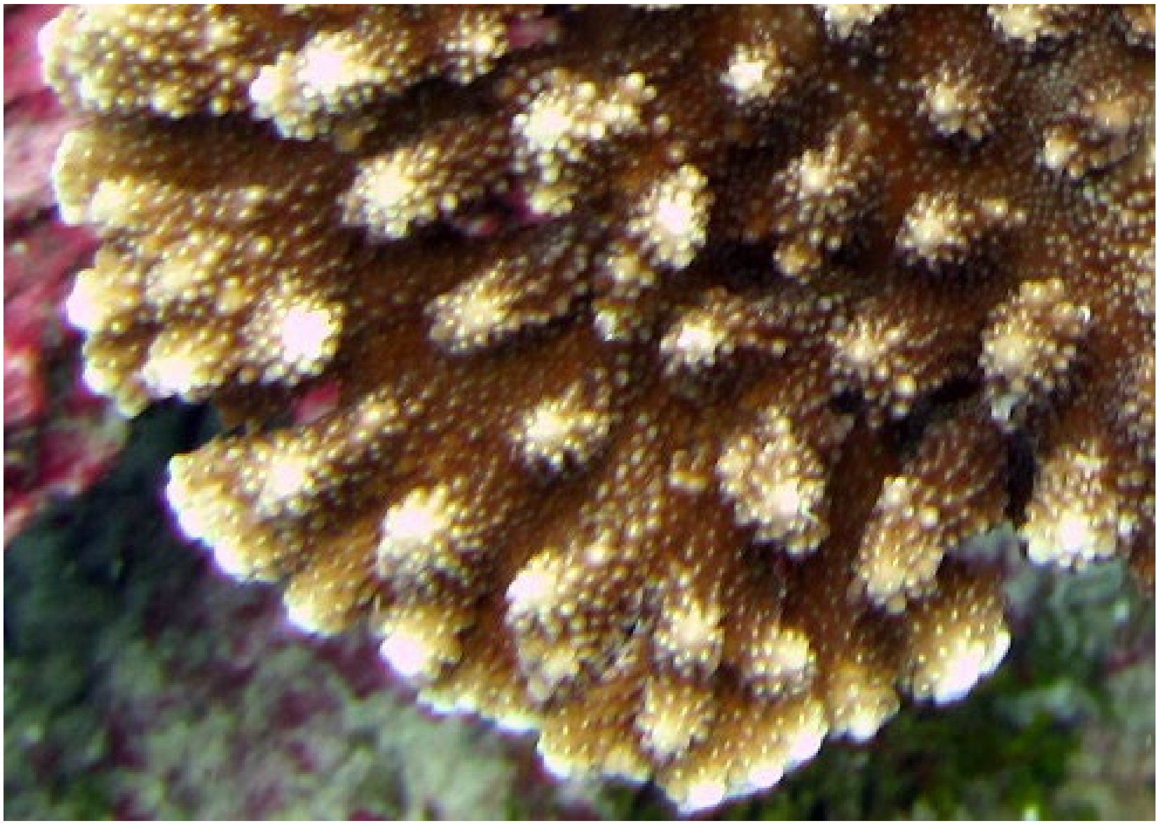


A close-up photo of *Acropora* cf. *retusa*.

Acropora sp. 1

This species forms flat colonies with short, fairly thick branches that grow upward except near the edge of the colony where they radiate. The edge of the colony is a nearly solid layer of fused branches, with some larger branches above it which may be partly fused to it. Corallites on the ends of branches are fairly large thick walled, and tubular. Corallites on branches are smaller but also tubular and thick walled. Colonies are brown with a white spot in each corallite that is the polyp. Only one colony was seen. This appears similar to an undescribed species in American Samoa that is moderately common there.

A colony of *Acropora* sp. 1.



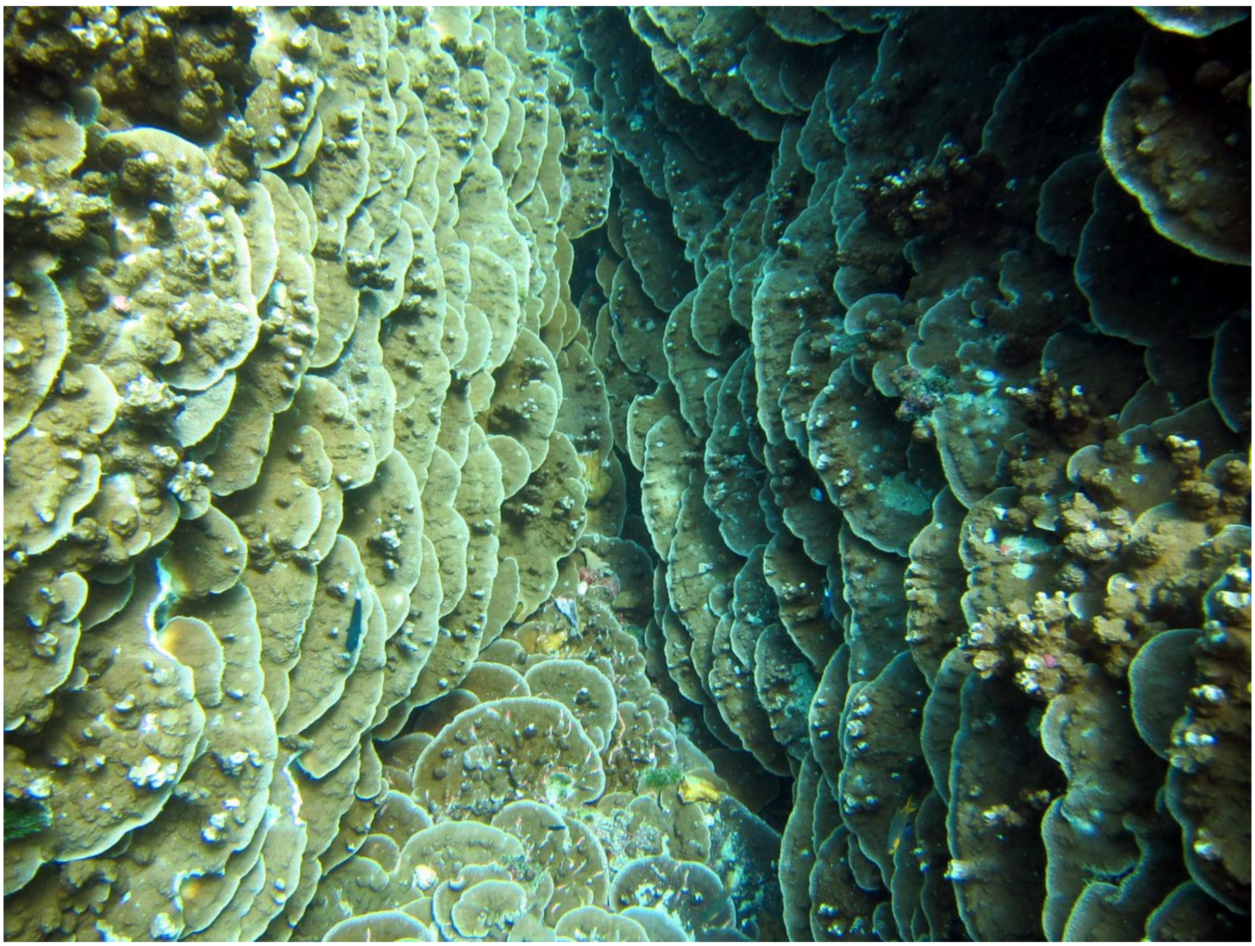
A close up photo of Acropora sp. 1.

Porites

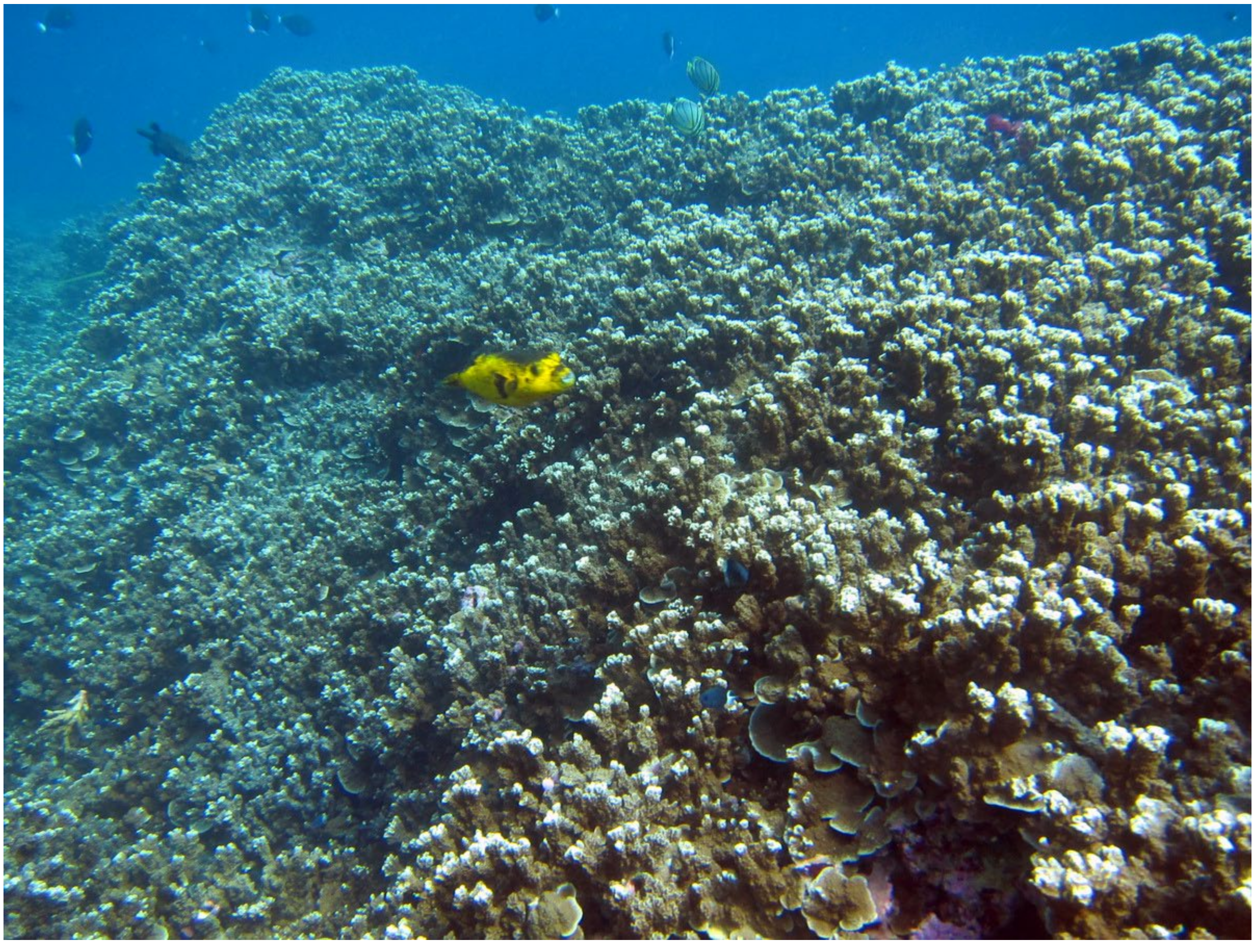
This genus forms colonies in a variety of shapes such as columns, plates, and rounded domes. The corallites are tiny, about 1 mm in diameter and there are no spines.

Porites rus Dominant

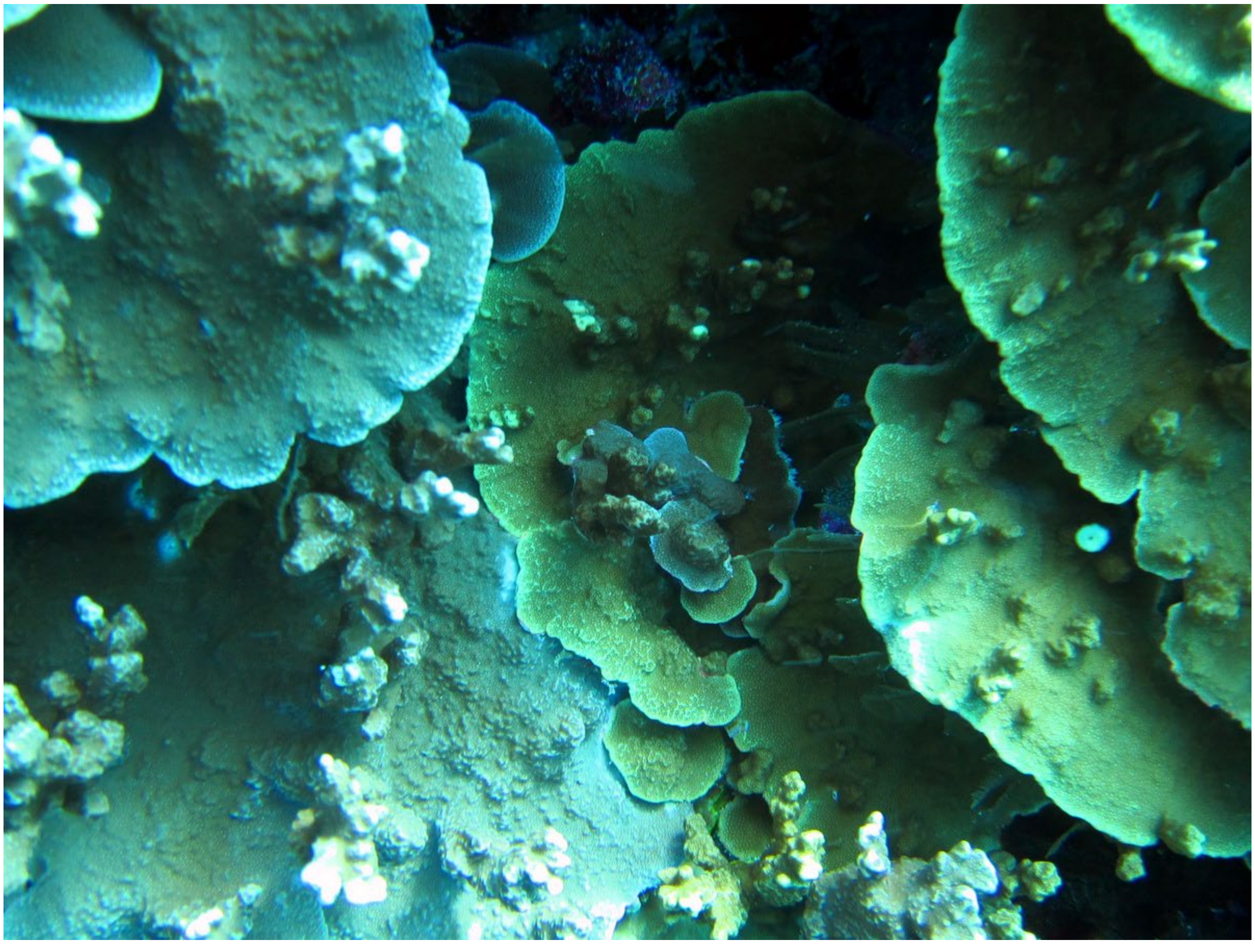
This species forms colonies that often have both irregularly lumpy columns and thin plates at the base of columns. Colonies can have just one or the other, but usually have some combination, such as columns or short lumps growing up from the upper surface of thin plates. The corallites are small and often appear as tiny dots. This species is by far the most common in Nauru and dominates most of the reefs except in shallow water. *Porites monticulosa* has rounded lumps instead of columns.



Here, *Porites rus* plates are like shingles covering the sides of a crack in the reef. These plates have some small knobs on them.



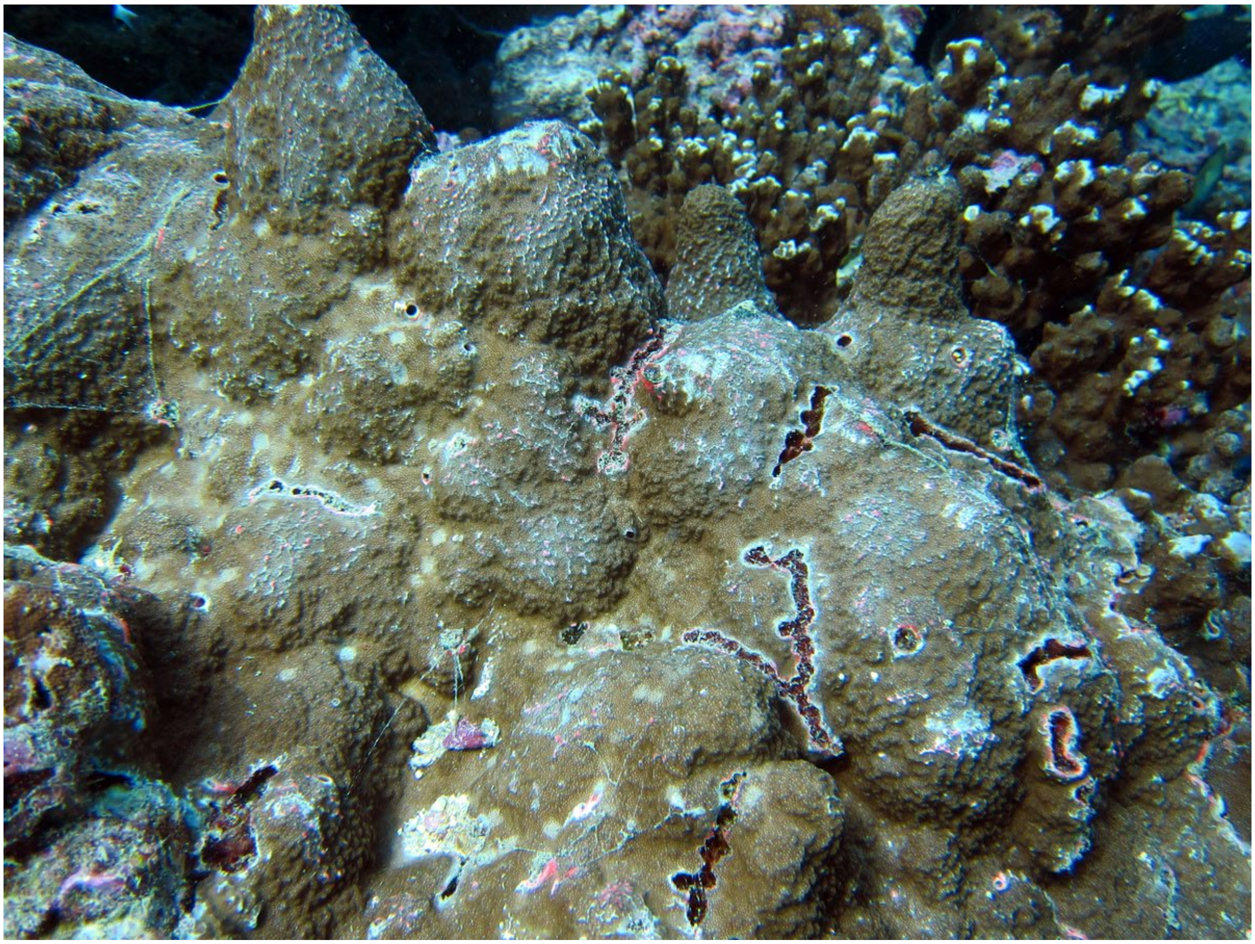
Here, columns of *Porites rus* dominate, though there are some thin plates at the bases of colonies.



Here, colonies of *Porites rus* in two different colors consist mainly of plates with some columns or small bumps on them.

Porites monticulosa rare

This species forms encrusting colonies, commonly with fairly large rounded lumps on them but without thin columns. This species differs from *Porites rus* mainly by not having columns and by some colonies being encrusting. Consistent differences in microscopic features between these two species have not been identified yet.

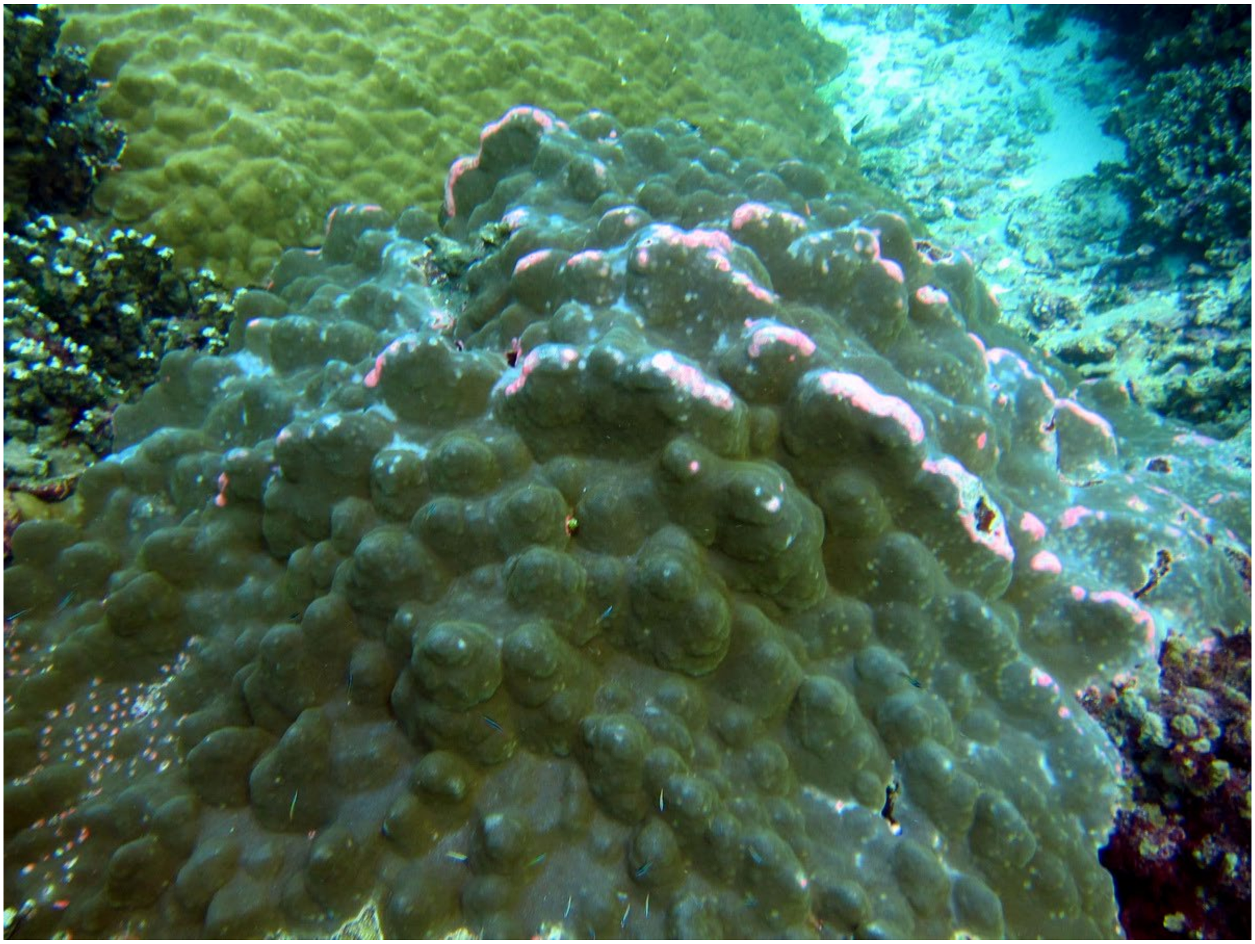


An encrusting colony of *Porites monticulosa* with low rounded lumps.

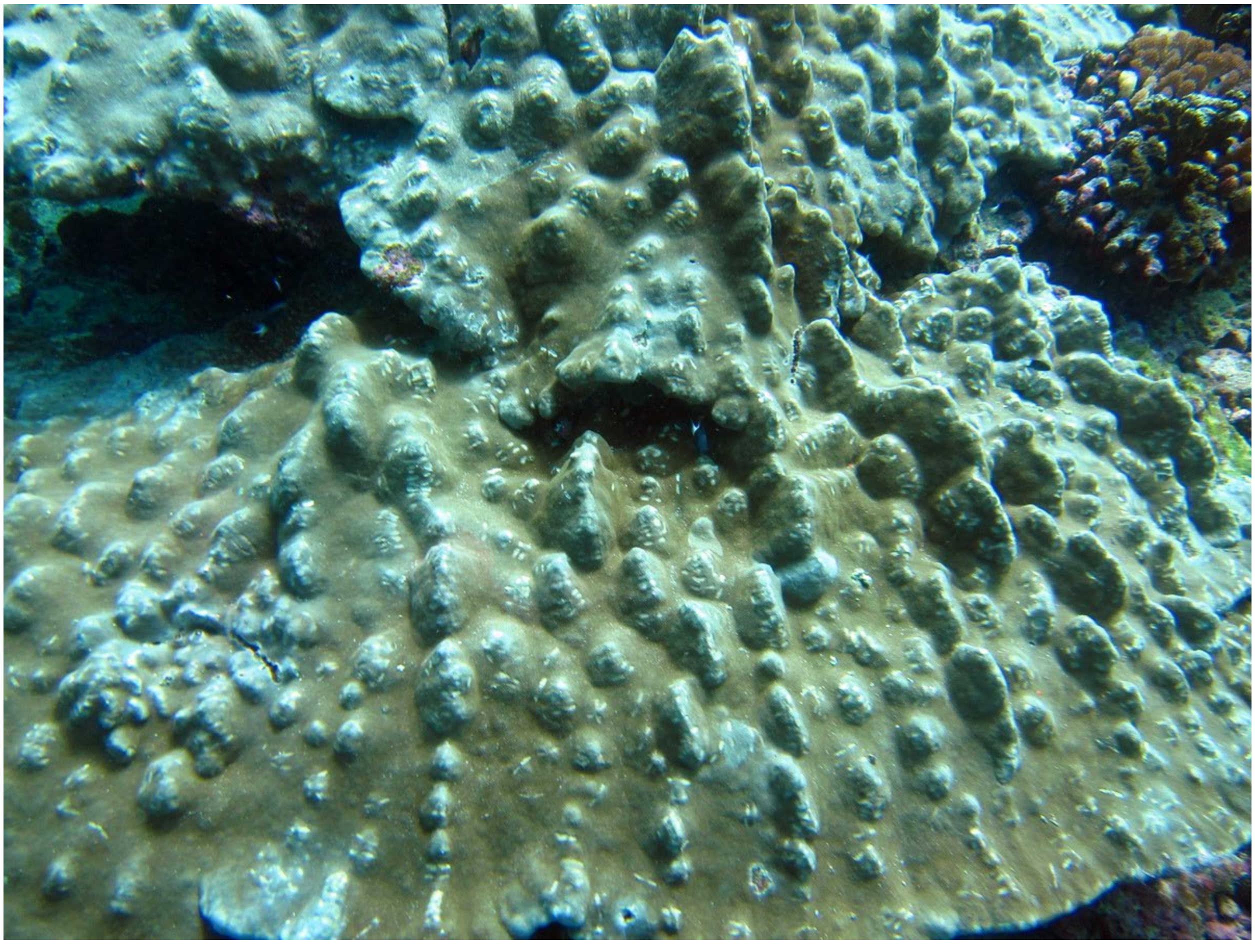
Another colony of *Porites monticulosa* that is mostly encrusting, though it has a small plate in the lower left. This colony has both low lumps and a couple of tall but rounded lumps.

Porites cf. evermanni uncommon

This species forms dome shaped colonies with many bumps on them. The bumps are typically rounded and somewhat uniform in size. They can be in rows across the surface of the colony. A few colonies have a flat surface between lumps. Small colonies may have small, low, rounded lumps. Colonies usually have tentacles partly extended as a tuft of tiny tentacles in the little corallites. Other *Porites* do not have their tentacles extended in small tufts.



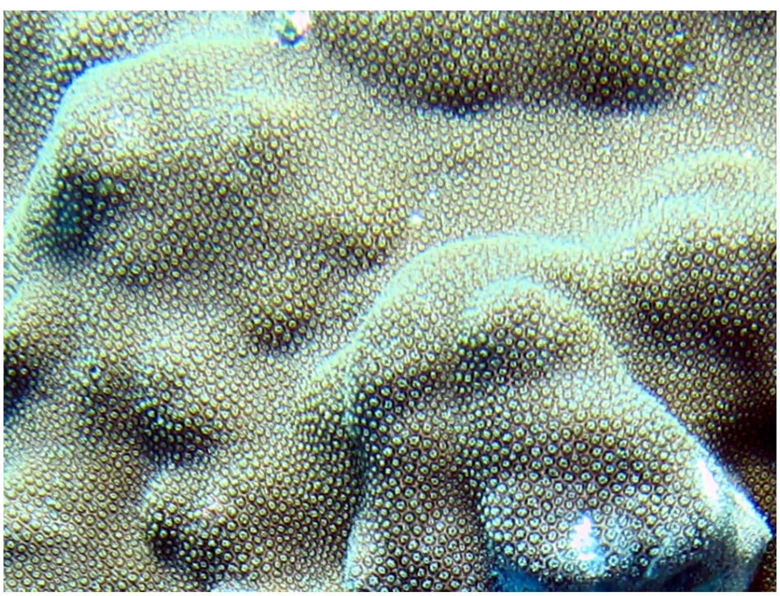
A relatively large colony of *Porites cf. evermanni* with relatively large bumps.



This colony of *Porites* cf. *evermanni* has lumps in rows and flat surface in between the lumps. This is unusual.

This colony of *Porites cf. evermanni* has small, thick shelves on its edges, and small rounded lumps on its upper surface.

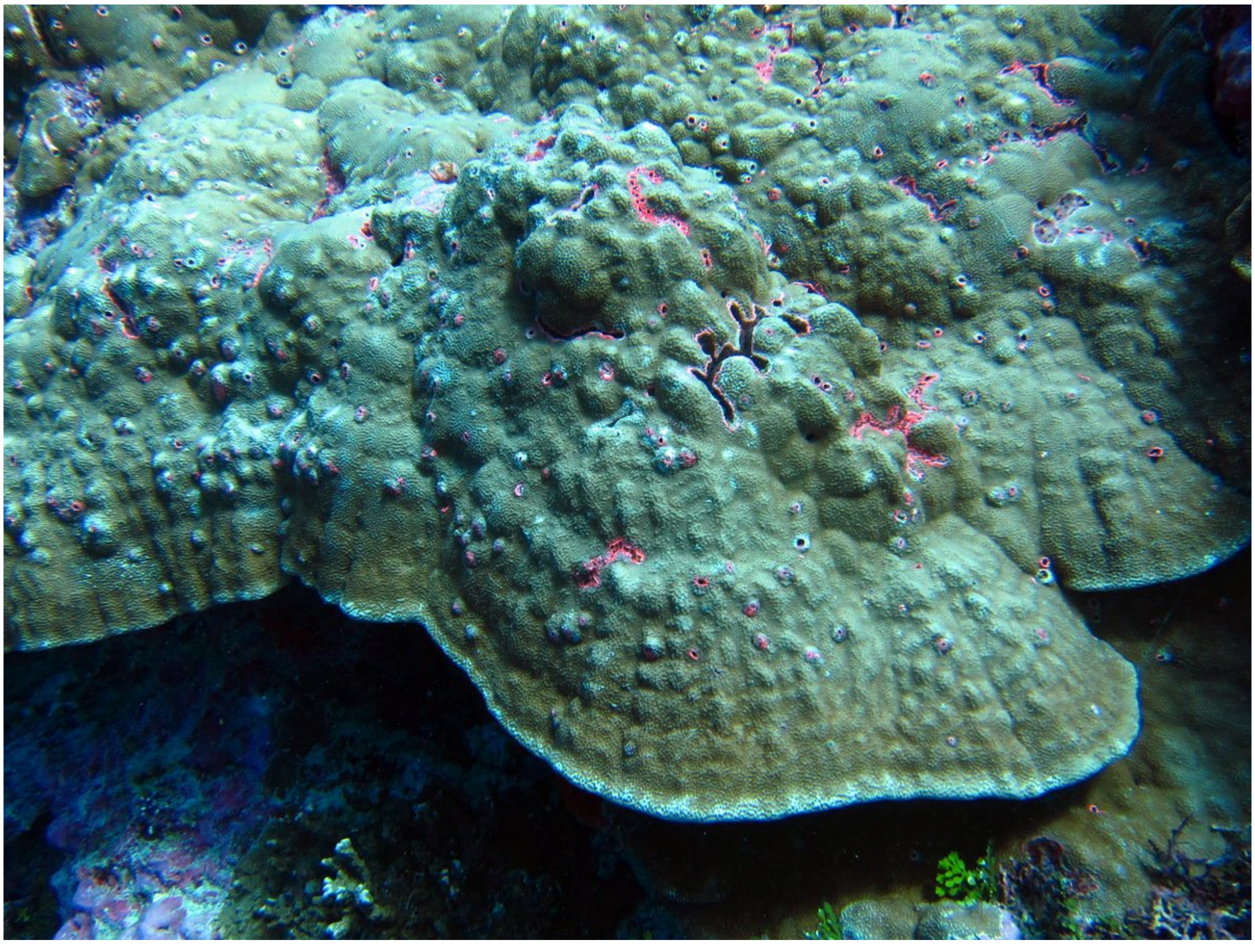
This colony of *Porites* cf. *evermanni* has tentacles extended more. The white marks along the edges are feeding scars likely produced by a fish.



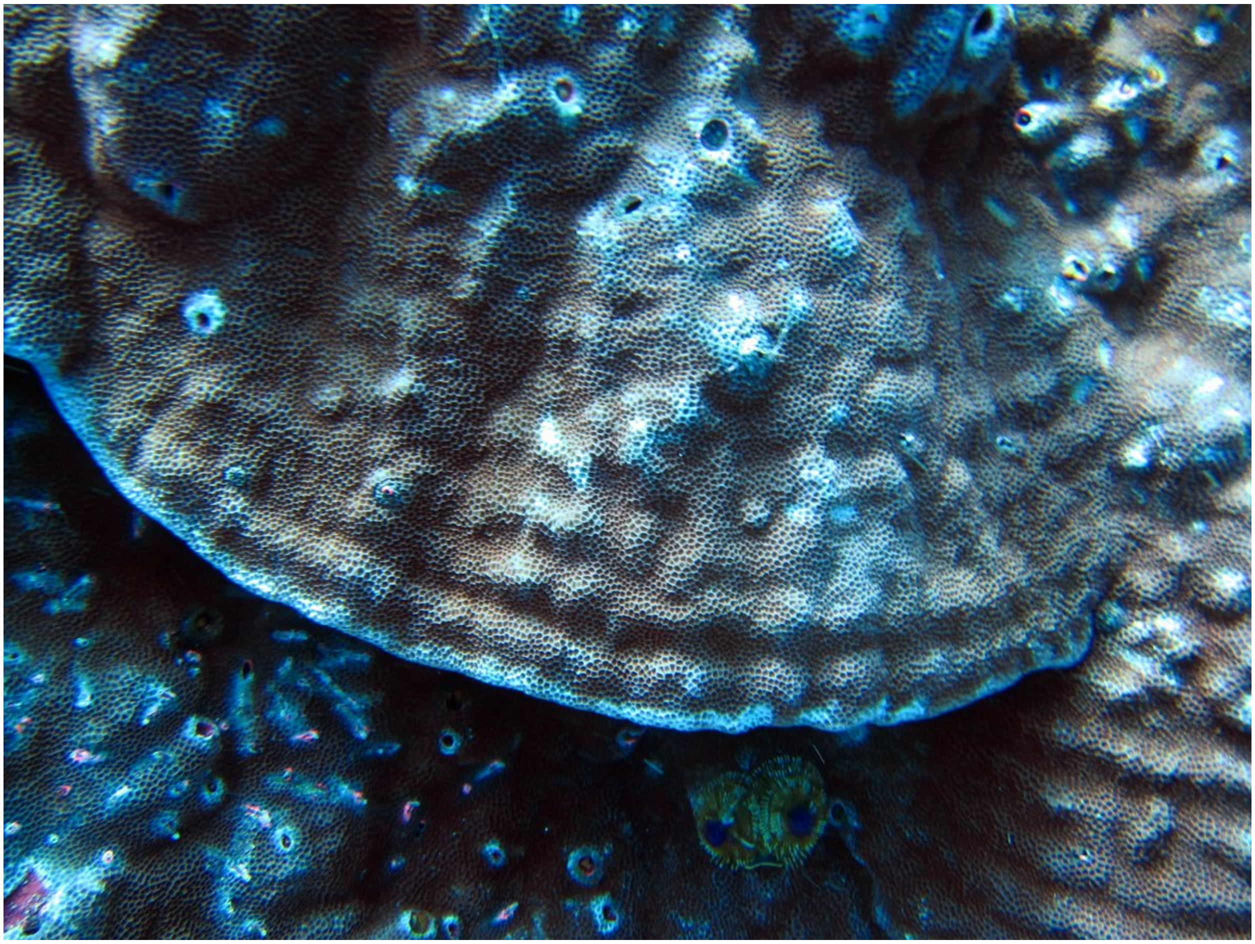
In this magnified view, the tentacles can be seen extended in a tuft in the center of each corallite.

Porites arnaudi uncommon

This species forms colonies that may be mounding or sloping, and which have a thick, rounded, projecting edge. The edge is about 1-2 cm thick and usually slopes steeply downward. The corallites are usually fairly deeply excavated. This is the only *Porites* that forms large, thick shelves on their lower edges and has deep corallites.



This colony of *Porites arnaudi* has small lumps. The pink areas are where the coral tissue is irritated or injured.



Here, a plate edge of a colony of *Porites arnaudi* can be seen. The corallites here are deep.

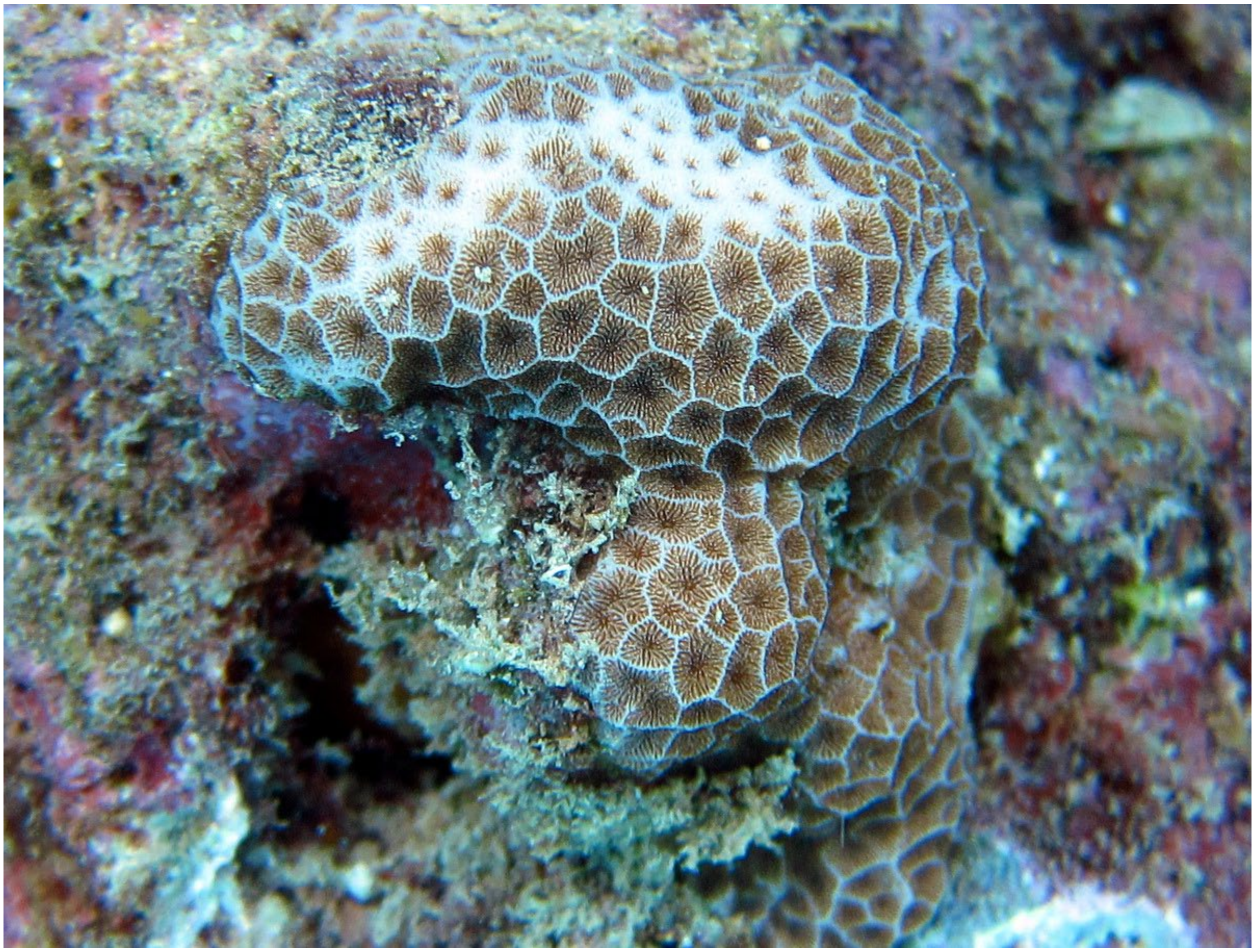
Psammocora

This genus forms encrusting sheets, lumps, or sometimes branches. The corallites are too small to see.

Psammocora profundacella rare

This species forms small lumps, usually 10 cm in diameter or less. The surface is covered with corallites that are not very deep and irregular polygon shapes, with walls between them that are not high but have a fairly sharp upper edge. Colonies can be green, brown, cream, or other colors. *Gardineroseris planulata* has larger colonies, deeper corallites, and taller, sharper walls between corallites.

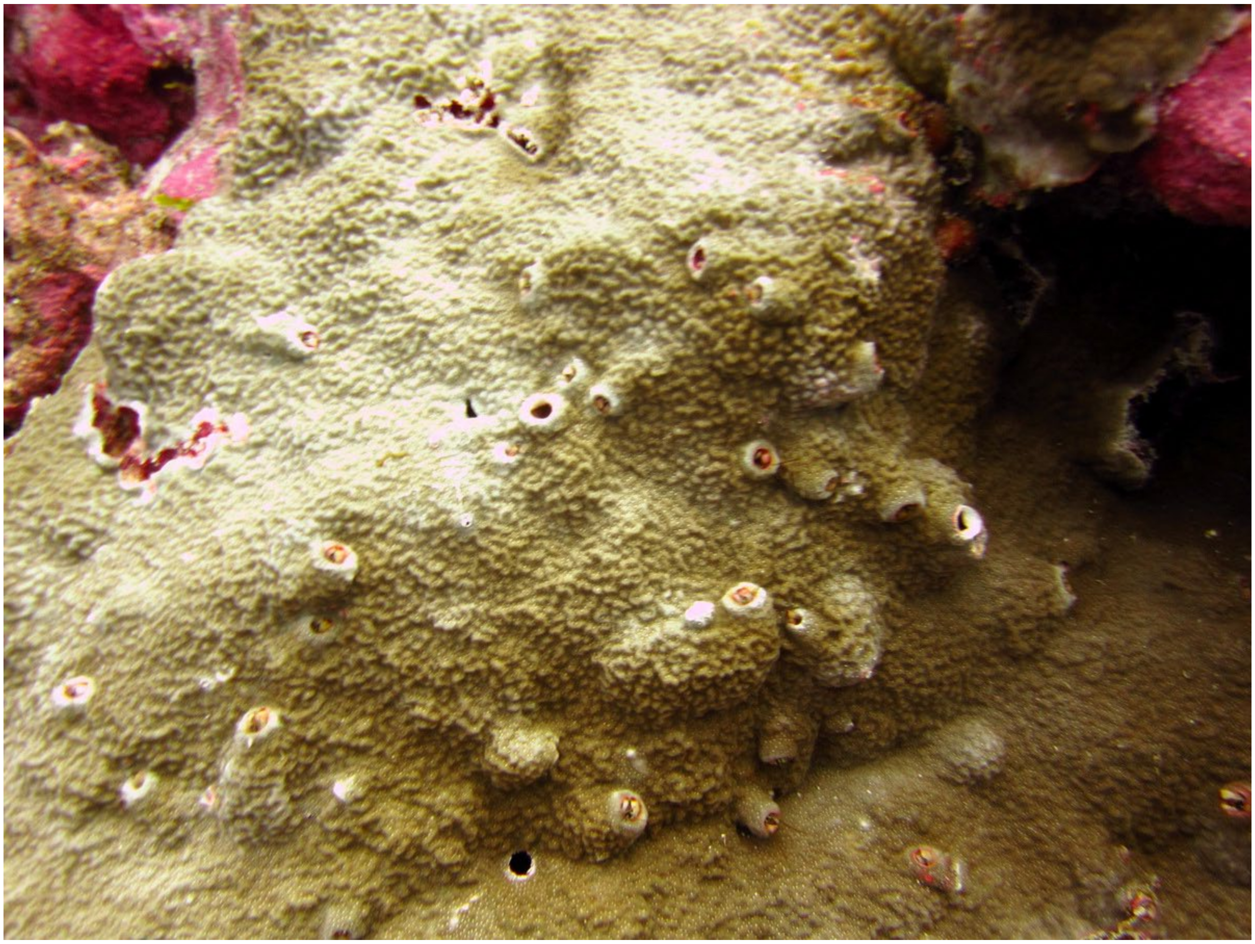
A relatively large colony of *Psammocora profundacella*. The black lines are sea urchin spines.



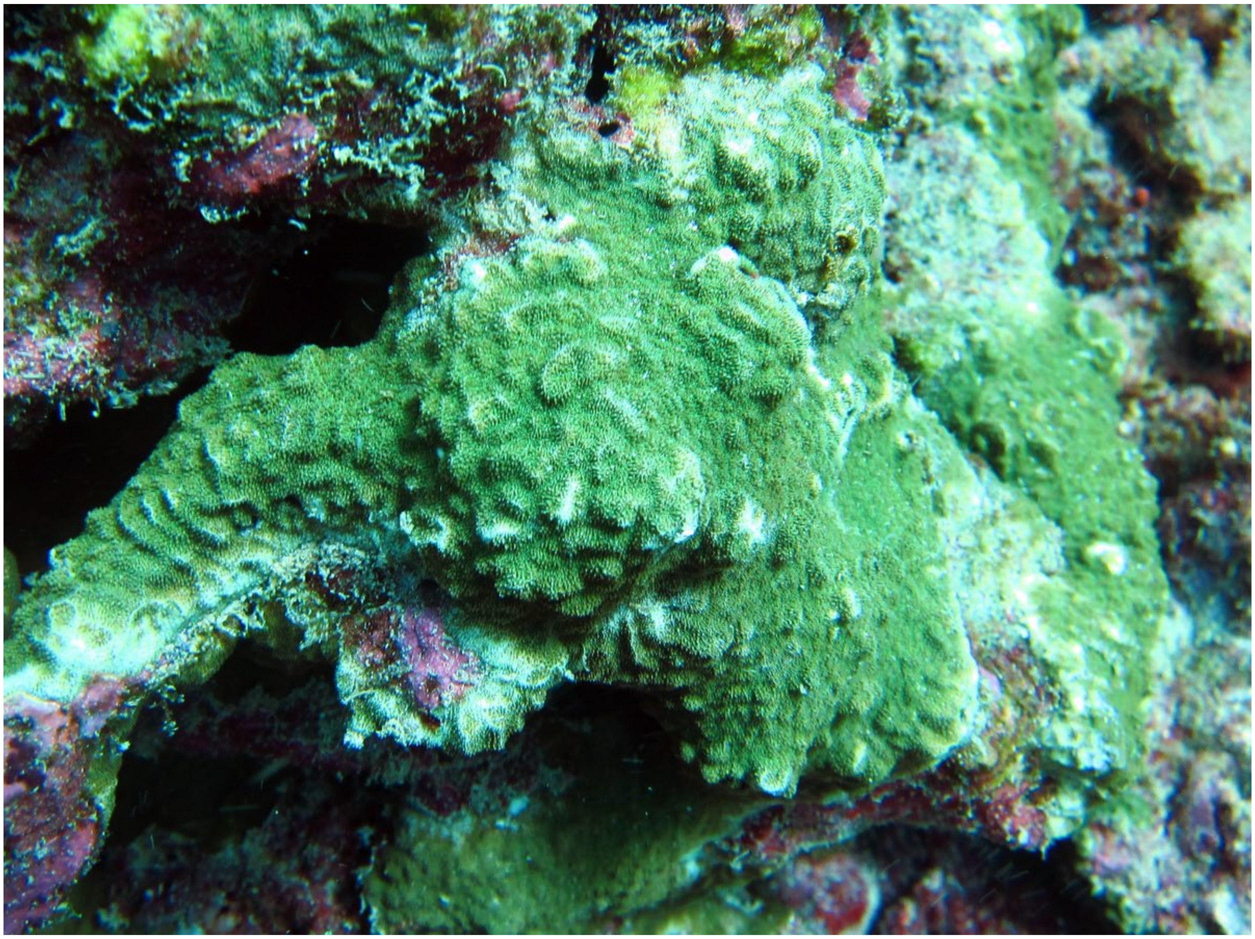
A highly magnified photo of *Psammocora profundacella*. The tiny radiating lines within the corallites are septa, but they are too small to be visible underwater usually.

Psammocora nierstraszi rare

This species forms encrusting sheets with small, rounded, winding ridges that usually don't go very far and sometimes are so short they are just little bumps. The surface appears smooth but under magnification looks slightly granular. *Pavona varians* can look similar, but usually *Psammocora nierstraszi* is not brown, the ridges are shorter and more rounded and do not connect, and the ridges do not have tiny ridges (septa) going down their sides.



A colony of *Psammocora nierstraszi* with a few longer ridges but most ridges so short they are little bumps.



A close-up photo of a green colony of *Psammocora nierstraszi*, with clearly visible ridges. The fine grainy texture of the surface can be seen in this photo.

Gardineroseris

This genus forms dome-like colonies, with corallites about 3-6 mm diameter. The corallites are separated by very sharp, high walls. There is only one species in this genus.

Gardineroseris planulata rare Honeycomb coral

Gardineroseris forms dome-like colonies which may be lumpy, with corallites about 3-6 mm diameter. The corallites are deep and rounded, with very sharp, high walls between them and look like honeycomb. They are often brown. *Psammocora profundacella* is similar, but has smaller colonies, shallower corallites, and lower ridges between corallites.

A colony of *Gardineroseris planulata*.

This magnified picture of *Gardineroseris planulata* shows the deep, smooth, rounded corallites with very shapr walls between them. The corallites are a variety of polygonal shpaes.

Pavona

This genus forms colonies that are encrusting, or lobes or thin plates or small crinkly vertical plates. The corallites are small to tiny, and have tiny ridges called septocostae that connect them.

Pavona varians uncommon

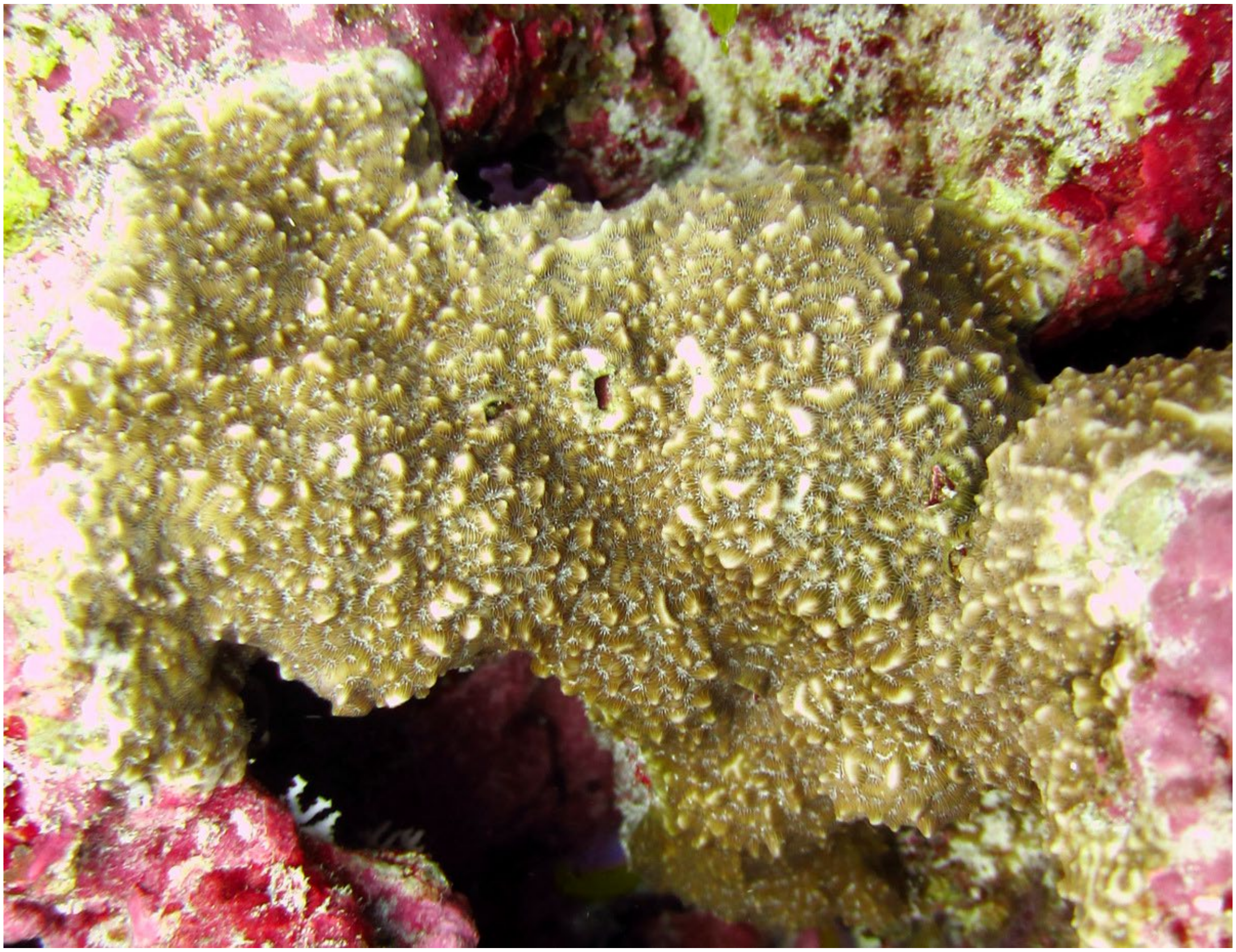
This species forms encrusting sheets, sometimes with lumps, and sometimes on slopes can have raised thin plate lower edges. The surface is covered with thin, curving ridges, and the tiny corallites are between the ridges. It can look like *Psammocora nierstraszi*, but the ridges are higher and sharper and connect, and they have tiny ridges (septa) going down the sides of the ridges. It is usually brown. This is probably a species complex.

A colony of *Pavona varians* that is lumpy.

This magnified view of *Pavona varians* shows the winding, curving ridges, and the tiny ridges (septa) running down the sides of the large ridges.

Pavona chiriquiensis uncommon

This species forms encrusting colonies with little bumps that are circular to oval on the surface. The bumps are variable in size. Sometimes there are a few short ridges. The corallites are between the ridges and are small enough they are hard to see, but can be like little white stars. There are tiny ridges going down the sides of the little bumps. Usually brown. This species is near identical to *Pavona varians*, except that instead of long ridges it has round or oval bumps.



A colony of *Pavona chiriquensis*, showing the variable little bumps and white corallite centers.

Pavona explanulata very rare

This species forms encrusting sheets with thin plate edges. The corallites are nearly flat with the surface, and have tiny ridges (septocostae) connecting them. Where the corallites are far apart, the septocostae radiate from corallite centers and then run perpendicular to the edge of the colony. There is no other plating species of *Pavona* with corallites this big.

A brown colony of *Pavona explanulata*.

This is a magnified view of the lower part of the *Pavona explanulata* colony in the previous picture. Here, the septocostae can be seen clearly.

Pavona frondifera very rare

This species forms small vertical plates that intersect many places with other plates, giving a very crinkly look. Usually the corallites cannot be easily seen. Colonies are usually just a few centimeters tall. Although they can grow to be quite wide, only small colonies were found in Nauru. Colonies are often orange-yellow-brown. No other species has crinkly colonies like this species.

A small colony of *Pavona frondifera*.

A magnified view of *Pavona frondifera*.

Pavona maldivensis rare

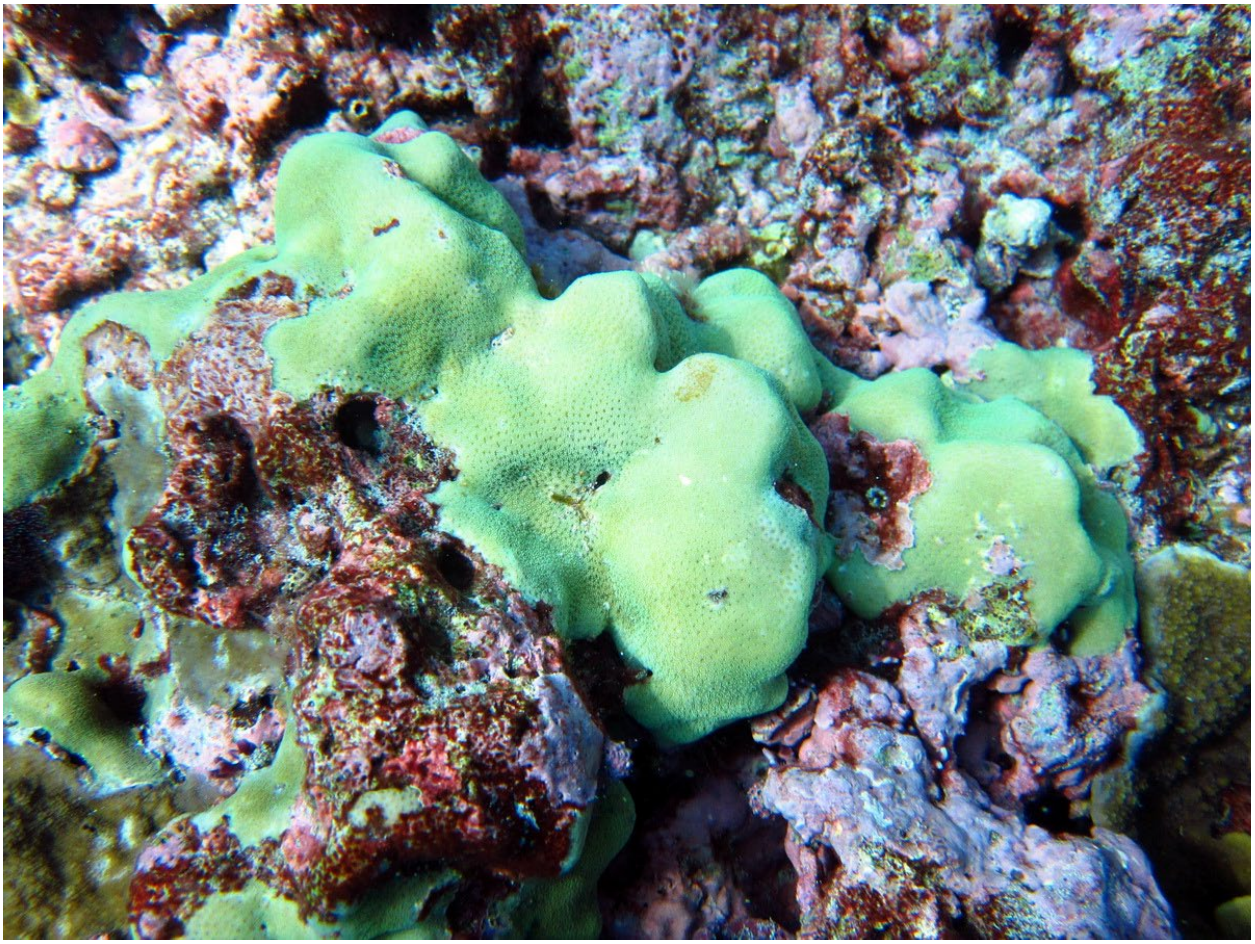
This species forms knobs, columns, or branches, with little raised circular corallites on them. There are tiny ridges (costae) running down the sides of the corallites and connecting with nearby corallites. Most colonies are brown. This is the only *Pavona* that makes nodules or short branches.

A colony of *Pavona maldivensis* with knobs and columns on it. The color is far too blue due to camera problems.

This is a magnified photo of *Pavona maldivensis*. The colony on the left is bleached and the colony on the right is partly bleached. The raised corallites can be seen on the colony to the right, along with the costae radiating from them and connecting to nearby corallites.

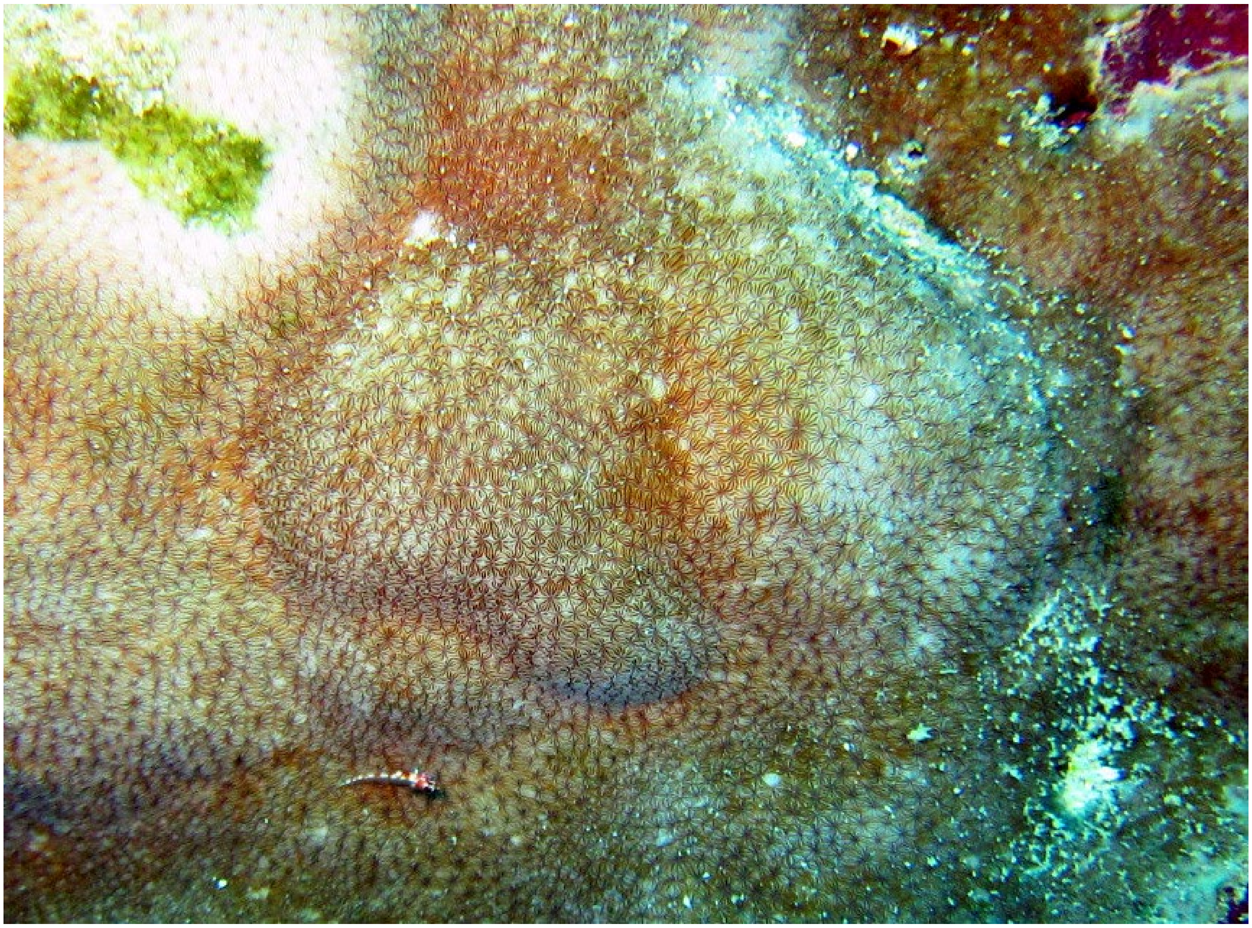
Pavona duerdeni uncommon

This species forms encrusting colonies, lumps of various shapes, and thick vertical plates that can look like pork chops. The surface is covered with tiny corallites that are so small they are hard to see. The most common colors are greens, browns, and grays. Lumpy colonies can look like Porites, though the corallites are flatter. *Pavona gigantea* often forms thick flattened lobes that can be similar, but it has larger corallites and usually has tentacles out.



A colony of *Pavona duerdeni*.

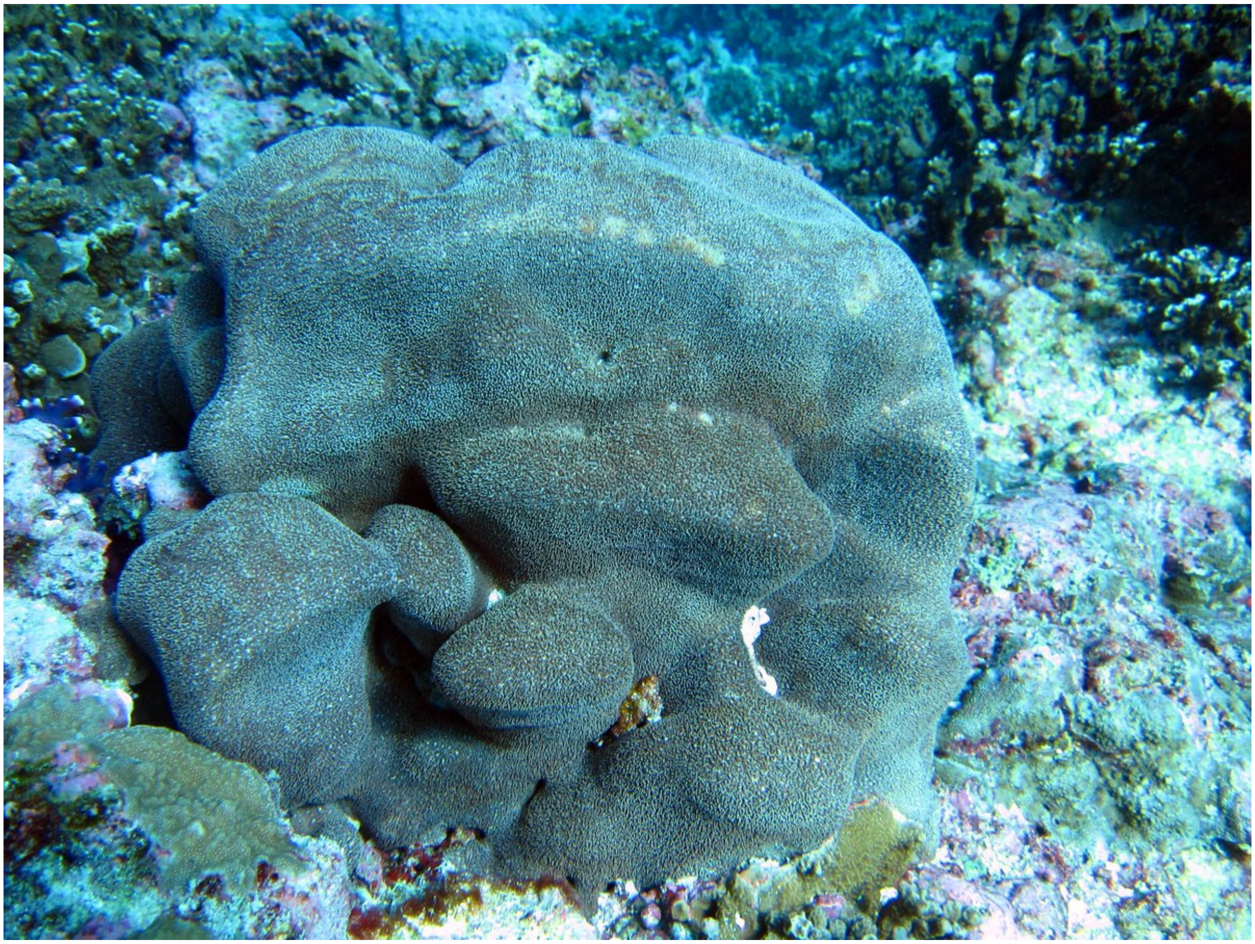
A larger colony of *Pavona duerdeni* showing some of the pork chop shape.



This photo shows the tiny corallites on the surface of an encrusting colony of *Pavona duerdeni*.

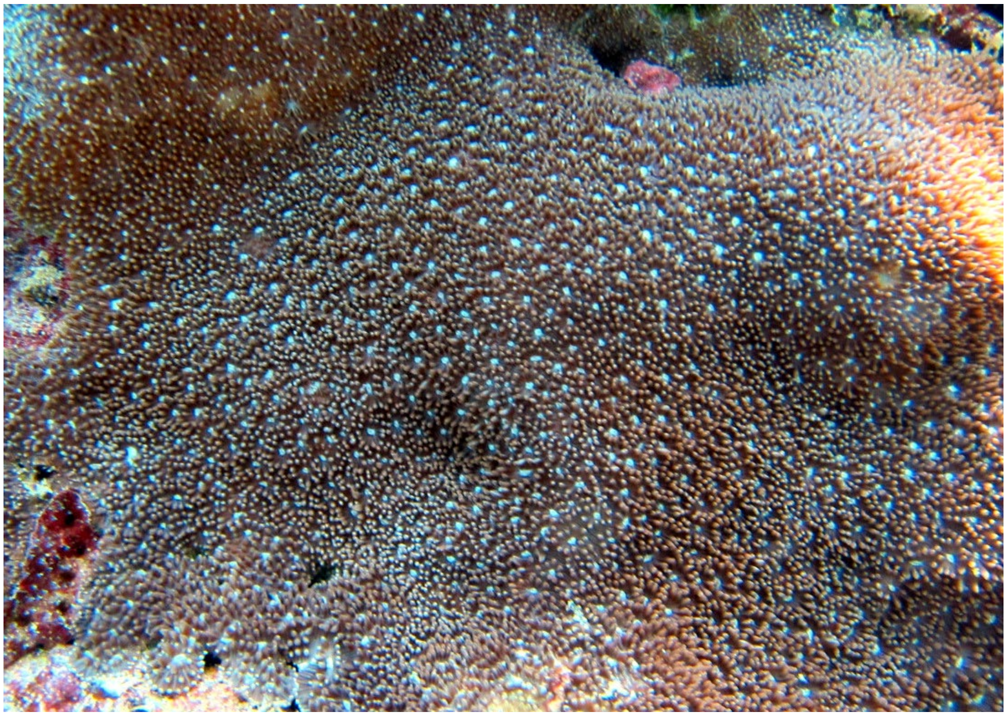
Pavona gigantea rare

This species forms lumps which often grow as a series of thick, flattened lumps that parallel each other. The upper surfaces often are fuzzy with little extended tentacles, but the lower sides often don't have the tentacles extended so far. Colonies most often are 50 cm or less long. The corallites are larger than on *Pavona duerdeni* and the tentacles are extended more often.



Here, a good size colony of *Pavona gigantea* is forming thick parallel flattened lumps.

This colony of *Pavona gigantea* has more developed thick parallel plates.

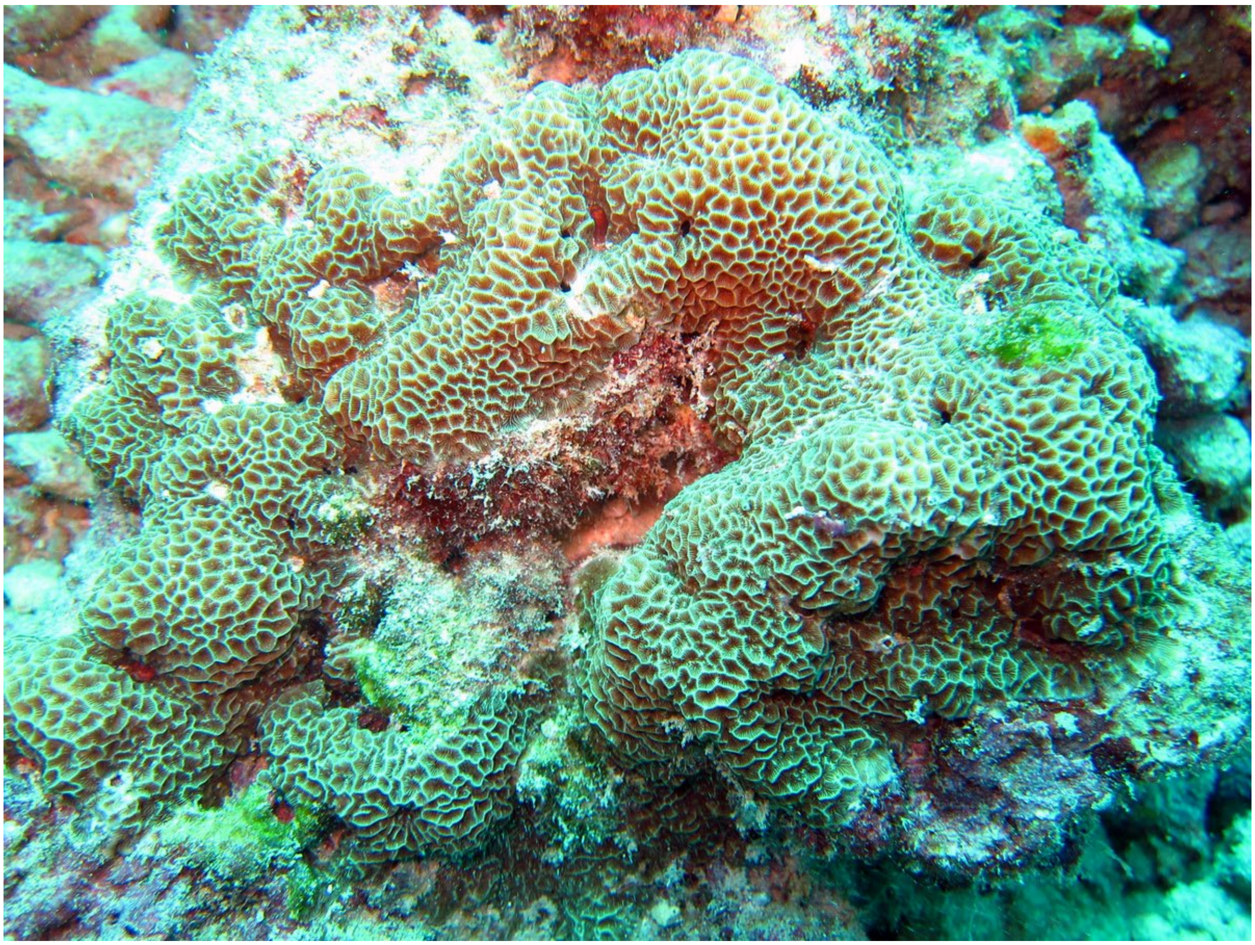


A magnified view of the lower side of a *Pavona gigantea* colony, showing the partially extended tentacles and the light colored polyp mouths.

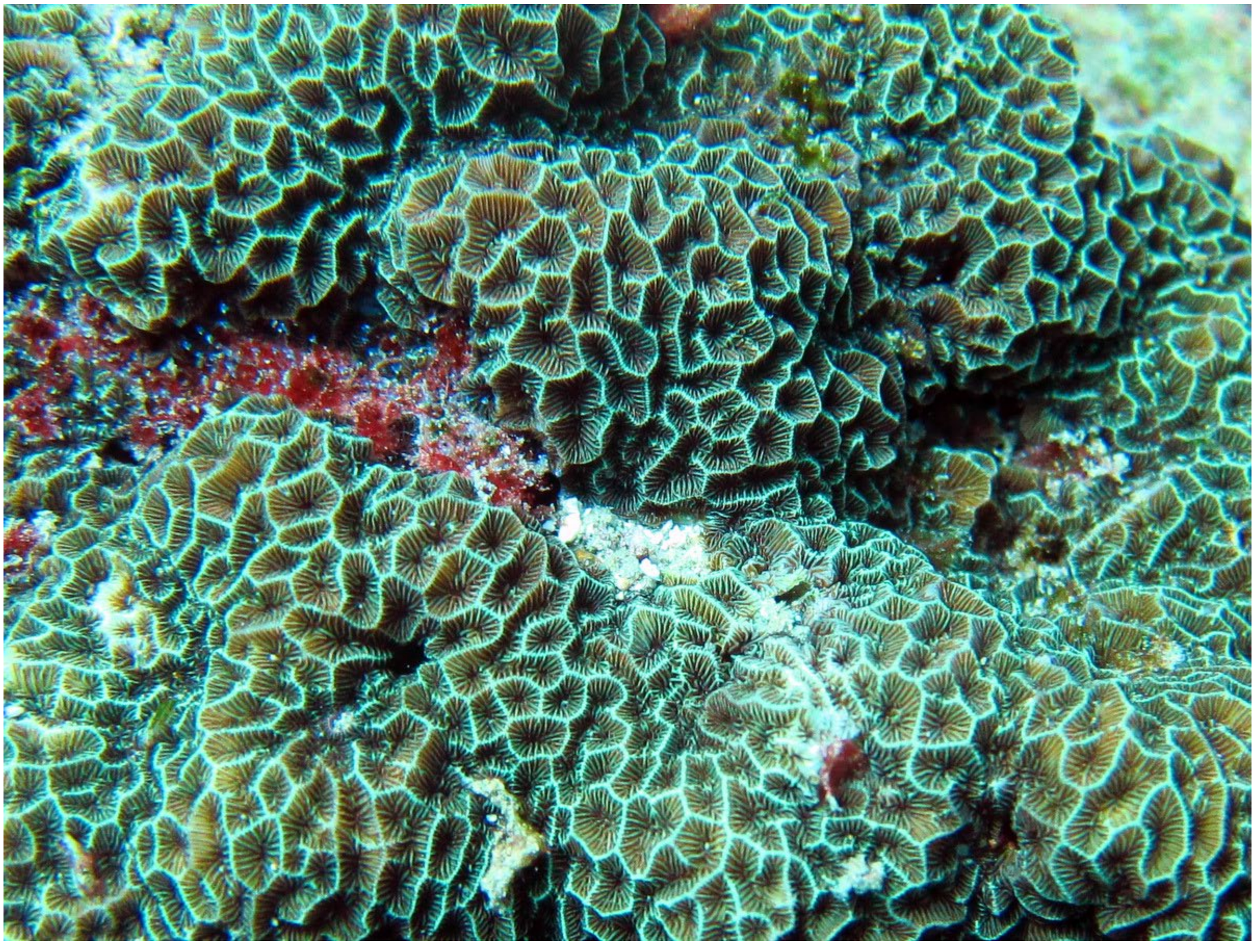
The top of a thick ridge of *Pavona gigantea*, showing the extended tentacles, which are usually white.

Pavona venosa very rare

This species forms rounded, lumpy, or irregular masses, which are covered with irregularly shaped, deep corallites separated by sharp ridges. The radiating ridges (septa) within corallites are large enough to be seen, especially in a magnified photo. Colonies can be green, yellow, or orange. *Psammocora profundacella* is similar, but the corallites are less deep and less irregular in shape, and the septa not as easily seen. *Gardineroseris planulata* is also similar, but the corallites are deeper and less irregular in shape, and the septa smaller and less easily seen.



A green colony of *Pavona venosa*. Note the irregular shapes of the corallites.



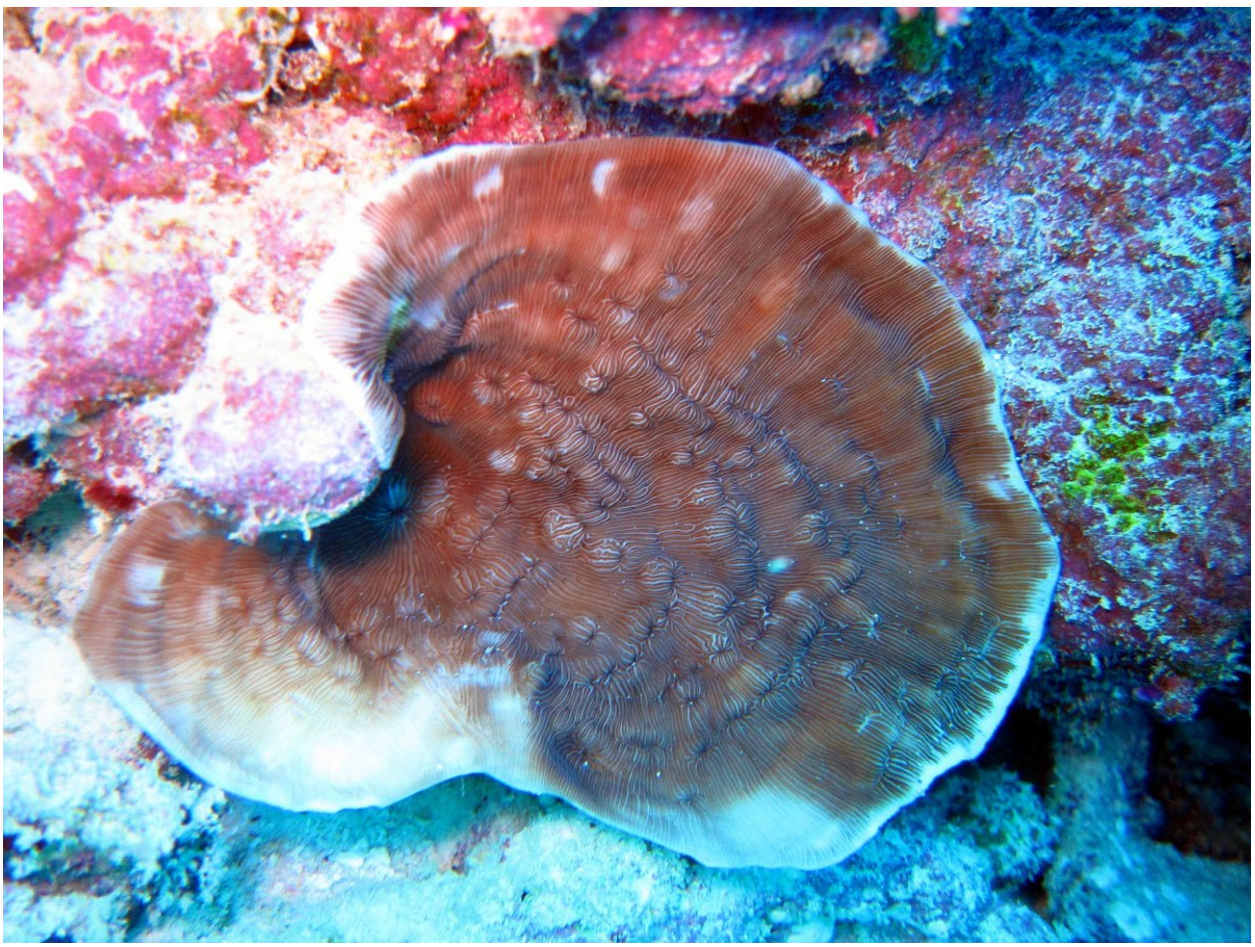
This is a magnified photo of *Pavona venosa*, showing the irregularly shaped corallites separated by sharp ridges, and with tiny radiating ridges (septa) inside the corallites.

Leptoseris

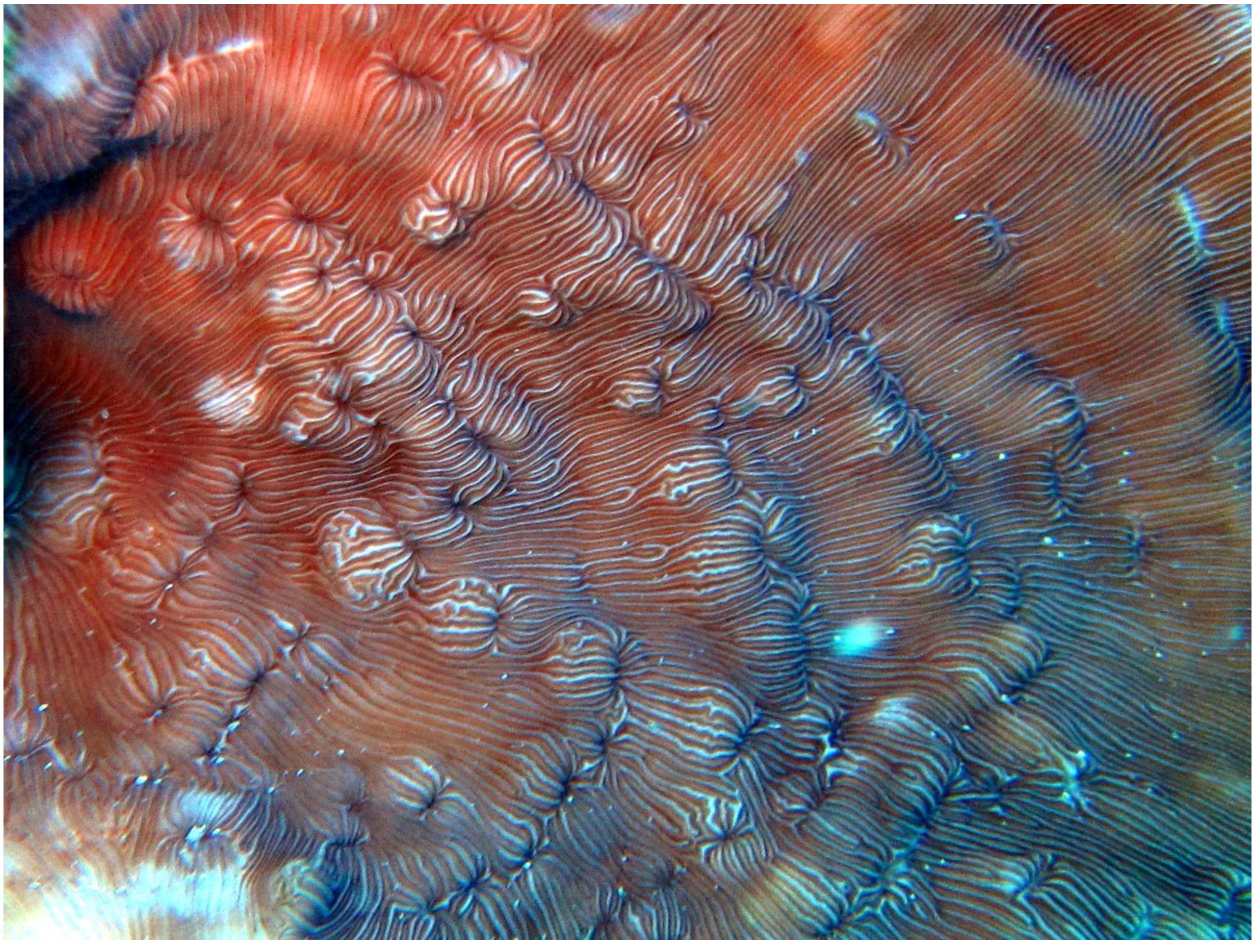
This genus forms thin plates or encrustations, and are usually in deeper water. Corallites may form small rounded mounds or depressions separated by high ridges.

Leptoseris explanata very rare

This species forms thin plates with corallites on the upper surface that are small raised round knobs, with the small hole in the center that is where the mouth is usually pointed towards the edge of the plate. Thus, the corallites are inclined towards that outer edge of the plate. In addition, septa alternate in height. The septa continue outside the corallites as "septocostae", which generally run perpendicular to the edge of the plate. Colonies are plates and do not have ridges, unlike *Leptoseris mycetoseroides*. Colonies have raised corallites unlike *Pavona explanulata*.



This is a colony of *Leptoseris explanata*, showing the outwardly inclined corallites. The alternation of the two sizes of septa can be seen on the coallites.



This is a magnified view of *Leptoseris explanata*, showing the inclined corallites and the alternation of septa.

Leptoseris sp. very rare

This species forms encrusting colonies that have winding, rounded, intersecting ridges with deep holes in between them that are where the corallites are. On the ridges, much smaller ridges (septa) can be seen, which are uniform in size and spacing. Colonies are encrusting with ridges instead of plates with raised corallites as on *Leptoseris explanata*.

A colony of *Leptoseris* sp.

A magnified view of a colony of *Leptoseris* sp., with the tiny septa (ridges) going across the much large ridges between corallites.

Cycloseris

This genus usually forms small, unattached discs that look a bit like an overturned mushroom cap.

Cycloseris sp. very rare

This species forms small, unattached discs, with ridges (septa) radiating from a central slit which is the mouth. The septa vary in size and have nearly smooth edges. *Fungia* forms much larger corals that look similar.

A close-up photo of the upper surface of *Cycloseris* sp. This individual was about 3 cm diameter.

Cycloseris sp. is not attached, and can be picked up and turned over. The underside is covered with uniform fine granules like sandpaper. Small ridges form only at the edge, and continue around the edge to the top as septa.

Lithophyllon

This genus has two colony shapes. Some species form small attached plates with multiple mouths. Other species form larger unattached discs, commonly 10 cm or more in diameter. Discs are circular.

Lithophyllon concinna or Lithophyllon repanda   rare   These used to be in Fungia.

This coral forms circular discs with one mouth slit in the center from which ridges (septa) radiate out to the edges of the disc. The septa vary in size and have small teeth on them. These two species are very difficult to distinguish in the field, secure identification requires microscopic examination of the skeleton. *Cycloseris* is smaller and *Lobactis scutaria* is oval.

The upper surface of a *Lithophyllon concinna* or *Lithophyllon repanda* coral.

Lithophyllon concinna or *Lithophyllon repanda* is not attached, and can be picked up and turned over. The underside has spines on radiating ridges. The ridges vary in size near the edge of the coral. The spines can be larger than on this coral.

Lobactis scutaria rare This used to be in Fungia.

This species forms ovals usually around 10-20 cm long. Ridges (septa) radiate from the single mouth in the center, which is a large deep groove. The septa are uniform in size and appear to have smooth edges. The inner ends of septa are slightly thickened and raised in what are called "tentacle lobes." When the tentacles expand at night, they can be seen to be located on these lobes. *Cycloseris* is smaller and circular, and L*ithophyllon concinna* or *Lithophyllon repanda* is circular.

An individual *Lobacis scutaria*. Here, the tentacle lobes are white. At other locations the tentacle lobes can be taller, sometimes green, and sometimes have small tentacles extending in daytime.

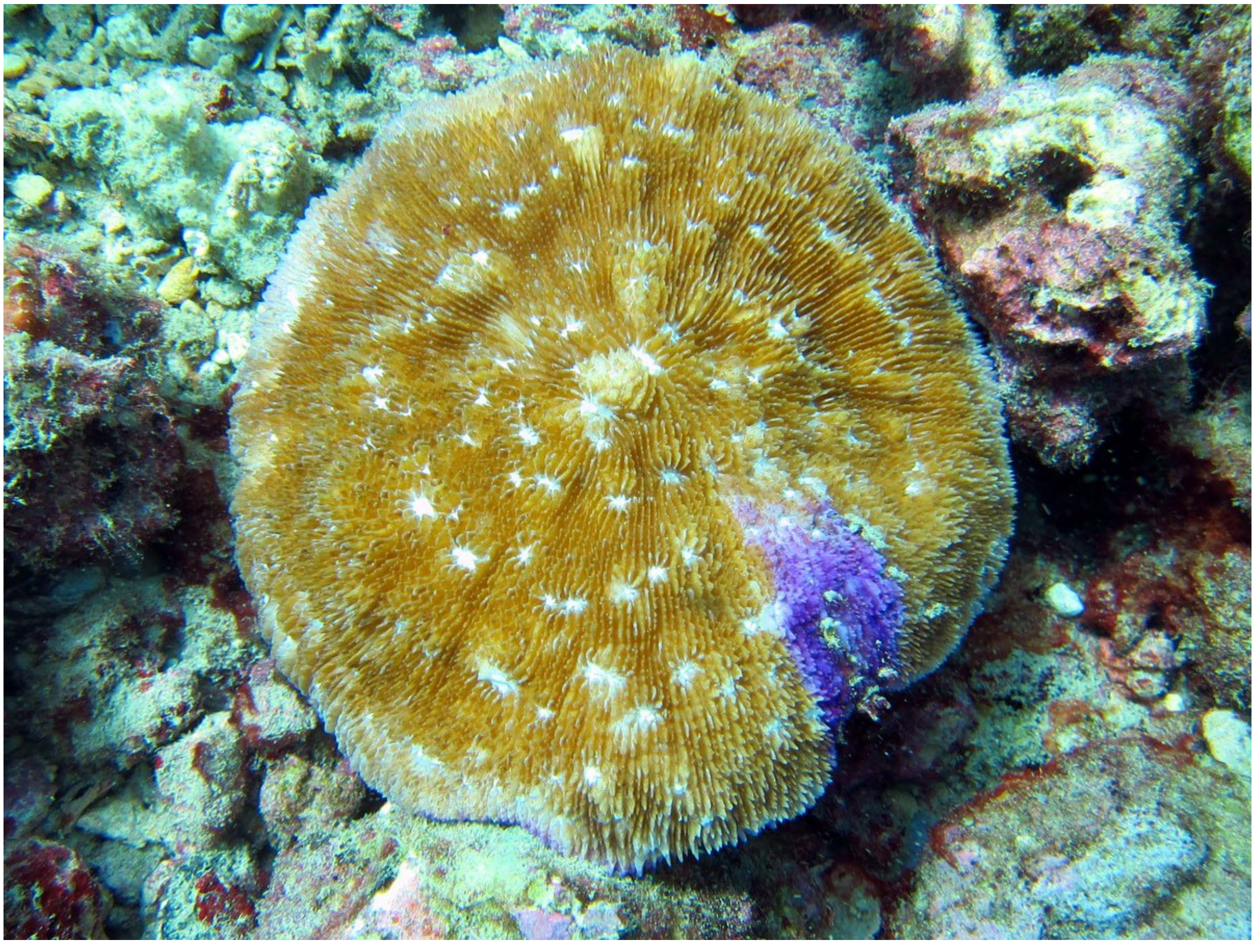
Lobactis scutaria corals are not attached, and so can be picked up and turned over. The underside is alive and is quite different from the top. The underside has tiny radiating ridges with small even granules on them, these are the costae which continue around the edge to the top side as septa. This individual is unusual in that it has a dead area in the center of the underside, with three small discs growing along the edge. These corals have the ability if they are badly injured, to have remaining small clusters of cells to organize themselves as tiny discs which can then grow into larger discs, in effect producing new individuals.

Halomitra

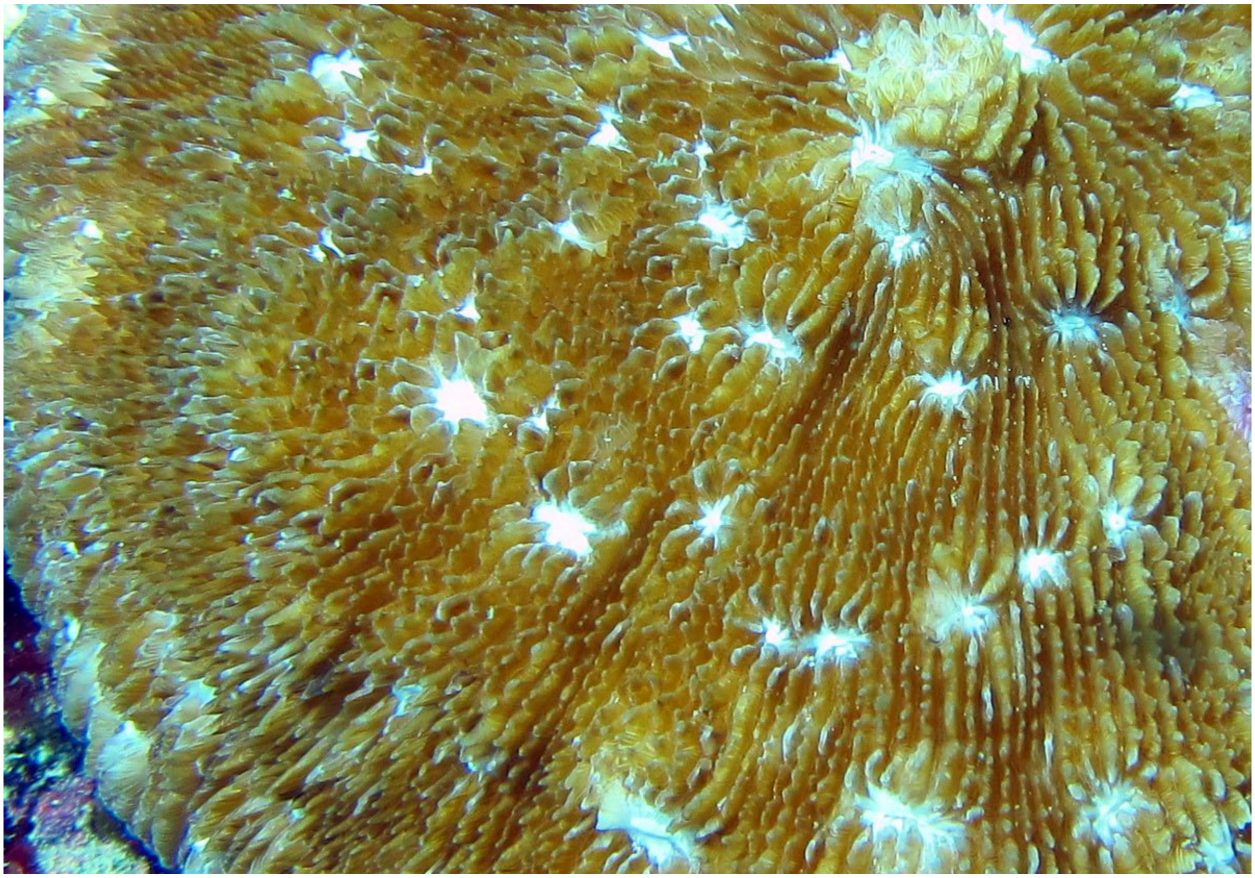
This genus forms large bowls that are usually upside down. The bowl is thin and can vary from barely curved to a high dome. There is only one species in Nauru.

Halomitra pileus very rare

This species forms bowls that can grow fairly large. The bowl is thin and in Nauru it is usually nearly flat. The polyp centers are where there is a gap in the ridges (septa) and polyp centers are usually bright white while the rest of the colony is yellow-brown. The septa have fairly large spines on them. *Sandalolitha* is oval and doesn't have white mouths.



A medium size colony of *Halomitra pileus*. The white spots are where polyp mouths are. The purple area is an area of injury and rapid growth and healing. The edge of this species always has purple where it is growing, often more obvious than on this colony.



This close-up shows the mouths, septa, and spines on *Halomitra pileus* clearly.

Sandalolitha

This genus forms large, unattached ovals. They are commonly about 20-40 cm long in the longer dimension. They are thick and just slightly dome-shaped.

Sandalolitha robusta rare

This species has many corallites spread over the entire upper surface. The mouth of each corallite is in a gap or pit between the ridges (septa) that connect the mouths. Spines on the septa are quite small. The color is usually uniform. *Halomitra* is circular and has white mouths.

This is a photo of *Sandalolitha robusta* from American Samoa.

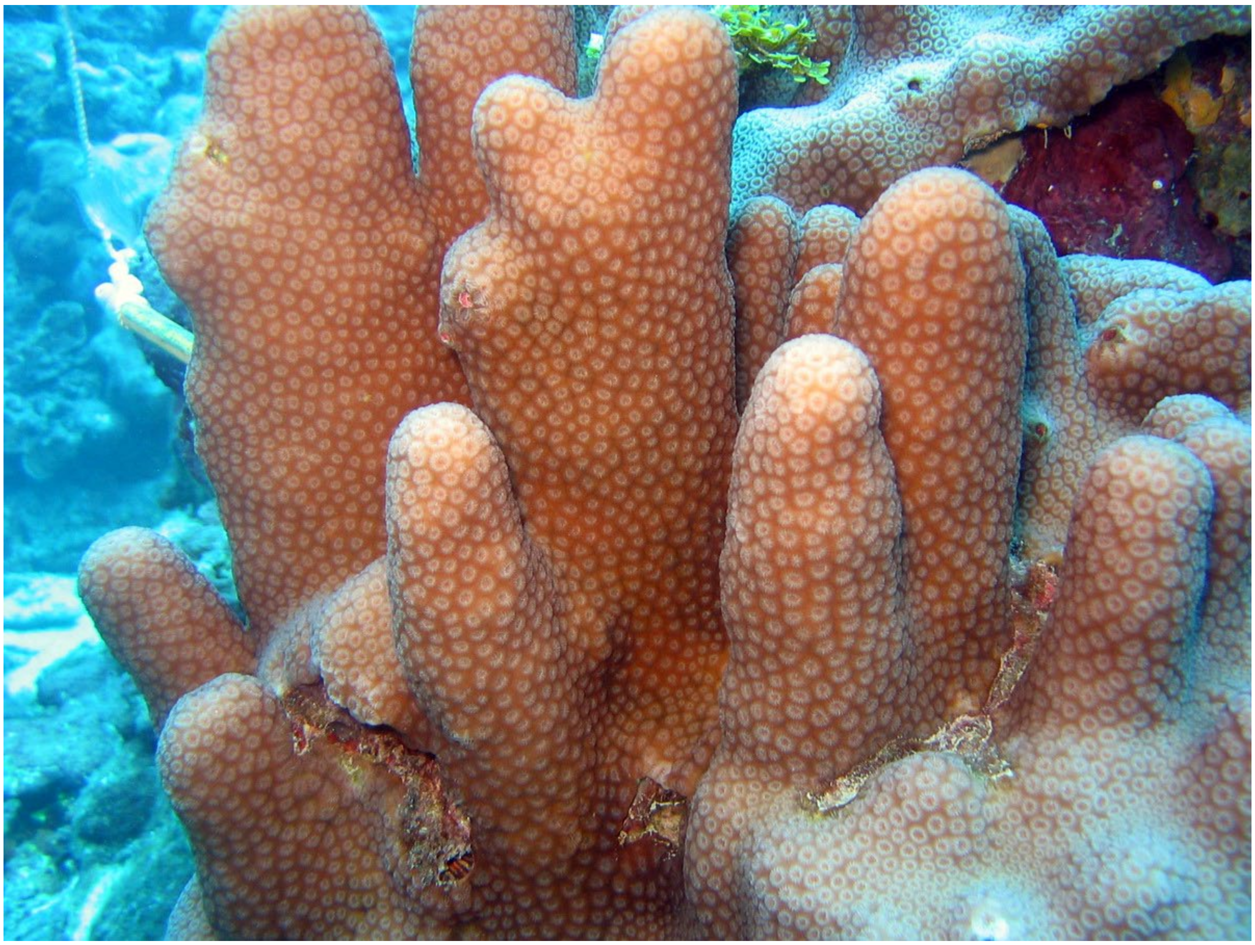
A magnified view of *Sandalolitha robusta* showing the septa, the corallite centers, and the small spines on the septa.

Goniastrea

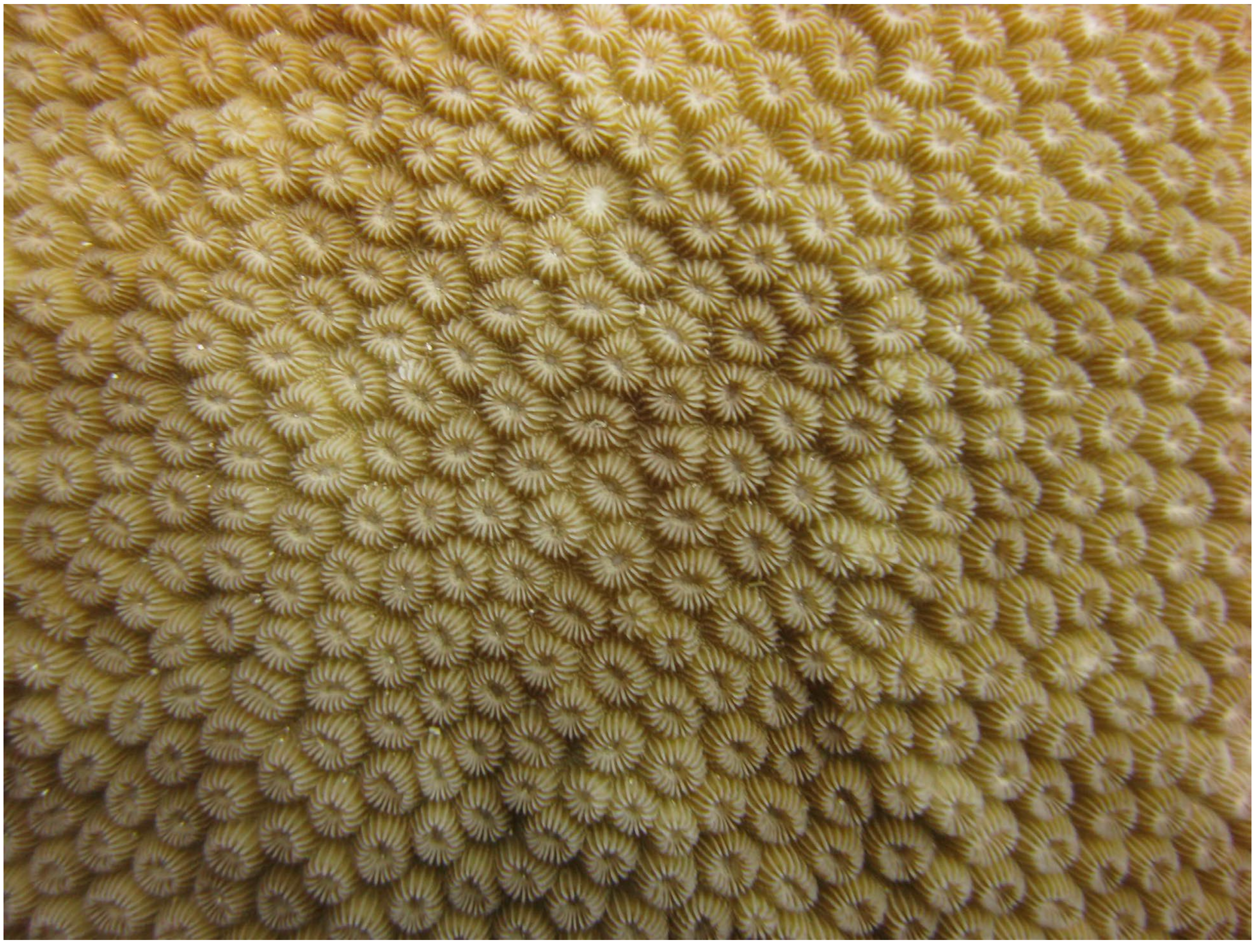
This genus forms columns or dome-shaped colonies. Only one species has been found in Nauru so far.

Goniastrea stelligera rare This species used to be in *Favia*.

This species usually forms columns. Small columns are usually cylindrical, and larger ones can be oval. The corallites are small for *Favia*, being about 5 mm in diameter. Usually light brown or reddish-brown. This species is one of only a few columnar coral species.



A colony of *Favia stelligera* in American Samoa.



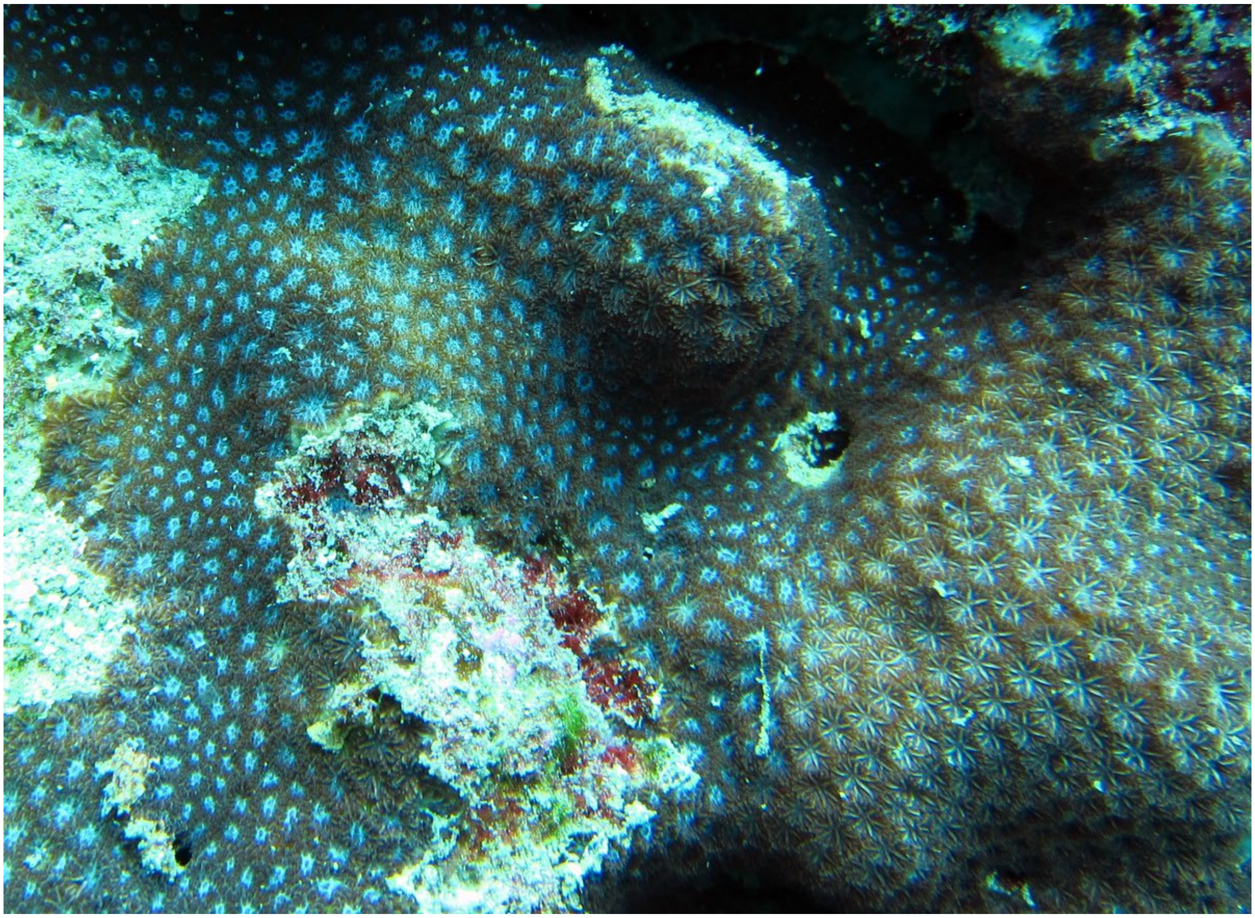
This is a close-up photo of the corallites on *Favia stelligera*. The photo is from American Samoa.

Leptastrea

This genus forms thin encrusting colonies with small corallites about 2-4 mm diameter.

Leptastrea pruinosa very rare

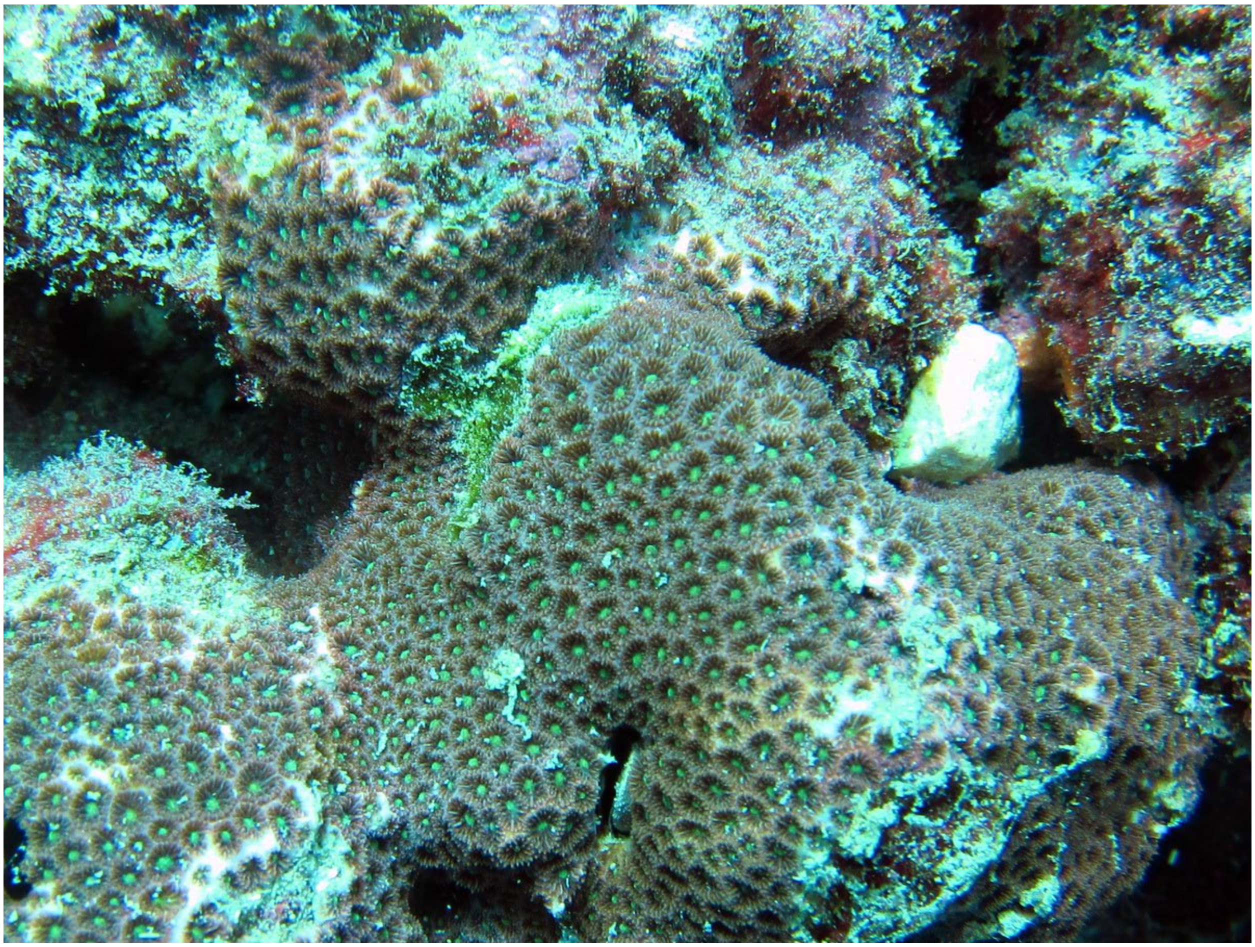
This species forms thin encrusting colonies with more flesh on the polyps than other species in the genus, which often can best be seen by the contrasting color pattern within the corallites. There is no apparent groove between corallites like there is on *Leptastrea transversa*.



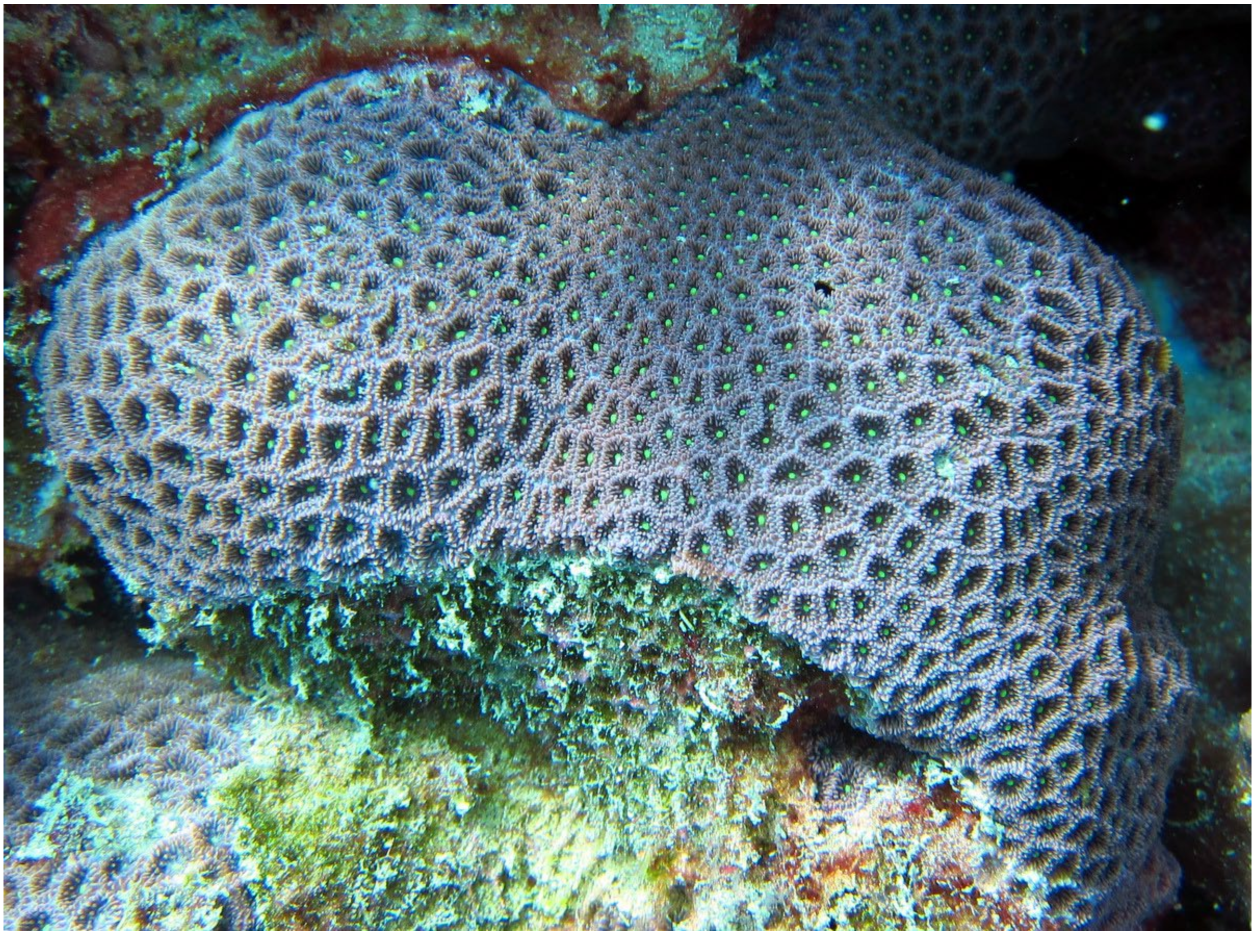
This colony of *Leptastrea pruinosa* has a relatively large white area in the middle of the polyp when tissue is expanded, seen on the left, and a star-like pattern when the tissues are contracted, seen on the right.

Leptastrea transversa rare

This species forms encrusting sheets with small corallites. The corallites are close together, but usually a small groove can be seen separating corallites. The corallites vary somewhat in size, but not greatly. Often green brown, or grey and may have bright green centers in the corallites. *Leptastrea pruinosa* does not have an apparent groove between corallites.



A brown colony of *Leptastrea transversa* with green corallite centers.



A close-up photo of a gray colony of *Leptastrea transversa* with green corallite centers and a clear groove between corallites.

Tubastraea

This genus forms colonies that are cushion-shaped, with projecting tubes which are the corallites.

Tubastraea sp. very rare

This species forms small colonies on steep overhangs, with fairly short tube-like corallites which are probably about 5-8 mm diameter. It is bright yellow. This is the only bright yellow coral here.

A small colony of *Tubastraea* on a steep overhang.

A close-up of a small *Tubastraea* colony on a steep overhang.

Class Octocorallia or Alcyonaria

Octocorals have exactly eight tentacles, and each tentacle has small regular side branches called "pini". Some, called "soft corals," are very fleshy and can form at least some external skeleton below them that is solid, without corallites. Some (gorgonians) do not form calcium skeletons. The octocorals include all of the soft corals, gorgonians, and sea pens, plus a couple of hard corals, *Heliopora* and *Tubipora*. Both of these have the zooxanthellae single-cell algae in their cells just like the Scleractinia. Many soft corals and gorgonia also have zooxanthellae, but many others do not. *Heliopora* and *Tubipora* do form skeletons of calcium carbonate (aragonite) with a thin tissue layer over them, much like Scleractinia. Soft corals are much fleshier than Scleractinia, but some do produce hard calcium underneath their tissues. They produce tiny knobs of calcium carbonate (aragonite) called "sclerites" in their tissues and move them down slowly and then extrude them beneath them and glue them to what is already there. Many species thus build an undulating smooth platform beneath them, which is as hard as the skeleton of Scleractinia. One species of *Sinularia* builds it in the shape of thick branches that can be up to at least 2 meters tall, and there are a few places in reefs where the reef is made more of this material (called "spiculite") than skeletons of Scleractinia. Most gorgonians are branching and have a flexible rod in the center of the branch under the thin layer of tissue.

Order Helioporacea or Coenothecalia

There is only one family in this order:

Family Helioporidae

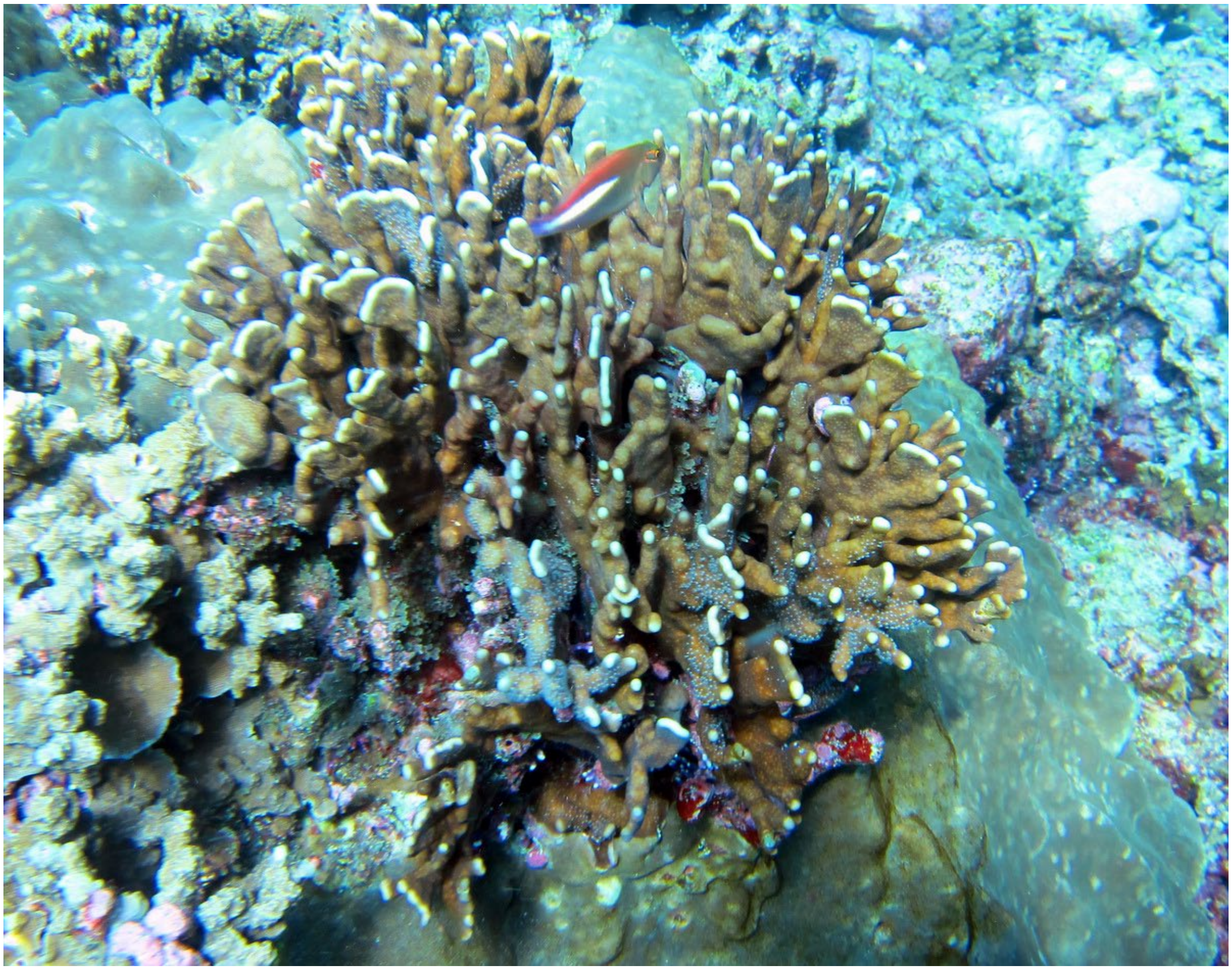
There is only one genus in this order:

Heliopora

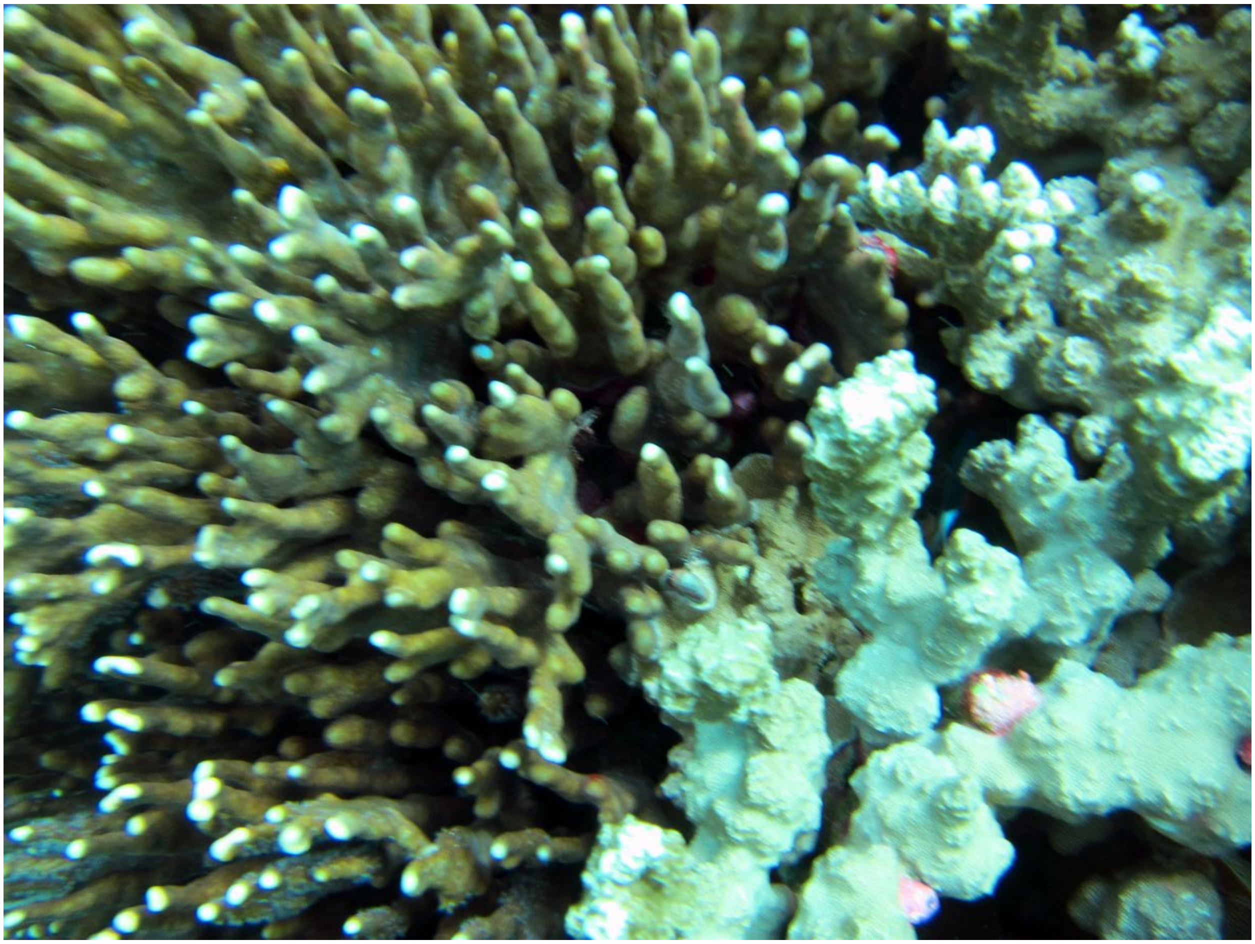
There is only one widespread species in this genus:

Heliopora coerulea "blue coral" common

Colonies have vertical columns or narrow paddles or blades that grow upward. They are usually brown or grey, but can have a light blue tint. If the polyps are extended they form a short white fuzz on the colonies. If a column or blade is broken, the skeleton is dark blue. This is the only species of hard coral with a blue skeleton. The blue comes from iron salts.



A colony of *Heliopora coerulea*. Some branches, mostly on the lower left of the colony, have a white fuzz on them, which is the extended polyps.



The columns on the left are *Heliopora coerulea*.

This colony has columns growing from an encrusting base. The white spots are where contracted polyps are.

Subphylum Medusizoa

These alternate between polyps and medusae**.**

Class Hydrozoa

Class Hydrozoa contains hydroids, some small jellyfish, and several genera that produce hard skeletons. All hydrozoans alternate generations between small polyps which asexually produce medusa (jellyfish), which in turn produce eggs and sperm which when fertilized grow into polyps. The stage that produces the skeletons we see in the next three genera are all colonial polyp stages and produce tiny medusa (about 1 mm diameter or less) that then release eggs and sperm. The few members of hydrozoa that have hard calcium carbonate (aragonites) skeletons and live on coral reefs are *Millepora*, *Distichopora*, and *Stylaster*. All of these have very small, hair-like polyps that require back lighting and a close up lens to photograph.

Order Hydrocorallina "Hydrocorals"

This order contains the forms that produce calcium carbonate (aragonite) skeletons, suborders Milleporina and Stylasterina. One genus (*Millepora*) is zooxanthellate and a common contributor to coral reefs, and several genera are azooxanthellate, only two of which are on coral reefs (*Distichopora* and *Stylaster*).

Suborder Milleporina

This suborder has only one family:

Family Milleporidae

This family has only one genus:

Genus Millepora

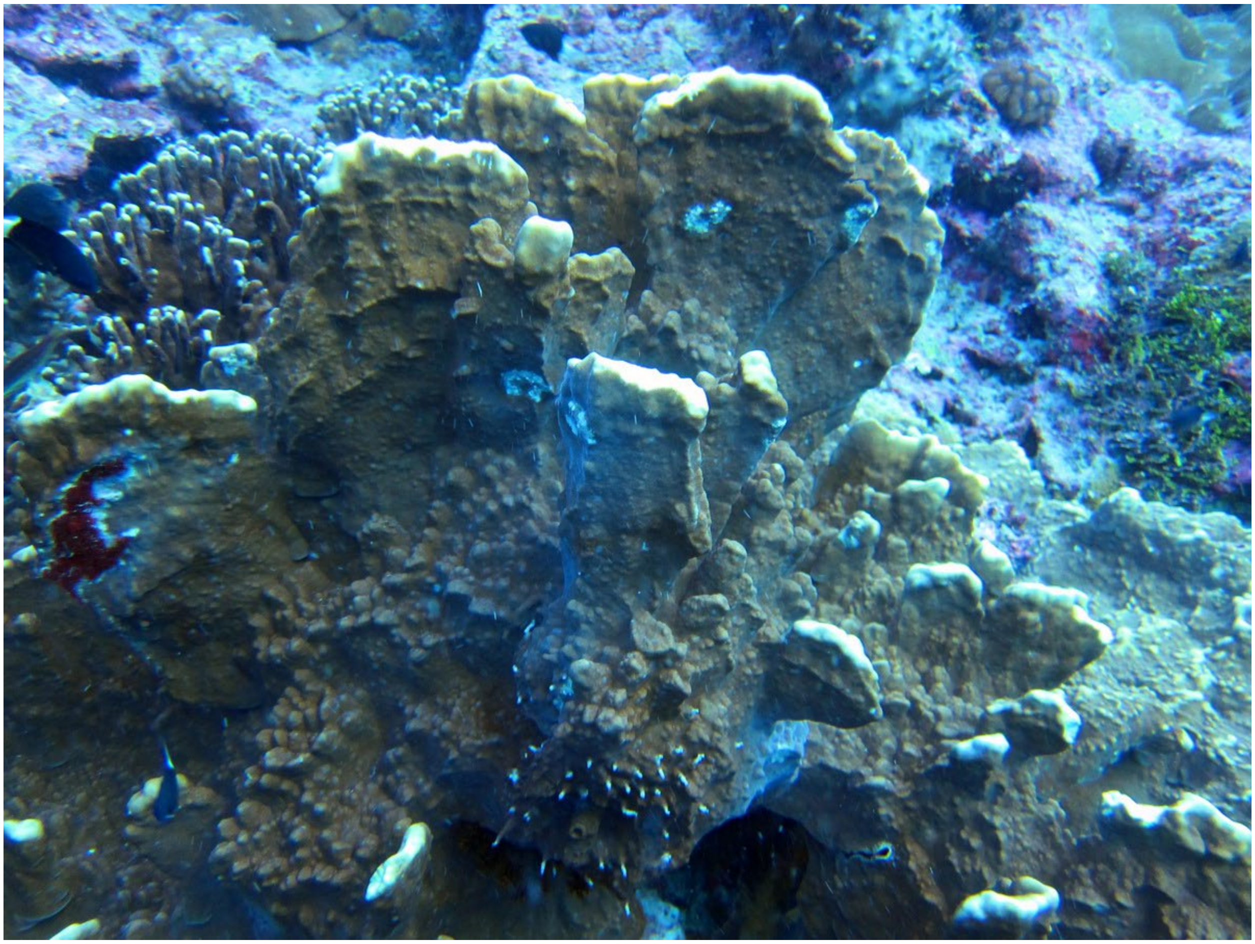
This genus produces a hard skeleton. The living tissue forms tiny, hair-like polyps that sit in tiny pores in the skeleton. The word "millepora" means "thousands of pores" in Latin, which is what the skeleton has, one for each polyp. There are long thin polyps with no mouths for stinging, and short thicker polyps with tiny mouths for eating. *Millepora* species all have the zooxanthellae single-cell algae in their cells and they are found in the light. They evolved the symbiotic relationship with the algae independently of the Scleractinia.

Millepora species are fairly fast growing. Branching species are also some of the most sensitive to mass coral bleaching

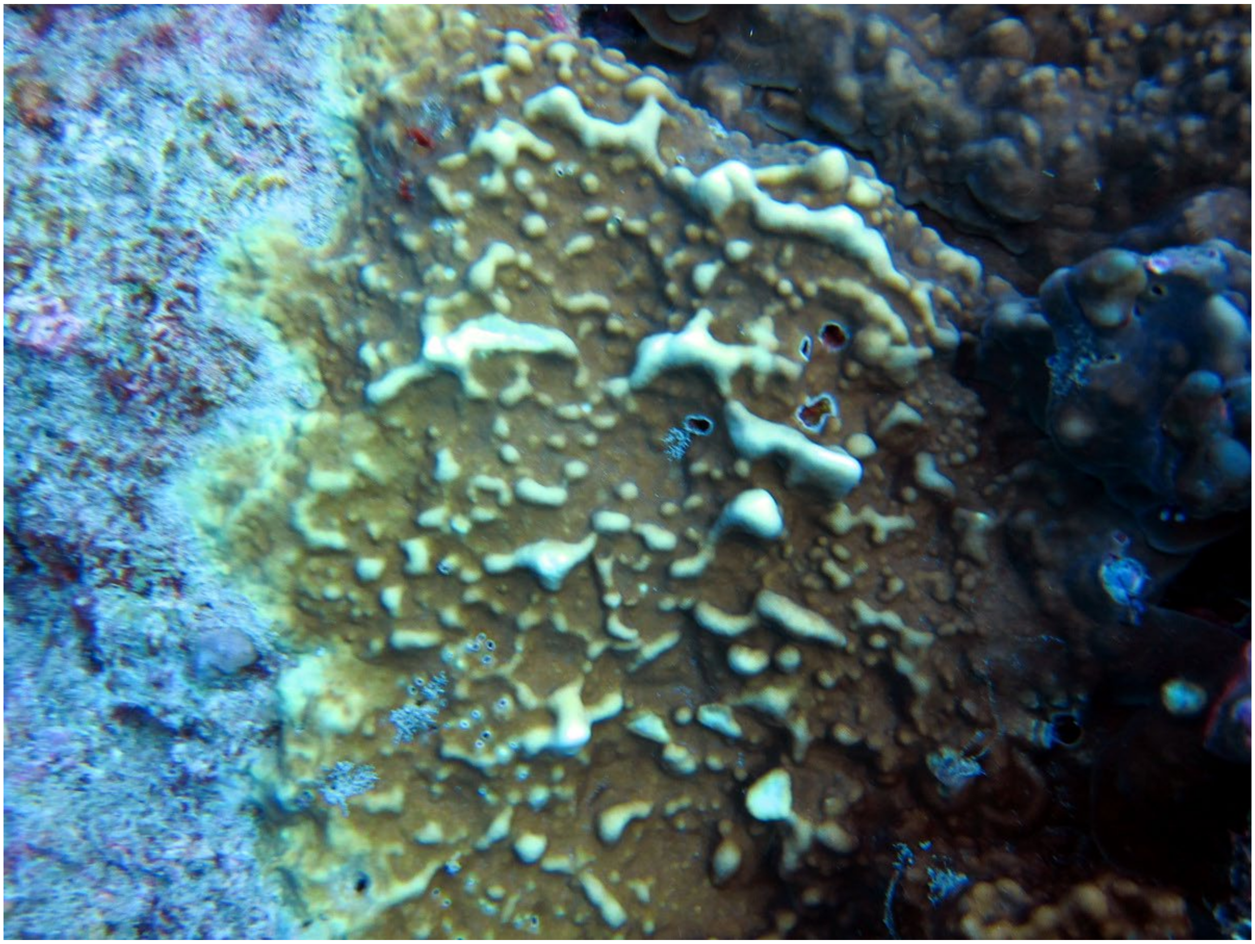
Millepora can be encrusting, encrusting base with vertical paddles, or branching. Surfaces may be smooth or bumpy. Colony shapes are highly variable. It is most often yellow or brown, but can be light green, pink, or dark reddish-purple. They have zooxanthellae and are found in light. Touching it with anything but your finger tips will likely give a sting, and it is the only coral that can sting humans. The stings are a brief burning sensation but not serious. They are called "fire corals" because of their sting. Other hydrozoans like the feathery hydroids can sting as well, but they do not have skeleton. The smooth yellow-brown colonies are distinct, and no other hard coral can sting humans.

Millepora platyphylla rare

This species forms flattened vertical plates, usually growing up from an encrusting base. It is usually a brown color. Corallites are not visible as they are pinhole-sized. No other *Millepora* forms plates or paddles.



Vertical plates of *Millepora platyphylla* growing up from an encrusting base.



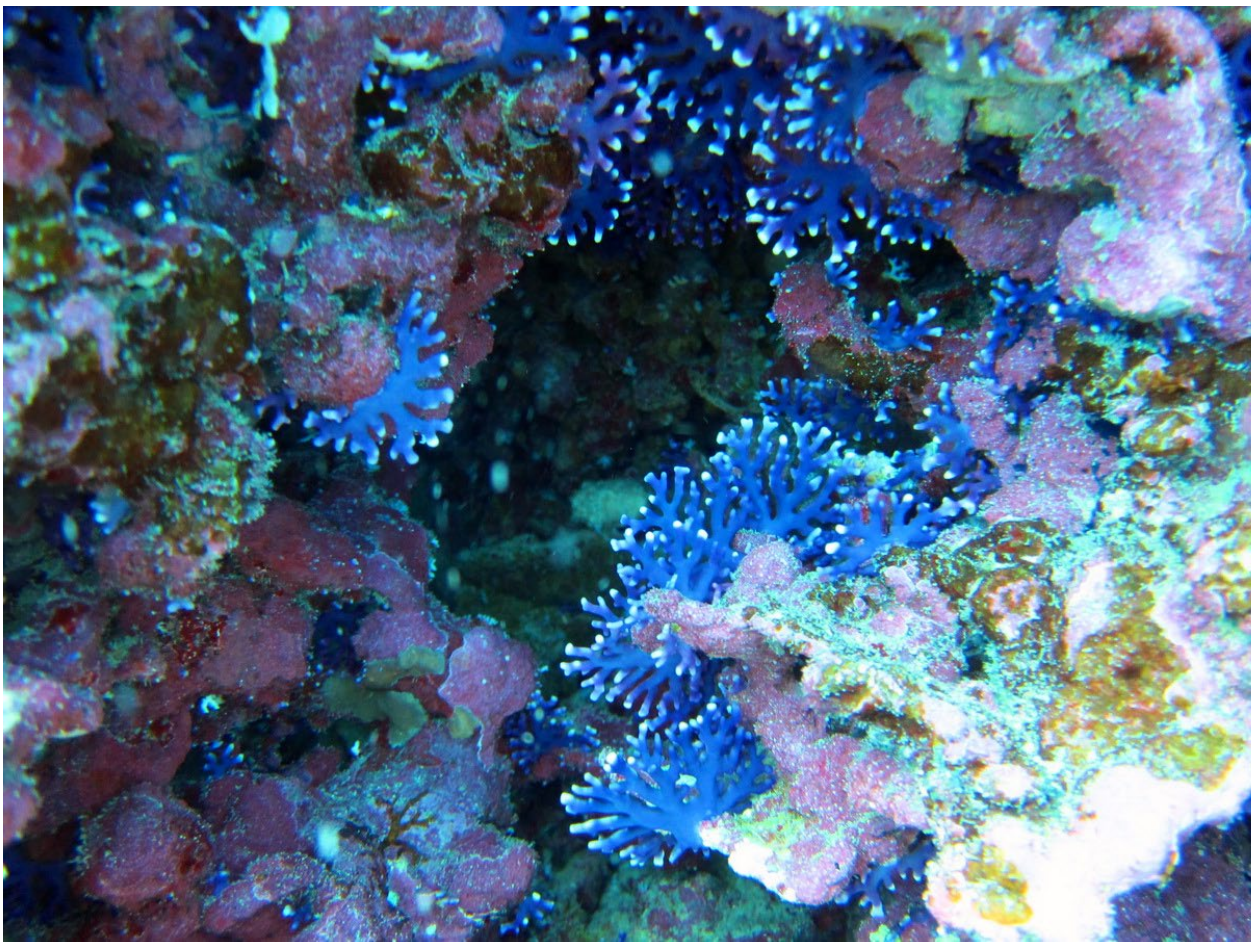
An encrusting colony of *Millepora platyphylla* with bumps that may grow upward and become plates.

Distichopora

This genus forms small blue or red corals that form fans of their small branches, usually in shaded locations. Colonies do not have zooxanthellae (single celled algae) and so they must feed on plankton for nutrition, but don't require light, and typically have relatively small skeletons.

Distichopora violacea common

This species forms blue or red fans of branches in shaded locations. Colonies can be up to about 5 cm across. This is the only small branching blue or red coral in the shade. It has thicker, smoother branches than *Stylaster*, which can be white, pink, or red.



Blue colonies of *Distichopora violacea*.

Red colonies of *Distichopora violacea*. It may be necessary to use a flash to see the red color.

Stylaster

This genus forms very small, branching colonies that are white or pink, and found in shaded locations such as in holes or cracks. In other places they commonly form small fans and are usually pink, red, or white. These corals do not have zooxanthellae (single celled algae) and thus must eat plankton for nutrition.

Stylaster sp. rare

This species forms tiny, branching, white colonies.

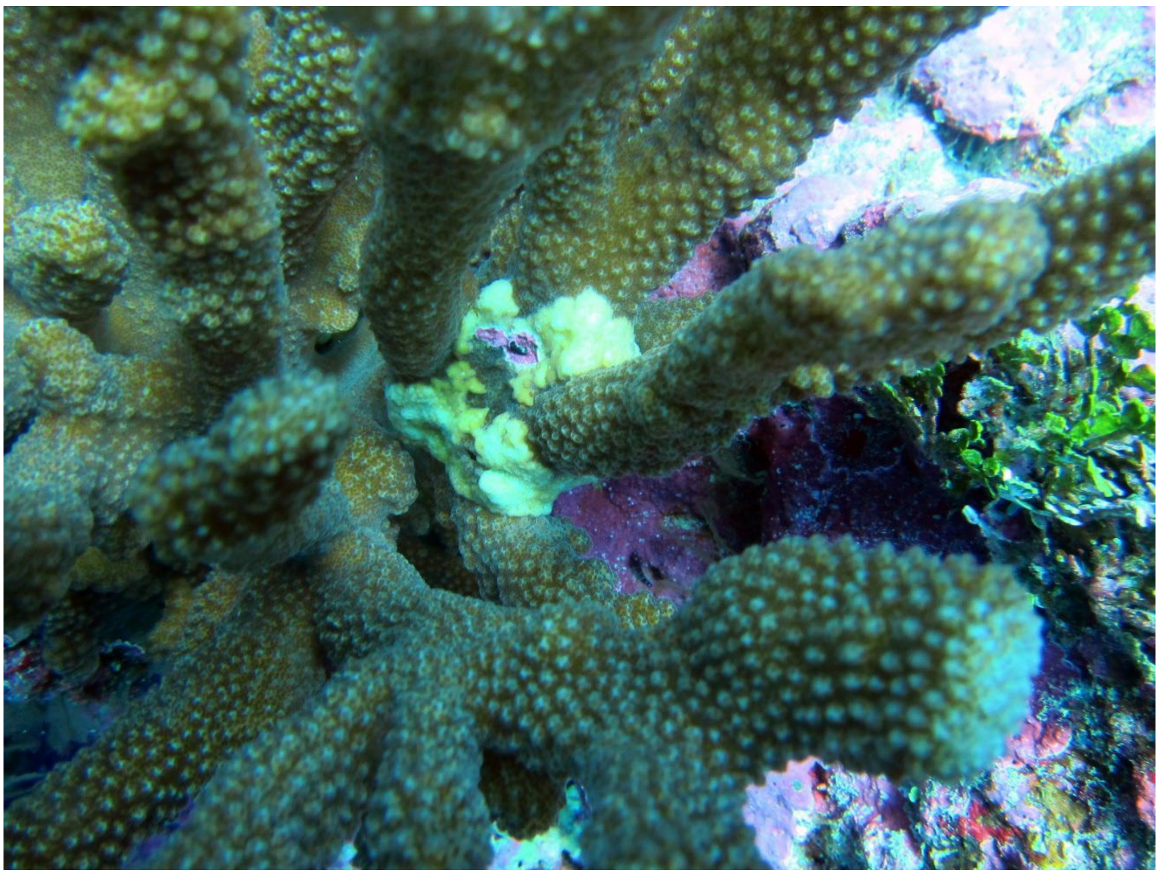
The white colonies in this photo are *Stylaster* sp.

Coral Diseases

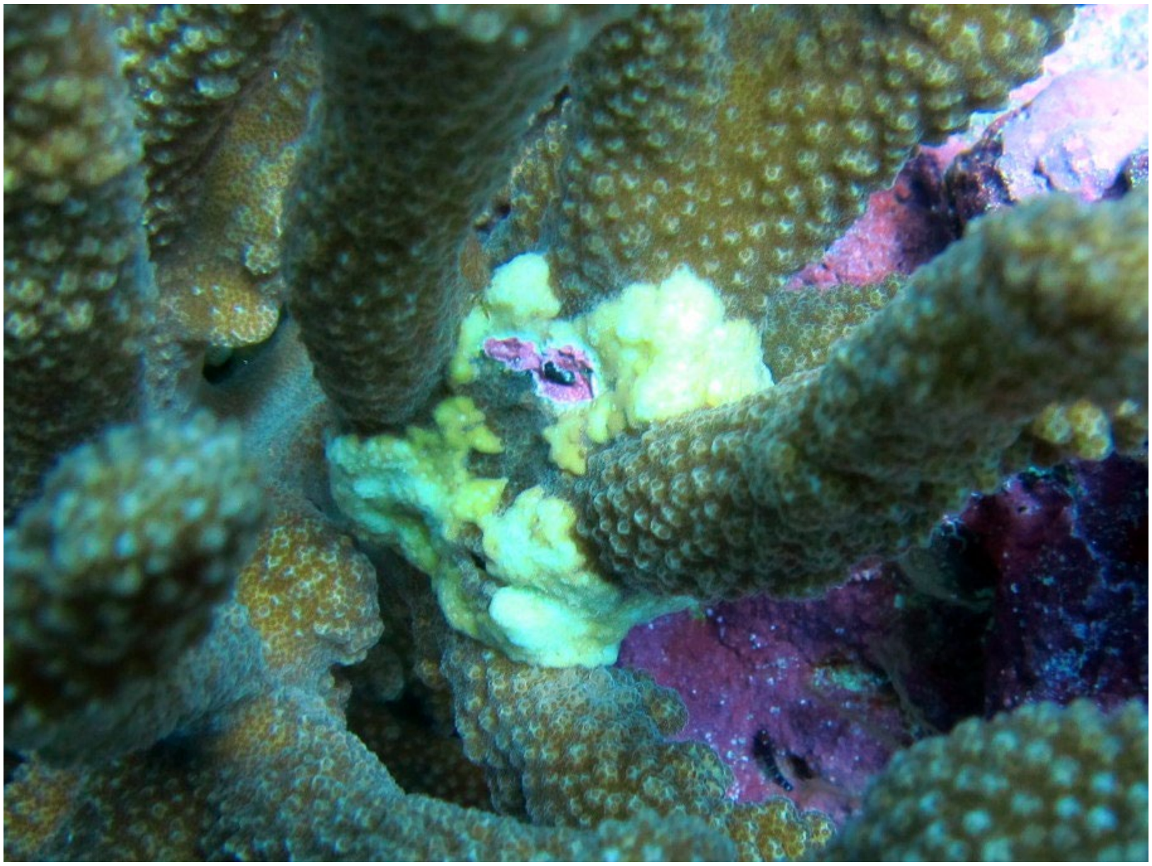
Only two coral diseases were found in Nauru in the one rapid survey program, and both were rare.

Pocillopora Growth Anomaly

Growth anomalies are abnormal growths of the skeleton, produced by the thin layer of tissue on the surface. One *Pocillopora* had a growth anomaly at the base of the branches, between branches. This growth anomaly had a relatively smooth surface with not verrucae, and was a lighter color than the rest of the colony. Growth anomalies are generally not lethal for colonies, but the growth anomaly probably takes energy from the normal part of the coral, and if the growth anomaly gets large and it lacks zooxanthellae and so is white, it can die, but the colony survives.



A growth anomaly between the branches of *Pocillopora grandis*.

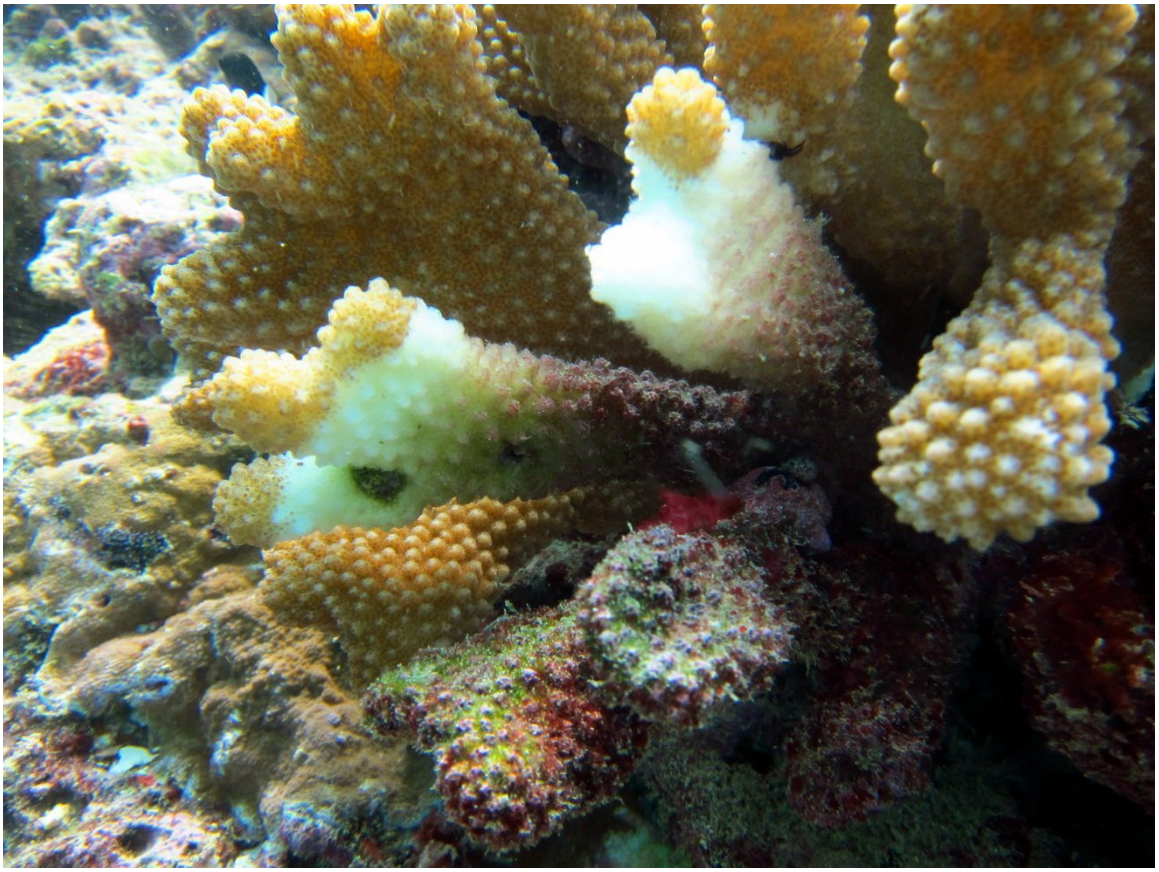


A close-up photo of the growth anomaly, showing the rippled surface and light color.

Pocillopora White Band

White band has living, normal looking coral on one side of it with a very sharp boundary between the two areas. On the other side of the white band, the white fades into color which is often green then darker with greater distance from the band. The white band is newly exposed white skeleton where the tissue has been recently killed. The area where the white fades into green and then brown or black, is where algae has been progressively growing larger on the dead skeleton as the band moves over the live coral, killing it. So the color indicates the white band is moving, and the wider the white band the faster the band is moving. White bands are usually lethal, they move over the coral until they have killed the whole colony. A very similar thing happens on table corals and is called “White Syndrome.” It is not clear whether this white band on Pociillopora is the same thing as white syndrome on table corals. Both can be called a type of “tissue loss” disease. Diseases are natural and are not a problem unless they become widespread. Their low abundance and diversity on Nauru is a good sign. White is almost always a bad sign on corals.

A *Pocillopora* White Band disease killing it. Long dead branches on the right are now covered with pink coralline algae. Many of the branches have white bands near their bases now. The bands will move up the branches, killing them.



This closer photo shows white bands on two or three branches of this colony. The branch tips are alive, with a very sharp boundary to the white band. Then the white fades to brown and dark color down the branch as the algae grows as the band moves up the branch, killing it.

References

Fenner, D. 2019. Nauru. Pp. 793-806 in: Sheppard, C. 2019, World Seas: an environmental evaluation, 2nd Edition, Vol II: The Indian Ocean to the Pacific. Academic Press.

Fenner, D. 2022. Corals of Hawaii, 2nd edition. Mutual Publishing, Honolulu.

Hoeksema, B. W. 1989. Taxonomy, phylogeny and biogeography of mushroom corals (Scleractinia: Fungiidae). Zoologische Verhandelingen 254: 1-295.

Lamberts, A. E. 1982. The reef coral *Astreopora* (Anthozoa, Scleractinia, Astrocoeniidae): A revision of the taxonomy and description of a new species. Pacific Science 36: 83-105.

McKenna, S., Butler, D.J, & Wheatley, A. 2015. Rapid biodiversity assessment of Republic of Nauru. Apia, Samoa: South Pacific Regional Environmental Programme.

Nemenzo, F. Sr. 1986. Guide to Philippine Flora and Fauna: Corals. Natural Resources Management Center and the University of the Philippines. 273 pp.

PROCFish/C and CoFish Team. 2005. Nauru country report: Profile and results from in-country survey work. Secretariat of the Pacific Community, Noumea, New Caledonia.

Randall, R. H. and Y-M. Cheng. 1984. Recent corals of Taiwan. Part III. Shallow water Hydrozoan Corals. Acta Geologica Taiwanica 22: 35-99.

Randall, R. H. and R. F. Myers. 1983. The Corals. Volume II. Guide to the coastal resources of Guam. University of Guam Press. 128 pp. (out of print)

Razak, T.B. and B.W. Hoeksema. 2003. The hydrocoral genus *Millepora* (Hydrozoa: Capitata: Milleporidae) in Indonesia. Zoologishe Verhandelingen Leiden 345: 313-336.

Sheppard, C. 2021. Coral Reefs: A Natural History. Princeton University Press. 240 pp.

Sheppard, C., S. Davey, G. Pilling, and N. Graham. 2018. The Biology of Coral Reefs. 2nd Edition. Oxford University Press. 384 Pp.

Veron, J. E. N. 1995. Corals in Space and Time; the biogeography and evolution of the Scleractinia. UNSW Press, Sydney. 321pp.

Veron, J. E. N. (2000). *Corals of the World*. Vol. 1-3. Townsville: Australian Institute of Marine Science.

Veron, J.E.N., Stafford-Smith, M.G, Turak, E., and DeVantier, L.M. 2020. Corals of the World. Version 0.01 (Beta). www.coralsoftheworld.org/v0.01

Wallace, C.C. 1999. Staghorn Corals of the World: a revision of the genus *Acropora*. CISRO Publishing, Collingwood, Australia. 422 pages.

Wallace, C.C., C.A. Chen, H. Fukami, and P.R. Muir. 2007. Recognition of separate genera within *Acropora* based on new morphological, reproductive and genetic evidence from *Acropora togianensis*, and elevation of the subgenus *Isopora* Studer, 1878 to genus (Scleractinia: Astrocoeniidae; Acroporidae). Coral Reefs 26: 231- 239.

Wallace, C.C., Done, B.J., Muir, P.R. 2012. Revision and catalogue of worldwide staghorn corals *Acropora* and *Isopora* (Scleractinia: Acroporidae) in the Museum of Tropical Queensland. Memoires of the Queensland Museum - Nature 57: 1-255.

The Author

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Born in Michigan, USA, the author has lived in a variety of places in the states, including Florida during his high school years, which stimulated an interest in tropical marine life. During his years at Reed College in Portland, Oregon, he was introduced to biology, including invertebrate biology, studied sea urchin tube feet and respiration for his thesis and spent two summers in Hawaii studying fish behavior with his professors. Once graduated he attended the summer invertebrate zoology course at the Marine Biological Laboratory at Woods Hole, Massachusetts and then another summer was a course assistant for that course.   Snorkeling trips to the Caribbean (including to Jamaica just before Hurricane Allen) during graduate school at the University of Pennsylvania were followed by scuba trips to the Caribbean. His coral reef research and publications began with surveys and description of reefs in the Caribbean, including Cozumel, Roatan, Cayman Brac, Little Cayman, and St. Lucia. It became clear that to do transects you need to know your corals, and existing guides were inadequate, so Caribbean coral identification and taxonomy were next to be studied. By this time the author lived in Seattle, Washington. Then the author began to study corals in Hawaii, which led to his identification book for Hawaiian corals. Following that, he worked in the Philippines for two years, learning many coral species in that area of high diversity. This was followed by six years of working with Dr. “Charlie” J.E.N. Veron at the Australian Institute of Marine Science on the “Coral ID” electronic key to corals of the world. At that time, the author began to be invited to study and record corals during Rapid Assessment Programs in a variety of places around the Indo-Pacific. In November, 2003, the author began work at the Dept. Marine & Wildlife Resources, in American Samoa. He began working on coral reef monitoring there a year later and continued with that, and continued to make trips to study corals around the Indo-Pacific. Currently, the author has studied coral at 14 islands in the Caribbean and 14 areas of the Indo-Pacific, plus southern Italy in the Mediterranean. He is an author of 17 book chapters and 46 peer-reviewed articles in scientific journals. He has worked as a contractor for NOAA NMFS Protected Species on the threatened coral species since 2013. That work has taken him around the Pacific each year to study corals and teach people how to identify corals. That effort includes photographing corals, writing field guides and building “practice modules” for teaching coral ID and people to practice with. He also works on describing new corals species and diseases and a variety of other coral reef topics. He continues to be based in American Samoa.