Reef Tank Water Motion: How to Design Good Water Movement

Drs. Foster & Smith Educational Staff

As we have developed a better understanding of the processes occurring in our reef tanks, equipment has been developed that mimics some of the natural conditions. Sadly, one major aspect that is one of the most noticeable aspects of the natural reef, water movement, is often overlooked. This is unfortunate in that creating adequate water movement can be one of the relatively least expensive aspects of setting up a reef tank, and one of the most important. Proper water movement goes a long way toward helping a reef system thrive.

The importance of water movement

Organisms present on the reef are accustomed to an environment with strong water movement. Anyone that has been out diving or snorkeling along a reef quickly realizes how difficult it is to remain in one spot due to the force of the water around him or her. This rapid and constant water movement has caused the life in the sea to develop physiologically to make use of the water moving around them. This is especially true of the sessile invertebrates, such as corals and clams, that we keep in our aquariums. These organisms have developed to make use of the currents bringing them such things as food, oxygen, and nutrients, as well as carrying away their waste products.

Most corals have little capacity for removing waste material from their surface. This is especially true of the small polyped stony corals, which owing to their relatively small amount of living tissue, do not waste their energy removing waste material, but rather depend on the water moving around their surface to clean them. When you look at the physiology of these corals closely, it can be seen that much of their body is designed for nutrient capture, while very little is designed for waste removal.

In addition to providing essential nutrients, and instrumental in waste removal, water movement also influences:

- Growth of corals
- The formation of new coral colonies
- Growth of problematic algae
- Fish health

Growth of corals

Changes in Size: Several authors have reported that new growth of *Acropora* is often spindly relative to the growth of the old colony when this colony is placed in less strongly moving water (Veron, 1986, Sprung, 1994). However, if the flow is increased, the corals may resume their original growth pattern, and the speed of growth may also increase if all other factors remain the same. This increased flow not only increases the thickness of the new growth, but the previously spindly growth may thicken as well. Author Dana Riddle has found that the growth rate of many stony corals could be increased dramatically by increasing the flow of water around them. Interestingly, his studies were contrary to the belief that lighting intensity determines growth, in that he found that strong water movement stimulated faster growth than increased light intensity.

Changes in Growth Pattern: Water movement may change the growth pattern of some corals. For example, *Acropora palifera* normally grows as thick, unbranched colonies on the portion of the reef where wave action is greatest (Veron, 1986). However, when placed in some reef tanks with less water movement, these corals begin to grow in a more branched manner similar to other *Acropora* species.

In my own tank, I have noticed that the optimum appearance of several corals only occurs when good water movement is present. Yellow Leather corals from Tonga (*Sarcophyton elegans*) only "polyp out" when the current across their cap is strong. If inadequate water movement is present, they seem to mucous over more frequently in an attempt to remove the detritus that settles on their surface, or they develop brown spots where this detritus settles. The Finger Leather corals (*Sinularia sp.*) tend to orient themselves so as to maximize their exposure to the current. When the current is proper these corals take on a fuzzy appearance, while when it is inadequate, they look barren and are almost devoid of fully extended polyps.

New colony formation

Xenia colonies grow much faster when the current adequately stimulates them, but their form also changes as a result of an increase in current. When water movement is low, the colony has only short polyps close to the stalk. However, as the water movement increases, the polyps extend out from the main body to the point that they are four times further out than when the current is low. The shorter polyped colony also reproduces at a much slower rate than does a long-polyped colony found in areas of high water movement. The only thing that I can attribute this to is that in the long polyped colony, the long polyps occasionally attach themselves some distance from the stalk and then break off.

The polyp then grows into a new colony. Shorter polyps do not have the opportunity to attach far from the mother stalk, and as a result, new colonies do not form from this method. They rely exclusively on the stalk splitting in half to produce new colonies, and this takes longer.

Problematic algae

Most algal blooms result from excess nutrients being present. In reef tanks, these patches of algae usually are in spots where there is little to no water movement. As a result, detritus settles in these spots. That is why, if algae are plucked from these spots, a cloud of detritus is usually raised as well. In order to reduce this "algal oasis," it is necessary to get more water movement over these areas. Therefore, one of the goals of good water movement is to keep the detritus in suspension long enough so that much of it can be removed by the filtration system, or so that it can settle in the sump, where there is little light, and can be removed later.

In a study conducted at Eilat in the Red Sea, it was found that soft coral colonies located in areas where sedimentation did not occur due to strong water movement, grew three times faster than did colonies where sedimentation was a problem (*National Geographic Explorer*, TBS, May, 1993). This reaction to sedimentation has several applications in captive reef systems. If sedimentation is allowed to occur on stony corals, the result will be bleaching in those areas of the coral where the sediment remains. This bleached area often becomes a site where detritus settles and soon thereafter, problematic algae begin to grow. Therefore, strong water movement is essential not only for growth, but also to keep algae from becoming problematic. In soft corals, when detritus settles on them, spots develop under the detritus that rot or cause black spots on the colony which can eventually lead to the coral's demise.

Fish health

Another often-overlooked aspect of water movement is its effect on fish health. If you look at the labels of many fish foods, you will find that one of the largest components is fat. This is an important component in nature in that fat is quickly converted into energy. This is great for fish in the wild, as these fish are, for the most part, very active and require large amounts of energy. If, however, fish are placed in an environment where they do not have to fight the current, the result can be the development of fatty deposits, and as a consequence, a shortened lifespan. Therefore, it is my opinion that strong water movement will also contribute to fish health and longevity as well.

Water movement flow patterns

There are three main types of water movement, each with very different characteristics:

- **Laminar flow**: Laminar flow is straight, unidirectional flow, like that produced from a powerhead, or at the latter stages of a wave whose energy has been channeled in one direction by the reef.
- **Surge**: Surge is similar, only on a larger scale. To an observer viewing a school of fish, surge is when the school remains in the same pocket of water, but due to surge, the pocket of water and the school of fish suddenly move six feet in one direction, and just as quickly move back.
- **Turbulence**: Turbulence is the random flow of water in multiple directions. Of the three flow patterns, turbulence is the most desirable and the most difficult to produce (Sprung, 1998).

Choosing equipment to produce water movement

Powerhead

For most of us, the powerhead is a readily available means for introducing water movement into our tanks. Powerheads are relatively inexpensive and can produce varying amounts of water movement. Their main shortcoming is that they only produce laminar currents. These currents can not be aimed directly onto a coral, as the force is so great that it will cause the polyps to close, or in the worst case, may literally shear the tissue right off of the coral colony. Hagen, Aquarium Systems, and Azoo manufacture some of the standard powerheads. These are good standard powerheads and with a little ingenuity and some additional electronics, they can produce more than simply one direction flow.

In order to spread out or diffuse the energy from the powerhead, it may be necessary to use PVC pipe and fittings on the outflow. On most powerheads, it is possible to attach a PVC fitting to the nozzle where water is ejected. In order to get the PVC fitting to fit snugly, it may be necessary to sand or file the inside of it so that it will match the outside diameter of the powerhead precisely. Otherwise, the force of the powerhead will soon force the fitting off of the nozzle. Once the PVC pipe fits snugly, it is then possible to spread the flow out from this nozzle by using 'T' or 'Y' fittings and reducing bushings to distribute the flow. By doing this, it is possible to produce a more gentle flow through several nozzles that will not cause the coral to close up. Please note that by restricting the outflow, you may reduce the flow rate, and over time, this may shorten the life expectancy of the pump.

Using this method, it is also possible to direct current on a specific spot to reduce detritus build-up, or to direct flow behind rocks to prevent detritus from accumulating at the back of the tank. It should be noted that this method will still only produce laminar currents, and as a result, it will affect the direction in which some corals grow. For some stony corals, the result may be that the portion of the colony closest to the current will take one form, while that portion of the colony that is exposed to weak current will take on another form.

Powersweep powerhead

An 'oscillating powerhead,' also called a 'powersweep powerhead' has recently come on the market. It allows water flow to be directed over a wider area so that the flow no longer is simply directed on one spot. This powerhead rotates so that the flow that it produces covers a much broader area. When several of these devices are hooked up, their patterns of flow can be set up so that they actually do produce a turbulence pattern similar to that found on a reef. These devices can be placed anywhere within the tank so their flow can be directed all over, including behind rocks, so the source of current can be hidden.

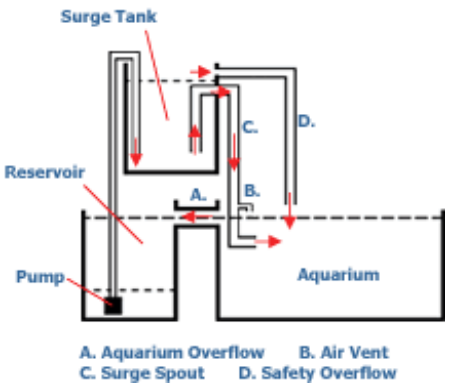
Electronic wavemakers

Another way to achieve proper water movement is to couple an electronic wavemaker, such as the Red Sea Wavemaster, to a powerhead and/or powersweep. An electronic wavemaker makes it possible to get closer to producing the desired effect by switching powerheads on and off on a random basis to try and mimic surge. The Red Sea Wavemaster does not just switch the pumps on and off, but it turns the pumps on gradually with a soft start. This "soft start" is advantageous in that it reduces the wear on the pump and prolongs its life. Additionally, this gradual increase in flow also mimics what occurs on the reef. Some powerheads are not designed to work with these types of electronics so I strongly urge you to consult the powerhead manufacturer before putting a powerhead/wavemaker combination together.

Using a powerhead and a wavemaker may make it possible to not only produce laminar currents and surge, but also turbulence as well. To produce turbulence, it is necessary to direct the flow from the powerheads either directly onto each other, or so that at least part of the flow from one is going directly into the path of the other. By having the powerheads activated randomly, the flow from them will intersect, producing a random pattern of water movement. There will still be laminar currents and surge as the powerheads come on, but as these different flows collide from multiple powerheads, a more random pattern of water movement with swirls and microsurges closely resembling turbulence should occur.

Using return flow: In addition to using powerheads to increase water flow within a tank, the return flow from a pump in the sump should also be used in all but the smallest tanks. This strong constant flow can be utilized in a number of ways. For those of you who desire the current in your tank to surge from side to side, like the surge on the reef, the flow from the pump needs to be split at a 'T' fitting. After this 'T' fitting, electronic ball valves can be inserted at either end of the 'T.' These electronic ball valves can be programmed using a microprocessor timer so that the flow passing through them will alternate from one valve to the next. The microprocessor allows you to adjust the time between surge changes. To achieve the surge effect, the outflows should be directed opposite each other across the length of the tank. This method is for anyone with an unlimited budget, as a single electronic ball valve costs over $200 each, and the microprocessor is another $50.

An alternative to having the pump direct its water flow into the tank is to use a surge device that has come to be known as the 'Carlson' surge device, after Bruce Carlson. In this system, a large, tall reservoir is placed above the tank. Three quarters of the way up this reservoir, a large diameter pipe runs into it and back down to nearly the bottom. The pipe coming out of the reservoir bends down to meet the tank's surface through the use of two 45-degree fittings. This pipe extends a couple or so inches down below the surface of the tank. Inside this outer tube, a small diameter piece of hard tubing runs to the top of the tube and extends out of the bottom of the tube and up into the air.



Adapted with permission from Delbeek, JC; Sprung, J. The Reef Aquarium Vol 1. Ricordea Publishing, Coconut Grove, FL, 1994.

This system works by the use of gravity and the creation of a siphon. Water from the tank is pumped into the reservoir slowly via a powerhead. When the water reaches the top of the pipe inside the reservoir, it will start to flow out and down the outside tube. As this flow increases, a siphon will form and draw the water out of the tube until the level reaches the bottom of the inside tube, at which time, the siphon will be broken and the water flow out of the reservoir will stop and the next cycle will begin. The flow out of this system will depend on the size of the reservoir, the height of the reservoir above the tank, and the diameter of the pipe extending into the reservoir. In order to make certain that the siphon is broken, I also suggest putting a small notch at the bottom of the pipe inside the reservoir.

Dump buckets: The last method for adding surge and turbulence to a tank is to use a 'dump bucket.' However, there are several reasons why I do not recommend using this method. First, this system is mechanical, and almost everything that I have utilized that is mechanical breaks down over time. However, a bigger reason is that all of the dump buckets that I have seen to date, by their very nature, produce a lot of air bubbles. These air bubbles not only make viewing the tank difficult, but they also irritate the corals. For soft corals in particular, this irritation leads to them not extending their polyps, making them less visually appealing. Lastly, dump buckets always produce salt spray, which is not only an annoyance, but can also be dangerous if the salt is allowed to get near any electrical outlets. Therefore, any alternative to a dump bucket should be employed as a means for producing proper water movement.

Potential problem situations

More is not necessarily better

This article has addressed many the positive aspects of good water movement. However, if you are like me, you may think that if a little is good, more would be better. This is not necessarily true with water movement. More likely, you will find that there is a window for the intensity of water movement that is optimal for coral growth, and if you go above this, some corals may be adversely affected. In one of my own systems, when I first put two powerheads into my system, my corals opened beautifully. When I added two more powerheads, my corals did not open as much. Gradually, over time, they opened less and less. However, I was too bull-headed having already spent the money on two additional powerheads to accept the fact that the corals were doing better with less current. This was only remedied when a friend suggested that I reduce the current's strength so that my Leather corals would open. The moral of this story is you can tell better than anyone when your corals are doing well, and sometimes, this is the result of doing something less, and not more. Over time, the corals will adapt to whatever water movement is present. If it is too strong in a particular area, they will grow around that spot. This is particularly true with stony corals.

Temperature increase

Most powerheads increase the temperature of the water by their method of being water-cooled. As a result, if a tank's temperature is showing an increase after the water movement is increased, the probable culprit is the powerheads. In this case, it may be necessary to either reduce the number of powerheads, or find more efficient models that do not heat the water so much. Otherwise, it may be necessary to add a chiller to the tank.

Salt spray

One last aspect of designing good water motion is to produce minimal salt spray. If your motion causes lots of bubbling and surface agitation, this will eventually lead to salt spray. This may not be problematic initially, but over time, a fine coating of salt will reduce the intensity of the lights and creep into everything around the tank. If it gets into anything electrical this can cause real problems, so keep this in mind once the system is up and running.

Electrical sources

If you plan to use a wavemaker in your reef aquarium, you will need a sufficient number of electrical outlets near the tank to accommodate multiple power cords. For safety purposes, use GFCI (ground-fault circuit-interrupter) outlets that are designed for safe operation in wet areas.

Conclusion

It is my belief that good water movement is essential for corals to really prosper. When designing good water movement in your system, do not make it too elaborate and always use reliable pumps and powerheads. Iwaki probably makes the most reliable and efficient water pumps on the market, so using them is a good place to start. With a little planning, and some of the new equipment on the market, it is now quite easy to get water motion within your tank that mimics what occurs on the reef.