XI. Introduction to Soft Coral and Colonial Polyps

This article discusses "Soft Coral" including Leather Coral, Xenia & Zoanthids

Coral providers often offer "Beginners Packages", an assortment of coral suitable for the early stages of a tanks maturity due to their durability. There are several species of coral that are capable of thriving in lower light conditions, some that have adapted to survive higher nutrient levels due to natural environmental factors, while others are so pervasive and low maintenance they are deemed durable simply due to limited needs to flourish. Most coral that possesses these traits to fall into the category of soft corals. In this article we will discuss the unique considerations of the most common examples soft coral, however, this is by no means a comprehensive list of all the varieties available.

Leather Coral

The moniker refers to the texture of these corals flesh. Lacking any rigid skeletal system, their bodies contain microscopic structural elements called spicule that interlocks creating a flexible, woven support system. Like many coral leather coral host symbiotic algae capable of converting sunlight into energy that is transferred to the host colony. Secondly, the polyps of most leather coral are capable of capturing prey as large as brine shrimp eggs.

Existing at deeper depths than many reef-building corals and often along the reef shelf, these coral have adapted to lower light intensity and higher currents due to the crashing waves on the reef above. As such, most leather corals are happiest when provided strong, multi-direction flow patterns. If an inadequate amount of current is provided the polyps of the leather coral will not open fully and the coral will not achieve optimum growth or appearance. Additionally leather coral as a whole will appreciate subdued lighting. When high-intensity lighting is used care should be taken to position Leather corals towards the bottom and sides of the tank as too not over stimulate them with light.

Throughout some leather corals life, it will go through periods of dormancy. Its polyps will not appear to expand and you will notice a sheen across the surface of the coral. The sheen you are seeing is a thing mucus coating secreted by the leather coral. Within a day or two, with the adequate flow, this mucus coating will lift away and be carried through the water column to your filter. You should not attempt to remove this mucus coating as it is part of the natural sloughing of the corals' flesh. Similar to when a snake sheds its outer layer of skin as it grows, coral purges their surfaces of debris and bacteria as they age.

Xenia

One of the most commonly suggested soft coral is included in this list due only to its existence on every other list. Xenia is a fascinating coral that displays a rhythmic pulsing motion with its polyps.

Capable of surviving in lower light due to its advanced filter feeding capabilities. Beyond filtering plankton from the water with its pulsing polyps, Xenia can also absorb nutrients from the surrounding water directly. Its ability to absorb nutrients from the water also makes it a great candidate for nutrient export in the same fashion macroalgae do.

In the wild Xenia inhabits large swaths of the shoreline. Found in exceptionally dense populations where sewage from nearby hotels and municipalities are expelled into the oceans. As far as a low fuss coral is concerned Xenia takes the cake. But it is in these many benefits that Xenia is a double-edged sword of a coral and why I hesitate to recommend it. Xenia not only survives but has no problem thriving in less than ideal conditions, when provided optimum conditions its growth is exponential and a small colony can quickly reproduce until every square inch of rock is covered in pulsing polyps. As time goes on the tank may become overpopulated with Xenia and other coral may begin to suffer from contact with the mucus produced by this coral.

While certainly a great candidate for many reef tanks, Xenia will spread uncontrollably in most tanks and as a result, I hesitate to nominate it for an early addition as it will take up valuable real estate as we move forward with other coral additions. I hesitate nominating for later additions as its invasive nature may negatively impact existing coral. As a closing note on Xenia I will mention that unlike much soft coral, Xenia does not appear to produce a copious volume of noxious chemicals when it is manually removed from the glass and equipment of your aquarium. Xenia will grow up the walls and on the equipment in your aquarium.

Zoanthids

Comprising dense mats of polyps about the size of a pencil eraser, Zoanthids are an amazing coral that is coveted equally by equally and veteran reef keepers. Having by far the largest variety of color combinations of any single species, entire aquariums can be filled with this single species and you would still achieve the full spectrum of color possible with a reef tank. Highly marketed with brand names referencing sports teams or pop culture this coral can appear expensive however their rapid growth means that a small fragment of only a few polyps is enough to populate a large portion of rockwork. There are sisters to Zoanthids, mainly Palythoa but they are so similar in care in the description I do not feel a need to split the two when discussing them on an introductory level.

Both Palythoa and Zoanthid even share the same precautions when considering. Any tank containing Zoanthids must run activated carbon filtration. Any time you handle Zoanthids or water Zoanthids have resided in for any period of time you must wash all affected areas thoroughly. Within the beautiful exterior lurks a powerful neurotoxin called "Palytoxin". Palytoxin is lethal to mice and has serious side effects in humans with symptoms persisting for days. Even the South Australian Government has a health page dedicated to the dangers of palytoxin exposure and while it is a serious risk, in my opinion, proper consideration and handling are supremely effective at avoiding all consequence. My opinions aside, however, if after handling coral or aquarium water you feel unwell, please seek medical attention.

Although I have only addressed three families of coral above, within these families are forty-four classified genus containing hundreds of options to consider. Soft coral makes amazing additions to a mixed reef tank with proper consideration, however, when given an environment more tailored to their needs soft coral really shine. Diffused lighting, alternating strong currents, routine feedings with zooplankton and pristine water quality will lead to phenomenal growth rates and vibrant coloration for a majority of soft coral.

XII. Intermediate Level Coral - Introduction to Large Polyp Stony Coral

This article discusses Large Polyp Stony Coral, Care & Recommendations

Upon observing an LPS colony for the first time you may notice the striking colors, the soft "fleshy" appearance, or, the tentacled lined mouths of their polyps. Beneath this exterior, however, lies a calcium carbonate based skeleton. It is this skeletal system that supports the polyp as it expands throughout the daily feeding cycles. This skeletal system, like our own, requires care and nourishment to grow and maintain its strength. It is in caring for coral with a skeletal system that we add additional requirements to our reef tank.

Large Polyp Stony Coral

Aptly named due to the relative size of their polyps. Unlike soft coral and the diminutive polyps of Small Polyp Stony(SPS) coral, LPS coral usually sports a large polyp structure. Many express their polyps through a colony as in the case of Favia or Echinophyllia while some, as in the case of Fungia are considered solitary with a single polyp making up the entire coral. All stony coral are voracious feeders, their tentacles capable of capturing prey with nematocysts. While preferred prey size varies from species to species, most LPS coral will appreciate a diet of zooplankton including rotifers, brine shrimp nauplii, and copepods. Larger, fleshier LPS may be capable of capturing larger prey but caution should be used to ensure prey items are able to be captured and completely digested.

Failure to use reservation when feeding LPS corals will result in them consuming all prey items offered. This is done by a reaction and involves a significant expenditure of energy from the coral. Once in the gut of the coral, it will attempt to digest the prey item. If the prey item at this point is too large to be digested by the coral, it will regurgitate the prey item. This again involves significant energy to be used by the coral. In the process of feeding the coral, in this case, we have made it "work-out" twice instead, the coral has expended more energy attempting to eat than it had gained from eating. In time this can lead to malnutrition and the "unexplainable" loss of a colony. Additionally, the unconsumed food is left to break down in the aquarium ultimately leading to increased waste.

Instead, care should be taken to observe the coral for sometime after feeding, if you notice any coral regurgitating food it means that the prey item was likely too large and smaller fare should be offered. Remove the uneaten food so that it is not able to rot in the system and foul the water. It is a good idea to not attempt to feed this coral again right away and instead give it a few hours to a day before attempting to feed again. This gives the time for the digestive fluids in its stomach to be restored so that the next food offering may be properly digested, much of the digestive fluids within a corals gut are expelled when regurgitating food. With proper care and feeding LPS, coral can obtain a balanced amount of carbon-based energy from digestion and leverage this with sucrose based energy obtained through photosynthesis and available calcium in the water column to complete the process of skeletal genesis.

Care

When comparing LPS coral to that of soft coral and colonial polyps, the care requirements of the former are a bit more precise. Due to a skeletal structure being present in LPS coral, the maintenance of key components in the water column becomes critical to success. When forming its skeleton, LPS require elements such as Calcium and Magnesium present and in biologically accessible forms. The general rule is to maintain a Calcium level of at least four hundred twenty part-per-million(420ppm) but no greater than four hundred sixty parts-per-million(460ppm) as participation may occur. Magnesium should be maintained at a level rough three times your calcium level. For example, a tank maintained with a calcium level of four-hundred twenty part-per-million(420ppm), should have an available level of magnesium equal to one-thousand-two-hundred sixty parts per million(1,260ppm).

The easiest way of maintaining appropriate calcium and magnesium concentrations is through reliable water changes with quality salt mixes. With a tank mostly populated by soft coral with only a few LPS coral, this may be all that is needed to maintain adequate calcium and magnesium levels. However in the case of tanks that are primarily LPS, or when there is just a high density of fast-growing LPS corals, the demand for calcium and magnesium may exceed levels maintainable through water changes. When caring for systems with a higher demand for these elements the use of additives in-between water changes is used to bridge the gap. Additives may be measured and added daily, or, dripped into the system at a steady rate throughout the day.

The most commonly used additive for the maintenance of these levels is Two-Part dosing systems. Many are available but all exist as two primary additives added in ration and correspondence to one another. While exact components differ from manufacturer to manufacturer, the general perception is that one half adjusts and buffering capacity of the water by adding ionic compounds that will bind to the buffering agents and the other contains a balance of buffering agents that are now readily absorbed into the water column and taken up by the coral. An older method to obtain the same result is through the addition of "Kalkwasser" or Calcium Water, known in the states as "Lime Water".

This process is easiest with auto-top-off systems, though it can be done through stand-alone reactors. When using an auto-top-off, the freshwater is simply dosed with an appropriate amount of kalk for your tanks needs for however long your top-off reservoir usually lasts. This involves less risk of accidentally adding too much kalkwasser. When using a reactor injection method, the kalk is kept in a reaction chamber, water from the tank is mixed with the kalk and an amount of kalkwasser is created relative to the volume and flow-rate of the reactor. The kalkwasser is then ejected from the reaction chamber and introduced to the system, usually via the sump. Due to the large volume of additional kalk stored in the reactor, there is a much greater risk of over saturation. If too much lime water is created and introduced to the system it can have drastic effects on the living things in our aquarium. Whenever Kalkwasser is used a much closer eye should be kept on the reactor itself as well as your calcium, alkalinity and pH levels. Any abnormalities should be corrected immediately by either shutting down the reactor to allow levels to drop, or, add additional kalk as the reserve is consumed.

It should also be noted that specific lighting and flow requirements will differ from species to species and proper flow and lighting is critical to the health of all coral. Lighting too strong will cause damage to the soft tissue of LPS coral and kill the underlying zooxanthellae, lighting too low and the polyps will grossly over-expand in an attempt to collect more light. The density of different zooxanthellae within the LPS may change to account for light as well, many taking on a dull green/brown appearance when given inadequate light. This is due to the coral now having a higher density of zooxanthellae that require lower light levels and a lower density of the accessory pigments used to shield or otherwise convert light for the underlying zooxanthellae. Many a browned out “bulk-lot” coral has become a stunning and vibrant coral given proper lighting and care, an unfortunately for many premium coral wash out and lose their pop when proper care and lighting are overlooked.

Recommendations

While the grouping of corals referred to as LPS is very broad, there are a few that I hold near and dear to my heart. These, in my opinion, exemplify LPS corals best qualities; photo-adaptive capabilities, an interactive feeding experience, bright colors, and durability that coincides with life at great depths in the ocean. These coral seem to thrive equally well under most lighting options commonly employed and all readily eat Mysis or Brine shrimp. As these are two of the most commonly used frozen foods for fish, it means that you likely do not have to add anything to your normal feeding supplies. The above factors combine for striking beauty with low fuss maintenance easily performed by most aquarists.

Fungia- One of the oldest coral recorded by science, Fungia are solitary polyps that spend the majority of their lives on the beds of ocean lagoons. Unlike most coral, Fungia is considered non-sessile, they use specialized tentacles along the circumference of their polyps to move along the ocean floor. This process is comparatively slow, even when compared to snails, but is never-the-less observable in the home aquarium. Fungia will often move from the place first introduced, exploring lighting and flow in different areas until it finds a suitable place to settle down. In some cases, we simply cannot provide "perfect" conditions for a Fungia on the floor of our tanks. When this happens, it is not uncommon to see a Fungia, over the course of days or weeks, shimmy up the reefscape to find a better home. Should your Fungia leave the sand bed its powerful tentacles may become a threat to nearby coral. Care should be taken to clear coral from around it and make a "fall-zone" free of other coral.

Echinophyllia- Referred to in the trade as a "Chalice" coral, Echinophyllia comprises a genus of three readily available species. Additionally, due to the confusion of taxonomy, the "chalice" and by extension Echinophyllia nomenclature are often assigned incorrectly to similar coral such as Mycedium and Echinophora and Oxypora. For all intents and purposes, these corals are easily confused especially when we consider demographical overlaps, morphological oddities, or a human error in transposing information from one place to another. All have similar growth patterns and form a large encrustment on the substrate before growing upwards into spectacular cup-like formations. Available in a wide variety of striking color patterns, Chalice coral is a staple in the industry and remain one of the top "designer" corals making waves whenever a new variant is discovered.

Duncanopsammia- Duncanopsammia axifuga, more commonly referred to as "Duncans Whisker" or more simply "Duncans" is an extraordinary example of colonial Large Polyp Stony Coral. Unlike most branching LPS, the branches of the coral have tissue covering the underlying carbonate based skeleton. Not only that but this tissue is a bright often neon mix of yellow and green. A top each branch are a cluster of equally beautiful, neon green flower-like polyps. Flowing in the current they resemble a field of psychedelic sunflowers the tentacles, petals in the wind. Beyond a striking appearance, Duncans also display extraordinary growth rates when fed regularly in addition to proper lighting. However, in lower lighting conditions, Duncan's owners may be happy to see an equally dense cluster of polyps by simply feeding the polyps more to compensate for lower light availability, within limitations of course.

XIII. Advanced Coral - Introduction to Small Polyp Stony Coral

This article discusses Small Polyp Stony Coral, Care & Recommendations

The most abundant of "reef building" coral or Scleractinian coral are the Small Polyp Stony Coral(SPS). Similar to the other Scleractinian Corals, LPS, SPS coral possess a calcium-based skeleton, by and large, this is where the similarities end. SPS coral grows in two primary forms, plating or branching. These corals often come from the nutrient desserts of the reef crest and are much much more sensitive to pollutants than most coral. Some tanks may suffer only a loss of SPS coral to see all other corals pull through some fluctuation of chemistry or abnormality with temperature or lighting. In short SPS coral have a reputation for being more fickle than most coral, however, with their unique requirements demystified long-term care becomes obtainable.

Small Polyp Stony Coral

Represented primarily by four genera', Acropora, Montipora, Stylophora, and Pocillopora come in thousands of colors and are at the heart of the coral trades "Premium Coral" market. Branching outcrops of neon coral, dotted with often starkly contrasting polyps reach and intertwine forming the dense underwater equivalent of a jungle. Montipora, on the other hand, is unique from the others mentioned in that it is available in branching, plating or encrusting morphs. Regardless of physical form, SPS coral comprises the backbone of the coral reef in a very literal sense and are exposed to the tumultuous currents of the waves above. The rigid calcium-based skeletons protect small delicate polyps that extend to catch floating phytoplankton and very small zooplankton. These coral have an extraordinary demand for calcium and proper alkalinity to maintain this rigid protection while remaining remarkably delicate.

As the water around the reef crest is constantly oxygenated and carried away by the waves so to are nutrients and ionic bi-products created by the reef itself. This means dissolved nutrient levels are very low and oxygen levels are fairly high. It is thus harder for bacteria and other pathogens to take a strong foothold in these conditions as redox levels are high enough to thwart their spread, however, in our tanks, this may not be the case and SPS coral is known to suffer from two highly researched but still fairly mysterious diseases. To prevent this, superb care should be taken of our SPS tanks and a proper coral dip should always be used to prevent the introduction of contaminants from new additions. Additionally, it is highly recommended the aforementioned diseases(Rapid Tissue Necrosis and White Band Disease) to know thy enemy.

Care

When keeping an SPS dominated fish tank, the need for calcium and alkalinity is only met through water changes with the most frequent of changes, becoming arguably too much hassle to even consider in most systems. However, unlike when keeping LPS coral, simple two-part or kalk may need to be added at such a rate this too becomes a hassle or at the very least a significant financial dependency for the system. In cases of SPS tanks, the employment of a Calcium Reactor is highly recommended. A calcium Reactor takes the ingredients of Carbonate Media, Carbon Dioxide, tank water and combines them in a reaction chamber. The Carbon Dioxide acidifies the carbonate media, breaking it down into the water column. The elements from within the carbonate media are absorbed into the water column and introduced to the tank in a similar fashion to a klakwasser reactor, via a slow feed to the sump. The most commonly used media is ground reef rubble. Due to the risk of carbon dioxide acidifying the water in the reactor too much and causing the pH to drop, careful monitoring of CO_2 and use of a pH controller is strongly recommended, if I may not outright insist.

In addition to much higher demand for stable calcium alkalinity and ph levels, these coral are exposed to far lower levels of dissolved organic compounds(DOC) than any other corals. This leads to a lower ability to tolerate and cope with nutrients. Where even some LPS tanks may see an occasional nitrate spike that regulates itself, perhaps due to overfeeding, and see no ill effects, an SPS tank may start to show visible signs of stress if any Nitrate is detectable. Truly committed reef enthusiasts have spent hundreds of dollars on ultra-low lab grade Nitrate test kits and all the equipment they can afford to assure stable nutrients within their SPS system.

With thousands of colors combinations available the possibilities are endless when considering Acropora alone as a tank inhabitant. Some of the most highly acclaimed displays throughout the world showcase these iconic beauties of the coral reef. Many fetch obscene prices while many more are available at quite modest costs. It is important to consider the unique care required for SPS coral, the flow required to keep the polyps exposed and the coral free of mucus would be too strong for many LPS corals; the light intensity required for the vibrant colors, too intense for many soft corals adapted to deeper depths.

Recommendations

Pocillopora- Available in a variety of colors this branching SPS boasts the ability to readily self reproduce in the aquarium at a success rate far greater than any other SPS. A happy Pocillopora will produce "bud" like structures it drops to form new colonies, in many cases, it has been recorded releasing gametes into the water column and new colonies forming through self-fertilization of the gametes. The ability to easily grow in captivity makes this a standout choice compared to the other coral in the SPS grouping. Many coral providers are even able to fully sustain their Pocillopora demand through aquaculture and mariculture endeavors meaning they have a very low impact(if any at all) on the reef populations.

Stylophora- The "Cats Paw" coral. Dense cropping of rounded, stub-like branches grown into nearly symmetrical clusters of bright pinks, purples, and greens. The Stylophora coral is a beautiful and comparatively durable SPS coral. While its demands for flow and water quality remains as high as the other SPS coral, Stylophora is unique in that it seems to adapt the most readily to lighting conditions. While like LPS coral they may brown or otherwise dull in color, lower light levels are possible with Stylophora and the above mentioned Pocillopora for that matter than with Acropora or Montipora. Unlike Pocillopora Stylophora does not bud and reproduce as readily in captivity, however, demand is again largely met by aquaculture and mariculture efforts and sourcing frags or colonies with no impact to the reef is simple.

Monitpora- Whether branching, plating, or scrolling, Montipora offers a stunning contrast of growth patterns to the other SPS coral. Available in solid colors, or with polyps that differ and often contract the underlying growth they offer a wide variety of color and shapes, so much so that a complete reefscape is possible within the single genus. As these SPS often occupy a lower niche on the reef, below the crest, they seem to be less demanding of light than Acropora, though high flow rates and lighting are appreciated.

XIV. Difficult Coral - The Heterotrophic Reef Tank

This article discusses Heterotrophic Coral, Gorgonia & Precautions

The vast majority of coral kept in the aquarium trade are considered Autotrophic, meaning that they in some way or another possess the capability to derive nutrients and energy from the environment around them. Some coral like LPS coral, supplement this autotrophic lifestyle by capturing prey to consume in addition to the energy it receives from photosynthesis. There are fewer corals available that are considered truly Heterotrophic. Heterotrophic coral requires the input of some form to obtain nutrients and survive. This means that all Heterotrophic coral must be fed in captivity or they risk starvation.

Heterotrophic Coral

While few in number they are striking an example. The Dendronephthya, known for its neon contrasting polyps and branching tissue is a soft coral and Tubastrea, a bright orange coral LPS coral that sports bright yellow polyps are the two most commonly available heterotrophic coral. While Tubastrea is a great example of a coral whose dietary needs can be met in captivity, Dendronephthya remains a difficult challenge to import and care for properly. Both these corals require very high flow as they come from the depth where the current is very high. Neither of these corals seems to react to low light levels and I have seen Tubastrea kept under simple fluorescent tubes. Additionally, neither of these corals are particularly well suited to an ordinary reef tank due to unique requirements.

Tubastrea is by far easier to keep than Dendronephthya. Spot feeding a Tubastrea several times a week with Mysis shrimp seems to be sufficient, with daily feeding leading to rapid growth and asexual reproduction through budding. Aquacultured Tubastrea is becoming more available as a result and this means survivability is much better through shipping as they can be fed properly before transporting. With proper planning and careful feeding to avoid waste, Tubastrea becomes less difficult and actually become a recommended addition to add some color to the unlit areas of your tank. Overall they are much more forgiving than Carnation Coral.

Dendronephthya does not extend their polyps without sufficient flow, once collected the colony closes and spends the next days in transit without an ability to consume any food. Upon arrival, most wild harvested Dendronephthya are shriveled and on the verge of collapse. Bringing them back can be a challenge if not impossible and requires a ready supply of phytoplankton to virtually cloud the tank several times a day. The coral may come around and begin to thrive with regular feeding, but your bioload will suffer as a result and it will put a strain on most systems to have such an abundance of phytoplankton added to the tank.

Gorgonias

While not technically coral Gorgonias are an example of Sessile invertebrates that live their life firmly anchored to the reed. They consist of a long sturdy backbone-like structure wrapped in a soft, often sponge-like tissue that comprises the skin which may or may not have prominent polyps visible. Some Gorgonia, like the Purple Sea Whip and the Golden Sea Rod, are photosynthetic and are thus autotrophic and great additions to any tank with lighting and flow rates appropriate for SPS coral. Many, like the Deep Sea Gorgonia, or my personal favorite the Blueberry Gorgonian are wholly heterotrophic. Like heterotrophic coral, gorgonia need to be fed adequately to maintain good health. The polyps of a Gorgonia are much smaller than Tubastrea which makes them more challenging feed, but not impossible.

Gorgonia should be fed very small prey items like rotifers or copepods. While not as readily available as Mysis shrimp, there are frozen, refrigerated and even live cultures available to the aquarist to feed to these creatures. Feeding of Gorgonias should take place daily and at several times throughout the day. Flow can be slowed or stopped during feeding however the Gorgonia may soon start to close without adequate flow so you will want to move quickly. With a baster or pipette create a cloud of the food source upstream from the Gorgonia. You may even be able to see the Gorgonia filtering the food source out of the water as it flows through. This should be done several times a feeding or until you feel a majority of the polyps have successfully captured food. Care should be taken to monitor waste levels closely in systems with the gorgonias present, as this routine style of passive feeding will lead to a significant waste build up in time.

Precautions

When choosing the more difficult Heterotrophic coral, more consideration is required during set-up of the tank. Due to the need to feed the coral, deeper tanks that are harder to reach the bottom of may not be desirable. Instead of shallow tanks that are easy to access from any angle are preferred to allow for easier feeding. Additionally, due to the high flow rates of these corals' natural habitat, considerable larger powerheads may need to be used to properly stimulate polyp expansion. These turbulent conditions may prove too forceful for LPS coral and tear their flesh against the sharp underlying skeleton. Lastly, there is a very high probability that in feeding these corals adequately you will need to do significantly more water changes to maintain lower nutrient levels. While not as sensitive as say Acropora, Heterotrophic coral too seem sensitive to an extent to nutrient build ups.

It is very important to the health of your reef tank to consider these factors before adding a heterotrophic coral. The additional waste, flow or necessary space for full expansion may not be accounted for and the heterotrophic coral may not fair well; or you may adjust to account and in response, other preexisting coral may not respond well to the changes made. Ultimately, deciding before you start the tank whether or not the tank will have a heterotrophic theme will reduce the difficulty of maintaining the coral, although perhaps not by enough in some cases.

When asked about heterotrophic coral, I almost exclusively discuss Tubastrea, Carnations, and Gorgonia as they so perfectly outline the unique qualities of heterotrophic coral, however, there are several related corals available such as Dendrophyllia and Nephthyigorgia but their care and success rate are so similar to Tubastrea and Dendronephthya respectively that they are easily lumped in with one or the other for basic descriptive purposes. If any of these coral appeals to you, the words patience, water changes, and possible heartbreak ought to be equally appealing or you may face disappointment.

XV. Refugiums - All Natural Nutrient Control

This article discussed Refugium Concept, Construction & Maintenance

In an attempt to emulate nature as much as possible many aquarists turn to refugiums as a supplementary filter. When employed properly a refugium serves to reduce waste, increase microbial biodiversity as well as serve for a haven for baby fish and settling invertebrates. Construction of a refugium is fairly simple and one can be retrofitted to most systems with relative ease. Refugiums offer additional benefits to your tank with very little extra on the part of the aquarist and it is easy to see why this popular feature is sworn by in some circles.

Concept

With a well-stocked aquarium we have a plethora of mouths, from invertebrates to fish and coral. All these mouths consume food and this food gets turned into waste. In the ocean, a really, really deep sand bed and thousands of pounds of rock serve to allow anaerobic bacteria that thrive on nitrates a safe haven free from disruption. In an aquarium, such means are obviously impossible but the same principles can be scaled down to suit our needs. In a separate aquarium, a deep sand bed, undisturbed by fish and currents can settle and water can be passed through this tank and the bacteria are able to then feed on the available nitrates.

In addition, macroalgae which would be greedily devoured by any herbivorous tank inhabitants can be allowed to grow freely. Macroalgae require both nitrate and phosphate to sustain growth in effect locking these nutrients away in their tissue to be safely exported through harvests. Similarly, the various bacteria of our tank often create microscopic films on the rock work, these films serve as a feeding ground for protozoans as well as flypaper for small particulate organic compounds. This serves as a dinner bell to copepods and helps to sustain a healthy population in the refugium that can be fed to the tank inhabitants.

Construction

To add a refugium there are two approaches, the in-sump refugium, and the flow through refugium. If your sump does not have a built0in refugium, but you have a lot of vacant space, you may consider adding a container to the sump to serve as a refugium. The container needs to be perforated starting a few inches above the sand to allow water to pass through. Looking at in-sump refugiums should give you an idea of the objective and the materials to build a sump from scratch with a built-in refugium may be comparable to setting up a flow through refugium. With a flow-through refugium, water from the primary display is drained into the refugium either completely or with some level of a bypass. Due to the consistent flow of water expected through the system a drilled tank with appropriate drain fittings is best. Additionally, because a deep sand bed is desired, taller tank configurations suit refugiums best.

However, with any option constructing the refugium begins by placing several large rocks on the bottom of the tank and filling around them with sand similar to any tank startup, however, the sand bed should be significantly deeper than four inches if denitrifying effects are desired. Build upon your existing base with a few pieces of quality well-cured live rock and scatter shell litter and rock rubble along the sand bed. Once in its final position either below, alongside or above your tank, plumb the refugium into the sump first and fill the tank with clean treated saltwater until it begins to overflow into the sump. At this point, you may shut off power to the system and plumb a return from your display tank to the refugium. When plumped, power the system back on, you may have to add a small amount of clean treated saltwater to obtain the desired operating water level throughout the system. Lastly, mount a quality light fixture to the refugium setting it to a photoperiod opposite of your tank lighting and place your macroalgae in the tank.

Maintenance

In the coming days you will notice new growth on the algae and on close inspection, you may see smaller critters like copepods and amphipods skittering along the rocks, a hard to spot detail in tanks with fish picking them from the rocks at every opportunity. These "pods" can be harvested and collected by weighing small pieces of Makrolon(a corrugated plastic similar to cardboard in design)to the bottom of the tank. Once a month remove a piece or two and shake them out in the tank. This process is not necessary but many fish will appreciate the treat of live food to hunt and chase. Algae-based maintenance is more involved, but fortunately, not by much.

As macroalgae grow they can form dense thickets of seaweed. Left to grow and macroalgae may grow to suffocate drainage, interfere with powerheads and pumps, or grow to a point that it shades itself and part of the growth dies off. Drainage, pumps and powerhead interference comes with the risk of overflows and equipment failure while dying off of algae will result in a spike of nutrients that were once locked up in the algae. To avoid the above, routine trimming of the algae should be performed. The growth rate of the algae in your refugium will dictate the frequency required however I would consider doing this at least once a month. The algae should not be fed to the tank as it will only serve to reintroduce these nutrients to the aquarium, instead it should be disposed of.

It should be noted here that in many parts of the world certain macroalgae are considered invasive species, as a result, they are heavily regulated and great care should be taken to assure that we do not introduce any algae species to local bodies of water. Never flush algae or introduce it to sewer drains, algae should instead be thrown away or ideally composted after harvesting. For best results consider Chaetomorpha or Gracilaria if available in your area. Both are fast growing to absorb a large number of nutrients but lack the cyclical mass die-offs of various Caulerpa species.

When set-up and maintained properly a refugium offers several benefits to the reef aquarist. With equipment readily available or perhaps even on-hand for some aquarist, this quick project can be carried out effectively during a water change if all components are available and ready to install. The results are lower overall nutrients, a more stable pH and salinity, higher biodiversity and an intake source of pods for feeding. As a final note, more and more hobbyists are incorporating "over-head" sumps into their systems. The primary focus of these systems appears to be more for pod production and introduction to the display tank and less for nutrient control, however, any live rock and sand added to a system will inevitably accomplish this to some extent. Wherever you put a refugium or however you choose to set it up the benefits will be readily visible through the growth of pods and algae in the refugium and the maintenance of lower nutrient levels in your tank.

XVI. Protein Skimmers - Dissolved Organic Nutrients

This article discusses Foam Fractionation, Protein Skimmers & CO_2

In a closed-loop system containing a living organism it is critical to address the nutrient and energy needs of the inhabitants. Through proper lighting and the feeding of our coral various metabolic processes create organic compounds to be used as energy within the coral for biological functions. When properly addressed in a closed-loop system the outcome of these biological functions are various dissolved organic compounds (DOC). Carbon dioxide, proteins and waste matter are the primary compounds we will address with foam fractionation.

Foam Fractionation

As you walk along an ocean beach the waves will lap against the shore and quickly recede. Along the surface of the receding water pockets of seafoam float back into the ocean. As the air and the water are mixed by a wave, millions of tiny microbubbles are created. When the water is particularly choppy and larger volumes of foam is created, or along rocky coves and jetties, you will often notice that the foam accumulated is beige tinted, or even has visible sludge accumulated on the surface of the foam deposit.

Oxygen is a highly reactive element and along with gases it becomes trapped by various DOCs cling to the surface tension of the microbubble formed. These surfactants form a molecular film around the gas bubble. A large enough volume of microbubbles generated in a small enough space and these bubbles will begin to bind to each other as the ionic charges contained within the films attract microbubbles with opposing charges generated in the same manner. The microbubbles combine into a matrix with the thin films of surfactants binding them to one another. As conditions change the films of the matrix weaken. If an interior film weakens between two bubbles the two microbubbles may combine to form larger bubbles with the surfactants redistributing along the outer film.

When we have a large volume of microbubbles in a small enough volume of liquid this process continues to scale up. Microbubbles form matrices and condense into tiny bubbles which form matrixes and condense into progressively larger bubbles. The surfactants combine as the bubbles accumulate reducing the surface tension further as the film increases in volume allowing for larger and larger bubbles to form. As these larger bubbles form matrices foam results as the surfactants are capable of encapsulating larger quantities of gas within the bubbles of its matrix until a critical mass is accumulated and surface tension can no longer be maintained by the accumulated surfactants. When this happens on a large enough scale the accumulated surfactants deposited by the popping bubbles is observable with the human eye as a sludge forming along the surface of the foam.

Protein Skimmers

In an aquarium, we can harness foam fractionation as an extraction process to remove dissolved organic compounds in our aquarium and reduce the amount of waste in the water column. A protein skimmer is a filtration device that does just this. Comprised of four primary components, available in both internal and external mounting formats, and with a relatively small footprint, it is easy to incorporate into a reef tank system. The benefits of a protein skimmer are well sung by aquarists so much so that it is often viewed as a core filtration component in a reef tank.

The overall footprint of a protein skimmer is usually dictated by the diameter of its reaction chamber. The reaction chamber is a large tube in which the process of foam fractionation actually takes place. A venturi is used in tandem with a water pump to continuously inject a mixture of tank water and microbubbles into the reaction chamber. The overall water level within the reaction chamber as well a the ratio of air to liquid introduced to the reaction chamber are controlled through knobs or valves.

Within the reaction chamber, microbubbles are allowed to accumulate away from conditions that would disperse a foam. As a foam builds in the reactor chamber it is pushed upward through a taper that causes the foam mass to condense and for the films within the foam matrices. Eventually, the force of upward escaping gases from the foam mass below will carry the viscous film developed into the collection cup.

The water within the reaction chamber is recirculated into the tank and leads to microbubbles being introduced where this return is plumbed. Due to the introduction of bubbles most aquarist prefer to plumb the skimmer to their sump. If you do not have a sump, you will need to pass the return water through a foam post filter to reduce the accumulation of bubbles in your tank. The waste in the collection cup will need to be drained periodically as part of normal tank maintenance. In removing the skimmate from the tank you are removing a large portion the dissolved organic compounds that would normally result in elevated nutrient levels, however, a protein skimmer offers a secondary benefit in our aquarium by heavily aerating the water.

CO_2 scrubber

Employing a CO_2 scrubber to feed your venturi increases the effectiveness of this process greatly. A CO_2 scrubber is a small reaction chamber air passes through containing CO_2 absorbing media. The media most often employed is simple soda lime which not only absorbs CO_2 but also naturally changes color as the media is exhausted leading to the easy visual indication of maintenance. The CO_2 introduced from the air around our tanks reacts readily with both Calcium and Magnesium which are critical to stony coral growth. For enthusiasts with a heavy population of stony corals available Calcium and Magnesium is so demanded a source such as Kalkwasser is dripped into the tank. To be spending money for additives or kalk for Calcium and Magnesium, the use of a CO_2 scrubber increases the effectiveness of these additives by ensuring we are not encouraging these minerals to become bound and inaccessible to our coral. Overall a CO_2 scrubber is a nice tool to help further control the environment within our tanks and ensure the efficiency of our systems.

Whether a CO_2 scrubber is employed or not, the added aeration from the use of a protein skimmer also increases the Oxidizing Reduction Potential(ORP) of our tanks. The ORP measures the ability of a liquid to oxidize nutrients; a process that overall reduces nutrient buildups in our tanks. A protein skimmer should not be viewed as a method to extend the time needed between water changes. There is no substitution to a proper water change schedule however employing a protein skimmer greatly reduces the accumulation of nitrate and phosphate between water changes. Nitrate and phosphate both cause stress to coral and we want to maintain these levels as low as possible.

XVII. Phosphate Control - Reducing Natural Accumulation

This article discusses the concepts behind Biological Methods & Chemical Methods

Phosphate is introduced to our tanks primarily from the food sources[1] we offer our fish and coral, however, there is a very low level of phosphate in many additives as well. Phosphate is a phosphorus compound expressed as PO_4 and is present in natural seawater at very low levels. While trace levels of phosphate present in an aquarium is not problematic, without proper export the levels of phosphate can accumulate to levels that will, in summary, impede the growth and generally stimulate nuisance algae growth. I would like to note there is a fine line between chemistry and biology. Here, biological methods focus directly on nurturing additional bacterial cultures while chemical methods refer to the application of any substance, organic or inorganic specifically to remove phosphates.

Biological Methods

We discuss beneficial bacteria a lot when discussing the nitrogen cycle, but there are also bacteria that aid in reducing phosphate as well. These bacteria, like nitrifying bacteria, tend to occupy anaerobic areas and require a carbon source to feed upon. This is because the consumption of phosphate is not done directly through gestation but instead through a complicated method called solubilization. These bacteria are known as Phosphate Solubilizing Bacteria(PSB), and they accomplish this passively as part of developing their natural slime coatings.

Many systems employ a reactor chamber of sorts which is filled with proprietary media for the bacteria to colonize. As the colony of bacteria consumes the chosen carbon-based food source, the slime coat grows along the surfaces they inhabit as a protective coating. This coating is primarily composed of the previously insoluble phosphate that the bacteria have absorbed and converted. The principle theory at work in these systems is that we allow the bacteria a protected area to colonize and establish a slime coat within. Periodically the media colonized is agitated so as to disrupt these films and introduce them to the water column of the reaction chamber. The protective slime coatings are then easily removed from the system using a protein skimmer.

Chemical Methods

While there are several proprietary systems employed to fill the niche of bacteria based phosphate control there are several more proprietary resins and additives that are marketed to reduce the phosphate levels of your tank. Many are added to the sump and changed on a regular basis although some involve the use of liquid additives. The various liquid additives have broad use instructions depending on brand consideration should be made to read the instructions thoroughly before purchasing. A bottle may last one aquarist *x* where it will only last aquarist *y* a much shorter time. It is important to make sure you will be adequately supplied as even brief stoppage of these systems due to running out can see spikes in phosphate and nuisance algae growth.

When referring to proprietary resins it is often a combination of components and rarely does this combination exclude granular carbon. Like granular carbon when uses on its own, these resins are exhausted in time and need to be replaced. The recommended time of effectiveness for most resins falls

[1] **Aquarium Chemistry: Phosphate And Math: Yes You Need To Understand Both By Randy Holmes-Farley, Ph.D.**
https://www.advancedaquarist.com/2012/3/chemistry

between thirty and ninety days before requiring replacement or in some cases recharging. When properly maintained these methods of control are equally effective as biological control options available. If more equipment is something you are not able to house then a liquid additive or resin based control method becomes an ideal solution to coral impeding, algae feeding phosphates.

Though of all the methods available, the following method is by far my favorite although it is very rare to see it officially endorsed by most. Vodka dosing[2] is a fairly simple and straightforward method of nutrient control that combines both chemical(in the form of liquid additives) and biological(in the form of overall function) to achieve reduced phosphate levels. Best of all this method does not require any specialized proprietary equipment, media, or devices as most reef tanks already have a protein skimmer. While the cited literature has served me well in the past I have to admit that it is more suited for larger systems over one hundred gallons, it is not a matter of effectiveness as it is "weighs justifying means". Frankly speaking in my smaller systems with proper water changes, skimming and feeding practices phosphate is well managed and the need for phosphate control is not there.

XVIII. Reverse Osmosis & Deionization - Reef Tank Prefilter

This article discusses Tap Water, Reverse Osmosis, Deionization & Alternatives

Reef keeping as a hobby nowadays has become common and the equipment and components available to maintain our ecosystems are readily available. Because of the modern ease of maintenance, it is possible to have aquariums in homes and offices with little consideration for specialty construction and alteration. Access to outlets and a willingness to move water from your tank to a drain and from the source to the tank are often the only considered factors when initially setting up our tanks. However, it is the very water we are moving is worth serious consideration when projecting for long-term success.

Tap Water

In the modern world, many municipalities or companies treat, supply and facilitate the capturing and recycling of water. In the treatment, process chemicals are added to the water to remove pathogens and impurities that lead to illness when consumed. This assures clean drinking water at command by simply turning on the tap. While many of these chemicals are regulated for human consumption, there is little consideration for the effects of drinking water on simple organisms that share traits and features with the pathogens we intend not to drink.

Chlorine and Chloramine are heavy metals added to drinking water as disinfectants.[3] Organic nutrients like Phosphate and Nitrate are present in the groundwater that is sourced for treatment and is a result of fertilizer runoff, biological processes, and septic systems. Other elements such as Copper and Zinc can be leached from the plumbing within our home and silicates are so abundant in nature that

[2] Vodka Dosing Distilled! By: Nathaniel A. Walton and Matt Bjornson
http://www.reefkeeping.com/issues/2008-08/nftt/index.php

[3] Disinfecting with Chlorine - The Center for Disease Control and Prevention
https://www.cdc.gov/healthywater/drinking/public/chlorine-disinfection.html

they exist in water supplies before and after the water has been treated. While certain quantities of any of the above can have ill effects low levels tend to be acceptable and are monitored for human consumption.

The above-outlined *contaminants* present in drinking water have detrimental effects on our aquarium. Nitrate and Phosphate are well known for their stressful effects on coral and fish, and along with silicates the three fuel the explosive growth of nuisance algae and cyanobacteria. Copper, Chlorine, and Chloramine are all outright disruptive to the biological functions of invertebrates leading to death upon exposure in many cases. Through proper care and testing, we can assure that these levels stay undetectable in our aquariums as long as their presence in tap water is first addressed.

Reverse Osmosis

The most effective way of removing the majority of particulate contaminants. Silicates as addressed above and a very inclusive variety of salts and organic matter are filtered out producing water that is ninety-eight percent H_2O containing very little contaminants. Reverse Osmosis units require plumbing to both a supply and a drain. It is possible to plumb these units yourself, or, many companies will install a reverse osmosis unit in your home.

Before reverse osmosis, water is passed first through a series of prefilters. A reverse osmosis membrane can filter hundreds of gallons if used without prefiltering this volume is drastically diminished and as a result, highly inadvisable. The number and configuration of prefilters are fairly broad and the reverse osmosis market offers a plethora of interchangeable options. The basic prefilter requirements are to remove as much as possible from the water without using the actual reverse osmosis membrane; Preserving the membrane efficiency for a longer period of time.

Tubes of tightly woven cotton or synthetic fibers are used as the first stage of prefiltering. These prefilters pass water through the fibers of the tube and into the hollow interior where it is passed through to the next stage. Emphasizing particulate remove these tubes are rated by the micron level they filter too. Commonly available in twenty, ten, five, and one micron, these filters are often used in conjunction with one another. Using a five-micron filter will allow all particles under five microns to pass through the system while capturing everything larger as well. Starting with a higher micron level and progressively stepping down serves to preserve the efficiency of each stage for a longer period of time. Care needs to be taken to assure that pressure within the system stays above sixty-five pounds per square inch (psi) for reverse osmosis if multiple micron filters are used a booster pump may be required to maintain this,

The second phase, though perhaps not the second stage of the system is to neutralize a portion of the smaller compounds below what a micron filter is capable of. Chlorine, chloramine and many dissolved metals require an ionic bind to pull them from suspension. To bind these dissolved compounds to another media so that the compound is removed from the water that is passed through the media. The most effective method of capturing these compounds on the ionic level is through carbon. Available in a block or granulated which dictates lifespan in gallonage. Granular Carbon offers more surface area at a higher rate of bypass meaning it is more suited for lower volume applications. Block carbon is capable of filtering a much higher volume with lower bypass at the cost of reducing system psi. Again a booster pump may be used to restore pressure to the desired levels.

Final filtration of the water is performed with a reverse osmosis membrane. A tightly coiled ribbon of perforated film is wrapped around a permeable core. Similar to the stages before water is passed over the exterior of the membrane and the force of incoming water pushes the water through the matrices of the membrane. Reverse osmosis membranes, however, filter down to a level of one one-thousandth of a micron. This removes virtually all contaminants from the water that remain after the initial prefiltering stages. During this stage, the pressure in the system must be regulated accurately to assure proper functionality of the membrane. If the pressure is too low water will not be sufficiently forced through the membrane to obtain the desired volume of filtered water and excessive wastewater will be created. Pressure too high will damage the membrane and the equipment possibly resulting in an explosion of the system, this is usually not an issue however as municipalities supply a line pressure right around sixty-five psi and we reduce it from there through filtering and booster pumps have maximum capabilities and restrictions.

Deionization

Organic and inorganic compounds display ionic polarity, attracting and binding to compounds of opposing polarities. To separate these compounds from the water column we can utilize anionic and cationic resins to attract positive and negative compounds respectively. Anionic resins are comprised of ions of a negative polarity, cationic - positive polarity. These resins are available individually, mixed, or in convenient color indicating mixes. In a similar fashion to reverse osmosis membranes care should be taken to prolong the life of the media employed to filter the water by prefiltering the water supplied to the deionization unit.

Because Deionization occurs at an ionic level, removing even colloids, the resulting water after deionization is considered ninety-nine percent pure H_2O. Best employed as the final stage of a full reverse osmosis system deionization assures lab quality water production by filtering the remaining traces elements missed by reverse osmosis. Lab quality water may not be required, but, manufacturer recommendations are usually based on the provided substances reaction to water of lab quality and the most reliable results are derived from emulating the test conditions. When deionization is utilized in our homes it provides the best possible starting point for all of our water needs leading to the increased overall health of our systems and fewer continuous nuisances such as unexplainable algae or bacterial blooms. Whether considering deionizing the water after reverse osmosis or filtering the water with solely reverse osmosis the system should be plumbed to a drain to accommodate the generated grey water.

Alternatives

Greywater generated as a result of reverse osmosis is of varied concern. In some municipalities, this water is simply sent to sewage treatment plants, however on wells this grey water may be more of a concern. If you are concerned about reducing the wasted water there are several alternatives solutions to the standard reverse osmosis options. Overall reduction of grey water can be achieved by adding a second reverse osmosis membrane to process the waste created by the first membrane. Providing proper pressure is maintained this reclaiming process will reduce grey water to the drain. Adding a second reverse osmosis membrane will bring production to waste ratios to around four gallons of water per one gallon of pure lab quality water created.

If prior thought is given to plumbing your reverse osmosis system, many of these systems can be plumbed to the feed of your homes hot water system, the grey water is completely treated tap water that has become more concentrated in ionic concentration. While not suited for human consumption, conservation enthusiasts repurpose this water into their hot water tanks as it is however usable for dishes and laundry. It is possible to some degree to have a zero-waste reverse osmosis system if both duplications of membrane and plumbing to a secondary use such as hot water are employed. This method conserves the most water in the process of fulfilling our need for purified water and is highly recommended by this writer.

If all else fails and reverse osmosis/deionization is simply not feasible in your situation you may obtain filtered water from most local fish stores providing you bring your own container. Additionally, some companies manufacture premixed quantities of salt water or pure water for aquarium use. Lastly, there is the option of proprietary additives that either celate the toxic metals present in the tap water or otherwise neutralize a contaminant present by altering their composition. The above are suitable alternatives when the home operation of reverse osmosis or deionization unit is not possible but some form of water prefiltration should be employed and tap water should never be used as is for our tanks in any circumstance.

XIX. Intermediate Filtration - Specialty and Purpose Specific Add-ons

This article discusses Ultraviolet Sterilizers, Ozone Generators & Calcium Reactors

Mature reef tanks teaming with life from microscopic protozoa and bacteria to the coral and fish will develop needs in time unique to a newly established tank. Once pristine tanks may begin to fall victim to cyclical algae or bacterial blooms, aging may be making fish more susceptible to infection or accumulated trace elements may have been neglected to lead to hampered or slow coral growth. To address the more advanced requirements of mature tanks there are several components available to the more experienced aquarist.

Ultraviolet Sterilization

Ultraviolet light has long been used in sanitation applications due to its ability to eradicate bacteria and other pathogens. The wavelengths of ultraviolet light disrupt cell function within many of these organisms killing them, the microscopic remains to be later removed from the tank through a protein skimmer. For aqueous applications, an ultraviolet light bulb is housed within a quartz sleeve, sealed away from the water that is exposed to the bulb as a function of the device. Baffles are often incorporated to slow the water passing through the sterilizer to increase exposure time to the ultraviolet radiation.

The longer the water is exposed to the bulb the more effectively sterilized the water will become. While slow rates are required to control pathogens like protozoa, bacteria, and parasites, simple algae control is obtained with relatively low exposure time. As the U.V. bulb irradiates the cells within the water column a scale will form on the quartz sleeve in time. It is important to keep this surface clean at all times and to continuously remove this scale as it forms. When servicing an Ultraviolet sterilizer assure power is off to the unit. The light is very damaging to our eyes and can have a lasting impact on our vision. As a result, the internal workings of an ultraviolet sterilizer are completely shielded and to know if your unit is functioning you check an indication window.

When the bulb inside the unit burns out, light captured and refracted through the indication window and the small semitranslucent indicator will not glow. Power off the unit and replace the bulb completely reinstalling the unit within the quartz housing and protective outer shield before powering on the unit. If the indicator does not glow, shut off the unit before attempting to adjust any connections and reassemble the unit completely before powering. Under no circumstances should an ultraviolet sterilizer bulb be serviced and changed while there is power to the unit to avoid long-term vision problems.

Ozone Generators

Ozone generators are an alternative to the above with similar purpose. The growth of algae and the threat of pathogens is reduced through the application of ozone. Ozone(0_3) is a highly unstable bond of three oxygen atoms that quickly oxidizes other compounds, splitting apart and altering the composition of the initial compound. Ozone is usually applied through specialized ozone generators designed for the aquarium trade. This unit is used to feed the venturi of a protein skimmer and allows for the application of pure ozone to aerate the aquarium, oxidizing bacterial slimes, and nutrients and raising the water column capability to continue doing so. It is a highly effective means of disinfecting the water in aquariums often employed by commercial and laboratory applications.

Ozone is highly unstable and able to leach to the air from the water column, this has serious health concerns for all life, additionally elevated ozone within the water column can cause stress and death to inhabitants. Use of a properly reviewed and rated ozone detector is a must. Improper use of ozone can lead to the death of aquarium inhabitants, other pets that come into contact with the air around a tank or serious health effects up to the death of any humans exposed to excess ozone generated by an aquarium. While a great option for the advanced aquarist with adequate resources and knowledge of the process, ozone should be avoided with ultraviolet sterilizers employed in most circumstances.

Calcium Reactors

While pathogen and algae control may be a factor of a maturing tank that we want to control through the additional equipment, some aging tanks require instead of supplementation. As coral grow they convert calcium, magnesium and several other trace elements into skeletal structures. Larger colonies have larger demands for optimum growth, as your coral grow and mature these vital elements may become depleted between water changes leading to stunted coral growth. To supplement the addition of calcium and other trace elements many aquarists use liquid additives or kalk. These process can be time-consuming or become quite costly with larger systems over one hundred gallons or in aquariums with dense populations of stony coral.

For applications where calcium and the other trace elements are at an extreme premium, the application of a calcium reactor offers an alternative to the addition of supplements. Comprised of three main components calcium reactors mix carbon dioxide with a steady supply of tank water to maintain a lower pH within a reaction chamber. The reaction chamber is filled with aragonite based media that begins to break down when exposed to the lower pH of the reaction chamber. The calcium and trace elements from within the aragonite are concentrated into the water column of the reaction chamber and slowly dripped into the system.

The pH within the reaction chamber is low enough to have detrimental effects on your aquarium. Too much of the high alkaline solution being applied leads to accumulation over time and leads to precipitation of the calcium, a clouding at the water is saturated with calcium and the remaining particles become insoluble to the solution within our aquarium. If we do not allow the water enough time in the reaction chamber, instead of the water we introduce to the tank will be laden with carbon dioxide which will strip the available calcium and magnesium from the water column of our aquarium. Due to the risk of pH altering effects as a result of malfunction, a pH controller should be used whenever calcium reactors are employed.

A pH controller is a device with a probe that detects pH of a solution. This device serves as a relay between a power supply and a given device. When the pH of the solution is within the preprogrammed range the circuit is closed and power can be transferred to the device from the power supply. When the pH of the solution measured fluctuates outside of the preprogrammed range the circuit is opened and the power is no longer relayed from the power source, effectively powering down the device. PH controllers passively monitor the output of a calcium reactor and serve as a failsafe to assure that the calcium reactor is shut off until the pH fluctuation is addressed or the situation balances on its own. When the pH of the tank returns to the desired level the calcium reactor will have power returned to it so it is important in the case of a drastic swing that has caused a shutdown, the root cause is addressed or the system will be shut down again. Routine and frequent powering off and on of the calcium reactor can lead to cavitation of the supply pump or shorten the lifespan of other pump components.

Once a tank has matured and the organisms within have become well established, the need for sterilization and supplementation through more advanced components becomes greater. The investment of time and love into these works of art is worth preserving with as much preparation for long-term success as possible. Neither of these options are required to start a reef aquarium, however, installation of components but reservation of use until a need arises is a great precaution. This not only assures the availability of components when the need arises but also assures no additional complications when addressing the need as it develops. When the needs develop components can be simply plugged in without unexpected alteration to your schedule or budget.

XX. Closed Recirculating Systems - Multiple Tank Loops

This article discusses a single example of a Closed Recirculation System

Emulating nature knows only the extent of our imagination. Aquarists may have multiple different tanks with different themes spread throughout their home, or perhaps in a dedicated fish room. When the maintenance of several systems begins to take its toll it is not uncommon for more serious aquarists to loop tanks into existing systems, taking this one step further we can emulate natural filtration processes seen in nature. Tanks arranged and design to facilitate different roles are plumbed together to form elaborate systems that share a single sump and primary filtration system.

By combining all the advances in the reef keeping trade with the sciences of biology and chemistry it is possible to design and construct a system that requires very little maintenance compared to maintaining several systems, it is possible to even reduce the need for water changes with this methodology. To achieve this we must focus on the import and export of all nutrients in the aquarium, accumulations of nutrients and depletion of essential and trace elements must be regulated. By harnessing natural processes and properly maintaining supplementary filtration we create a closed system that is equivalent to that of display venue aquariums and research facilities.

The accumulation of nutrients is a critical concern, with multiple tanks and potentially hundreds of inhabitants in each tank the waste will need to be neutralized and exported. To do this we employ several controls. Starting in the sump components rated for the total gallonage of your system including the sump and the volume of plumbing interiors are selected to filter the system:

- Wet/Dry Tower
- Media Reactors
- Oversized Protein Skimmer
- Calcium Reactor
- pH Controller
- Accessory Monitoring Equipment

The water from the sump is then filtered mechanically to reduce microbubbles before being pumped to the display(s). One or more tanks may be considered a display, the tank primarily serves an aesthetic purpose in the system and a significant source of waste accumulation and mineral depletion. Live food is dripped into the system, coral and fish consume the live food and create waste while consuming elements in the water column.

The nutrient-rich, low mineral water is drained by an overflow system in the display(s) to a settling refugium. Here a deep sand bed, low current, copious live rock and forests of macroalgae filter particulate matter and nutrients from the water current. Additionally, eggs and offspring of display inhabitant have a chance of settling in this haven. Mangroves are not uncommon in these large refugia these not only extract a large number of nutrients from the water column but provide stunning possibilities for unique aquascapes. While often beautiful in their own right this tank serves to provide nutrient reduction, passive particulate filtration, a haven for detritus scavenging crustaceans and settling coral so it isn't necessarily a display tank and care and reservation should be taken to preserve a low density of fish and coral if any at all.

Once the flow of the system water has slowed and been partially cleaned of particulates and nutrients the water from our refugium can drain into the next stage of our recirculating system. A collection of fast-growing anemones or coral such as Xenia can be propagated within a confined area of our system to harness their beneficial qualities without risk of an overwhelming invasion in our display tanks. Xenia absorbs excess nutrients from the water column while anemones are voracious particulate feeders. Water leaving this thank has slowed dramatically compared to within the primary display, this allows more time in contact with beneficial bacteria films for phosphate reduction. In addition, the lower flow at this point in the system lends itself to effective ultraviolet sterilization as the next step.

The sterilized water can be drained into a Wet/Dry tower to allow for further biological filtration to occur before returning to the sump for nutrient stripping and element supplementation from the components outlined previously. A protein skimmer with its return passed through a filter sock feeds a chamber where a quality heater with thermostat maintains a minimum temp. Into this area we can plumb our calcium reactor, returning elements to the water on its way back to the display.

To recap the system process;

1. The tank water has entered our system and pumped into a display where nutrients accumulate and particulate, as well as dissolved organic compounds, are formed as a result of live food introduced to the tank. Key elements such as calcium and magnesium are absorbed through coral growth and many other trace elements are consumed through various biological functions.

2. The now nutrient-rich element poor water is passed through two stages of natural filtration that allows for thorough nitrification of waste, absorption of nutrients and polishing of water through removing particulate matter.

3. The polished, low element and now low nutrient water is then sterilized aiding in water clarity, pathogen reduction and isolation of Xenia and anemones to the tank they reside in preventing their spread to other tanks.

4. Low nutrient, sterilized & polished water is then processed further by bacteria based media reactors and remaining dissolved organic compounds are stripped from the water using a protein skimmer, its return filtered with a filter sock to reduce.

5. Processed water is heated and key elements are replaced in the final stage of the sump before being returned to the display to begin the process again.

In theory, this system requires reduced water changes as nutrients are sufficiently exported through natural means. Supplemental equipment bridge the gaps where time or space is not available for natural biological processes to occur. The time and investment to create such a system is certainly not for the newly introduced hobbyist and left to the more experienced. Thorough knowledge of components, plumbing, and proper protocols for feeding, quarantine, disease treatment are all prerequisites learned in-time exploring the hobby. This article is meant to inspire hobbyist to continuously push forward with their passion. There are many challenges involved to reef keeping but with a commitment to the purpose, it is possible to face these challenges and arise victoriously.