

Reef Aquarium Setup Guide

Your guide to setting up a marine reef aquarium.

By J. Charles Delbeek

Nothing holds the attention of visitors to a marine aquarium store more than the sight of a healthy, completely stocked, miniature reef aquarium. The variety of colors, shapes and odd-looking creatures is both bewildering and intoxicating. The gentle swaying of the coral polyps, the sparkling of light on the rocks and the darting of the fish in and out of the rock work, like so many butterflies in a field of flowers, can quickly entice the novice aquarist to purchase such a system. Yet, there is much more than meets the eye to these systems, and unless one is prepared, you can quickly become discouraged, and drop out of this branch of the hobby. Unfortunately this does not happen before hundreds, if not thousands, of dollars have been spent, and even more unfortunate, before dozens of animals have died. The secrets to having a successful reef aquarium include, having patience, gaining knowledge, exercising caution, reading everything, and practicing common sense. I also believe very strongly that you should not follow the advice of someone unless you can see what they themselves have accomplished using those methods. If you follow someone's advice you will most likely end up with what they have, so it would be a good idea to see if that is really what you would like your tank to look like.

There are so many factors to consider when setting up a reef tank that it is impossible to cover everything in a single article. Therefore I have provided a list of references at the end of this article that I encourage you to read as much of as possible BEFORE you start your aquarium. It often strikes me as strange that although most rational people will spend weeks researching and reading everything they can about a major purchase such as a car, these same people can turn around and hand over \$5000 to purchase a reef aquarium setup, knowing very little about it. In my experience, most aquarists end up spending 3x as much money as they should have by fixing mistakes they made out of ignorance or by purchasing equipment/supplies they later learned they could do without. One owes it to the animals that will eventually be put into these systems, to learn as much as you can BEFORE you begin. Reading everything you can get your hands on will probably serve to show you that there are many different ways advocated to keep these systems, and you will become quite confused. At this point you should seek out knowledgeable people in your area who have reef systems and see what they are doing. If there is an aquarium club in your area with a marine group, then join it. If there is no aquarium club then join the specialty societies listed in many aquarium magazines. In the aquarium club I belong to, the most common comment made by new members is "I wish I had known about you people before I started!" Also, frequent the marine store in your area and get their advice. But more importantly, frequenting a marine store will expose you to other hobbyists, and it is from these people that you can also learn a great deal. Finally, no matter what advice you get, you must learn to exercise caution, a healthy dose of skepticism and common sense.

Cost Breakdown

Below is given a rough outline on the costs involved in setting up a 65 gallon reef system. It is very difficult to give an accurate cost breakdown due to the wide variety of equipment and prices available. Careful comparison shopping should lower the total.

65 Gallon Aquarium \$200
Stand \$100
Light System
Fluorescent \$400
Metal Halide \$500
Trickle Filter \$300-\$400
Water Pump \$200
Powerhead \$30
Plumbing Materials \$200
Protein Skimmer \$200-\$400
Live Rock \$5-\$8 per lb.
Salt \$20
Test Kits \$150

Total: ~\$2500

Having said all of the above, I would like to say that the methods I will cover in this article are based on my own experience, those of dozens of others and what I have seen in my travels across North America and Europe. I am not

saying that this is the only way to do it, nor necessarily the best way, but it is what has worked for me and many others. If anyone tells you that their way is the best or only way to proceed then they are not only fooling you but themselves as well. The intent of this article will be to serve as a guide to get you started with a 65-gallon aquarium in such a way as to ensure the greatest possible chance for success, at a reasonable expense. Once you gain experience and confidence, then you can start looking for ways to change or improve your system.

1. Aquarium Selection and Placement

The first thing you must decide upon is what type of reef aquarium you want to maintain. Do you want to keep mainly soft corals or stony corals or are algae more your thing? The types of animals you choose to keep will have a great deal of influence on the type of aquarium and ancillary equipment you will need to purchase. You must realize that beginning a marine reef aquarium is a major commitment. You will be keeping animals that come to you directly from the wild. Therefore, you must be prepared to do what ever it takes to keep them in the best possible health. A reef aquarium is not something you can just set up and walk away from. Really good reef aquariums require time and nurturing to reach their full potential two or three years down the road. As a good friend of mine once wrote, only bad things happen quickly in a reef aquarium; good things happen slowly (Paletta, 1992). If you are not prepared to make this type of commitment, then this branch of the hobby is not for you.

Generally speaking, the larger the aquarium, the more forgiving it is of mistakes in water quality management. Not to say that aquariums of less than 50 gallons cannot be kept, only that one needs to be a little more vigilant that's all. A small mistake, such as a stuck heater, will have a much greater and quicker effect in a small aquarium compared to a larger aquarium. The greatest drawback to large aquariums though, is that you have to spend quite a bit of money to fill it with animals, perform water changes and it takes longer to clean.

When looking for an aquarium, beware the tall, narrow variety often available. They present numerous problems such as a poor surface area to volume ratio (very important for proper gas exchange), and difficulties in decorating and cleaning. An aquarium should at least be as deep as it is high. The standard 48"x18"x18" 65-gallon aquarium is an ideal size to begin with. It's length easily allows for the use of the most commonly available 48" fluorescent and metal halide lighting systems, and its depth and height make it easy to decorate and maintain.

Before purchasing an aquarium you should make sure that it fits in with the dimensions of the room and that the floor where it will be placed can support the weight. Placing a reef aquarium where it will receive a few hours of natural daylight is not a problem. In fact, it can be quite beneficial to the light loving invertebrates you will be keeping. As long as no overheating problems can occur, I see nothing wrong with this. The belief that natural sunlight will cause algae outbreaks is nonsense in a properly run reef tank. When choosing a site for the aquarium, keep in mind the availability of electrical outlets and a sink, both of which you will need ready access to.

2. The Basic Requirements

There are five main factors that one must keep in mind when running a reef aquarium. If these factors are not met, you will not be very successful. They are temperature, water movement, light, nutrient limitation and water chemistry.

If the temperature of your system cannot be maintained below 80F you will experience problems sooner or later. The ideal temperature range lies between 72F and 78F. How you achieve these temperatures is up to you but they must be achieved.

Water movement is extremely critical in a reef aquarium. Many of the organisms you will be keeping such as corals, cannot move from where they are growing. They depend on the water to bring them oxygen and nutrients, to take away wastes such as carbon dioxide, to remove fouling organisms and to ensure that all the polyps get enough light. This water motion can be achieved in many ways but it should not flow in a straight line (laminar flow). Best are small eddies and swirling masses of water that cause the water to flow in a chaotic manner through the aquarium. This is best achieved by having a number of water returns and/or powerheads in the aquarium, located such that their flows can interact with each other. Water motion is also critical for the suspension, and removal of detritus and debris from the aquarium. Make sure that you have good turbulence at the water surface too, as this greatly aids in gas exchange.

Light is an extremely important component in a reef aquarium. Since the majority of the corals we keep possess zooxanthellae (single celled, symbiotic dinoflagellates), they must receive both the proper intensity and spectrum of light to flourish. More will be said about lighting in a moment.

Regular Maintenance

Daily

Although these items are listed as daily you will find that as the tank matures you can do some of these less frequently.

1) Check that corals etc. have not become dislodged. If corals have fallen replace immediately. 2) Check the sump level. 3) Check that skimmer is properly tuned. 4) Look for leaks in the plumbing. 5) Check the temperature. 6) Replace evaporated water with pure freshwater. This is best done through the use of a float valve attached to a reservoir.

Weekly

1) Replace/clean the prefilter every 2-3 days. 2) If you have a freshwater reservoir refill it with kalkwasser. 3) Check specific gravity, pH, alkalinity and ammonia. As the tank ages and you settle into a routine you will find that these measurements can be performed less frequently. I only check S.G., pH, and alkalinity about once a month. I only check ammonia if the tank does not look healthy 4) Add weekly additives such as strontium and iodide. 5) Clean viewing areas with a non-scratching pad. 6) Clean skimmer foam riser tube and collection cup (2-3 times a week).

Monthly

1) If using wooden airstones in the skimmer, replace with new ones. 2) Siphon out detritus from bottom. 3) If you wish to do water changes, the standard 10% a month is more than enough. 4) Measure the calcium ion level.

Yearly

1) Every 6-8 months replace fluorescent lamps, metal halides should be replaced once a year. Do not replace all lamps at once. 2) At least twice a year dismantle, clean and lubricate if required, all major water and air pumps. Clean all powerheads.

One goal most reef aquarists strive to achieve is that of low nutrient levels in the aquarium. Namely nitrate and phosphate (since these are easily measured) plus numerous other substances generally classified as dissolved organic carbon (DOC), need to be kept at low levels. Keeping these under control is often the difference between a successful reef aquarium and an algae coated mess. Having said this I should also add that no real connection has ever been made between nitrate levels and poor coral growth. Levels as high as 40 ppm nitrogen as nitrate, have been measured in aquariums with beautiful stony coral growths (Sprung, 1992c). However, nitrate can fuel undesirable algae growth in some cases and should still be maintained as low as possible. The best way to control the levels of these wastes is through the use of protein skimming (foam fractionation) and activated carbon.

Finally, unless you can maintain proper levels of pH, alkalinity and calcium, then you will be restricted in the amount of success you will achieve in keeping and growing corals, coralline algae and clams. The field of trace elements is an extremely active area at the moment as new aquarium additives seem to appear each month. Unfortunately, how many of these products are actually the product of any original research or long-term testing is open to question. However, this is definitely an area where breakthroughs are occurring as more is learned about the requirements of corals for certain trace elements.

3. Filtration

There has been much written concerning the filtration required to maintain a reef aquarium. Everything from pressurized trickle filters to just plain airstones has been advocated by various people over the years. Basically, filtration can be classified into three main categories: biological, mechanical and chemical. How these three are achieved is where all the variety and debate comes in. Some would have you believe that you need to purchase several hundreds of dollars worth of equipment to keep a successful aquarium. Devices such as ozone generators, automatic water change and top-off systems, alternating surge controllers, denitrification filters, redox controllers and meters, pH meters, CO2 injectors, molecular absorption resins and trickle filters have been heavily promoted by many as absolute necessities. In my experience, while it is nice to have many of these aids, they are not necessary for success. As a corollary, having all these things on your aquarium will not guarantee success either; if you are a poor aquarist, all the technology in the world will not help you cover up that fact. I would much rather you spend your money on good quality lighting, a properly designed protein skimmer and the highest quality live rock you can afford. When these requirements have been met, then you can add other "gadgets" if you so desire.

a. Mechanical Filtration

The first component of any filtration system is the method by which water is removed from the aquarium. Here there is little argument that an overflow of one type or another is the best option. An overflow functions to continuously remove the surface layer of water, thereby increasing gas exchange and removing surface active pollutants to the filtration system. An overflow also maintains a constant level in the display aquarium.

The overflow can consist of a commercially available unit that hangs on the side of the aquarium and operates on a simple siphon. However, many hobbyists still use the drilled tank overflow where a hole is drilled either in the bottom or side of

the aquarium and an overflow box built around the hole. Hang-on-the-back overflows are convenient to use and are the quickest way to retrofit an existing aquarium. Drawbacks include a low surface area for water flow, breaking of the siphon can occur, and one needs to be sure to select a pump whose flow rate the siphon can handle. Drilled overflows generally offer greater surface area for water extraction and they can not break a siphon. Drawbacks include making sure the pump is properly sized, any leaks could drain the entire tank, and the difficulty in cleaning some designs.

The mechanical removal of large particulates usually occurs in the overflow. For this reason the overflow should be easily and quickly accessible so that it can be cleaned on a regular basis. Usually some sort of untreated sponge or floss material is used to trap particles in the overflow. This prefilter, as it is called, should be cleaned or replaced on a regular basis i.e. every 2-3 days.

b. Biological Filtration

Biological filtration refers to the transformation of substances in the aquarium by many different species of bacteria. These transformations generally result in substances that can be harmful to the aquarium inhabitants. Fortunately, these substances are further acted upon by other bacteria to produce less harmful substances. Toxic by-products of waste such as ammonia, are oxidized by bacteria into less toxic nitrite, which is then further oxidized by other bacteria into least toxic nitrate. This nitrate then accumulates in the aquarium. This is, in essence, the basis of nitrification in the marine aquarium. Nitrate levels are then reduced by water changes, by assimilation by other organisms or by other biological processes such as denitrification, where yet more specialized bacteria act on the nitrate to convert it into nitrogen gas, which is quickly released from the water.

How one provides for biological filtration in a reef aquarium has come under some interesting discussion lately. Some believe that the modern trickle filter is the best way to achieve this while others, including myself, feel that in aquariums with live rock, trickle filters are not necessary for adequate biological filtration to occur. Trickle filters achieve biological filtration by presenting a favorable environment for nitrifying bacteria to grow. These bacteria then rapidly convert ammonia into nitrate, which is then returned to the aquarium. However, trickle filters do not only contain nitrifying bacteria but numerous other types that can produce still more ammonia and also phosphate. For a more in-depth discussion of trickle filters, their construction and design, I refer you to Delbeek (1990a).

Live Rock

Live rock consists of the calcium carbonate skeletons of long dead corals, or other calcareous organisms. Therefore the name "live rock" is really a misnomer as the rock itself is not actually "alive" but it does contain a multitude of life both inside and out. Most live rock are NOT collected from coral reefs themselves, but from adjacent areas known as a "rubble zones." These are areas where natural decay processes and storms have deposited large amounts of dead coral fragments that have become overgrown with numerous organisms. The vast majority of these pieces are eventually eroded with time or buried under sediments. These rubble areas are continuously buried, exposed and reburied by natural processes such as storms and currents, therefore any life on them is transient at best. Collection of live rock from reefs may be carried out by unscrupulous individuals and should definitely not be encouraged. Do not purchase any live rock that has sea fans and/or live stony corals attached, as these were probably illegally collected and transported.

Suggested Water Chemistry Values

pH 8.2-8.4
ammonia 0.0 ppm
nitrite 0.0 ppm
nitrate < 40.0 ppm (the lower the better)
phosphate < 0.2 ppm (the lower the better)
temperature 74-78oF
specific gravity 1.022-25
alkalinity (dKH) 2.3 meq/L or 8 dKH
calcium ion 380-450 mg/L

The use of live rock immediately introduces into the aquarium numerous algae, bacteria and small invertebrates all of which contribute to the overall quality of the aquarium water. Live rock has just as much, if not more, surface area for bacteria than a trickle filter. Since live rock in the aquarium contains various types of bacteria, algae and corals, waste products such as ammonia, nitrate and phosphate can have a number of fates. Ammonia, nitrate and phosphate are readily assimilated by algae and photosynthetic corals growing on and in the rock. Ammonia can also be quickly converted into nitrate by the bacteria on and in the rock. This nitrate can be either absorbed by the algae and corals, or it can be denitrified by bacteria in close proximity to the nitrate-producing bacteria.

In reef aquariums that are heavily loaded with fish or where overfeeding occurs, the production of nitrate may overcome the rock's ability to handle it and you will get a build-up of nitrate in the system. This is where additional protein skimming (foam fractionation) becomes important. For more information on this topic I urge you to read Sprung and Delbeek (1990) and Sprung (1992c).

There are various methods employed today in setting up reef systems, many of which are successful; some more than others though (Sprung and Delbeek, 1990). However, I feel that the most important ingredient, the one that will ultimately determine the appearance of the system and the time taken to achieve that state, is the quality and amount of live rock used. The reason for this is that it takes time for any system to reach a balanced state and the key to achieving this balance is the condition of the live rock. The better conditioned the live rock, the more stable the system. One method used to improve the condition of fresh live rock is to let it sit in an unlit, well-filtered aquarium for at least a month (this is called "seeding" the rock). The rock is of course first stripped of all sponges and algae that could die-off and pollute the system. After about a month of seeding, the rock is placed into the intended reef tank. By seeding the rock in this way, any fouling organisms will have died off and the rock will have begun to develop significant encrusting red, pink and purple coralline algae growths. This rock is then used to build-up the basic structure of the reef. Specialized rock such as plant rock or anemone rock are not used until much latter, if at all.

Seeding the rock in this way is not always practical for the hobbyist and we are often forced to place freshly collected rock into our systems. The removal of potentially fouling organisms becomes even more important in this case as the reef tank becomes the seeding tank. The amount of time required to seed live rock depends entirely on the state the rock is in when it first arrives. In some cases there is very little die-off on the rock and the seeding period can be as short as a week. In other cases it may take much longer. Seeded rock is also commercially available. If live rock is purchased from a collector, depending on how long the rock is in transit, then some additional seeding time may still be required when it arrives. A complete description of the process of setting up a reef tank using seeded and unseeded live rock is given in Sprung and Delbeek (1990).

The source of rock is another factor that should be taken into consideration. I prefer to use "reef rock," that is, rock that has been collected from outer reef areas. These consist basically of pieces of coral and coral rock that have been broken off of the reef during a storm or through natural decay processes, and have fallen to the bottom, where they are then covered by numerous encrusting organisms such as sponges and coralline algae. To my mind this type of rock makes the most beautiful and successful reef tank. It also cycles very quickly and stabilizes the tank rapidly. Inshore rock tends to be denser and is usually covered with numerous growths of macroalgae, clams, mussels, crabs, shrimps and other unwanted organisms, in my view less desirable.

Although it is possible to start a reef tank using dead base rock and only a veneer of live rock, this takes much longer to mature and the possibility of algal outbreaks is much greater. Yet, in some aquariums, the dead base rock eventually becomes so encrusted with purple coralline algae that it is indistinguishable from live rock. In the not too distant future aquacultured live rock will be available but it will require long term experience with this type of rock before it can be determined how suitable it will be for reef aquariums.

The way the live rock is arranged in the aquarium can also have a profound influence on the long term success and maintenance of a reef tank. What one sees in many reef aquariums is a haphazard conglomeration of rock piled into a brick-like wall, with very little regard given to water circulation and detritus build-up and its removal. When arranging live rock it is much better to construct a loose arrangement of rock, with many overhangs and bridges between the rock. Try and couple this with as few contact points between the rocks, and between the rocks and the substrate as possible. Do not pile the rock up against the back of the aquarium, leave enough space behind the rock for water circulation and for detritus removal. Some aquarists suspend their live rock above the bottom of the tank with sheets of acrylic light diffuser material or feet of acrylic. This allows detritus to accumulate below the rock for easy removal by siphoning. The same effect, however, can be obtained by the judicious placement of live rock.

Of course arranging the rock in such a manner is not easy to do when most of the live rock offered for sale are smallish, rounded pieces. The ideal shape for this type of arrangement are elongated flattened pieces that can be easily arranged to form platforms and bridges. By arranging the rock in this manner, organism placement is easier, water circulates freely around the rock on all sides and detritus is quickly carried away from the rock and collects either in the prefilter or on the bottom of the tank where it can be easily removed.

The amount of live rock required in a system is difficult to assess. The general rule of thumb is to place the rock such that it takes up about 1/3 of the visual volume of the aquarium. Using estimates of mass to determine how much rock is required are crude guidelines at best. The reason for this is that live rock can vary greatly in density. To fill a 65 gallon tank 1/3 full of a dense type of rock may require 200 lbs., but if a very low density rock were used only 100 lbs. may be

required.

I cannot stress enough the importance of the quality and placement of live rock in having a successful reef tank. Whether you use a trickle filter and a skimmer or only skimmers to filter your tank is irrelevant, if you have good quality rock with very little die-off, this will have a much greater affect on water quality than the filtration system. I feel that the importance of the filtering capacity of live rock has been greatly down played, and that of some filtration systems has been, perhaps, overrated.

c. Chemical Filtration

Protein Skimmers (Foam Fractionators)

The one piece of equipment I feel you should purchase is a good quality protein skimmer (foam fractionator). These devices play an extremely important role in maintaining coral reef aquariums. In my opinion, a protein skimmer is an indispensable piece of equipment for the marine aquarium, doubly so in a reef system. Foam fractionators have been in use in European aquariums for years and are often the sole form of filtration used. Obviously this cannot be achieved with the smaller, internal skimmers sold for years in North America, but by larger, external models. Such models are now commonly available in North America, the majority being North American built.

Protein skimmers consist of a column through which a very fine mixture of air and water is pumped. If any of you have been to the beach you may recall seeing foam along the shoreline. This foam is produced by the action of the waves which combine air, water and certain surface active organics to form a stable foam. A protein skimmer works in a similar manner. By collecting the foam, proteins and other nitrogen containing organics are removed before they are metabolized into nitrogenous compounds such as ammonia and nitrate, which is very beneficial to the health and maintenance of the system. Therefore there is nothing artificial or unnatural about protein skimming, it is merely the extension of a naturally occurring process. Of the various chemical filtration methods available, only protein skimming completely removes most organics before they begin to decompose (Moe, 1989). The list of substances removed by skimming includes, amino acids, protein, metals such as copper and zinc complexed with the proteins, fats, carbohydrates, phosphate, iodide, fatty acids and phenols.

Skimmers come in two popular designs, counter-current airstone driven and Venturi driven. A Venturi skimmer uses a strong water pump combined with a small air inlet to create a suction that forms a fine mixture of air and water in the skimmer. Such devices are more powerful and require less maintenance than the standard wooden airstone driven models; they can also be made smaller. Small Venturi models are more selective in what substances they will remove than counter-current designed airstone driven models. Counter-current models have an airstone at the bottom of the tube and the water flows from the top of the tube to the bottom. One of the drawbacks of these units is that they require frequent maintenance. In my opinion airstone models work quite well and remove a much thicker, darker green/brown sludge. There is no real need to purchase a more expensive Venturi design unless there are other considerations such as available space, that need to be met. The important thing to remember is that you cannot overskim an aquarium. For example the above mentioned 65 gallon could be easily run on a single 2 ft. tall, 4 in. diameter counter-current skimmer but adding another one would do no harm. For more information on protein skimmers, and instructions on how to build your own refer to Dyer and Delbeek (1991).

Bearing the above in mind, a reef aquarium can operate beautifully with or without a trickle filter but there are many variables that can affect the level of success achieved. Above all, limiting the sources and storage zones for nutrients is a general means of keeping the system operating properly whether a trickle filter is used or not. One can see, for instance, how important a piece of equipment a protein skimmer really is as a complement to the trickle filter. In removing nitrogen rich compounds before they are broken down, the protein skimmer lowers the trickle filter's potential production of nitrate. Its value is not lost in systems without a trickle filter either. This is also why most hobbyists running their aquaria with skimmers only, consider them an essential element for long-term water quality (Sprung and Delbeek, 1990).

Activated Carbon

Many of us are familiar with the use of charcoal in the old cornerbox filters of our freshwater days. These usually consisted of small, shiny, irregularly shaped pieces of bone or wood charcoal. This type of carbon is not really suitable for use in marine aquariums and has been replaced by "activated" carbon. In this form the carbon has been subjected to extremely high pressures and temperatures to drive out all impurities and gases leaving behind extremely porous and pure grains of carbon. Particle size, type of gas used, activation temperature and, in some instances, inorganic salts of zinc, copper, phosphate, silicate and sulfate added before activation, provide carbon with specific adsorption characteristics (Moe, 1989). Therefore, activated carbon can be tailored to the specific type of impurities that one wishes to remove. By creating such extremely porous structures within the carbon grains we have, in effect, created a gigantic sponge that can absorb many impurities from the passing water.

In order for this absorption to take place, water must flow through the carbon. Although simply placing the carbon in the sump beneath the aquarium may suffice, the most efficient use of the carbon will occur if water is actually forced to go through it. This can be achieved by placing the carbon beneath the outlet of the overflow or by using it in a separate canister filter.

One of the most common questions concerning the use of activated carbon is how much to use and how often it should be replaced. These questions are very difficult to quantify simply because no two systems are identical. Differences in bioload and the type of organisms being kept greatly influence the type and amount of DOC produced. For example, aquariums filled with macroalgae will produce a greater variety of DOCs than systems with very little algal growth. Wilkens and Birkholz (1986) recommend 500 grams per 100 liters. Although this does seem excessive one could use this as an upper figure and work downwards. The real indicator will be the condition of the inhabitants in the system and the color of the water. Too many aquarists today are turning towards technological wizardry to maintain their aquariums. People are constantly talking about ozone, redox potential and carbon dioxide systems when the majority cannot correctly identify their tank inhabitants or don't fully understand what alkalinity is. The occupants of our aquariums are far more sensitive to water chemistry than any instrument and if one spends more time watching them instead of the flashing lights on your equipment, you will be more in-tune with what is really going on in your tank.

For the same reasons mentioned above, it is difficult to recommend a specific time period after which the activated carbon should be replaced. However, various authors have stated that activated carbon should remain active for 5-7 months before needing replacement (Moe, 1989; Wilkens and Birkholz, 1986). Usually, the presence of yellowing substances in the water can be used as a guide to determining if your activated carbon needs replacing since these are easily removed by activated carbon and will start to accumulate when the carbon begins to lose its activity. Moe (1989) describes the following method. Obtain a strip of white plastic and color one half a faint yellow with a marker. Place the strip in the water and observe from a distance. When you can no longer distinguish the yellow half from the white half, your water contains yellowing substances and you should replace your activated carbon.

There are numerous brands of activated carbon being marketed today, some of which have fancy names such as research grade. Unfortunately, not all activated carbon is created equal and the levels of efficiency and quality vary greatly. The grains of activated carbon should be small, dull black in color and as dustless as possible. Recent measurements of activated carbon filtered aquarium water have shown that certain brands will actually add phosphate to the water, which is exactly what we are trying to avoid. Some activated carbons contain high levels of ash that also can contribute to undesirable algae growth. If you are unsure if your carbon brand leaches out phosphate you can rinse the activated carbon in pure freshwater thoroughly and then use it. This should remove some, but not all of the phosphate. One way to determine phosphate release by carbon is to purchase a phosphate test kit. Perform the test on purified freshwater and then add a few grains of your activated carbon to the test vial. If you see blue trails behind the falling pieces, you will know that it releases phosphate.

A final caveat concerning activated carbon is that it uncontrollably removes substances from the water, including some useful ones. Therefore, regular water changes or trace element additions (especially iodide) take on added importance when this form of chemical filtration is used for long periods or in large quantities. For example, when it comes to keeping delicate stony reef-building corals such as Acroporidae and Pocilloporidae, or soft corals such as Xenia, continuous use of activated carbon has been found to be detrimental for the reasons mentioned above (A. Nilsen, personal communication; D. Stuber, personal communication). Under intense illumination and continuous use of large quantities of activated carbon, coral bleaching and death are not unheard of. In some cases continuous use of activated carbon has led to reduced growth rates. For this reason many aquarists use activated carbon for only a few days each month, to quickly remove accumulated toxins from the aquarium.