Equipment for a Reef Tank

by Bob James, President, MAST

1. Introduction

This article provides some thoughts about the selection of equipment for a reef tank. It was originally written for someone planning to install a reef tank of dimensions 6.0′ x 3.0′ x 3.0′. That tank is to be built into a wall, with only the front face on display.

The article was not intended to provide a list of equipment, rather to discuss issues that the system designer should take into consideration. The article may therefore be of general interest to an aquarist planning a reef of a different size.

Before finalizing the design and equipment specifications for any tank, one should do a detailed layout, which would depend on the specifics of the tank's location. That is, the shape and size of the room from which the tank is to be viewed, as well as the available space behind or below the tank for equipment and maintenance activities.

Recommendations about lighting and circulation *etcetera* in this article would, of course, need to be scaled up or down for a larger or smaller reef than the one for which the article was written.

The document draws on my experience with my own tank, which has been running successfully for 17 years. It has somewhat different dimensions than the planned aquarium, but is quite similar in total volume and in surface area.

My tank	7.5′ x 2.5′ x 2.5′	nominal volume 43.7 cubic ft.	surface area 17.5 sq. ft.
Planned tank	6.0′ x 3.0′ x 3.0′	nominal volume 54.0 cubic ft.	surface area 18.0 sq. ft.

It makes for a useful comparison, although suggestions for the planned new tank take into consideration new knowledge and equipment availability. It is recommended that a new hobbyist also supplement this article with further research and discussion with experienced hobbyists, prior to selecting specific brands and models of equipment for their new tank.

2. Basic design

When I set up my own tank, I called the project, *'A Window into the Ocean'*. My tank was built into a wall, to hide all the equipment, and to de-emphasize the very fact it was a tank. I still like that approach.

I have, however, seen some spectacular tanks designed to show three sides, with just one short end up against a wall. This works well if you need a room divider. The normal arrangement is to have a rock wall down the middle of the tank, so corals can be placed on both sides of the aquascaping. Some would say this gives you more *'real estate'* for a given sized tank.

Ultimately, the specific layout depends on your room and personal preference.

In any event, equipment inside the aquarium distracts from the aim of presenting a natural vista, and should be minimized.

In recent years, there has been a trend for display tanks to be placed in the living quarters on the ground floor, with equipment largely in a basement below the tank. This gets pump noise and heat away from the viewing area. Such an arrangement may also serve to move some of the messy jobs into an area where water spills are less catastrophic.

For large tanks consideration should be given to floor loading. Some hobbyists have found it wise to reinforce the floor by using support poles in the basement under the tank.

3. Aquarium Design

3.1 Dimensions

As noted earlier, this article was written for someone planning a display tank having outside dimensions of: 6.0′ x 3.0′ x 3.0′.

A tank with a width under 3 feet has a tendency to result in a solid wall of rock along the back of the tank, and insufficient free space at the front for active fish to swim in a relatively unimpeded manner. The planned width of three feet avoids this problem and provides scope for some imagination in the aquascaping.

A tall tank provides more scope for aquascaping, as well as a potentially more stunning vista. However, the inability to reach to the bottom of the tank with one's hands increases maintenance difficulties. Extra depth also increases lighting requirements. The planned 3 feet is a good compromise.

The length of a tank is usually determined by the available budget or, sometimes, by the available room. Having limited the size of the tank, many hobbyists then overstock it. This causes both corals and fish to engage in territorial battles, with resultant stress on the livestock, as well as the aquarium keeper. A more healthy and attractive display will result, if a somewhat larger, but less heavily stocked, tank is utilized. The planned length of six feet is adequate for an attractive display.

3.2 Material

The front glass should be *'Starfire'*. (This is a brand name, rather than a style of glass.) The glass is much clearer than 'regular' glass and is well worth the cost premium, which has dropped significantly in recent years. Strength and scratch resistance *etcetera* are essentially the same as regular glass.

3.3 Structural Integrity

The tank manufacturer/supplier should provide a design with adequate strength and reliability.

My own tank uses the *'floating bottom'* principle. The tank sits on the lower edge of its four side panels. The bottom sheet of glass is siliconed to the four sides, such that it is suspended. This avoids potential stress cracking, which can result if the bottom glass is supported over its whole area. The design was chosen because it was then in use by the New York Public Aquarium. It has lasted 17 years with no sign of a problem. However, the design does not seem to have become a universal standard, and doubtless other designs will work. The reputation of the designer/manufacturer is probably one's best assurance of tank integrity.

For a tank of the proposed dimensions, ¾″ thick glass is a minimum.

There will need to be braces, across the top of the tank. Their size and location should be checked before manufacture, to ensure they do not interfere with planned placement of other equipment.

4. Lighting

A lighting hood has aesthetic benefits, if it can be seen from the normal viewing location. However, if the tank is enclosed in a wall, so only the front panel can be seen, an expensive multi-bulb unit may not be the best use of limited funds. Indeed, it may simply reduce flexibility in the placement of individual bulbs and reflectors. It may be better to use several fixtures each containing one bulb and a reflector.

Over the last few years, there has been increasing use (by hobbyists) of higher and higher lighting levels. My own tank utilizes four x 250 watt bulbs and, until recently, I have recommended these bulbs. However, some other hobbyists use 400 watt metal halide bulbs, some even utilize 1,000 watt bulbs. I now believe that there is enough experience with the 400 watt bulbs to recommend them. The brighter light seems to result in better colouring and faster growth of the corals. The costs of electric power may, however, become a factor. Also, if the tank is enclosed in a relatively small area, heat dissipation may become a problem. Even with 250 watt bulbs my chiller runs a considerable amount of the time, both summer and winter.

The other consideration is the Kelvin temperature of the bulbs. For many years, my tank operated successfully with 5,400 ºK bulbs. More recently, I have 'up-graded' to 10,000 ºK, while some hobbyists are using 14,000 ºK or even 20,000 ºK. I think that 10,000 ºK is a good spectrum for coral health, as well as an aesthetic look to the tank. I prefer these bulbs, supplemented by actinic lighting, rather than the higher Kelvin rating. This allows a dawn and dusk arrangement, with just the actinic bulbs lit. While I haven't read all the recent papers on the higher Kelvin bulbs, I suspect they put out less total light, have a shorter life, and are less reliable than the lower Kelvin bulbs. However, I am conservative, at least as far as operating a reef is concerned. The experience with higher Kelvin bulbs is growing all the time and my recommendation may change in the years ahead.

My own bulbs are the double-ended Power Star (or equivalent). My reading strongly suggests the double-ended bulbs put out more light than a single-ended bulb of the same wattage. They may also produce more of the shimmer usually associated with sun light, and therefore a more pleasing look to the tank.

Electronic ballasts are recommended, because they are claimed to give a longer life to the bulbs, and they create less heat. They can also be acquired with built in dimmers. While the dimmers will normally be set to maximum output, they add a useful degree of flexibility.

The compact fluorescent actinic bulbs probably work fine, but I prefer the VHO (very high output) 140watt, five-foot-long actinics. Apart from the extra output, they will provide a more spatially distributed light.

For moonlight, 4 x 1 watt blue moons would be nice, but a single, cheap, 10-watt incandescent bulb will serve almost as well.

All lights should be on timers, providing about 10 hours per day of full lighting, and an extra hour morning and night of dawn/dusk actinic only.

Hence my recommendations, for the size tank we are discussing, are:

- 3 x 400 watt double-ended, metal halide, 10,000 ºK, bulbs.
- Electronic ballasts, with dimmers, to match above bulbs.
- 2 x 140 watt VHO actinic (Phillips 03 or equivalent).
- 1 low-wattage incandescent bulb, in simple socket, for moon-light.
- Timers for all the above.

5. Temperature Control

My tank uses a ½ horse-power chiller, which runs a significant fraction of the time, to keep my tank at 76 °F. This is at the lower end of the recommended temperature range, of 76 °F to 79 °F. Perhaps a shade higher temperature may be closer to the temperature on the natural reef. Perhaps coral growth rates may be marginally higher at a little higher temperature. However, the marginally lower temperature gives a degree of safety margin, with little or no downside.

Temperature stability (as well as level) is important, and few locations will provide good stability without a chiller.

A chiller utilizing titanium coils (rather than copper) is absolutely essential, because copper is highly toxic to corals. The chiller should also come with a remote temperature probe, so it is controlled by the tank temperature.

The lack of a chiller will be less of a problem, if the area behind the tank is fairly spacious and has good ventilation - and preferably air-conditioning - to help disperse heat generated from the aquarium lighting.

A simple fan blowing across an open-topped aquarium will help disperse the heat. It will also produce evaporative cooling, particularly useful in the absence of a chiller. The only down-side is a little noise and the increased need for top-up water.

6. Filtration

Keepers of reef-tanks are nearly unanimous that the primary means of removing organic material from the water is by skimmers. Commercial manufacturers rate their skimmers by the size of tank that they will support. Such numbers have traditionally been grossly optimistic, although I was recently told (by a reliable source) that this is less of a problem than it was a few years ago. Nevertheless, I would use at least twice the level of skimming as recommended by skimmer manufacturers. I think a useful approach is to adopt the attitude that one cannot over-skim.

To slightly qualify the above remark, it may be possible to reduce organic material to a level below that which is optimum for some soft corals, namely those which inhabit lagoons. I don't think it is possible to get organic concentrations below that found on an open reef, or to a level below that which is desirable for smallpolyp, stony corals. Lots of skimming may require the replenishment of some trace elements, such as iodine. However, such replacement is an easy task.

My own tank utilizes two Klaes skimmers, with water columns about 7 inches diameter, by 6 feet high. The amount and size of air bubbles, flow rates and doubtless much else determine the efficiency of a skimmer, but the water column is a first order indication of efficiency. The Klaes and H&S Marine Life Support System are both respected brand names.

Many of the better skimmers will include pumps or venturies to generate air bubbles, but some will require an air pump. Most will require a water pump to push the water through the skimmer - discussed later under 'water movement'.

The wet/dry filter with bio-balls is no longer considered a useful addition to a reef tank. While skimmers aim to remove proteins and other organics early in the biological cycle, the wet/dry concept was to convert organics (using bacteria) to relatively non-toxic nitrates. Many reef keepers refer rather disparagingly to wet/dry filters as 'nitrate factories'. The risk is that, if anything gets out of balance, the filter may suddenly release the nitrates back into the tank. Skimmers avoid this problem by permanently removing the organics from the system, and are therefore much preferred to the wet/dry (bio-ball) concept.

One other useful filter material is activated carbon. Carbon is best utilized by letting a fairly slow stream of water pass over it, rather than having a fast flow forced through the material. Putting a bag of the material in the sump is therefore more desirable than utilizing a cartridge filter. There is therefore no capital outlay involved.

7. Water Chemistry

Calcium and alkalinity control is vital. When my tank was first set up, the method of adding calcium was to dose calcium chloride and a buffer. It works well enough, especially if you are lucky enough to have a spouse who dutifully tips a little of each of the chemicals into the sump each day. There is zero capital outlay, but a fairly high operating cost for chemicals.

A more recent innovation was to utilize a calcium hydroxide drip to make up for water evaporation. The drip method, as against batch dosing, is necessary to avoid severe, detrimental swings in the tank's pH. This method also works fairly well, although it can only be used for maintaining an established desirable level. The concerns about pH make it an unsuitable method for significantly increasing the calcium level of a tank, if the level is already too low. As an aside: I have long protested that there is no logical connection between the rate of evaporation of tank water and the required dose of calcium hydroxide. However, in many systems the two happen to be at roughly the right level.

I have no personal experience operating a calcium reactor, but concede that it is quickly becoming the standard tool for calcium control. Certainly, a number of hobbyists for whom I have the greatest respect use a reactor. They tell me that the capital outlay is quickly recouped in less expense for chemicals. They can be a little fiddly to set up, but once running well require little maintenance.

A hobbyist setting up a new tank or, indeed, just bringing his equipment up-to-date, should seriously consider a 'calcium reactor package' comprising:

- A Calcium Reactor
- CO_2 Cylinder and Regulator
- A pH Monitor

I will let you know when I catch up with this century's technology.

8. Water Movement

8.1 Water Movement Within the Tank

As with lighting, the trend has been for *'more'*. Over the last ten or fifteen years, typical water turn-over has increased from a range of one or two tank-volumes per hour to a range of five to ten. Mike Paletta in his book, *'Ultimate Marine Aquariums'*, describes 50 successful reef tanks around the world. He notes that one of the common characteristics of these tanks is much more water movement than is found in a typical hobbyist's tank. He computes the total water flow of each of the tanks (based on manufacturers' specifications) divided by the total volume of water in each system. He concedes this is *'a rather crude measure'*, but it gives some indication of what works. The overall average for the 50 tanks is a water turnover rate of 17 times per hour.

It is well recognized that the strong, constant water jets of old are unsatisfactory. What is required is a variable, turbulent water flow. Methods of generating such a flow are becoming much more common - as discussed later.

There are basically three means of generating water flow available to the reef keeper: submersible power heads, air-cooled power heads, and magnetic drive pumps.

Power Heads

Power heads are submerged in the tank and require no plumbing, but have significant disadvantages:

- They are generally visible in the tank, which distracts from the naturalness of the display. The better hidden they are, the more nuisance they are to maintain.
- They add heat to the water, increasing the cooling load.
- There is a possibility that they can lead to very low-level static voltages or electrical currents in the tank. This is detrimental to the fish and potentially hazardous to the hobbyist.

They are not recommended for routine use, although the availability of a power head for short-term use to address a specific problem is not a bad idea.

Air-cooled Power Heads

There are reliable, high-flow, power heads now available, which sit higher in the tank than traditional power heads. The motor is above water-level. They are therefore less visible from the front of the display tank, they don't add heat to the water, and they avoid potential induced (or stray) electrical currents. In short, they largely avoid the traditional problems. However, depending on the specifics of the tank set-up, their optimum location, from a water-flow point of view, may still clash with maintenance access or other equipment.

The power heads don't need plumbing, which is a plus, but this does not compensate for the lack of flexibility in locating the equipment.

Magnetic-Drive Pumps

Magnetic-drive pumps are the recommended means of water circulation. They are generally more powerful than power heads and avoid the disadvantages of power heads, as described above.

There are a variety of pumps on the market. The somewhat more expensive ones pay for themselves in longer life and quieter operation.

It is noted that the pump rating provided by the manufacturers is for a new, clean pump operating at zero head. The actual flow will always be less, often substantially less, than this figure. Reputable manufacturers will provide a flow versus head curve, but in practice the reef keeper generally doesn't have a good grasp of the operating head. This is because the pump head depends on the length and, in particular, the number of sharp bends in the piping, as well as the height the water has to be pumped. In any event, allowance for actual flows needs to be considered when ordering equipment. (Mike Paletta was well aware of this, so knows the turn-over rate of 17 times per hour, which he calculated, was not being achieved in practice.)

Pumps are designed with a different impellor for 'low-head high-flow' and 'high-head lower-flow' applications. The correct model needs to be specified when ordering.

Plumbing Design

At one time, it was common to design water circulation such that all water flowed (or was siphoned) out of the tank via an 'over-flow' device. It went into a sump and was then pumped back into the tank. After reef hobbyists had suffered countless floods due to system malfunction, closed-loop designs were adopted. (The concept seems obviously superior, once one has thought of it.)

A 'closed loop' consists of a drilled hole in the bottom or side of the display tank, piping to a pump, and then piping back to another hole in the tank. Of course, the piping into and out of the tank is via a bulkhead, and there will be a short length of pipe protruding into the display tank to direct the inflow and outflow. There will a shut-off valve at either side of the pump, so it can be isolated from the tank for maintenance or replacement. The beauty of this is that there is no open path to the floor. The system is immune to the potentially disastrous consequences of power outages or flow blockages.

The pump in a closed loop can be underneath the display tank, which minimizes piping and the head of the pump. However, this is by no means essential, the pump can be at any convenient location. In my system, it is in another room from the tank. This removes both the heat and noise of the pump, to an area remote from the viewing and working areas.

As a rough guide, I would locate the holes in the tank for a closed-loop circulation about a foot out from the back wall, and about a foot from each end of the tank. Going too close to the sides may stress the bottom glass. Being slightly behind the centerline will facilitate aquascaping, to disguise the presence of the inflow and outflow pipes.

My own system uses an Iwaki 100 RLT for the main closed loop. A second closed loop, using an Iwaki 40 RLT, goes through the chiller. Both pumps have run for years (touch wood) with no maintenance. Iwaki was the 'state of the art' when I bought my pumps, but other options are now available. For example, a friend has recently set up a beautifully equipped (and highly successful) tank using Baldor Reeflo pumps. They have high water flow and are not very noisy.

8.2 Water Flow to External Equipment

Water flow to Skimmers

Some of the organic material in a tank floats to the top, and it is the surface water that is best fed to a skimmer. This is achieved by having surface water flow into an overflow box, and the water then flowing directly to a skimmer; or into a sump tank, which in turn supplies a skimmer (direct to the skimmer is best).

The outflow from an overflow box is either by siphon or by a hole in the tank. The siphon is subject to problems, if the water flow is temporarily broken due to a power outage. Its sole benefit is avoiding the need to drill a hole in the tank. Siphons should not be used.

If a hole is drilled in the bottom of the tank, it is normal to use a standpipe, to reduce the fall of water and resultant noise. Generally, it is best to have the hole in the side of the tank.

The overflow should address two issues. First, the longer the length of the surface of the tank that is adjacent to the overflow, the greater will be the proportion of surface water that is removed. In principle, this maximizes the concentration of organics reaching the skimmer. Second, the less obtrusive the overflow is to the viewer, the better. These considerations led me to have a glass partition a few inches from one end of my tank, and the overflow stretching the whole tank width. These last few inches of tank are hidden from the viewer by having the partition made of dark *Plexiglas*, so it is not translucent. The framing of the front of the tank hides the overflow. This is better than the much more common practice of having overflow boxes in the corners of a tank. Aquascaping can largely disguise these overflow boxes, but my design totally avoids this problem.

The details of the plumbing from the overflow to the skimmers and back to the tank are dependant on the space available, the make and model(s) of skimmer chosen, and the layout of other equipment. Therefore, I am not recommending a specific design, but note the following general considerations.

Skimmers require fine adjusting of water flow. This will best be achieved by a dedicated pump, with a control valve (or valves) between the pump and the skimmer(s). For the size of tank under consideration here, the pump will be roughly the size of an Iwaki MD 30 RLT.

The flow from the skimmer back to the display tank will contribute to the general level of water movement and turbulence in the tank. The location of the return pipe should try to make best use of this contribution.

Water flow to Cooling Unit

There will need to be a pump to supply the cooling unit. An Iwaki MD 40 RLT is about the right size for a half horsepower chiller. A closed loop generally provides the simplest arrangement.

9. Sump

The sump typically used to be located under the main display tank. As systems have become more sophisticated, other locations have been chosen. For example, as mentioned earlier, many hobbyists have located sumps one floor below the level of the display tank. This may serve to move the maintenance area (and potential mess) away from living quarters to a basement.

The original and crucial role of a sump is to hold (with a good margin for error) all water that may flow down to it during off-normal operation, for example, during a power outage. (My own sump is located at about the same level as the display tank, so during power outages the water levels in the two locations equalize.)

The sump provides a number of other benefits.

The sump increases the water volume in the system without increasing the bio-load. In principle, the larger the sump, the lower is the bio-load per gallon of system water. The lower the figure, the greater is the stability of the system. In practice, the bio-load per gallon of water is not usually calculated, but the implication is that for sumps ‘the bigger the better’.

A sump also provides working room away from the display tank for adjustments to the water. As long as water is overflowing from the display to the sump, evaporation will reduce the water level in the sump, not the display tank. The control mechanism for an automatic top-up system is therefore located in the sump, and controls the flow from the fresh-water reservoir (by gravity, pump or spouse) into the sump. The control valve may be anything from a dinky plastic float valve, of the kind found in humidifiers, to an infrared beam and detector. The former are unreliable, the latter somewhat overkill. A floating electronic switch controlling a small power head works well. Whatever method is chosen, it is wise to have an emergency shut-off, due to ‘high sump level’.

The sump (as mentioned under filtration) is a good place for a bag of activated carbon. It is also a good place to add trace elements, such as iodine, so the dose is well diluted before it reaches the living specimens in the display tank.

The sump may be used occasionally if an organism needs to be removed from the display tank. This avoids subjecting it to a change in water parameters that would occur, if it was moved to a separate quarantine tank.

All the above considerations suggest that a large sump, while not essential, offers a degree of safety and convenience. If space considerations are not a limiting factor, a sump of 100 to 200 gallons would not be excessive for a display tank of about 300 gallons.

Some hobbyists have touted the benefits of a mud substratum for the sump, for chemical filtration of the water. *'Magic Mud'* is commercially sold (at a considerable cost), but most experienced hobbyists do not believe the 'mud' is better than crushed coral or sand.

10. Refugium

The idea of a refugium is to provide a refuge for zooplankton that would not thrive in a display tank, mainly because of predation. The concept is that these creatures will rapidly multiply in the refugium. They will be carried by water flow (harvested) in an on-going, sustainable fashion, into the display tank, thus providing food for the display tank inhabitants. The refugium may also be used to grow caulerpa.

The refugium is a tank that contains a sub-stratum of crushed coral, because that is a desirable environment for the zooplankton (copepods, *etcetera)*. The refugium will benefit from some small quantity of live rock. It will contain a flow of system water, which will take care of temperature control and water quality. It will need a modest source of lighting, such as a compact high-output fluorescent bulb. Some people advocate that the light in the refugium should be 12 hours out of sync with the display tank lights. This (theoretically) minimizes day to night pH swings.

The use of a refugium sounds like a wonderful concept in theory, but I am highly skeptical that, in practice, it provides substantial benefits in terms of generating a food source. I am not aware of anyone who has developed a system for reliably controlling the outflow of zooplankton, such that the display gets a significant supply of food, while not depleting the refugium population.

An additional benefit touted for refugia is that the caulerpa that is grown can be manually transferred to the display tank as a source of food. Alternatively, the caulerpa may be disposed of, thus exporting organics from the system. Both these benefits may be real but, I would guess, are trivially small. (Disposing of the caulerpa is, in effect, using the refugium as an algae filter. Algae filters will not be discussed in detail, because I prefer using skimmers, for removing organics from the system.)

Nevertheless, while refugia may be only of marginal benefit to the display tank, they do not have any negative factors. (There is a small capital cost, a space requirement, and a minor amount of maintenance, but these are fairly trivial in the overall scheme of things.) Reef keepers find refugia interesting. They are a handy refuge if one wishes to keep small shrimp, and they will be an extremely healthy and safe environment for an occasional small sick fish that needs to be 'nursed' back to health.

To summarize, a refugium could be a tank of about 20 to 40 gallons. It would require a single high-output fluorescent light. It would only need a small power head to pump water from the main tank or sump. The outflow from the refugium could be arranged to flow by gravity back to the display tank. (Gravity flow is better than a pump, because it gives any entrained creatures the best chance of surviving the journey to the display tank.)

Note that a refugium should be a separate tank from the sump. Although some of the functions of the refugium may be carried out in a partitioned-off part of the sump, the sump is designed in a different way for a different purpose.

11. Aquascaping

Live rock is practically essential for (at least) the following reasons:

- to provide bacteria to sustain biological breakdown of organic waste;
- to provide a population of copepods and zooplankton, which contribute a food source;
- to provide a natural habitat for the fish;
- to provide an attractive display.

The best kind of live rock is porous, not very dense, and in interesting shapes. Some large flat pieces are helpful in constructing imaginative aquascaping, such as shelves and caves. The rock should contain a large variety of marine life - a multitude of attached and boring invertebrates and algae, bacteria and microorganisms.

As a point of comparison, my aquarium contains approximately 1,000 lbs of rock. Unfortunately, my initial 500 lbs of rock was acquired before a good source of live rock became available. It is non-porous, dense, and rather brick-like. (One piece even contained something looking suspiciously like asphalt!) It therefore occupies much less space than better quality rock would occupy. The second 500 lbs was much better. I was aware of the need for caves, shelves and some free-swimming areas for fish when I designed the aquascaping. Indeed, my recollection is that the aquascaping incorporated all such features. However, I would aquascape less heavily, if I were setting up a new system today.

In short, I think about 500 lbs of good quality live rock would be adequate for a tank of 300 gallons or so.

Although there is no real measure of the bio-diversity in a tank, in the very long term, it can only decline if there is no infusion of new species. The idea of occasionally replacing live rock with a new source may have some merit. Provision for doing so may be a consideration in the initial design of aquascaping.

12. Power Supply

The Ontario electrical grid is quite likely to become less reliable in years to come. We are also at the mercy of ice storms and other causes of power interruptions. Therefore an independent electrical supply to run at least one circulation pump and a skimmer is highly desirable. The loss of a skimmer's function of removing organic material is not critical in the short term. However, a skimmer is a major source of oxygenation and it is for this reason it should be kept running if at all possible. The lighting and cooling systems are much less critical during outages lasting for a day or less.

The state of the art solution is to have a generator, which automatically starts up when it senses a loss of external power. This multi-thousand-dollar solution may be justified for hobbyists with very large investments in their tank. For most of us, a battery back-up is a much cheaper, more pragmatic solution, which will still cope with power outages lasting for less than a day. An example is the Noma Backup Power System, which can be wired to automatically power designated equipment, in the event of a loss of external power.

If nothing else is available, a bicycle pump and air-stone is better than nothing.

A last thought on a different subject: it is prudent to have GFI electrical sockets anywhere near water.

13. Miscellaneous Lab Supplies

Water Supply

A supply of pure water is required. It needs to have been through a reverse osmosis filter and/or a deionization column, preferably both. This water is needed to make up for evaporation loss, as well as to produce new salt water.

Food-quality plastic drums are useful for storing both fresh and salt water.

Test Kits

These might include test kits for alkalinity, calcium, and total carbonate hardness, a pH monitor, a hydrometer, and thermometer, *etcetera*. Manufacturers such as Hach produce professional grade test kits.

14. Concluding Thoughts

The hobby has reached a level of maturity. The knowledge and technology is now available that any serious hobbyist should be able to achieve success. We cannot expect radical breakthroughs, which will suddenly make reef-keeping simple. However, there is a constant evolution in equipment availability and techniques that are making our marine life thrive and our tanks look increasingly beautiful.

Success does require some devotion to your captive marine life. It requires a realistic budget. It requires the accumulation of knowledge and sound planning.

This article has just ‘skimmed the surface’ of the knowledge base. There are many good books that deal with the subject much more comprehensively, but none that I know of which will give you a simple recipe for success. Read widely. Talk to experienced hobbyists. MAST has so much experience within its membership, and many members who give selflessly of their time to help newcomers. Use, but don’t abuse, their goodwill.

Happy Reef-keeping !

Bob James,
March, 2007.
