Coral Aggression in Reef Aquaria

By Michael Paletta

The first thing that comes to mind when looking at a tropical coral reef is the great diversity of life within the reef. Every nook and cranny is teeming with different organisms specifically suited to a particular niche within the reef. This diversity is the result of the organisms evolving through competition. The factor underlying this competition is aggression, both subtle and overt. This subtle aggression takes the form of gradual conflicts that occur slowly on a continuous basis. Subtle aggression is particularly prevalent among corals as a result of their constant battle for survival. Coral has to cope with currents, predation by fish and other invertebrates, as well as competition from neighboring corals for light, nutrients, and food.

Consequently, coral has developed several specialized mechanisms for protection and competition with other corals. These include sweeper tentacles, mesenteric filaments, and terpenoid compounds (Aites, 1989). Sweeper tentacles are the most common of these defense mechanisms in the hard corals. These mouthless elongated tentacles form on the outermost portion of the coral colony and act as a “petrol” along the periphery. When this tentacle encounters a competing coral, it may attack the competing coral and literally “burn” the offending coral to the point of either killing it or severely damaging it. The relative toxicity of these tentacles differs among various species of coral as does the length to which these tentacles can elongate (Sheppard, 1982).

In addition to these tentacles, several hard coral species can produce mesenteric filaments from their stomachs. Corals of the genera Favia, Solymig, and Pavona all have this capacity (Chadwick, 1987). These filaments can also kill or devour other coral polyps through a process similar to digestion. Some corals even have the capacity to produce both of these defensive structures, enabling them to fight a battle on several fronts (Wallace, 1984).

These two defense mechanisms are utilized exclusively by the hard corals. The soft

Ozone, Protein Skimmers, and U-V

By John Dawes
Aquatic Consultant Wilshire, England

Mention ozonizers, protein skimmers, and ultra-violet sterilizers to a novice marine hobbyist and you are likely to end up either with a case of extreme panic on your hands or a look of utter confusion.

If the aquarist is an experienced one, then he will almost certainly have strong views of these subjects. Either they are the best things that have ever happened to the marine hobby or, at the other extreme, they are complicated, expensive pieces of equipment which do absolutely nothing at all and can even be dangerous.

As with everything else, neither of these extremes represent the whole truth. Sure, an overdose of ozone won’t do either you or your fish and invertebrates any good at all. But then again, neither will an overdose of that otherwise vital vitamin found in oranges and lemons, Vitamin C.

The key, of course, lies in a common-sense approach. Use them in a sensible way and ozonizers, protein skimmers, and U-V sterilizers will reward you in no uncertain manner. Use them unwisely and you could create problems for yourself.

Here then are brief summaries of the principles behind these three pieces of equipment.

Ozonizers

As their name suggests, ozonizers generate ozone, a gas made up entirely of oxygen atoms. However, while atmospheric oxygen occurs as stable molecules made up of two oxygen atoms bonded together, ozone consists of molecules made up of three oxygen atoms. This state of affairs is very unstable, with the third oxygen atom behaving as if it were all the time “looking” for some substance to form a stable association with.

It just so happens that some of the toxic waste products generated by aquatic organisms are, themselves, unstable. If they could be oxidized by means of receiving an extra oxygen atom, they would then become stable and less toxic.

Clearly, therefore, if ozone is brought into contact with these chemicals, it will react

(Continued on page 2)
corals generally compete with the hard corals by releasing terpenoid compounds and then overgrowing the injured coral. This release of terpenoid compounds allows the soft corals to grow above or on top of the hard corals and block out light which consequently kills the underlying hard coral.

In a miniature reef this aggressiveness can have severe and dire consequences in that, if allowed to progress to its conclusion, a large and expensive coral head would die. If these sweeper tentacles or mesenteric filaments are observed, the reef keeper should make sure to move all invertebrates in their proximity out of the way. However, if these tentacles have reached their target, they should immediately be removed from touching the other organism, and if a portion of the tentacle remains attached, it should be physically removed, otherwise the toxic substances these tentacles secrete will continue to work and will kill their competitor. Fortunately, if the reef tank is well maintained and no microalgae are allowed to grow on the skeleton, the coral colony may recover and grow back over the damaged area.

Similarly, care must be taken when handling corals as the toxic tentacles may attach to the aquarium’s hands. If another coral is then picked up, it may be injured by the remnants of corals left on the hands. Scrubbing of hands with freshwater between specimens is beneficial.

While a miniature reef does not contain the great diversity of life that an actual reef does, provisions should still be made to try to minimize the aggression among corals. As noted previously, the relative aggressiveness among coral species varies.

Consequently, when setting up a miniature reef adequate space, which is invertebrate free, should be given around each coral head. This zone should be at least 15 cm in all directions, as sweeper tentacles have been reported to be at least this long (Sheppard, 1982). Another factor that should be allowed for is growth. In a properly maintained miniature reef, some corals may grow at a rate of up to or even exceeding 4 cm per year. This factor should be considered when the coral is originally placed within the aquarium as the less frequently coral is moved the less the chance of injury.

It has also been my experience that several coral species become more aggressive when hungry. These corals generally have a single large mouth rather than being a group of small polyps. Corals that fall under this category are Bubble coral (P. sinuosa), Euphyllia (all species), Mushroom coral (Fungia species), and Elegance coral (Calliactis parasitica).

These corals are also generally among the most aggressive and will burn not only other corals but also other invertebrates. Therefore, particular care should be taken to isolate these corals from other organisms. These corals, however, will not attack members of their own or related species. I have seen very strong evidence of this genus specific non-aggressive behavior in the case of corals of the genus Euphyllia. I currently have four species of Euphyllia (fimbriata, divisa, glabrescens, and ancora) that have grown together for 20 months without burning each other. In fact, at several points the tentacles of two different species have interwoven to the point that two look like one. However, these corals have not lost their capacity for aggression in that they have been observed to burn the neighboring Elephant Ear Anemone as well as partially burned a Tridacna Clam. This non-aggressive behavior has also been observed in two different coral variants of Elegance Coral.

As a result of my experience with corals and other invertebrates, I have comprised a list of the relative aggressiveness of commonly kept sessile invertebrates (Table 1). Those organisms that are the most aggressive need the widest berth while those that are less aggressive can be placed closer together. However, in no instance should different invertebrates be allowed to touch. In addition, allowances should be made for the direction of the current in the tank. That is, a greater distance should be allowed between two coral heads with regard to the direction of the current. Also, soft corals should not be placed so that current across them and onto a hard coral as the terpenoid substances these soft corals produce could effectively inhibit the growth of these neighboring hard corals.

The successful maintenance of corals in a miniature reef is now becoming more commonplace. However, this success is producing other problems, such as the opportunities for the aggressive behavior just described. But with continued success and experimentation even these problems should eventually be overcome and even greater success will be realized.

<table>
<thead>
<tr>
<th>Table 1</th>
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<tbody>
<tr>
<td><strong>Relative aggressiveness of commonly kept reef invertebrates</strong></td>
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<tr>
<td><strong>Most Aggressive</strong></td>
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<tr>
<td>Elegance Coral (Calliactis parasitica)</td>
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<tr>
<td>Hammer Coral (Euphyllia ancora, E. fimbriata)</td>
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<tr>
<td>other Euphyllia (E. glabrescens, E. cristata)</td>
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<td>Bubble Coral (Plerogyra sinuosa)</td>
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<td>Grape Coral</td>
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<td>Physosgyra lichensteini</td>
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<td>Mushroom Coral (Fungia actiniformis)</td>
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<td>Flower Pot Coral (Goniopora spec.)</td>
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<tr>
<td>Open Brain Coral (Trachyphyllia seforoyi)</td>
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<td>Cup Coral</td>
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<td>Tuxbinaria peltata</td>
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<td>Moon Coral</td>
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<td>Galaxea fascicularis</td>
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<tr>
<td>Closed Brain Coral (Palythoa sp.)</td>
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<tr>
<td>Star Polyps (Clavularia spec.)</td>
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<td>Leather Coral (Sarcophyton spec.)</td>
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<td>Dead Man’s Fingers (Dendronephthya spec.)</td>
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<td>Tree Coral</td>
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<td>Sinaleria spec.</td>
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<td>Finger Coral (Cladialia spec.)</td>
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<td>Gorgoniana</td>
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<td>Gorgonacea sp.</td>
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<td>Waving Hand (Antheila sp.)</td>
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<tr>
<td>Xenia</td>
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<td>Xenia spec.</td>
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<tr>
<td>Giant Mushroom (Rhodactis spec.)</td>
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<tr>
<td>Mushroom Anemones (Actinodiscus spec.)</td>
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| Least Aggressive |

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Water Analysis—
A Step Forward

Maintaining optimal water quality has long been the objective of serious marine aquarium keepers. A vast range of elaborate filter systems have been devised to eliminate the build up of toxic metabolites in the aquarium. All the systems have one need in common, the need for accurate water analysis methods to evaluate the performance of the system.

**Freshwater test kits vs. Saltwater test kits—They are not the same**

Because salt water is such a complex chemical solution, tests that are perfectly good in fresh water are often subject to interferences in saltwater, causing erroneous readings from vital tests. Special chemicals or modifications to standard tests are necessary in order to get accurate, reproducible results in the ranges needed by marine hobbyists.

A case in point would be testing copper for a standard ionic copper treatment where 0.15 to 0.20ppm copper is the recommended therapeutic level, but 0.20 to 0.25 may cause stress for sensitive fishes. Of what value is a test where the first discernable faint color comparison is 0.25ppm copper? For successful treatment of Amyloodinium and Cryptocariaon, (white spot) levels below 0.15 are ineffective and above 0.20 may be dangerous. Thus, a test must allow accurate monitoring of the 0.10, 0.15, 0.20, and 0.25 levels as found with SeaTest® for Copper.

Another source of confusion occurs in pH testing. Tests developed for freshwater pH give inaccurate results in salt water due to the combination of salt interference and buffer effects. Thus, for saltwater use, the pH test must be specially calibrated or erroneous readings will result. SeaTest® for pH is adjusted for marine use and is not recommended for freshwater aquaria. Tests marketed for both fresh and saltwater are generally inaccurate in one medium or the other, and in some cases, both.

**Increasing Reagent Shelf Life**

Beyond the issue of chemistry are two other important factors; reagent stability and color matching.

The three most important factors in determining reagent stability (or shelf life) of a formulation at room temperature are: oxygen, moisture, and light.

Liquid reagents are generally considered to be the least stable form for reactive chemicals. Although tablets are an improvement, they have a certain amount of moisture inherent to the tabiing process that may accelerate deterioration. Furthermore, they require binders that may cause variations in solubility affecting timed tests particularly.

Powdered reagents represent the most stable, fast mixing system available.

Polyethylene powder pillows, for a number of years, have been the best available method for ensuring activity of tests; however, they are subject to light effects and gradual permeation by oxygen and moisture with obvious results.

**The Ultimate Barrier**

Aquarium Systems, Inc. has recently introduced a new reagent system incorporating dry powder reagents into multi-layer aluminum foil pillows. These foil pillows provide an ultimate barrier to light, oxygen, and moisture. In addition, due to the compact nature of the pillows, excess air is excluded further eliminating exposure to air. Thus, the new reagent package provides the most stable system yet for the marine hobbyist. In addition, the new foil pillows can be easily opened by hand, eliminating the need for scissors or clippers.

**The Perfect Match**

Regarding color matching, see-through color comparators have long been preferred for color matching over opaque color spots or charts. In the past, a series of colors were supplied to the aquarist for comparison. Often the actual color of the water sample was somewhere in between the levels presented. Furthermore, when color comparators were made, it was often difficult for the manufacturer to match exact colors from one printed group to the next so accuracy was sacrificed.

But, new design SeaTest® color strips now provide continuous gradient color to allow more accurate matching of in between shades. The accuracy of the strips is further improved because the concentration scale is not printed until the actual colors in the strip have been checked. This fine tuning step eliminates any possible color printing variations.

Additionally, through-the-sample viewing feature automatically compensates for light source variations so readings are accurate every time.

This new test fixture is also designed to allow both short path comparison for regular testing and long path length for copper and low range nitrate determination. This long path length modification, coupled with a dual-range Nitrate scale, extends the test range down to the 1 part per million Nitrate Nitrogen range that is often desired by miniature reef aquarists.

The new SeaTest® multi-kit and individual ammonia, nitrite, nitrate, and pH reagent refills are completely compatible with the previous comparators. Hobbyists will still be able to use the old test cube with the new foil pillow reagents.

As mentioned above, the copper test has been modified to use the new cube in its long path length mode. Since this change reduced the test volume by about 75%, the new reagents will not be compatible with old style kits. For questions on copper compatibility call 1-800-822-1100.

**Book Review:**

Helmut Debelius

*Fishes for the Invertebrate Aquarium* 3rd Edition, is now available in new expanded version.

**Fishes for the Invertebrate Aquarium, 3rd Ed.**

With the surge of interest in miniature reef aquaria came the need for a reference book to identify the fishes suited for this specialty aquarium. Out of print for over a year, *Fishes for the Invertebrate Aquarium* is now available in an expanded 3rd edition.

This updated version discusses 12 popular families of fishes with over 180 beautiful photographs of fishes in their natural habitat as well as in reef aquaria. Helmut Debelius, in addition to his own magnificent work, has drawn upon the talents of numerous other photographers, including Rudie Kuiter, Roger Lubbock, John Randall, Roger Steene, and Gerald Allen, to put together this exquisite collection of photos.

Observation on the behavior and habitat of fishes in the wild, together with hints on their care and maintenance in the aquarium, will make this a valuable addition to the reef aquarist's library.

Combining correct scientific designations with meaningful common names makes this volume appealing to scientists, divers, and aquarists.

Available through your local pet dealer, the suggested retail price is $27.00. This new edition was published for Aquarium Systems, Inc. manufacturers of Instant Ocean® sea salt.
Ozone

(Continued from page 1)

with them, oxidizing them and rendering them stable.

Equally important is the fact that ozone can help destroy pathogenic (disease-causing) organisms, such as viruses, bacteria, and ectoparasites.

It is for these reasons that ozonizers are so helpful, particularly in marine aquaria. There are several models on the market and you, obviously, need to look at the range available before you decide. Aim for one that can easily be adjusted to the size of the aquarium in question and always stick to the prescribed dosage levels. A rate of 10 mg of ozone per hour, per 100 litres (25 gallons) of water, is usually deemed quite satisfactory but this may need to be increased slightly if water pollution is heavy or reduced if the water is exceptionally clean. Directions on how to use this piece of equipment must be followed. If you don’t, it can cause respiratory discomfort and nausea.

Introduction of ozone directly into an aquarium is not recommended. The use of some sort of contacting chamber is, therefore, necessary. Also, to avoid risks of overdosing, it is generally advisable to direct the ozone treated water through activated carbon before it returns to the aquarium.

This should not, however, put people off after all, we use gas and electricity in our homes without a second thought, even though we know that misuse can have rather dramatic and distressing consequences.

Ozonizers can, and often are, combined with the next piece of equipment - the protein skimmer.

Protein Skimmers

Protein skimmers, or more properly foam fractionators, have long been used in marine aquaria as a means of removing organic waste products from the water.

Irrespective of refinements and sophistication, all skimmers use the basic principles that surface active organic substances and small particles brought into close contact with an air-water interface, such as the surface of small bubbles, will attach to the bubbles. As the bubbles rise, they carry with them the attached compounds. As these substances accumulate at the top of the skimmer contact chamber, they increase the surface tension of the bubbles leaving a foamy froth at the surface that continues to build up, similar to the froth seen along a beach on a stormy day.

If you then provide somewhere for the foam to collect, you have devised a very useful and effective method of water purification.

Protein skimmers do precisely this. Further, if they are used in conjunction with ozonizers (and in accordance with instructions), the extra oxygen available will increase the efficiency of a skimmer significantly. Ozone, at low levels, breaks some of the long organic molecules, producing more charged particles. However, overdoses of ozone may oxidize or bleach the organic carbon compounds to a point where they are no longer surface active, reducing the efficiency of the fractionation process.

Protein skimmers do require regular maintenance. Airstones must be cleaned or replaced in units utilizing them, and the “scum” must be removed as it sometimes interferes with efficiency.

Ultra-Violet Sterilizers

U-V sterilizers have occasionally come in for some heavy criticism. Usually, I feel, this is unjustified. One of the arguments which I have heard against U-V sterilizers is that, if they kill off bacteria, then regular use will result in a sterile, i.e. bacteria-free, environment, making biological filtration impossible.

U-V sterilizers are, indeed, effective at destroying fungal and algal spores, as well as bacteria and viruses. However, for this to happen, water laden with these microorganisms has to be pumped through the sterilizer. Therefore, the beneficial bacteria which live attached to the filter medium and are responsible for biological degradation (purification) of water, never come anywhere near the U-V source.

Consequently, they can survive quite happily and continue with their job, whether or not the tank has a sterilizer attached to it. Furthermore, all micro-organisms are equally susceptible to U-V radiation - some require a higher dose than others. As a result, it is, in fact, very difficult, if not impossible, to produce a totally sterile environment through the use of U-V sterilizers on their own.

Again, as with ozonizers and protein skimmers, there is a range of U-V sterilizers available. For optimum effect, make sure that you match sterilizer and tank size appropriately. Follow the manufacturer's instructions, including the recommended intervals for lamp renewal.

Most manufacturers of U-V sterilizers base suggested tank size and flow rates on the exposure of 35,000 microwatts/sec/cm². This level is generally effective against all viruses, bacteria, fungi, and some smaller protozoans. Where a range of flows is given, this exposure would normally apply only to the slowest flow rating, and at higher flows, exposure would be reduced. To put this into perspective, average bacteria generally are killed by 10,000 microwatts/sec/cm². Viruses usually take even less. However, Paramecium, a ciliated protozoan, can survive up to 200,000 microwatts/sec/cm²!

Since the exposure factor is primarily the result of bulb output and exposure time, it can be increased either by slowing the flow or using more or larger bulbs. Slowing the flow is not a good answer as it results in less water being sterilized.

Thus, if your goal is to control bacterial levels in the water, units operating at higher flow rates should be effective. On the contrary, if you wish to eliminate larger protozoan parasites, larger units operating at lower flow rates would be suggested which, due to the costs of the units, may not be a cost effective control measure.

Conclusion

I have only been able to provide the briefest of summaries in this article. I have intentionally steered clear of the actual design of the various pieces of equipment in the belief that an appreciation of the basic principles is a more important first step than the "nuts and bolts" aspect.

For details of the various models available, contact the relevant manufacturers, agents, or distributors - they will, no doubt, be able to supply you with the necessary literature.
A Successful Cultivation of the Comet Calliplesiops altivelis (Steindachner, 1903)

By: Herman Wassink
Marine Aquarist 'MiniReef'
Apeldoorn, The Netherlands
Rob Brons: Marine Biologist 'MiniReef'
Utrecht, The Netherlands

A number of years of experience with seahorses and Amphiprion species, led us to attempt cultivation of Calliplesiops altivelis (Comet). The particular species was chosen due to the relatively large eggs and larvae it produces which obviously increased our chance of success.

The Aquarium System

The Calliplesiops altivelis pair were held in one of the compartments of an aquarium system that had proved quite satisfactory during cultivation of Amphiprion species. The construction consists of two rows of aquaria on top of each other. The top four compartments, each with a capacity of 130 liter, are for the mating pairs. The lower row consists of the cultivation tanks in which the fish larvae develop. Underneath the cultivation tanks is a large aerobic biological filter, consisting of two DLS modules with rotating sprinklers. A denitrification filter and protein skimmer are also attached. A submersible pump (capacity 2,200 liters/hour) in the filter, pumps the water to the upper row of aquaria where it is channeled into the two outside compartments. The water flows via a steppe system up and over into the two middle chambers of the upper row and, by way of a mechanical filter and the protein skimmer, back to the biological filter.

Water is fed to the cultivation chambers in the lower row from the biological filter via a branch off in the submersible pump. In contrast to the upper row of aquaria, the cultivation tanks are independent, each with its own water circulation system, also operating through a flow-off construction similar to that described above. Cultivation tanks with very young fish larvae, however, are usually unhooked from this system and receive exchange water only by droplets at a time. An extra internal filter is also often installed.

The capacity of the complete system is 1,100

(Continued on page 2)

Sea Salt Formulation

When looking at formulas for making synthetic seawater, it often appears that there are nearly as many recipes as researchers. The book, Artificial Sea Waters: Formulas and Methods, by Joseph P. Bidwell and Stephen Spotte (1985), has 169 entries. Many of these were designed for special uses but a good portion were designed to simply mimic natural seawater.

How can there be so many ways to duplicate seawater? In natural seawater, at least for major and minor ions, the ratios of the components are consistent worldwide. However, for each element that is found in seawater there may be several salt compounds that can be used to provide it, and, for some of these, there are different hydration levels and crystal shapes.

Thus, supply magnesium, a formulator may select magnesium chloride in any one of 3 hydrama states or magnesium sulfate in its various forms. Of course, combinations of magnesium salts are often used further expanding the possibilities.

Thus, when a major, minor or trace ion varies from natural seawater levels (NSW), the formula may be the reason. (Inefficient mixing is another possibility, but this will be discussed later.)

Why would a manufacturer want to mix a salt

(Continued on page 4)
...Larval Rearing

Breeding and Cultivation System

The Cultivation Method

The young Comet larvae proved to be unusually sensitive to stress and must, therefore, be handled as carefully as possible. A special trap, designed for the collection of the hundreds of free-swimming larvae and their relocation to the cultivation tank, is attached to the overflow of the aquarium. The larvae float with the water into the next tank through the trap - a construction of glass and fine plankton screen. The extra water flows out through the screen; the larvae are deposited in the detachable glass container with a capacity of 0.5 liter. When a large number of larvae have been collected, the container is removed and placed underwater in the prepared cultivation tank.

The cultivation tanks have a capacity of 33 liters, and possess a V-shaped bottom in which refuge collects and from where it can be removed without overly disturbing the larve. A small amount of coral sand from a flourishing sea aquarium is distributed on the bottom as well. The attendant micro-organisms contribute to the cleanliness of the cultivation tank.

Circulation in the tank is, in the beginning, minimal, and aeration extremely weak (large bubbles, 5cm under the water surface). Incremental addition of fresh sea water begins after one week via a slender hose (from the biological filter), starting at 50ml per minute and gradually increasing to 500ml per minute.

We have indications that the larvae react negatively to strong light and - especially - sudden movement outside the cultivation tank. To avoid these negative influences, the front of the aquarium was covered with black plastic for the first two weeks. The top of the chamber was kept in shadow, so that the larvae develop in continuous darkness. A half liter of algae culture is added to the water in the cultivation chamber directly before the larvae are transferred to it. Although the fish larvae do not feed on these one-cell algae, they do contribute toward a positive milieu for their development. Further, the algae do nourish the rotifer *Brachionus*, which are introduced as food to the larvae the day after they emerge. Additional amounts of algae and *Brachionus* are added daily to the cultivation chamber as necessary.

Further nourishment for the developing Comets include dry food (grains of 300 micron) from three days on, freshly hatched *Artemia* (brine shrimp) from the 7th day on, and from the 14th day, very small pieces of *Mysis* (shrimp) and beef heart.

Results

*Culicepsops altivelis* produces a roughly ball-shaped clump of eggs of approximately 2.12 centimeters, which is attached to a wall in one of the live rock hollows. The individual eggs have an average circumference of 1 mm and possess sticky threads, which bind them together into a stable unit, and to the wall. A spawn produces about 500 eggs.

Development takes approximately 5-6 days at 26 degrees C. Spawning does not occur as regularly as with the *Amphiprion* species. Rest periods of 10 days occur regularly, but a longer period of time in between is not unusual.

Hatching of the larvae occurs at night, when darkness has completely fallen. The larvae are 3mm long with a deep black pigmentation. The long larval tail and weakly developed thorax are enveloped by a rudimentary fin, and they further possess pectoral fins, well-developed eyes and a large mouth. Movement occurs in sudden starts and stops. There are no remains of a yolk-sack to be seen, and the larvae begin to feed immediately, upon or soon after, hatching.

Comet larvae prove to be excellent swimmers after only a few days, moving with precision and purpose through the cultivation chamber after feeding. This was reduced to the observation of this behavior, which contributed to the general cleanliness of the tank. The young larvae show a preference for flowing water, and large concentrations are often gathered near the aerator.

The length of the larvae doubles within the first 14 days, the circumference notably increasing as well. After the first two weeks, usually on the 16th day, a remarkable bit of maturation takes place in both appearance and behavior. The larvae, previously pitch black, now exhibit a spot on the flanks which grows increasingly lighter. Microscopic inspection shows that the black pigment cells slowly disappear from this area. This development continues until the flanks are completely white, contrasting sharply with the black head, tail, and fins.

Even more remarkable is the change in behavior to which this is linked. The heretofore freely swimming larvae begin crowding into the corners of the tank on the 16th day, apparently in an attempt to hide. When two pieces of split PVC tube were placed in the tank, all the young Comets were gathered underneath them within 15 minutes and the restless behavior had completely stilled.

We conclude that the change in appearance marks the evolution from a free-swimming lifestyle, to the adult behavior which is bound to hiding places. After this development, the behavior increasingly reflects that of the adult - the young
hide for the most part during the day under the PVC tube halves and forage through the cultivation tank at night. As the tail and fins develop, the style of swimming also gradually begins to resemble that of the adult.

The development of the adult color pattern is a very gradual process. Although the flanks remain white for approximately 5 months, a white spotted pattern begins appearing on the head at about 2 months. The tail and fins of the young fish have taken on the characteristic adult form by the time they are 5 months old. By this time the well-known eye spot has also developed. From this time on, the amount of white on the flanks decreases as black pigment is slowly added to the area where black and white merge.

Within 7 months of birth, we had a number of young Comets with a completely adult color pattern, although white spots could still be seen on others in the group less quick to develop. The fish are then approximately 3 cm long. After 6 months, the young fish had been transferred to an aquarium furnished with live rock. The length at 8 months was 4 cm.

**Q and A**

**Question:**

Our store was recently visited by a representative of the manufacturer of a range of test kits that competes with your SeaTest™ kits. He carried a copy of your "Instructions for use" and pointed to a section that tells how to convert Nitrate-Nitrogen readings to Nitrate-lon readings. He then proceeded to state that some SeaTest™ kits utilize the "wrong scale" and that the reading must be multiplied by a correction factor to obtain the actual reading, which his kit supposedly indicates directly.

Following some discussion, I must admit that I was so confused that I didn't know what to believe. Can you help me?

**Answer:**

If a highway sign indicates that the distance to the next city is 10 miles or 16 kilometers, is one number right and the other wrong? Of course not. The distance is exactly the same. The numbers shown in miles and kilometers are not the same because each utilizes a different scale of measurement. Both are correct indications of the actual distance.

This same situation exists with some test kits. For example, nitrate tests can utilize one of two scales: Nitrate-Nitrogen (NO₃⁻) or Nitrate-Ion (NO₃⁻⁻). Both scales refer to the same chemical substance, but identical concentrations of nitrate will have different numerical values on the two different scales.

It is easy to convert miles to kilometers. Simply multiply the miles by 1.6. It is just as easy to convert Nitrate-Nitrogen readings to Nitrate-Ion readings. Simply multiply by 4.4. We show the conversion factor in our instructions, only for convenience of comparing SeaTest™ results with tests that utilize the Nitrate-Ion scale.

For example, 10 milligrams per liter (or ppm) Nitrate-Nitrogen (NO₃⁻) is the same as 44 milligrams per liter (or ppm) Nitrate-Ion. The nitrate concentration is exactly the same in both cases; only the numbers are different, because different scales are used.

Aquarium Systems™ kits utilize the Nitrate-Nitrogen scale, because it is the recognized standard for scientific and research purposes. Respected authors, such as Martin Moe and Stephen Spotts, refer to Nitrate-Nitrogen readings in their writings, as well.

In any case, one scale is not better than the other. It is most important, however, to know the appropriate "safe" range for each scale. A Nitrate-Nitrogen level of 20 to 40 milligrams per liter is generally recognized as acceptable for most purposes. The Nitrate-Ion level is exactly the same in both cases; only the numbers are different, because different scales are used.

Aquarium Systems™ kits that use the Nitrate-Ion scale are often puzzled because they always obtain readings near or over the top of the scale. Much confusion results because, as amazing as it may seem, some manufacturers of test kits apparently do not appreciate the difference between the two scales. They produce kits that give readings on the Nitrate-Ion scale, but still recommend 20 to 40 milligrams per liter as the acceptable range. That corresponds to a range of approximately 4.5 to 9.0 milligrams per liter on the Nitrate-Nitrogen scale.

This is an unrealistically low range for conventional aquariums (those that contain primarily fish).

Granted, it would certainly not be harmful to maintain such low levels, and as the manufacturer of Instant Ocean® sea salt, we would benefit greatly, because extensive, substantial water changes (often more than 25% weekly) would be necessary to maintain such low levels. However, we, from years of marine hatchery experience, and other skilled aquarists realize that, the benefits obtained do not justify the cost and effort required to maintain such low nitrate levels.

We know that even lower nitrate levels are the ideal for reef aquariums (those that contain primarily sessile invertebrates), but this is a distinctly different situation. To recommend the same nitrate range for both is not appropriate.

The SeaTest™ nitrate kit is the most sophisticated and practical kit available. The new, continuous-gradient color standard allows the user to exactly match the color that develops for every concentration, not simply at 4 or 5 points. Additionally, dual range capabilities permit accurate determinations in conventional aquariums, where higher nitrate levels are usually encountered and in reef aquariums, where extremely low levels must be detected. There are no better choices than SeaTest™ kits.

**SeaScope** was created to present short, informative articles of interest to marine aquarists. Topics may include water chemistry. Nutrition, mariculture, system design, ecology, behavior, and fish health. Article contributions are welcomed. They should deal with pertinent marine aquarium topics and are subject to editorial reviews that in our opinion are necessary. Payment will be made at existing rates and will cover all author's rights to the material submitted.

**SeaScope** is published quarterly for free distribution through local aquarium dealers. Dealers not receiving copies of **SeaScope** for distribution to their customers should call Aquarium Systems, Inc. to be added to the mailing list. Telephone: 1-800-822-1100 or (216) 255-1967. Aquarists interested in receiving copies directly should send their name and address, along with $2.00 USA ($4.00 foreign countries) for postage and handling (four issues) to **SeaScope**, Aquarium Systems, Inc., 8141 Tyler Blvd., Mentor, OH 44060. Address questions, and suggestions to: Thomas A. Frakes, Editor.

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**Information & Acknowledgements**

The co-authors of this article have worked closely together since 1980 on various projects involving the cultivation of tropical seafish and invertebrates under aquatorium conditions. Actual cultivation and relevant experiments are in the hands of Herman Wassink; Rob Brons is responsible for research concept, data processing, and photography.

Herman Wassink was director of Minireef Holland through the assistance of Director Larmontre de Van and currently president of Dutch Aquarium Systems in Dallas. Realization of the cultivation tank alone (designed by Herman Wassink) would not have been possible without it, and the authors extend their gratitude to him and his support.

The authors are further indebted to Han Blok (chemical biologist) for his valuable advice concerning water chemistry and biological filtration. Thanks also go to translator Kenneth Holt.

This is a compiled, condensed, and extended version of an article that appeared in:

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4th edition, No. 3 (March 1988)

p. pp. 126-10
that did not exactly match natural sea water? There are two valid reasons. First, if adequate research has been compiled to show that an elevated level of an essential element is beneficial, higher levels may be included. Examples might include iron and iodide, which are both actively removed by biological and chemical processes.

Second, elements that are not biologically necessary and may, in aquarium situations, be detrimental, might be reduced. An example of this would be bromide. Natural seawater and artificial seawater with normal bromide levels, when treated with ozone, can develop bromiform or bromate compounds that have been shown to be toxic to delicate organisms like oyster larvae. Thus, natural seawater and blends that are "guaranteed" to have every element in natural proportions may not be compatible with the highly tech reef systems using ozone.

A manufacturer could also reduce the proportion of a particular component simply to reduce costs, or to improve solubility without the expense of higher quality materials, but this would hardly be considered a valid reason.

This brings up a delicate question. If a manufacturer "guarantees" that its "synthetic marine salt contains 70+ trace elements found in natural seawater, all in their natural proportions, and that the seawater made with the product (Tropic Marin) is practically indistinguishable from natural seawater," how can a hobbyist substantiate this claim? In general, lab analysis of seawater is very difficult, especially for trace elements in the parts per billion range and, of course, expensive, costing thousands of dollars for complete analyses. Thus, the claim goes unchallenged and is assumed to be correct.

Aquatronics, as part of its ongoing quality control program, periodically obtains packages of other brands of sea salts. These, along with Instant Ocean" sea salts, are sent to an independent testing laboratory, experienced in the analysis of salt solutions. Table 1 shows results for just two ions, calcium and potassium from several studies that were conducted.

Over time, each brand begins to develop a pattern of consistency or inconsistency, but one in particular raises questions about the accuracy of the "guarantee". Calcium! This key major element has consistently been found to be 17 - 25% below natural seawater levels in Tropic Marin sea salts. Similar results are noted with Forty Fathoms' marine mix.

These levels certainly distinguish the products from natural seawater and ironically Tropic Marin has been especially promoted for use in miniature reef tanks. Many hobbyists are adding calcium supplements to encourage coral and calcareous algae growth, probably because of this initial calcium deficiency.

Unlike trace elements that are virtually impossible for hobbyists to test for, calcium can be evaluated by concerned aquarists, because tests are available.

Lower calcium is beneficial to the manufacturers as it can improve initial solubility. Improvements in the quality of other raw materials can generally be used to compensate, and provide comparable solubility, without decreased calcium levels.

Blending Uniformity

Significant variations in a key elements like calcium and potassium raise questions about blending uniformity and/or segregation of components in packaging. Not all brands utilize the pharmacological quality blending technology and particle size selection that is needed to assure consistent results.

This uniformity is particularly important when small quantities of seawater are prepared. If a package is not uniform throughout, large ionic variations can occur that are potentially hazardous. Often, particle separations can be seen visually. The table shows the considerable variation of some brands. Instant Ocean" sea salt has long, unsurpassed history of uniform blend to blend and bag to bag.

Although some brands claim to be practically indistinguishable from seawater, we have shown there are differences! Such claims seem impressive, because, except for calcium, there is no practical way for a hobbyist to certify the accuracy of these "guarantees". Unlike chemicals intended for human use or fertilizers for agriculture, there are no agencies that enforce labeling claims by manufacturers in the aquarium industry. This is certainly a case of "let the buyer beware".

There is another visible example of questionable package claims. It is found in the labeling of package size. The only standard that is legally enforced is the net weight of a product. The gallon ratings are completely arbitrary. Instant Ocean" sea salts have continued to package the full 8 pounds per 25 gallons that was once the standard of the industry. Over the years, other manufacturers have reduced package weight while still retaining the 25 gallon size designation. This means that at equivalent salinities, Instant Ocean" salt will produce more gallons of sea water.

The table below compares the weights of "50 gallon" mixes for 4 brands and approximate gallons produced at 1.023 specific gravity level.

A question remains. If a company makes elaborate claims about trace elements, and yet, as was shown earlier, major elements like calcium and potassium are not even accurate, and the package weight is reduced significantly, then should not all the claims be taken with a grain of salt? Pardon the pun.

Next issue we will continue with an in depth look at the "Trace Element War" and what it means to the hobbyist. A

Table 1

<table>
<thead>
<tr>
<th>BRAND</th>
<th>ELEMENT</th>
<th>SAMPLE 1</th>
<th>SAMPLE 2</th>
<th>SAMPLE 3</th>
<th>SAMPLE 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instant Ocean®</td>
<td>Calcium</td>
<td>388</td>
<td>400</td>
<td>420</td>
<td>420</td>
</tr>
<tr>
<td></td>
<td>Potassium</td>
<td>388</td>
<td>410</td>
<td>410</td>
<td>360</td>
</tr>
<tr>
<td>Marine Environment®</td>
<td>Calcium</td>
<td>799</td>
<td>480</td>
<td>-</td>
<td>370</td>
</tr>
<tr>
<td></td>
<td>Potassium</td>
<td>729</td>
<td>380</td>
<td>-</td>
<td>450</td>
</tr>
<tr>
<td>Forty Fathoms®</td>
<td>Calcium</td>
<td>309</td>
<td>260</td>
<td>310</td>
<td>270</td>
</tr>
<tr>
<td></td>
<td>Potassium</td>
<td>460</td>
<td>500</td>
<td>340</td>
<td></td>
</tr>
<tr>
<td>Tropic Marin</td>
<td>Calcium</td>
<td>332</td>
<td>300</td>
<td>310</td>
<td>310</td>
</tr>
<tr>
<td></td>
<td>Potassium</td>
<td>332</td>
<td>400</td>
<td>350</td>
<td>320</td>
</tr>
<tr>
<td>Natural Sea Water</td>
<td>Calcium</td>
<td>400 mg/l</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Potassium</td>
<td>380 mg/l</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comparative study of two major elements, calcium and potassium from four separate group analyses of the brands listed. All samples adjusted to natural seawater salinity of 35 ppt.

Table 2

<table>
<thead>
<tr>
<th>BRAND</th>
<th>Weight 50 gal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tropic Marin</td>
<td>13.75 lb.</td>
</tr>
<tr>
<td>Forty Fathoms®</td>
<td>14 lb.</td>
</tr>
<tr>
<td>Marine Environment®</td>
<td>1.5 lb.</td>
</tr>
<tr>
<td>Instant Ocean®</td>
<td>16 lb.</td>
</tr>
</tbody>
</table>
Trace Elements and Sea Salt Mixes

Over the years, the topic of trace elements in synthetic sea salt mixes has become a major issue. Because trace elements are so difficult for aquarists to evaluate, the guarantees of elements often fail to the point where it has become more of an emotional issue rather than a scientific one.

In the Spring 1990 SeaScope, it was pointed out that some major brands (Tropic Marin® sea salts, Forty Fathoms® marine mix), in spite of advertisements of being virtually indistinguishable from seawater, have in repeated testing been found to be in the range of 20% below the natural seawater level for calcium, a critical element, and that interested aquarists can verify these results using commercially available test kits.

Guarantees of over 70 elements in their "natural proportion" can seem impressive. The fact is, for the brands tested, the trace element profiles are relatively uniform. But keep in mind that the number of elements being identified by scientists worldwide as essential for ANY marine organism is less than 30 including major, minor, and trace elements. Table 1 presents data from a recent (December 1989) partial analysis of 4 commercial brands of synthetic seawater. This is not intended to represent a typical analysis for these products since variations in mixing and uniformity may exist for some products. These salt mixes from factory sealed bags, were evaluated by an independent laboratory experienced with salt water testing. Significant discrepancies are highlighted.

A key observation in reviewing this data is the fact that with only a few exceptions the trace element levels are quite similar. Results from other tests show similar results, confirming what was reported in the Spring 1985 SeaScope. Thus, when selecting a brand of salt mix, a history of proper formulation, consistency, and uniformity become the major issues, rather than a "guaranteed" list of elements.

Part of the confusion in comparing brands of commercial salt mixes stems from the contradictory and misleading advertisements circulated by certain manufacturers. Left unchallenged, some hobbyists might conclude that all the statements are correct. Statements by the manufacturer of Marine Environment® sea salts in a recent pseudo-article placed in popular aquarium magazines are particularly troublesome for any serious marine aquarist. First, the statement that "one step formulas seriously lack necessary levels of essential elements" and the assertion that they cannot

Reef Invertebrate Feeding

By: Michael Paletta

When trying to successfully establish and maintain a miniature reef system, it is a hobbyist's nature to try and improve conditions in the tank by adding things to the tank. We are, out of habit, often looking for a quick fix, and unfortunately, this is not always the best way to maximize success with miniature reefs. The reef's inhabitants are used to a stable environment with a low level of nutrients, particularly nitrogen, phosphate, and dissolved organics. According to Julian Sprung's Nutrient Deficit Hypothesis, the concern in an enclosed environment should be more for removing excess nutrients than adding to already high levels.

From my own experience and from viewing other miniature reef aquariums, I have found that high nutrient levels are the most frequent cause of failures, which are indicated by massive micro-algae blooms. Most of this excess nutrient formation is due to overfeeding the invertebrates and to adding unnecessary supplements. Many mini-
...Trace Elements

(Continued from page 1)

be incorporated into a one part medium is perplexing at best, especially when this company's own product label is scrutinized. The component list for the dry part (1°) guarantees 78 elements in spite of the contention that this is not possible. The implications are that the little bottle (part 2) will supply all the trace elements. In looking at the contents and analysis lists for the little bottle, at first glance it seems impressive until it is noted that only 12 trace elements (ions found at less than 1 ppm in sea water) are included and one of these is nitrate, which most hobbyists are trying to avoid.

More confusing are the inconsistencies in ionic levels reported by this manufacturer in his own "Independent Laboratory Analysis" sheets that have been circulated over the years. For example, levels for some major ions, reported in parts per million (ppm), have been variously reported as follows: calcium: 312, 400, 535; sulfate: 22525/2250, 13235; magnesium: 3030, 1300, 896; and the list goes on. In addition, 42 elements are listed as trace impurities of which only 8 are found in part 2, including nitrite and nitrate.

The size of this publication necessitates a complete review of the half truths and erroneous statements listed in this paid advertisement "Selecting the Best Saltwater Mix", but taking credit for spawning, raising, and selling the world's first tropical fish is absurd. Martin Moe, Jr. is universally acknowledged as the first to commercialize marine tropical fish breeding in the early 1970's using primarily natural seawater and on occasion some Instant Ocean® sea salts (personal communication). Instant Ocean® Hatcheries followed closely using Instant Ocean® sea salts and in fact during the next 10 years, more tank raised marine tropical fish were reared in Instant Ocean sea salts than any other medium, including natural sea water.

As a side note, during the late 1970's, literature was circulated claiming a new species of anemonefish "Amphiprion americanus", the common clownfish (A. ocellaris) with one white spot in place of the normal midbody bar, had been cultured in Marine Environment. This of course was not a species, but rather a developmental deformity generally attributed to environmental deficiencies during larval rearing, according to the top breeders in the country (personal communication: Martin Moe, Frank Hoff, Godfrey Waugh, Forrest Young, Chris Turk, Tom Frakes). This fish still appears on their packaging today.

The negative attitude of this article is regrettable, yet necessary, in light of the type of exaggerated and erroneous advertising that has recently begun to dominate this market. We hope that we will move to a period of more accurate labeling and advertising where a rebuttal of this type will not be necessary.

TABLE 1

<table>
<thead>
<tr>
<th>Element</th>
<th>Instant Ocean® mg/L</th>
<th>Forty Fathoms® mg/L</th>
<th>Marine Environment® mg/L</th>
<th>Tropic Marin mg/L</th>
<th>Natural Sea Water (NSW) mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major Elements</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ca</td>
<td>19,600</td>
<td>19,900</td>
<td>20,200</td>
<td>20,100</td>
<td>19,000</td>
</tr>
<tr>
<td>Mg</td>
<td>360</td>
<td>340</td>
<td>450</td>
<td>310</td>
<td>400</td>
</tr>
<tr>
<td>Na</td>
<td>1,400</td>
<td>1,100</td>
<td>1,000</td>
<td>1,300</td>
<td>1,350</td>
</tr>
<tr>
<td>B</td>
<td>5.5</td>
<td>4.9</td>
<td>0.54</td>
<td>5.0</td>
<td>4.5</td>
</tr>
<tr>
<td>Ba</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.03</td>
</tr>
<tr>
<td>Cd</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Co</td>
<td>&lt;0.03</td>
<td>&lt;0.03</td>
<td>&lt;0.03</td>
<td>&lt;0.03</td>
<td>&lt;0.0003</td>
</tr>
<tr>
<td>Li</td>
<td>0.18</td>
<td>2.7</td>
<td>3.5</td>
<td>&lt;0.08</td>
<td>0.18</td>
</tr>
<tr>
<td>Mo</td>
<td>2.2</td>
<td>1.9</td>
<td>1.9</td>
<td>1.8</td>
<td>0.10</td>
</tr>
<tr>
<td>Ni</td>
<td>&lt;0.04</td>
<td>&lt;0.04</td>
<td>&lt;0.04</td>
<td>&lt;0.04</td>
<td>&lt;0.007</td>
</tr>
<tr>
<td>Pb</td>
<td>&lt;0.08</td>
<td>&lt;0.08</td>
<td>&lt;0.08</td>
<td>&lt;0.08</td>
<td>&lt;0.0003</td>
</tr>
<tr>
<td>Ru</td>
<td>&lt;0.10</td>
<td>&lt;0.10</td>
<td>&lt;0.10</td>
<td>&lt;0.10</td>
<td>&lt;0.12</td>
</tr>
<tr>
<td>Sb</td>
<td>&lt;0.20</td>
<td>&lt;0.20</td>
<td>&lt;0.20</td>
<td>&lt;0.20</td>
<td>&lt;0.0003</td>
</tr>
<tr>
<td>Si</td>
<td>0.34</td>
<td>0.32</td>
<td>0.29</td>
<td>0.31</td>
<td>2.0</td>
</tr>
<tr>
<td>Sn</td>
<td>0.15</td>
<td>0.13</td>
<td>0.13</td>
<td>0.15</td>
<td>0.0008</td>
</tr>
<tr>
<td>Sr</td>
<td>7.1</td>
<td>4.5</td>
<td>6.9</td>
<td>8.5</td>
<td>8.5</td>
</tr>
<tr>
<td>V</td>
<td>&lt;0.04</td>
<td>&lt;0.04</td>
<td>&lt;0.04</td>
<td>&lt;0.04</td>
<td>&lt;0.002</td>
</tr>
<tr>
<td>Al</td>
<td>&lt;0.04</td>
<td>&lt;0.04</td>
<td>&lt;0.04</td>
<td>&lt;0.04</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Cu</td>
<td>0.011</td>
<td>0.009</td>
<td>0.030</td>
<td>&lt;0.005</td>
<td>&lt;0.003</td>
</tr>
<tr>
<td>Fe</td>
<td>0.012</td>
<td>0.028</td>
<td>0.027</td>
<td>0.011</td>
<td>0.003</td>
</tr>
<tr>
<td>Mn</td>
<td>0.004</td>
<td>0.012</td>
<td>0.055</td>
<td>0.009</td>
<td>0.002</td>
</tr>
<tr>
<td>Zn</td>
<td>0.018</td>
<td>0.023</td>
<td>0.033</td>
<td>0.015</td>
<td>0.010</td>
</tr>
</tbody>
</table>

Comparative analysis of four commercial brands of sea salts made up to the same specific gravity with distilled water. This indicates major elements over 20% different from NSW, this indicates major elements over 10% different from NSW, this indicates minor and trace elements less than 1/10th of, or more than 10 times NSW levels.

In conclusion, Instant Ocean® sea salts has an unsurpassed history of consistent, uniform performance. It was formulated initially for university and institutional scientific research and stringently tested under intensive culture conditions at Instant Ocean® Hatcheries when generations of fishes, invertebrates, and macro algae were reared. This commitment to providing the highest quality synthetic sea salts to the marine aquarist is why Instant Ocean® sea salt has grown to be the world leader, combining the best of European and American technology into one product. &

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Forty Fathoms® is a registered trademark of Marine Enterprises Baltimore, MD 21204.

Tropic Marin is a trademark of Dr. Blener, GmbH, Aquarientechnik, Wartenberg, West Germany.

Instant Ocean® is a registered trademark of Aquarium Systems, Inc. Mentor, OH 44060.
MOLLUSCAN TOUCH

Text and Photos By: Alex Kerstitch

Of all the animals in the sea, molluscs have been the most widely exploited by man for numerous uses—food, money, medicine, trade goods, tools, ornaments, objects of art, and for dozens of others. Today, with the ever growing interest in the marine aquarium trade, molluscs have found a new niche in man’s life, not as pretty shells decorating a book shelf, but as living creatures in the marine aquarium.

Although molluscs are still considered a novelty in the community aquarium, more and more species are becoming available to the marine aquarium enthusiast. Three main groups are regularly imported into the U.S.: gastropods (snails), pelecypods (clams, scallops, etc.), and cephalopods (octopuses, cuttlefishes, and nautiluses). In order to thrive successfully in captivity, these animals must be given their appropriate food-prey, which at times could consist of other aquarium residents. So care must be taken to learn about their feeding habits before introducing them to a community tank.

For example, certain species of cone snails of the genus Conus prey exclusively on small fish and obviously would not be desirable in a fish tank. Fish-eating species occasionally found on the market include Conus geographus, C. purpurascens, C. ermineus, and C. tulipa. These voracious nocturnal predators hunt sleeping fish with venomous harpoons attached to a strong ligament. Like Amazonian blow-gun hunters, cone snails can shoot their harpoons from a long tube (probscos) into the flesh of the unsuspecting fish. In seconds the fish is paralyzed and swallowed whole by the snail. A note of caution, fish-eating species are dangerous to man and should not be handled bare-handed. Conus geographus and C. striatus have been responsible for a number of human fatalities after careless handling by their collectors.

Other species of cones feed on other marine snails, other cones, and even octopods; these include Conus textile, C. dalli, C. marmoratus, and C. penncinesus. Like all cones these too should be considered dangerous to man and preferably handled only with a net.

But most of the 350-400 cone species are verminous, or worm-eaters. These range in size from the tiny one-inch California Cone, Conus californicus, to the mammoth seven-inch leopard cone, Conus leopardus. The only problem in trying to keep these species alive is finding their food prey. Marine worms are rarely available in pet shops. Some fishing stores carrying live bait may have polychaetes that could be used for feeding verminous cones.

Less selective in their feeding habits, murex snails are occasionally available on the market. In the wild many seem to feed on bivalves, such as clams, other snails, and barnacles, but in captivity they seem to accept a variety of food items, such as pieces of fish, shrimp, or clam meat. Like cone snails, the carnivorous murex possesses a specialized radula tooth, not for stinging but for drilling. After finding its prey a murex will begin to bore a cylindrical hole through the shell with the aid of a secretion which helps dissolve the shell. The resulting hole enables the murex to insert its mouth parts through the shell to feed on the contained flesh. Some murex snails, however, simply use their powerful foot muscles to pry open the valves of the prey.

One group of the molluscs occasionally in demand are cowries. They are popular among some aquarists because of the brilliant gloss and bright colors of the shells. They are considered the jewels of marine molluscs. Since the feeding habits of many cowries have been documented they can adapt well to a community tank. Malacologists agree cowries are both herbivorous and carnivorous. Although some feed on selected prey items, such as sponges or colonial anemones, most will feed on small pieces of fish, graze algae on the aquarium glass, or scavenge dead material on the substrate. One requirement needed to keep cowries healthy is well-oxygenated water. Given the proper living conditions, some species, such as Annette’s cowrie, Cypraea annetiae, will live for three or four years.

A number of gastropods often seen for sale have no business in the aquarium trade, yet they are collected in large numbers only to starve to death in captivity. These are the colorful shell-less nudibranchs, or sea-slugs. Spectacular in color, they are to molluscs what orchids are to flowering plants. Although the diet of most species is unknown, based on the food preferences of those species studied, nudibranchs are quite specific in their food prey selection. A large number of species prey on soft corals, or colonial anemones, and are species specific, feeding on only one particular species. Even knowing a nudibranch feeds on soft coral is not enough since a specific species of soft coral is required. Finding the right species is almost impossible unless the original collector has witnessed the nudibranch feeding on a particular prey item.

Such close dependence upon a single prey species makes nudibranchs poor candidates for the aquarium. Without the proper food they simply diminish in size until they starve to death within two to four weeks.

Spanish shawl sea slug (Flabellina iodinea) does not survive well in the aquarium due to its specialized diet and should not be sold in the trade. W. Mexico

With the ever growing popularity of miniature reef systems some marine animals, such as the giant clams, can now be successfully maintained in living reef aquariums. Several species of giant clams, such as Tridacna gigas, T. deraisa, or the smaller T. crocea, can now thrive in such environments provided the correct lighting system is used. Like many corals and anemones, giant clams get their food primarily through a symbiotic relationship with a unicellular algae living in the clam’s tissues. Known as zooxanthellae, the algae photosynthesize in sunlight and provide the clam with energy for growth and other biological activities. Using high output lights, it is now possible to provide the photosynthetic material needed by the clam to survive.

Unfortunately, just as the interest in keeping giant clams developed, their availability declined. Because of poaching and harvesting of giant clams for food, at least two species are now threatened and the importation of all six species to the U.S. has been severely restricted. Most of the tridacnids offered on the market today are the product of mariculture projects aimed at restoring dwindling giant clam populations on depleted reefs. Through these restoration efforts, some cultured clams are occasionally imported to the U.S.

Perhaps the best known and most popular molluscs for aquaria are the octopods. Believed to be the most intelligent of all invertebrates they are occasionally called “primates of the sea.” Octopods are among the easiest of all molluscs to keep in the home aquarium because most are opportunistic predators. They will readily accept pieces of fish, shrimp, and other similar food items. The only drawback in keeping octopods is their short life-span, most living only a few months and rarely over a year. Therefore, when buying an octopus it is almost impossible to tell how old the individual is and how long it will live. Still, the element of chance when purchasing an octopus is outweighed by the knowledge this unique animal will be a fascinating addition to the community aquarium. One word of caution, however; some species will bite if handled carelessly, and a few species are extremely venomous. For example, the blue ring octopus, Hapalochlaena maculata, is occasionally imported into the Philippines and should be treated with respect. Although this beautiful species is small and is not prone to bite unless abused, its venom can kill an adult human in minutes. Perhaps it would be more prudent not to purchase any of the three known blue-ring species.

Related to the octopus, the nautilus is a unique animal not often seen in the home aquarium since they are seldom available to marine hobbyists. This is unfortunate since it is easy to maintain, with relatively little care. Although they do best in cool water, they will still thrive in temperatures of 70-78°F. In the wild they are both carnivorous and scavengers, feeding on slow crustaceans like hermit crabs, and molluscs. Each exoskeletons of spiny lobsters, slipper lobsters, or crabs. However, in captivity they will readily accept pieces of fish, shrimps, and other seafood.

With today’s sophisticated marine life support systems, keeping marine invertebrates healthy for extended lengths of time is now possible, provided their food requirements are known. Unlike many invertebrates, such as numerous anemones and corals which demand special care, molluscs are relatively easy to maintain (except giant clams) even in the simplest aquarium system. Since relatively little is known about the natural history of molluscs, marine aquarists can contribute considerably to our knowledge of this unique and remarkable group.
Reef Invertebrate Feeding

(Continued from page 1)

cumultitude of fauna in the live rock and the controlled growth of algae in the tank providing most of the fishes' nourishment, this feeding does not have to be large, and some of this food does get to the invertebrates.

From a quantitative standpoint, I have found that by preparing the redox potential (as an indication of how different treatments affect a reef tank. (Note: a lowering of the redox potential is generally indicative of a lowering of the water quality). I have found that feeding with most frozen preparations lowers the redox potential by 30-50 millivolts for a 2-4 hour period, and this has been replicated by Thiel (1988). When I have added bottled invertebrate formulations as per manufacturer's directions (which for my 135 gallon tank meant from 6-19 milliliters of food), the redox potential then dropped by 60-120 millivolts for as long as 7 hours before returning to its normal average of 435 millivolts. In addition, the response of some invertebrates (Sarcophyton, Anthelia, Xenia, Gonipora, among others) was to retract from the cloud of food, which generally indicative of an aversive stimulus. This coupled with the redox changes, has led me to believe that these invertebrate foods are not providing proper nourishment for these invertebrates.

Vitamins and trace element supplements have for me also produced negative effects. They do not lower redox to the same degree as the foods or cause retraction of the invertebrates. However, their effect may be just as deleterious in that they cannot effectively increase the growth of algae, which may subsequently die off once the nutrients are exhausted and foul the tank, or the bloom can be so great that the algae overgrow the rocks and invertebrates. This effect can be very frustrating in that the algae covers everything and eventually out-compete the tank's inhabitants for light and nutrients, and can also produce wide fluctuations in pH from night to day. None of these conditions is conducive to a successful miniature reef.

There is, however, some evidence that certain compounds can be deleterious and should be replaced. These include iodine, calcium, and strontium. In replacing these substances, it would be better to replace these specific compounds or make water exchanges, rather than to use the shotgun approach to supplement everything, whether it's depleted or not.

As I stated above, it is my opinion that invertebrate foods and trace element compounds do not need to be used in a properly functioning mini reef. In addition, I have viewed several very successful reef tanks and the common theme in each of these tanks was intense fluorescent lighting, proper filtration, strong water movement, and no excess in nutrients from either food or supplements. The most outstanding of these tanks belonged to John Burleson, Julian Sprung, and Roger Bull. Recently, two articles reported on successful miniature reef aquaria where no invertebrate foods or trace element supplements were used, and they did not encounter problems with dinoflagellates or algae (Jeffries, 1990; Montgomery, 1989). I realize some hobbyists are probably having success using these supplements, and I'm glad they are; however, for those people who are having difficulties while using invertebrate supplements, this alternate approach may lead to greater success.

In a miniature reef, nothing good ever happens fast, only bad things happen fast. Keep this in mind the next time you add something in search of a quick fix for your invertebrate aquarium.

Supplying the Marine Aquarist

Over the past 30 years, the marine aquarium hobby has seen dramatic growth in size, diversity, and technology. Dramatically colored fishes and invertebrates from all over the world have become readily available along with equipment specially designed to provide optimal conditions for these animals. With this growth has come the question of what effect continued collection of marine specimens will have on the delicate reef environments where most of the organisms are found. Marine hobbyists are sometimes made to feel guilty by elements in some of the environmental groups for the reported "raping of the reefs". Although there have been some instances of abuse due to cyanide collection, over-harvesting, and habitat destruction, in most areas the marine aquarium industry has played only a small part in the environmental degradation of the reefs. Other factors such as pollution and siltation due to over-population, dynamiting and other destructive food fishing methods, and coral collection for construction and curios have had far more serious consequences.

Actually, the reef conservation goals of many of the environmental groups are being embraced by responsible members of the marine aquarium industry as well. We must not lose sight of the fact that the growth in interest in public aquaria and the marine aquarium hobby significantly increase public awareness of reef ecology. Further, the technologies developed by marine aquarists constitute a major contribution to the scientific understanding of marine systems. Species that were virtually impossible to keep alive just 10 years ago are now routinely being cultured. New species are being spawned and bred. In short, the scientific understanding of marine tropical reef organisms has dramatically increased as a result of the efforts of marine aquarists.

Still, our industry from collector to wholesaler to dealer to hobbyist must behave responsibly if we want to continue. Certain environmental and animal rights groups would prefer to see the collection and keeping of marine organisms stopped or severely limited. We do not want to let this happen as in Germany where importation of Butterflyfish and Angelfishes was banned. The only way to defend our hobby is to eliminate the abuses and manage the collection and care of specimens professionally as a renewable fishery so that the supplies will continue indefinitely.

A number of these issues were covered in a presentation by John Tullock to the Marine Aquarium Conference of North America, MACNA 2, in Cleveland this past April. Similar feelings were expressed by several of the other speakers at the conference that steps should be taken soon including:

1) Boycott the use of dead coral heads.
2) Formulate a listing of fishes and invertebrates that should not be sold in the aquarium trade.
3) Improve fishery management techniques so that over-exploitation will be avoided.
4) Work to improve the education of everyone in the industry from collector to hobbyist, to eliminate unnecessary losses due to improper handling procedures.

Work has already started on some of these goals. In Florida, the Florida Marine Life Association has begun to work with the Department of Natural Resources to develop reasonable regulations to protect fish. Collectors are now beginning to report all fish collected so that data will be available to evaluate changes in the fishery.

There have been discussions of dealer training certification courses for aquarium shops to assure at least a minimal understanding of aquariology. Regarding species that are unsuitable, a voluntary listing of unsuitable fishes needs to be developed and circulated so that hobbyists, shop owners, and importers can all be aware of which fishes and invertebrates to avoid. Several criteria for this can exist:

1) Endangered or threatened species
2) Dangerous organisms
3) Animals that do not survive in captivity due to dietary or other limitations

Reef building corals fill the first group. For category 2, stone fish, certain cone shells, and Blue Ring octopus come to mind. For number 3, butterflyfishes and nudibranchs that feed on coral polyps are obvious choices along with the Parrotfish and batfish. Often these species are sold to unsuspecting dealers and hobbyists even though they have very little chance of surviving.

Comments and suggestions from interested aquarists on developing a register of unsuitable aquarium species, as well as input on the other conservation suggestions are welcome.
Eliminating Problem Algae

By: Michael Paletta

One of the most frequently encountered problems in successfully maintaining a miniature reef is that of algal overgrowth. This problem occurs in virtually all reef tanks to some degree and may manifest itself from mild cases of golden diatom growth on the front glass to complete overgrowth of the live rock and invertebrates with filamentous algae.

There is, however, an assortment of remedies for reducing an algal problem including chemical, physical, and biological methods, with various costs and benefits for each.

The problem of algae blooms can occur with any type of algae whether it be macroalgae or microalgae, although microalgae problems are generally what is meant when algae overgrowth is discussed. All algae share one common property and that is that they function solely to produce more algae. By their very structure they cause an accumulation of detritus and its concomitant nutrients at their bases and under their runners. It is my opinion that a tank is healthier and has fewer problems when all algae (other than coralline and calcareous) are eliminated. This is because a large population of macroalgae (i.e., Caulerpa) has the potential to cause fluctuations in pH and also accumulate detritus along and under its runners and holdfasts. In addition, a tank is much more natural looking (i.e., more like what occurs on a natural reef) when macroalgae growth is kept to a minimum. Macroalgae, however, can be maintained in a separate tank or algae filter if one wishes to keep them for their potential nitrate lowering properties.

Before algae problems can be effectively eliminated or reduced, their causes must be determined. In addition, these causes must be dealt with in a manner that does not harm the zooxanthellae present in the mini-reef's corals and other desired inhabitants. In general, this rules out chemical algicides. The most common cause of algae blooms in a mini-reef is excessive nutrients within the system. This situation begins with the introduction of live rock, which is full of nutrients, and progresses continuously as more specimens, food, and sometimes unnecessary supplements are added to the tank. The essential set-up of a miniature reef system, a conscious effort should be made to reduce the amount of free nutrients present.

The three main nutrients considered to be the culprits in stimulating algae blooms are phosphate, nitrate, and silicic acid. Phosphate and nitrate are present in many substances added to... (continued on page 3)

Jewelled top shell snail (Calliostoma annulatum) among a bed of anemones.

The Temperate Reef Aquarium

By: David Wrobel

Monterey Bay Aquarium

Living reef aquariums, with flourishing corals and gardens of algae, have spawned a tremendous advance in the techniques and design of aquarium systems. With the increasing popularity of invertebrate aquariums has come the realization that certain coral reef species may be endangered from various human activities. As a result, collection and selling of many corals, anemones, and live rock are becoming increasingly regulated. The aquarist interested in establishing a tropical living reef aquarium faces an increasing cost and greater difficulty in obtaining many invertebrates.

One potential means to ease the strain on tropical coral reefs exists right at our doorstep. The temperate coastal waters of California, Oregon, and Washington teem with an astonishing array of fishes, invertebrates, and algae. Most people are only dimly aware that the cold, often murky water harbors rich communities of life. Many of these attractive fishes and invertebrates survive quite well in the home aquarium. You can discard the notion that bright colors are solely the domain of tropical species—many temperate animals (invertebrates in particular) are endowed with a palette of flashy hues that rivals anything their tropical counterparts can muster. Advances in aquarium systems now make it possible to bring a piece of the beautiful reef into your home.

The bias for flashy tropical fish has made it very difficult for all but a hardy band of self-collectors to obtain temperate animals. Attempts are now being made to surmount this barrier, and temperate animals gathered by registered collectors should soon be available. Responsible collection practices will ensure that temperate habitats are not endangered. Collection of animals on your own must be conducted carefully to ensure that all local fish and game regulations are strictly followed. (continued on page 2)
Reef aquarium...

Advantages of Temperate Reef Aquariums

1. Most of the temperate fishes and invertebrates are remarkably hardy and easy to keep. This, of course, should not be an excuse to become lax in the maintenance of a healthy aquarium environment. Many delicate tropical animals, on the other hand, have specialized requirements that render them difficult to maintain in an aquarium.

2. Expensive lighting systems are unnecessary since light-demanding corals are absent from temperate communities. For most fishes and invertebrates, a simple fluorescent unit for illumination is all that is needed. This also reduces the growth of fouling algae.

3. Temperate fishes are generally free of the disease and parasite problems that plague tropical species. Quarantine of all new arrivals is advisable, however, since monogenetic trematodes (flukes) and parasitic copepods may occasionally appear.

4. Use of the vast temperate habitat resources will help to relieve some of the collection pressure on tropical coral reef environments.

5. It is possible to construct an aquarium habitat that more closely matches the natural assemblage of species. With tropical reef systems, it is more difficult to trace the origins of the different fishes and invertebrates.

Requirements for a Temperate Reef Aquarium

Biological Filter: A well established biological filter is essential for good water quality and the maintenance of fish and invertebrate health and vitality. The traditional undergravel filter can function quite admirably as the backbone of the temperate system. The recent proliferation of trickle filters enables even more effective waste control. A trickle filter system does not eliminate the need for care in adding animals, as overcrowding and decaying material can still stress the system beyond its capacity. Water changes on a schedule of about 5% per week are also an important part of the maintenance scheme regardless of the type of filtration.

Accessory Filtration Methods: In addition to the biological filter, secondary modes of filtration can come into play that will enhance your chances of success. Mechanical filters are a useful way to collect detritus before it is converted to ammonia. The prefilter of a trickle filter system or a canister filter can serve this function. Canister filters are also useful for combating high organic compound loads when used with activated carbon. Foam fractionators are enjoying a resurgence in popularity as an additional means to limit the build-up of harmful organics, and should be considered an essential item for top water quality.

Feeding Temperate Fishes and Invertebrates

Temperate fishes pose few problems in feeding. Extreme specialists, like those of the coral reefs, are generally uncommon, and you will find that most greedily accept whatever comes their way. Chopped squid, prawn, clam, non-oily fish and other seafood, along with commercial fish foods, are all fine. Feeding habits and behaviors do vary, however, and you must have an understanding of these differences. Some fish tend to be more aggressive in grabbing food, leaving their shy cohorts without a bite. Others stay put and must have the food placed directly by their mouths. Food size is also an important consideration, as certain small-mouthed nibbles may have trouble downing large chunks. Careful observation at feeding time will allow you to sort out the various feeding patterns.

Invertebrates of the temperate reefs are often more specialized in their feeding habits than the fish are. While some actively pursue their prey, others sit and wait to grab or filter out passing plankton. Numerous grazers harvest algae or nibble on sessile invertebrates. All this variation requires a general understanding of the feeding methods of each species you wish to maintain.

Some types, particularly filter feeders like sponges and bryozoans, should be avoided since their diets are restricted to extremely tiny particles that are difficult to provide in an aquarium. Others, like anemones and crabs, present no problems in feeding and are more likely to survive for long periods of time.

Fishes and Invertebrates for the Temperate Reef Aquarium

Invertebrates dominate the scene in temperate reef aquariums, and the same can be true for temperate aquariums. Although generally not as active as fish, their often bold patterns and colors and unlimited diversity create the potential for stunning aquarium displays. As with the tropical reef aquariums, anemones and their relatives are the primary focus. Brilliant pink and red colonial strawberry anemones are the shining stars, forming spectacular crimson carpets. Giant green and red spotted anemones add to the show. A dazzling variety of colorful sea stars provides mobile splashes of red, blue, and violet. Numerous crabs, snails, urchins, and a host of other invertebrates contribute to the miniature community.

Fish are not to be left out of the menagerie. Although not as brightly colored as their tropical brethren, they nonetheless are well endowed with their own beauty. Interesting bottom dwellers, like sculpins, gobies, keelfish, fringeheads, and stickback scrawls scurry about as they dart in and out of crevices. A wide variety of surfperch, rockfish, and other active swimmers completes the display. Together the diversity of fish, invertebrates, and algae creates a spectacular mini-habitat that will provide endless hours of fascination.

The Catalina goby (Lythrypnus dalli) prefers the cooler temperate aquarium.
Problem algae...

(continued from page 1)

The largest contributor to high orthophosphate and nitrate levels is overfeeding. Therefore, the first step in reducing phosphate and nitrate levels is to reduce feeding. Since most of the inhabitants within a mini-reef are photosynthetic, it is not necessary to constantly feed these creatures as they are capable of supplying most of their own nutritional needs.

The second largest source of phosphate and nitrate is make-up water. The two most common methods of treating this water are deionization and reverse osmosis. Both are considered effective; however, reverse osmosis may not reduce bicarbonate which has been implicated in golden damo blooms (Thiel, 1988). Therefore, deionization may be the most effective process for removing excessive nutrients from make-up water when the aim is elimination of microalgae. These steps, however, are only the preliminary methods for reducing microalgae. The next big source of nutrients for microalgae overgrowth is detritus buildup within the tank. Detritus acts as a reservoir for phosphate and nitrate in that detectable amounts of these nutrients have been shown to be released from detritus over time (Meadows, 1986). This condition can easily be controlled by frequently siphoning off detritus before it can be broken down and released nutrients into the aquarium. For this same reason, the pre-filter should also be changed frequently in order to minimize nutrient release from trapped wastes.

In addition to reducing algal growth chemically, it is also possible to control it biologically. Recently several herbivorous mollusks have been touted as being excellent at removing microalgae. I have used two different types (Turbo snails and Astrea snails) for the past year, and I have found them both to be excellent at controlling algae with some small shortcomings. The Turbo snails significantly reduced levels of encrusting microalgae and the remnants of hand-pulled hair algae (Derbesia), but they did not eat golden domatome or the brillo-like hair algae (Cladophora). The Astrea snails ate all of the forms of microalgae, including those not eaten by the Turbo grazers. Unfortunately, these snails are much smaller than the Turbo grazers so more of them are needed to reduce the same effect. Therefore, I recommend that a combination of both of these snails be utilized to reduce algae. In addition, Tangs have also been found to be effective at reducing some forms of microalgae, particularly filamentous algae which may be projected by the snails. All of these animals effectively consume algae and after digestion excrete the algae’s remains in pellet form which is full of partially metabolized nutrients. Therefore, it is very important to remove these pellets before they can release these nutrients into the water and begin the cycle gain.

The methods mentioned above should be used from the start-up phase of a mini-reef in order to minimize the likelihood of algae overgrowth. They can also be utilized once a problem has developed in this case some additional measures need to be employed.

First, remove as much of the microalgae as possible, either by physically pulling it out, scraping it, or brushing it off. After this is done, a water change should be undertaken utilizing nutrient-free water. That is, both the make-up water and the salt used should have no detectable amount of nitrate or phosphate in them. If the algae continue to overgrow, then other steps are needed. More frequent siphoning of detritus and pre-filter changes need to be undertaken, and the bioload may need to be reduced. Also, it has been my experience that algae overgrowth is worse during the summer. This may be due to the higher temperature increasing the metabolism of the tank’s inhabitants; consequently more nutrients are released into the water. Or with summer comes an increase in the use of agricultural fertilizers that get into the water supply and contribute to high nutrient levels. In either case, the steps and procedures outlined above should help to reduce the likelihood of an algal bloom.

These methods will not only help to reduce the available nutrients, but they will also help to raise the redox potential, limiting the types of microalgae that can grow. By limiting algal growth through reducing available nutrients the conditions of the reef are more closely replicated. Consequently, corals and other reef inhabitants will have a greater opportunity to thrive.

(Editor’s Note: A copy of references cited in this issue may be obtained by sending a self-addressed, stamped envelope to: SeaScope Fall 89, Aquarium Systems, Inc., 8141 Tyler Blvd., Mentor, OH 44060.)
Spawning Behavior of the Decorated Firefish (Nemateleotris decora)

By: Guenter Schiller

My interest in trying to spawn the firefish began in the mid seventies with the common Firefish (Nemateleotris magnifica), (Fish Views and News, January 1977, Desert Aquarist Society). At that time it was my belief that the heavier bodied firefish was the male and the more slender bodied one the female. I tried different size fish combinations, tank sizes, and decorations. Within time, the weaker fish were always picked on or harassed by the stronger ones. With no apparent sign of pairing off or other indications that things would settle down, sooner or later the net would have to come to the rescue.

It appears that the Decorated or Purple Firefish (N. decora) are more peaceful towards each other than N. magnifica. The Decorated Firefish is wide ranging in the tropical Pacific Ocean and Great Barrier Reef regions. In general, they are quite hardy and ready feeders, with most commercially available food being accepted. Feeding is usually in mid-water, seldom from the top or bottom of the aquarium. In the aquarium, N. magnifica and N. decora basically stay stationary and on the lookout for small food particles. When frightened, they can be fast swimmers and retreat to little nooks and crannies or go straight up. For this reason an aquarium lid is a must. If there is none, sooner or later one may find his prize possession on the floor. The pair of N. decora that I have have been obtained at a local retailer (the male heavier bodied and the female slender bodied) in May of 1988 with a size of 2 inches standard length (female slightly smaller). Their home is a 40 gallon aquarium, 36x18x18 inches. Aquarium decorations are basically reef rock and small pieces of dead coral for hiding and sleeping quarters. Tankmates include a small Flagfin angel (Apolemichthys trimaculatus); a Sailfin Dottyback (Pseudochromis celferus); a pair of Mandarin fish (Pterophysetris splendidas); a species I was able to spawn in the early eighties; and eight species of live coral. At one time an Ornate Angelfish (Genicanthus bellus) was introduced. Although the angelfish showed no aggression toward either male or female firefish, the female firefish hid. After one week the G. bellus was removed and everything returned to normal.

Aquarium parameters were: temperature 78.3°C to 78.6°F, salinity 30ppt (1.0225G), ammonia and nitrite - 0ppm, nitrate - 5ppm, pH 8.3, and alkalinity - 3.6 meq/l (8.4 DKH). Filtration was by conventional undergravel filter and a 4 section trickle filter including skimmer box with prefilter, floss and small dead coral pieces, protein skimmer, and approximately 1 cubic foot of bio-pack. Water motion was provided by two power heads connected to a solid-state timer to provide the alternate water motion that is extremely beneficial for live coral. Water changes of 20% were made every 3 weeks with a high quality salt, mixed in distilled water. No magic lotions or potions were added to the water. Lighting devices varied over time including Grow-Lux, Actinic, uncoated black light, etc. The lights were on from 9:00 AM to 8:00 PM daily, controlled by a timer.

With the basics covered, let's take a look at some observations on the behavior of N. decora. Spawning took place 3 times, from the beginning of October, 1988, through late November, 1988.

Sexual differences: The male was larger and more full bodied compared to the female. Body color, pattern, and size of dorsal spine appeared to be the same in male and female.

Behavior: Several days prior to spawning, the male exhibited aggressive tendencies towards other tankmates and started to court the female by positioning himself crosswise in front of her and quivering his pectoral, dorsal, anal, and caudal fins. With a small intensification of color in the male, this type of behavior increased in frequency and duration.

Spawning site: The spawning site was prepared by the male and female late in the evenings, several hours after the lights were turned off, by preparing a depression in the substrate. This particular pair chose the corner of the aquarium. Pieces of gravel were carried from the depression in jawfish fashion. The depression was tried on for size and fit by the female. This site was used for all three spawns, with some cleaning and removal of gravel prior to spawning.

Spawning: Prior to spawning, usually one hour before the lights were turned off, the vent tube on the female became visible. The vent tube was surprisingly long compared to other fish which I had spawned. In the case of N. decora, it was 3-4mm. The stomach before the vent tube took on a large and deep distension which reached to mid-body, causing the female to look almost deformed. After the lights were off, instead of scurrying toward their hiding places for the night, both male and female stayed in the open water close to the spawning site. Spawning took place between midnight and 2:00 a.m. with the female lying in the depression. The male positioned his mid-body next to the female. The female deposited all the eggs at one time, which were about the size of Amphiprion eggs and the male fertilized them. The eggs were transparent and adhesive. No parental care could be observed after spawning, even in the morning when the rest of the tankmates devoured the eggs.

No effort was made to save or raise the eggs since the aquarium was basically an experimental aquarium, and food cultures were not available. No courtship or spawning activities have been observed since the last spawning in late November. At this time, I do not know if spawning takes place only during a certain time of year or this is only a lull in activity.

In summary: Spawning and breeding mark fish can be a frustrating, difficult, time consuming, and expensive project for the marine hobbyist, but it is well worth the effort, even if it is just for the satisfaction of accomplishing it. It is best to obtain a pair that has been sexed, either by color pattern or by size. When asking a retailer for a mated pair of a certain species, one may get funny looks and comments in return, but it is well worth the ridicule to do something out of the mainstream. My next project will be the angelfish of the genus Genicanthus. I especially want to work with G. bellus, if I can obtain the male from the Cocos-Keeling Islands, or G. watamabeli. If anyone is interested in spawning these fish or has any information about them, let me know. It is only through trial and error and sharing of information that this part of the hobby can be revved up.

The Decorated firefish (Nemateleotris decora), a popular fish for reef aquarists.

SeaScope was created to present short, informative articles of interest to marine aquarists. Topics may include water chemistry, nutrition, mariculture, system design, ecology, behavior, and fish health. Article contributions are welcomed. They should deal with pertinent marine aquarium topics and are subject to editorial reviews that in our opinion are necessary. Payment will be made at existing rates and will cover all author's rights to the material submitted.

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