Marine Aquarium Hobbyist Day Highlights Responsible Aquarium Keeping

By Sylvia Spalding, Marine Aquarium Council

More than 500 marine aquarium enthusiasts opted to attend the first Marine Aquarium Hobbyist Day at the Aquarium of the Pacific despite a conflict with Super Bowl Sunday celebrations. The Jan. 26th event at Long Beach, Calif., focused on responsible aquarium keeping. It attracted hobbyists and retailers from as far away as Arizona—a eight-hour drive.

Julian Sprung delivered the keynote address, "A Responsible Marine Aquarium Hobby: From Sea to Your Home," to a standing room only crowd. Sprung is the co-author of the popular book The Reef Aquarium, Volumes I and II.

"When properly handled, delicate marine creatures have better survival chances in captivity, and the proper handling of living creatures is both ethical and consistent with aquarists' concern for their welfare," Sprung noted. Sprung's presence was made possible through a sponsorship by Marineland, manufacturer of aquarium filtration systems and accessories.

The event was co-hosted by the Aquarium and the Marine Aquarium Council (MAC), an international not-for-profit organization dedicated to protecting coral reefs by setting standards and certification for the global trade in marine aquarium organisms. MAC Certified exporters, importers and retailers are authorized to carry marine aquarium organisms labeled as MAC Certified, a sign to buyers that they have been harvested in a responsible, environmentally friendly manner and handled properly to ensure their good health.

Marine aquarium enthusiasts were treated to free admission to the Aquarium, a series of presentations on responsible aquarium keeping and a dozen informational exhibits. The talks ranged from "What to Look for in a Good Local Fish Store," by Rick Preuss, owner of MAC Certified Preuss Animal House, Haslett, Mich., to "Saving Reefs with the Marine Aquarium Trade," by Gregor Hodgson, Ph.D., founder of Reef Check, an international network that tracks the global status of reefs.

"Marine aquarium hobbyists and public aquarists are both concerned about the sustainability of marine ornamentals and the coral reefs they come from," notes MAC Executive Director Paul Holthus. "Events like these help Continued on page 4
Nitrate in Marine Aquarium Systems

Continued from page 1

About Testing Methods/Units of Measure

A brief mention that there are two common ways of expressing the nitrate concentration: one is as the nitrate ion itself (NO₃⁻) and the second is nitrate as nitrogen (NO₃-N). Due to the latter’s consideration of the three oxygen atoms atomic weight per molecule, measuring the nitrate ion by itself results in value 4.4 times as much as nitrate-nitrogen. However, it’s like measuring in inches or centimeters: both give the right answer, just in different units. Do check your test kit so when comparing your values with others or recommendations in book you are comparing apples to apples, so to speak.

Importance

Most fish groups are remarkably tolerant of practical concentrations of nitrate (30-40 ppm nitrate-nitrogen (NO₃-N)). A few tens of ppm in their water, changes in same over days time is not life-threatening or stressful compared with fluctuations of temperature, varying light/dark cycles, measurable ammonia or nitrite or hobbyist hands coming into their space, for instance. For fish-only or FOWLR (fish only with live rock) systems, nitrate by itself is rarely a worry.

Some invertebrate groups are notably touchy to too much or sudden increases of nitrate in their water. Fifteen to twenty ppm NO₃-N are upper limits for most non-vertebrate marine livestock. Many corals are reported to touchy to too much or sudden increases of nitrate in their water, changes in same over days time is not life-threatening or stressful compared with fluctuations of temperature, varying light/dark cycles, measurable ammonia or nitrite or hobbyist hands coming into their space, for instance. For fish-only or FOWLR (fish only with live rock) systems, nitrate by itself is rarely a worry.

Methods of Control

Ammonia is the main excretory product of fishes and invertebrates. And toxic to them at sufficient concentration. It must be dealt with. The easiest, simplest, surest, most fail-safe method is through biological conversion. Hence, the great hub-bub regarding “cycling” (establishment of beneficial microbial populations) in new captive systems and the protection of said bacteria… Ammonia becoming nitrate is a good thing.

But there are techniques, gear, and approaches that can be employed for reducing and removing nitrate, or even preventing some nitrate production.

Prevention

Feeds, Feeding and Livestock Loads

Too much nitrate is the result of too much food input, simply put “you’re feeding too much” and your maintenance routine can’t keep up with the nitrate production. One easy approach for limiting nitrate is to simply stock and feed your system lightly, particularly with foods of high protein content.

Some supplements and sea salt-mixes

have an appreciable amount of nitrate in them. Read labels and if in doubt test these products by diluting with pure water and using a test kit.

(Editors Note: Instant Ocean is nitrate-free.)

Dilution

Here comes the usual pitch for frequent partial water changes. Obviously switching out ten-twenty percent of your water with water of zero nitrate reduces the percentage of nitrate (and other metabolites) by the same amount.

Bio-mediation/Bacterial Denitrification

The so-called “reverse reaction” of nitrification: denitrification is a largely anaerobic set of reactions by microbes that serve to convert nitrate ultimately into dinitrogen. A summary of the reactions involved is:

Nitrate to Nitrite to Nitrogen

NO₃⁻ ⇔ NO₂⁻ ⇔ N₂

Note, these reactions are reductive (the reactants on the left are “gaining electrons”) which is this case are supplied by H⁺ (protons) thus the pH is elevated. (Editor’s note: in improperly run denitrifying systems the nitrate can be reduced to ammonia, a process called dissimilatory nitrate reduction).

Live rock, sand use

NNR: Natural nitrate reduction systems include such propositions as Plenums (Jaubert et al.), DSBs (Deep Sand Beds), and various contraptions that are anaerobic to hypoxic containers (boxes, coils, trays) for culturing and feeding denitrifying microbes. All makes and models of the latter have proven fickle. It is tricky to slowly drip system water into the filters and provide “bacterial feeder media” (typically sugars, alcohols, even sulfur). Plenums and DSBs can be great expedients to reducing nitrate accumulation, but are often difficult to manage/manipulate when employed in the main/display system. Aquarists are encouraged to build these in separate sump/refugium where their utilization will not disrupt the principal tank they service.

ASD: Autotrophic sulfur denitrification, a type of anaerobic denitrator utilizing elemental sulfur as a chemical feed source for reducing nitrate has been advanced and used in places. The reaction series (4N O₃⁻ + 35 = 2N₂ + 350 e⁻) involved is acidic, can be best tied-in with melting down a source of carbonate, does result in excess sulfate, but these don’t appear to be problematical (natural seawater contains about 2,700 ppm of sulfate).

Skimming/Foam Fractionation

Agressive foam fractionation, also known as protein skimming, removes much organic matter before it is converted to nitrate. I’ve stated this a bazillion times: almost all marine systems should utilize skimming, even if only on a punctuated time basis.

Chemical Filtration

Entails many possible areas for discussion. Of most practical importance is that while there are “nitrate chemical filter materials” sold in the hobby/trade; they don’t work in many sets of circumstances, and never directly. There is no practical chemical means of removing nitrate from aquarium systems.

Biological Uptake/Export

In the early days of reefkeeping, mid- to late-1980’s, vigorous algal growth was touted as the sure-fire means of reducing nitrate accumulation. In actuality, a good deal of nitrate can be taken up by many groups of algae, microbes and other photosynthetic life forms. With regular harvesting considerable nitrate can be exported from a system.

Other Methods

These are numerous and, for the most part, unrealistic or otherwise impractical for aquarium
Protein Skimmers

by Dr. Timothy A. Hovanec

Many people involved in the marine aquarium hobby seem to think that protein skimmers are relatively new devices (i.e., developed in the last 10 years). Actually, protein skimmers have been in the hobby for at least 40 years in the United States and longer in some European countries.

What follows are some basic questions and answers about skimmers to provide a better understanding of their nature and function.

What Is A Protein Skimmer?

A protein skimmer is a device that concentrates and removes dissolved material from aquarium water using air bubbles. In general, a skimmer consists of a tube (the contact column) for the concentration and mixing of bubbles and water, an aeration device, a water inlet and outlet, and a collection cup. Some units may add additional features but the basic design is the same.

The name “protein skimmer” is essentially misleading. These devices do not skim the water surface and they remove more than just protein. A more appropriate name for a protein skimmer is “foam fractionator,” due to the fact that the bubble concentrations (foam) serve to separate (fractionate) dissolved material from the water. Most of this material, termed DOC (Dissolved Organic Carbon), is produced by the biodegrading activity of certain bacteria, but some is released by algae and other organisms. Because the DOC is dissolved in the water, DOC cannot be removed by mechanical filtration methods.

Why A Protein Skimmer?

The accumulation of DOC in an aquarium can, among other things, inhibit the nitrifying bacteria and increase the biochemical oxygen demand (a way of measuring water pollution), thus lowering water quality. Preventing this from occurring is, therefore, a worthwhile goal.

How Does A Skimmer Work?

Two keys to effective foam fractionating are air bubbles and surfactants. DOC are surfactants—compounds whose surface is defined as “active.” This means that when a surfactant compound is in water, its non-polar end, labeled hydrophobic or “water hating,” seeks the surface, or the air.

Normally, the only “air surface” in the aquarium is the surface of the water. However, if bubbles are added to the water, more air surface is created. More air surface means more surfactants (DOC) are attracted and removed. Smaller bubbles have more surface area than larger ones. Also, the longer the bubble stays in the water, the longer its contact time with the surfactant. Bubble size and contact time determine how effective and how fast a skimmer will work.

Protein skimmers take advantage of these physical properties by producing a large amount of bubbles in a controlled space—the contact column. This serves to concentrate the bubbles and the DOC. As the bubbles in the column rise, the DOC attach to the surface of the bubble so that the hydrophobic end is “inside” and in contact with the air. The bubble carries the DOC to the water surface, where the bubble bursts to form foam. The air-preferring DOC stay at the surface rather than re-dissolve into the water. This process is repeated tens of thousands of times a minute and a large amount of foam can be generated. The foam grows over time, is collected in a cup and is removed at regular intervals. While there is considerably more physics involved than mentioned here, this is the basic operative mechanism involved in protein skimming.

What Kinds Of Protein Skimmers Are There?

The difference between brands of skimmers is most evident in the ways they move water and generate bubbles. There are two basic types of protein skimmer: co-current and countercurrent. Current pertains to water flow, while “co-“ or “counter-“ indicate whether the air is moving with or against the water current, respectively. Other skimmers employ a venturi air injection system instead of an airstone to produce bubbles without an air pump. These skimmers pump water through an injector using a water pump or powerhead. The injector has a narrowed pathway in its center and an additional opening that admits air into the unit.

Differential pressure is generated at the other end of the restriction which causes air to be sucked into the water stream. Venturi operated skimmers can be very effective and tend to be smaller than other skimmers—a positive consideration in areas of limited dimensions.

Who Needs A Protein Skimmer?

In most cases, every saltwater aquarium would benefit from the addition of a protein skimmer. But any aquarium with high levels of pollution is a sure candidate for a skimmer.

What Are The Location Requirements?

The most simple skimmers, although not that common anymore, fit inside the aquarium, hanging from the top lip of the tank. An airstone placed at the bottom of the column produces the foam which is collected at the top. This type has no water pump, no hoses. A more common version hangs on the outside back of the aquarium. Water is pumped into the unit, either co- or countercurrent, and returns to the tank via a spillway at the top. Perhaps the most commonly used type of skimmers sit in sump under the tank. Exit water is diverted into the sump, where it is pumped back up to the aquarium. No particular placement is superior to another. Selection is usually a matter of individual space and budget restraints.

Will I Still Need Activated Carbon?

The primary benefit of activated carbon is the removal of organics. Since this is also the function of the foam fractionator, does the hobbyist really need both? The answer is yes. Studies show that foam fractionation does not remove all types of organics; nor will it remove 100% of any one of them. The same can be said of carbon. The two filtration devices effectively complement each other.

How Long Should I Run The Skimmer?

Twenty four hours a day. There will be some periods of the day when the skimmer will produce more foam than others, but that is natural.

Is It Possible To Over Skim?

No. While some may disagree with this, no studies have shown a deleterious effect from over skimming.

What Maintenance Is Required?

To retain its effectiveness, a protein skimmer must be clean to allow the bubbles to form at the top and flow into the collection cup. A greenish brown sludge will form on the walls of the skimmer. This should be brushed off regularly. The airstone should be replaced each month. For a venturi skimmer, the venturi should be cleaned often to prevent the build-up of calcium or other deposits.

Is Ozone Required With My Skimmer?

It is not necessary to use ozone with a protein skimmer. While ozone can be beneficial, it is dangerous to the aquarium inhabitants and, therefore, should be carefully considered and studied before added to any system. Foam fractionators can prove a welcome addition to many types of aquarium filtration systems. By understanding the basic operative mechanisms and functional nuances of these devices, you should be able to use them effectively and reduce the time needed to service these units.
Marine Aquarium Hobbyist Day Highlights Responsible Aquarium Keeping

Continued from page 1

them, and the public, understand how we can work together to ensure the responsible marine aquarium trade and hobby do support healthy reefs and fish, healthy fishing communities and a healthy marine ornamentals industry and hobby.”

“The Marine Aquarium Hobbyist Day attracted a variety of hobbyists and industry operators, which ran the gamut from young aquarists who had recently acquired their first saltwater tanks to seasoned retailers who have been in the business for up to 25 years,” noted MAC Communications Coordinator Sylvia Spalding. “Many of the aquarists wanted to know if there were any MAC Certified retailers in their area, and many of the retailers wanted to know how to become MAC Certified. This event to promote responsible aquarium keeping succeeded in bringing together marine aquarium enthusiasts with different experiences and a common value.”

For more on MAC Certification and a list of MAC Certified marine aquarium companies, visit the MAC website at www.aquariumcouncil.org

MACNA XV
hosted by the Louisville Marine Society
will be held Sept. 5-7, 2003.
See www.masna.org/m15
or www.imas.org for details.

Nitrates in Marine Aquarium Systems

Continued from page 2

hobbyist use. Some have involved electrical current (yes, with saltwater aquariums), ion-exchange resins for removal of nitrate from tap water (where there is generally little to start with). Folks would/will be better off utilizing an inexpensive reverse osmosis (RO) filtration rig for their personal and pet-fish use if they have appreciable nitrate in their source water. Most R.O. units remove 95% plus nitrate.

Close

Any amount of investigation into “dreaded nitrate” in hobby literature, the Net and conversations with others will reveal an enormous amount of differing opinions on the significance/significance of nitrate. Is nitrate poisoning most marine livestock? By and large, for most species of aquatic life, no. Can the routine measurement of nitrate be useful as an overall indicator of system health, trends in water quality changes, wake-up calls for altering and/or enhancing methods of overall system improvement? Sure.

With implementing some of the above methods of control, nitrate will accumulate in marine aquariums. Your role as the “creator”, and on-going manager, is to devise and impose balance between the inputs of nitrate and their removal. Ideally, you want your nitrate to be as low as possible. For delicate reef systems 10 ppm and below NO₃-N is acceptable, for invertebrate-containing marine systems up to 20 ppm NO₃-N and 40 ppm NO₂-N for fish-only systems. Just having “some” nitrate concentration present in the grand scheme of things is not a real menace to livestock health.

Bibliography:
Anderson, Frank. 1992. NTS. New tank syndrome may be on its way to oblivion. FAMA 4/92
Atz, James. 1971. Some principles and practices of water management for marine aquariums. Marine Aquarist SI.
The Purple Tang, Zebrasoma xanthurum, Functional and Gorgeous!

Bob Fenner

While at the pet-fish industry’s largest trade show in Nurnberg, Germany (the biannual InterZoo Show) recently, I was reminded of the relative interest and “worth” of currencies while viewing a very large exhibit containing most all species of Sailfin (Zebrasoma spp.) Tangs. While I was commenting to my friends regarding the beauty of the Purple Tangs on display, another fellow (from Europe) was most impressed with... the Yellow Tangs! Yes, turns out that Purple Tangs are one of the least expensive fishes in western Europe, whereas Flavescens Tangs command a big price. Despite its big price tag in the U.S., Z. xanthurum is a perennial favorite of fish-only marine to reef aquarists in the New World. It’s hardy, beautiful, generally easygoing (more on this below), and typically readily accepts all types of foods with gusto. The few downsides for this species involve a penchant for developing “environmental” and nutritional diseases like HLLE (Head and Lateral Line Erosion). With adequate provision for set-up, feeding and maintenance, these problems are easily avoided or even cured.

Distribution: Purple Tangs are endemic to the Red Sea southward to the Arabian Sea about Oman.

Size: Reported to nearly nine inches (22.9 cm) in length. Most are about half that in maximum size in captivity.

Selection: As with most species of the Tang family, Acanthuridae, Purple Tang specimens should be graded/sorted by three general criteria:

1. Index of Fitness: healthy specimens are full-bodied; in particular the head area above the eyes should not have a pinched-in appearance. There is an extended time period from collection, holding, transport to wholesale transhippers over and through stateside. This can take several days to a few weeks. If watching tangs in the wild teaches you anything, it is that they feed continuously. When deprived of grazing Surgeonfishes fade to thinness and pale color, at some point giving up on feeding altogether. Seek and pick out ones undergravel filter and recirculate it back into the aquarium.

2. Size: most species of the Tang family, Acanthuridae, Purple Tang specimens should be graded/sorted by three general criteria:

A Comparison of Coral Reef Filtration Systems: Preliminary Results

Dr. Timothy A. Hovanec

The trickle filter was first introduced to the marine aquarium hobby in the United States by a series of articles by Smit (1986). The trickle filter, a type of fixed bed biological filter, uses a stationary bed of plastic filtration media to provide a substratum for the attachment of nitrifying bacteria. There are various shapes and sizes of the filtration media but all have a few basic properties which include a high void space, so that water can easily pass over and through the media without a chance of clogging, and the media sitting above the water rather than submerged underwater.

The basic design of the trickle filter is in sharp contrast to the undergravel filter which was the most popular type of biological filter used in the marine aquarium hobby at the time the trickle filter was introduced. The undergravel filter consists of a perforated or slotted plastic plate which sits on the bottom of the aquarium. An aeration system is used to move the aquarium water through the
A Comparison of Coral Reef Filtration Systems

Continued from page 1

because it originated in the city of Berlin, Germany, and the Jaubert System, which was developed by Dr. J. M. Jaubert of the University of Nice, France.

In the last several years, the use of the trickle filter, however, has fallen out of favor among the cognoscenti of mini-reef aquariums with adequate amounts of live rock, in fact, they can be detrimental in hard coral aquaria. But to date there have been no published studies which compare the different types of filtration methods for mini-reef aquaria with long term water quality data and observations of coral health.

The goal of this test was to set-up and run the four mini-reef aquarium/filtration types for an extended period of time and determine if a) there were any significant differences in the water chemistry of the four systems, b) if the systems with dedicated biological filters (the trickle and Bio-W heel® aquaria) had higher nitrate concentrations, as some would predict, and c) if coral health and growth is different in the trickle and BioWheel® aquaria) had higher systems with dedicated biological filters (the Jaubert System, which was developed by Dr. J. M. Jaubert of the University of Nice, France.

In the last several years, the use of the trickle filter, however, has fallen out of favor among the cognoscenti of mini-reef aquariums with adequate amounts of live rock, in fact, they can be detrimental in hard coral aquaria. But to date there have been no published studies which compare the different types of filtration methods for mini-reef aquaria with long term water quality data and observations of coral health.

The goal of this test was to set-up and run the four mini-reef aquarium/filtration types for an extended period of time and determine if a) there were any significant differences in the

metal halide fixtures and two 40 watt actinic tubes. A water chilling unit was installed on each aquarium to maintain water temperature at 26.5 °C ± 1°C. All aquaria received 32 kg of cured Fiji live rock and had weekly additions of Kalkwasser except for the Jaubert style tank. The set-ups differed in the following aspects: Tank 1 (trickle filter) had an Amiracle™ trickle filter, Knop protein skimmer (Model ss100), 9 kg of crushed coral, and used activated carbon; Tank 2 (Bio-W heel®) had a Tidepool filter using a Bio-W heel®, Knop protein skimmer (Model ss100), 20 kg of crushed coral, and used activated carbon; Tank 3 (Berlin) was a Berlin style system with no dedicated biological filter, with a Knop protein skimmer (Model ss100), 20 kg of crushed coral, and used activated carbon; Tank 4 (Jaubert) was a Jaubert style system with a plenum using 50 kg of crushed coral but no protein skimmer or activated carbon. The salinity of all the aquaria was maintained at 30 ppt.

Details on the animals placed in the aquaria and methods of water chemistry determination can be found at www.marinelandleabs.com.

RESULTS:

The results for several water quality characteristics, over the first 156 days of operation of the aquaria, are presented in Figures 1-4. The ammonia-nitrogen and nitrite-nitrogen trends for the four filtration systems are presented in Figure 1. Comparisons of the nitrate-nitrogen and orthophosphate concentrations for the four filtration systems show that there were no differences among the systems for the first 100 days (Fig 2). However, at day 114 the nitrate concentrations increased in both the Berlin and Jaubert aquaria (Fig 2). The pH, alkalinity and total inorganic carbon trends are presented in Figure 3. There are no major differences between the filtration types. The Jaubert system had a slightly lower pH than the other three systems since day 100, and this same system also had slightly greater alkalinity and total inorganic carbon values (Fig 3). The differences, however, are not significant.

The greatest difference in water quality between the four filtration systems is that the Jaubert filtered aquarium had a significantly greater concentration of total organic carbon (TOC) (Fig 4). The trickle, Bio-W heel® and Berlin systems had TOC values of less than 1 mg/L-C. However, the TOC in the Jaubert system never dropped below 2 mg/L-C. The water change on day 101 resulted in a temporary drop in the TOC concentration, from 3.4 to 2.4 mg/L-C, but this was short-lived and the TOC concentration was soon back up to 3.5 mg/L-C (Fig 4).

In terms of coral health, the corals in the Jaubert system did not do well and this may be linked to the increasing TOC concentration. This was the only overt problem with coral health experienced with any of the systems. The water in the Jaubert aquarium was much more colored (a brownish-green tint) than the others and the bottom substrate was blanketed by a film of green algae. The water change on day 101 was done because the organisms in the Jaubert system did not look healthy. The other three systems did not need a water change but in an effort to treat all the systems equally they were given the same volume water change as the Jaubert system.

DISCUSSION:

While replication is needed in future tests, the results of this experiment show that mini-reef aquaria with dedicated biological filters do not exhibit higher nitrate-nitrogen concentrations when compared to other types of filtration methods. There were daily inputs of ammonia into each aquarium via the resident fish population as ammonia is the chief nitrogenous waste product of the fish. There are two possible fates for the excreted...
ammonia; 1) the ammonia could be oxidized, via bacterial nitrification, to nitrate or 2) the ammonia could be utilized by algae, including the symbiotic algae in the coral, for growth. For the first choice to be correct, denitrification must be occurring at virtually the same rate of nitrification as there is no net increase in nitrate, the end product of nitrification. While this scenario cannot be dismissed it seems unlikely that a newly set-up aquarium would be able to establish the conditions for denitrification so quickly. The most likely explanation for the low nitrate concentrations seen in the four aquaria is the ammonia produced by the fish is utilized by primary consumers which live on the live rock and are part of the coral community.

While it is beyond the scope of the present study to definitively answer the question of the fate of the ammonia produced in the aquaria, one can look for common factor(s) amongst the test aquaria in an effort to find the possible location of the ammonia consumers; be they autotrophic nitrifiers, working in close conjunction with denitrifying bacteria, or primary consumers. The common component of the four systems is the live rock. Thus, a strong correlation can be drawn between the presence of an adequate amount of live rock and the stable water chemistry exhibited in the aquaria. Live rock is the main filter device for nitrogen and phosphorus via the action of microorganisms. However, there does not seem to be a process associated with live rock to remove organic carbon from the water which is why the Jaubert system, without a nitrification. Furthermore, as previously mentioned, authors suggest that the bacteria then entered into what is called a viable-but-not-culturable (VBNC) state. This is basically a resting stage where the bacteria wait until conditions are more favorable for their multiplication.

Many questions remain such as the mode of transmission as not all coral that bleach may come in contact with an infected fireworm. Furthermore, as previously mentioned, whether the results of this study can be applied to a reef tank are unknown at this time. In any case, it is better to be safe than sorry and removing fireworms from your tank might prevent a disaster.

While the bacteria wait until conditions are more favorable for their multiplication.

References Upon Request
that have a convex appearance when viewed head-on.

2.) Behavior: this is very telling with Surgeons. Healthy Tangs are curious about their surroundings. Buy ones that are checking you and their tank out; never ones skulking in corners or otherwise “spaced-out”.

3.) Color: Purple Tangs of good health and behavioral adjustment are very purple with extremely deep yellow tail fins. Be wary of ones that lack radiance in these areas. Related to poor color and quality in general are degrees of “open pores” on this species’ head and body associated with their lateral line system. This is manifestation of HLLE, and unless you intend to nurse such animals back to health, it is best avoided by not buying them in the first place. This being stated, it has become easier and faster to do just this with improvements in water quality and nutritional quality of prepared fish foods. Good filtration and high quality feeds are exemplary in this regard.

Habitat: Purple Tangs inhabit rocky and coral-rich reef areas where they forage and can duck under cover for sleep and safety. You should provide similar habitat for your aquatic charges sense of place.

Concerning inclusion of this tang in “reef tanks”; I do suggest it. This fish will nibble away at peaky undesirable algae, as well as many filamentous forms. Purple Tangs have, however, been noted to nibble on some large polyp stony corals (notably Trachyphyllia and Catalaphyllia spp.). As is common for most marine fish, start with small ones and keep an eye on your fishes’ behavior which is always good aquarium husbandry.

### Filtration & Circulation

This should be in a word: brisk! These fishes live in high motion waters with near saturation oxygen. Surgeons eat and defecate large quantities yet are intolerant of waste. A dequate filtration coupled with frequent partial water changes are requisite.

### Inter- and Intra-specific Aggression

Purple Tangs are almost always fine tankmates as juveniles (under 3 inches/7.5cm in length). Often, growing up in under-crowded circumstances with other fishes, they grow to the same as larger adults. As is often stated as a rule of thumb, this Surgeonfish is better not stocked with similar-appearing fishes, especially other Acanthurids that occupy a similar niche; especially those in the genus Zebrasoma. Under-crowding is always the safest bet, followed by introduction of smaller individuals first. More aggressive species like Purple Tangs should be the last fish to be placed. But there is no sure-bet with stocking this species. Careful observation is a hallmark of a successful aquarist.

The acanthus or thorny spine on Tangs’ caudal peduncles is a formidable weapon, which they can and will unsheathe and use. Have no doubt, while mainly for show, Purple Tangs are capable of cutting up newcomers they consider a threat.

### Foods, Feeding Nutrition

All Tangs are herbivorous to a degree. O bserwing Purple Tangs in the wild and aquariums, and examining their stomach contents has shown that they ingest principally micro-algae, secondarily macro-algae, and that the bulk of the rest is material (associated invertebrates, fish eggs) taken incidental to these. In captivity, surgeons require regular offerings of “greens”. Vegetable flake, pellet and frozen prepared foods are to be had in pet fish stores; better and cheaper are dried and fresh algae from the Asian food sections of human food stores. The very best opportunity is to provide some live material that your tangs can nibble on at their leisure. Though others endorse their use, I am very unimpressed with the results of feeding lettuces, boiled, frozen or fricasseed to Surgeons. Be leery of relying on terrestrial plants for marine fish nutrition.

**Disease:** Purple Tangs are not as readily susceptible to the common protozoan infections of other Surgeon fishes, and can happily be easily treated by common methods. HLLE is a common developmental disorder of the species and can be the result of diminished water quality, malnutrition, low pH, high organics, vitamin deficiency or a disease organism, to name a few. Water changes and proper feeds all help prevent HLLE.

As with almost all species of marine fishes, quarantine of Zebrasoma and other Tang species should be standard operation procedure. By pH-adjusted freshwater dip/bathing and keeping new specimens in a separate system, all parasitic disease can be avoided in your main/display systems.

**In Conclusion:** Other than a tendency to become testy with their tankmates with growth and disposition for developing HLLE, Zebrasoma xanthurus ranks high as a species of use for reef and general marine aquariums. Do start with smaller species and if possible, make your Purple Tang your last fish introduced to the system. Keep up water quality, provide a varied, supplemented diet and you will be richly rewarded with a hardy, startlingly colored specimen.

---

**Publication Information**

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 topics and are subject to editorial reviews that in our opinion are necessary. Payments 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. The SeaScope® newsletter is now available on-line at www.marineland.com under the News tab. Go to the “W h at’s N ew” section and choose SeaScope® newsletter for the most recent issue.

Address comments, questions, and suggestions to Dr. Timothy Hovanec, Editor, Marineland, 6100 Condr Dr., Moorpark, CA 93021 or E-Mail: seascope@marineland.com

Aquarium Systems is a Marineland Company
An aquarium overgrown by Asparagopsis taxiformis.

Asparagopsis taxiformis: A troublesome reef algae

By Michael P. Janes

In the past, the thought or mention of algae was something that conjured up concern, emotion, and even fear in some marine aquarium hobbyists. Today, most modern coverage on the topic of algae emphasizes the important role they play on a healthy coral reef and how they may do the same in your tank. A relationship exists on coral reefs between algal growth, nutrient processing, and grazing. Nuisance algae in aquaria can be the result of a change in the pathways by which nutrients are processed. These changes can be subtle and difficult to detect. By the time a problem occurs it can be too late for any kind of rapid correction. Another important component of algae control in aquaria is herbivore diversity. Typically excessive algae growth is the result of an insufficient variety of algae consuming animals and/or excessive nutrients.

Even among reef keeping hobbyists who are well aware that over feeding and insufficient water changes can contribute to algae problems, and who diligently do maintenance and routine testing occasionally an algae can appear that defies conventional reasoning and solutions. Such is the case with the red hair algae, Asparagopsis taxiformis.

The genus Asparagopsis contains two species A. taxiformis and A. armata. They belong to the red algae division Rhodophyta that has about four thousand described marine species. Examining the branches in sexual forms at medium magnification can separate the two species of this genus. As its name suggests the species A. armata has small spines on the branches. Asparagopsis taxiformis has smooth branches.

Red algae have the most elaborate lifecycles of all the marine algae. Successive generations alternate between an asexual sporulation stage and a sexual stage composed of male and female plants. The physical appearance of these two stages is quite different making identification difficult at times. Examination of the branches in sexual forms at medium magnification can separate the two species of this genus. As its name suggests the species A. armata has small spines on the branches. Asparagopsis taxiformis has smooth branches.

Red algae have the most elaborate lifecycles of all the marine algae. Successive generations alternate between an asexual sporulation stage and a sexual stage composed of male and female plants. The physical appearance of these two stages is quite different making identification difficult at times. Early investigations into the species A. taxiformis initially lead to its asexual stage being classified as a different species!

The characteristic red color in the Rhodophyta is the result of a water-soluble pigment called Phycoerythrin. This pigment not only reflects light but also absorbs and converts it to a fluorescing

Continued on page 4
Asparagopsis taxiformis: A troublesome reef algae

Continued from page 1

Aquarium Observations

Asparagopsis taxiformis is typically introduced into aquaria attached to the substrate of coral specimens. Cured or uncured live rock does not seem to harbor these algae, suggesting that it is not usually associated with fish only tanks but rather reef aquaria. It initially appears as small tuffs or balls growing to about one inch in diameter. They are soft to the touch and are comprised of thin, segmented threads that break apart easily. Once present, this insidious alga usually spreads quite rapidly. It is often epiphytic and will attach to almost any available surface including the fronds of macro-algae, sand, coralline covered rocks, and even corals where any skeletal portion is exposed. Fortunately this alga does not cause direct harm to corals resulting from any chemical secretions or allelopathy. It will, however, shade coral tissue from being exposure to passive water flow. Both of these events ultimately produce ill effects on corals.

Environmental conditions such as light and water chemistry would be the typical trouble-shooting areas to investigate. Unfortunately, no direct link has been found to indicate lighting or a particular water parameter was to blame. Examination of parameters from a number of aquaria showed that Asparagopsis taxiformis can grow in low light refugia, brightly illuminated reef aquaria with metal halide and/or power compact lighting, and even dark sumps. W ater chemistry of the systems tested revealed no abnormal parameter. N utrients were low with orthophosphate levels reading 0 parts per million (ppm) and nitrate 0 to 10 ppm in various aquaria tested with low range test kits.

Kalkwasser will often reduce the abundance of unsightly filamentous algae and may also assist in the control of these red algae over time. It is used as a means to encourage encrusting coralline algae to flourish and at the same time bind orthophosphate. Iodine tests on a number of systems revealed levels that were most often 0 or did not exceed 0.06 ppm, which is near natural seawater concentrations. Interestingly, Codmier et. al. (1979) working on Asparagopsis armata found that iodine levels of 0.6 ppm provided the most rapid growth in this algae species. Growth was inhibited when concentrations of iodine were increased above 1.8 ppm.

Control of Asparagopsis

The first line of defense is prevention. Carefully inspect the substrate of new corals and even live rock for signs of the red hair algae. Consider placing new specimens in a quarantine tank for the first one to two weeks. Not only will this quarantine period reveal the unwanted algae but it will also allow time for the coral to be monitored, feed, and given a period to adapt to captive conditions. Unfortunately for the reef aquarist the most common herbivores offered for sale do not rapidly consume this algae. A number of algae eating fish and invertebrates were rotated through a large tank with an outbreak of Asparagopsis taxiformis. These included the rabbitfishes Foxface (Lo ptilopus), and Gold-saddle (Siganus guttatus), Yellow Tangs (Acanthurus flavescentis), Desjardini Tang (Zebrasoma desjardini), the Lawnmower Blenny (Salaria fasciatus), and a number of invertebrates such as the Sally Lightfoot Crab (Percon gigipes), Emerald Crab (Mithraculus sculptus), Blue leg reef hermit (Clibanarius tricolor), Red leg reef hermit (Calcinus tibicen), a Sea hare (Elysia sp.), and a variety of snails from the Atlantic. None of these animals were observed to consume enough of the algae to overcome its prolific growth.

Fortunately there are two ways to control a case of excessive red hair algae. The first is the least effective and that is manual control. In essence, the hobbyist becomes the “grazer” and physically removes the tuffs of algae from the aquarium. The best a hobbyist can hope for is a stalemate where the problem algae do not get much worse, but it remains an unsightly presence in the aquarium. Perhaps a more realistic solution is in finding a grazing organism that has a taste for Asparagopsis. Such is the case with the Pacific Turbo Snail, Turbo fluctuosus. It finds red algae very palatable and preferable to other green and brown micro-algae. This species should not be confused with another turbo snail sold in the hobby, Astrea tectum from the Caribbean. Ten Pacific Turbo Snails can typically be supported in a fifty-five gallon aquarium where micro and filamentous algae are present.

Patience is a key component in controlling an outbreak of any algae. It is more important to maintain a more diverse assemblage of herbivores than to keep too many of one kind. Certainly there are bound to be other grazers out there that feed on Asparagopsis taxiformis and other red
Herbarium Press

Reef aquarium hobbyists are consummate collectors. Whether it is equipment and spare parts, books, or even logs of their tank's history, the accumulation of aquarium materials is almost inevitable. Many hobbyists will even hang on to coral skeletal samples or clamshells from previous inhabitants of their tank. It is both possible and advantageous to preserve algae samples as well. Preserved algae specimens offer a hard copy record of the types encountered over the lifetime of a tank. Preservation is also a convenient way to help identify a particular type of algae by taking it to a local aquarium shop, photographing it, or sending it off to a university or museum. A simple herbarium press can be built to dry algae samples.

The procedure for preserving soft, fleshy algae is as follows.

Specimens must first be fixed to harden the tissue and prevent them from breaking down over time. Place samples in a small jar with just enough saltwater to cover them. Prepare a solution of formalin that has been buffered to a pH of seven with a little pH buffer (Caution formalin is a toxic substance and needs to be handled very carefully - Ed). Add three to five percent of the buffered solution to the total volume of the jar. Cover with a tight-fitting lid and store in the dark away from ambient light overnight or longer.

To prepare the samples for drying remove them from the formalin fixative and gently rinse them in a little saltwater. Inspect the algae for any bits of substrate or sand and remove excess debris at this time. Three and a half by five-inch cards can be cut from waterproof, acid-free paper and be used to mount the specimens. This kind of paper can be obtained from aquaculture supply sources. Larger or smaller cards can be made depending on the size of the samples and how they will be stored. Place the cards in a shallow bowl containing RO/DI water. Using forceps or an artist's paintbrush spread out the algae samples in the bowl over the cards. Gently lift the cards out of the water at a low angle. This will cause the water to run off of the cards away from the algae and help to spread the branches in a single layer. Cards should be placed on a paper towel to absorb excess water.

Pressing the samples is both easy and inexpensive. Cut pieces of corrugated cardboard, cheesecloth, and wax paper six or seven inches square. Crumple wax paper so it is wrinkled and has an uneven surface and lay it on top of the algae cards. Next lay a few squares of cheesecloth down then follow with a few pieces of paper towel. For multiple samples, just place a piece of the cardboard between each layer and repeat the procedure. Bundle this package between two squares of corrugated cardboard and strap together with a few taunt rubber bands. Place a brick or other heavy object on top of the press and store in a warm dry place. Check the pressing daily and replace paper towel pieces as needed. It may take a week or more for the samples to completely dry. Once complete check the algae to see if it has remained attached to the paper card and if not, tack it in place with a few drops of hard-setting glue. The finished pressing should be labeled. It can then be stored in a transparent sleeve like those used to hold photographs.

Acknowledgments

I would like to thank the kind assistance of Dr. Allan Miller, Royal Botanic Gardens, Sydney, Australia, and Dr. D. W. Isom Freshwater, Center for Marine Science, University of North Carolina, Wilmington for help in identification of the algae and Dr. Allan Miller, Royal Botanic Gardens, Sydney, Australia, and Dr. D. Wilson Freshwater, Center for Marine Science, University of North Carolina, Wilmington for help in identification of the algae.

References


Life History and Treatment of Uronema marinum

Continued from page 1

infections (Uronema can cause lesions similar to those produced by bacteria such as Vibrio spp. and Pseudomonas spp.) When viewed under the microscope, U. marinum is pear shaped, contains a single macronucleus, and has long caudal cilia (a tiny hair-like structure that is used for locomotion and/or feeding). Salinity, temperature, and pH influence the motility of U. marinum. U. marinum replicate by binary fission and low salinity can affect their ability to produce daughter cells. These protozoans are also greatly affected by temperature which is a key factor influencing their activity and metabolism. As the temperature increases the metabolic activity of U. marinum increases. The warmer water speeds up the life cycle of the parasite.

Survival of the aquarium population requires the elimination of virtually all parasites, prevention and treatments will not work unless followed through to completion. The best way to eliminate problems with U. marinum is to prevent its introduction into the aquarium by quarantining new arrivals. Quarantining new fish in a separate holding tank will prevent infecting the whole aquatic habitat. It is recommended to quarantine them for a period of three weeks and observe their eating and swimming habits. There are a number of methods and methods that can be used as a possible cure.

Chloroquine has been shown to work very well in eradicating these parasites. This drug is used to treat and prevent malaria in humans. Chloroquine appears to be the drug of choice by most public aquarium and zoological parks. One treatment will cover a three week cycle but is difficult to use and can also be harmful to humans. The quarantine tank lighting should be reduced since this drug is light sensitive. Additionally, it is difficult to dispose of so proper care should be taken.

Formalin (37%) added to the quarantine tank at a dosage of 2 drops per gallon has also been used to aid in eradicating the parasite. Care should be exercised when handling since formalin is considered to be a carcinogen and can be harmful to humans.

Malachite green can be used to control U. marinum. At 50% strength, Malachite Green is normally administered by adding one drop per gallon and treating for 3 days straight. Care should also be exercised when handling this medication.

Copper Sulfate is an effective treatment for U. marinum also. This treatment should be administered at levels of 1.6 to 2.5 ppm directly to the quarantine tank to provide adequate levels. Keep the temperature at 78°F. Maintain a specific gravity of 1.022 to 1.023 and a pH of 8.1 to 8.4 and maintain proper levels of copper sulfate for the three weeks.

Freshwater baths have produced good results in removing this parasite. The infected fish should be placed in the freshwater bath for a period of three minutes or until the fish shows signs of stress. Due to a change in the osmotic pressure, the cell wall of the parasite will burst. Be sure the temperature of the water in the bath is the same as the quarantine tank to help reduce stress. This treatment should not be used for sensitive fish.

but most marine fish can endure it with no lasting problems.

A hydrogen peroxide (H₂O₂) bath for ten seconds has also been shown to work. Hydrogen peroxide is a colorless, heavy, strong oxidizing liquid. It is also an environmentally friendly disinfecting agent: the only by-products are water and oxygen. For this application, 35% hydrogen peroxide is commonly used. To make a 3% solution using 35% H₂O₂ and dechlorinated freshwater use the following formula:

- For a gallon of 3%: Remove 10 oz. of water from a gallon of dechlorinated water and add back 10 oz. of 35% hydrogen peroxide to the water.
- For 3/4 pint of 3%: Mix 1 oz. of 35% with 11 oz. dechlorinated water.

Again, the water temperature of the bath should be the same as the aquarium.

Another approach is a low salinity (hyposalinity) treatment. Lower the salinity in the quarantine tank to a specific gravity of 1.011 and maintain at this salinity for 21 days. The parasites when exposed to this low salinity will die due to changes in osmotic pressure. This treatment should not be used for invertebrates or especially sensitive fish such as sharks and rays, but most marine fish will tolerate it well.

When fish are stressed by overcrowding or introduction to a new aquarium, the fish's ability to fight off parasites is greatly reduced. In a healthy aquatic habitat, fish normally are able to fight off parasites but when there is a husbandry problem, the fish may suffer weight loss, dehydration and their protective covering, which usually keeps parasites at bay, can be compromised enabling these parasites to attack the animals. Secondary bacteria can also occur as the fish weakens and is unable to mount a defense. If untreated, the fish immune system is overcome with the fish dying as the result.

Timely water changes will aid in parasite removal but water changes alone are not completely effective because some parasites will inevitably attach to fish before they can be removed. By improving water quality through proper water changes, fish are not as stressed. In summary, the best way to control problems with U. marinum is to prevent its introduction into the aquarium in the first place. Quarantining new arrivals for a period of three weeks and treating with medication mentioned above as a prophylaxis, will keep your current fish safe from parasitic infection.

References:


Uronema marinum, host Squirrelfish

Uronema marinum, host Waspfish
Editor’s Corner

This issue of Seascope is dedicated almost exclusively to an article by Martin Moe, Jr. on a fantastic project that he and Ken Nedimyer conceived and implemented regarding the reintroduction of the sea urchin Diadema to reefs off the coast of Florida. Martin needs no introduction to readers of Seascope and I won’t ruin the punch line here but, as with all of Martin’s writings, this article is important, educational and shows what two concerned individuals can do! Congratulations are due to Martin and Ken for a fine project that yielded important results.

Still on my soapbox: pH

One part of water quality that I have constantly talked about is pH. pH has to be the most misused term in the fishkeeping hobby. It is difficult to discuss many important processes in aquaria without a correct understanding of pH. pH plays an important role in subjects such as ammonia and nitrite toxicity, calcium carbonate and carbon dioxide chemistry, alkalinity and many others.

In most articles, pH is usually defined as the measure of acidity or alkalinity of a liquid. This definition is not correct. Simply put, pH is a measure of the hydrogen ion concentration in a liquid. Technically, pH measures the molar concentration of the hydrogen ion (the weight of one mole, abbreviated “mol,” is equal to the molecular weight of a material in grams). For our purposes a good working definition of pH is the hydrogen ion intensity or activity in a liquid. The “p” stands for power while the “H” stands for Hydrogen ion (always capitalized because it is a chemical element), together they mean the power of the hydrogen ion. The concentration of the hydrogen ion is measured on a logarithmic scale which ranges from 0.1 to 0.00000000000001 mol/Liter (L). These numbers can be rewritten as $10^{-1}$ to $10^{-14}$ mol/L. To make it easier to read, the mathematical definition of pH was written as the negative logarithm of the hydrogen ion concentration which converts the above numbers to the familiar pH scale of 0 to 14. For example, if the pH is 4, then there are $10^{-4}$ or 0.0001 moles per liter of hydrogen ions in the solution.

Since higher levels of hydrogen ion activity mean an increased acidic level, it should also be apparent from the above discussion why a “lower” pH is more acidic than a “higher” pH. A solution experimentally to the familiar pH scale of 0 to 14. For example, if the pH is 4, then there are $10^{-4}$ or 0.0001 moles per liter of hydrogen ions in the solution.

Still on my soapbox: pH

One part of water quality that I have constantly talked about is pH. pH has to be the most misused term in the fishkeeping hobby. It is difficult to discuss many important processes in aquaria without a correct understanding of pH. pH plays an important role in subjects such as ammonia and nitrite toxicity, calcium carbonate and carbon dioxide chemistry, alkalinity and many others.

In most articles, pH is usually defined as the measure of acidity or alkalinity of a liquid. This definition is not correct. Simply put, pH is a measure of the hydrogen ion concentration in a liquid. Technically, pH measures the molar concentration of the hydrogen ion (the weight of one mole, abbreviated “mol,” is equal to the molecular weight of a material in grams). For our purposes a good working definition of pH is the hydrogen ion intensity or activity in a liquid. The “p” stands for power while the “H” stands for Hydrogen ion (always capitalized because it is a chemical element), together they mean the power of the hydrogen ion. The concentration of the hydrogen ion is measured on a logarithmic scale which ranges from 0.1 to 0.00000000000001 mol/Liter (L). These numbers can be rewritten as $10^{-1}$ to $10^{-14}$ mol/L. To make it easier to read, the mathematical definition of pH was written as the negative logarithm of the hydrogen ion concentration which converts the above numbers to the familiar pH scale of 0 to 14. For example, if the pH is 4, then there are $10^{-4}$ or 0.0001 moles per liter of hydrogen ions in the solution.

Since higher levels of hydrogen ion activity mean an increased acidic level, it should also be apparent from the above discussion why a “lower” pH is more acidic than a “higher” pH. A solution experimentally to the familiar pH scale of 0 to 14. For example, if the pH is 4, then there are $10^{-4}$ or 0.0001 moles per liter of hydrogen ions in the solution.

Coral Reef Restoration: Returning the caretakers to the reef

Despite the growth of civilization and the impacts of developing human populations, the reefs of the Florida Keys and the Caribbean thrived for hundreds of years while human populations exploded on the coastlines and islands, but then, suddenly, something changed. Within the geological blink of an eye, about 20 years, these reefs, those near human populations and those far from human impact, have precipitously declined. Coral cover on the Florida reef track has declined from about 70 percent in the 1960s and 70s to less than 10 percent today. Coral reefs throughout the world are in decline and none more so than the reefs of the tropical western Atlantic.

So what happened? Well, there are many factors implicated in the decline of tropical western Atlantic reefs. Broadly, these factors are increased nutrients, sedimentation, and turbidity from coastal development; direct impact from human visitation, over fishing, and destructive fishing methods; great ecological changes in reef organism diversity stemming from human exploitation and disease; and global warming (probably also anthropogenic) that raises surface seawater temperatures. This warm water so stresses corals that they release their symbiotic zooxanthellae algae (termed bleaching), weaken, and then die if the warming is severe and prolonged. The relative importance of these various factors vary with the location of the reefs.

There is one factor, however, that was constant. Through the millennia, the long-spined sea urchin, Diadema antillarum, were the keystone herbivores that grazed the reefs and maintained the balance between coral and algae growth that allowed the corals to flourish and build the vast calcium carbonate structures of the reef. There were immense populations of long-spined Diadema urchins on these reefs. Throughout this vast region the long-spined urchins were present in numbers of 2 to 20 urchins per square meter on the reefs and in the Florida Keys, 4 to 6 Diadema per square meter could easily be found on most reef formations. Small patch reefs could be easily identified from the surface by a mysterious white ring of exposed sediments that surrounded them. Research showed that these rings of exposed coal sand were caused by Diadema urchins moving off the reefs at night and feeding the surrounding reef at dawn.
Coral Reef Restoration: Returning the caretakers to the reef

Continued from page 1


algae cover on the shallow reefs increased from 1% to as high as 95% within two years of the loss of the Diadema urchins, and at St. Croix, algal biomass increased by 27% within five days of the Diadema mortality and then algal biomass increased by 300–400% above the pre Diadema mortality levels. Similar increases in algal biomass following the mortality were observed throughout the Caribbean and tropical western Atlantic reefs.

After 20 years, even the limited return of the Diadema populations that has occurred in the Caribbean has not been seen along the Florida reefs. The return of Diadema to Florida waters may not occur for decades, if ever, and by that time there will be little left of the glorious coral reefs of the Florida Keys. It may be possible, however, to aid the return of these urchins to the reefs and it is imperative that we at least research this possibility. Perhaps the first step would be to find out what would happen to a reef in the Florida Keys if a pre plague population of Diadema could be returned to the reef. And this first step has already been accomplished.

Ken Nedimyer, a marine life fisherman, and Martin Moe, a retired marine biologist, both members of the Florida Keys National Marine Sanctuary Advisory Council, were convinced that the loss of Diadema on the Florida reefs precipitated the drastic decline of these reefs and were determined to demonstrate what would happen if Diadema were returned to the reefs. They obtained a small grant from a NOAA reef restoration fund and began work on a Diadema restoration project with the support and counsel of the Sanctuary staff.

The project began in the fall of 2001 offshore of the Upper Keys. We wanted to explore the feasibility and ecological results of translocating juvenile long-spined sea urchins from areas with relatively high settlement and extensive winter urchin mortality, the unstable reef crest rubble zones, to a nearby deeper water (about 25 feet, 7.5 m) patch reefs at densities approaching those on Florida reefs before the Diadema mortality. This project, involving just the straightforward transfer of at risk juveniles from rubble zones to deeper reefs, was designed to determine whether these juveniles could survive such translocation and if they did survive in adequate numbers, could they change the ecology of the reefs.

The same star coral head in September of 2002, one year after placement of Diadema urchins on the reef. The algae on both coral heads have been greatly reduced and the coral tissue appears healthier.

Four patch reefs: two experimental and two controls, varying in size from about 44 to 96 m² were selected for the study. During the period from September 2001 to December 2001, 434 juvenile long-spined urchins were placed on experimental reef #1 (96 m²), a total potential density of 4.5/m², and 262 were placed on experimental reef #2 (88 m²), a potential density of 3.0/m². An additional 16 urchins were placed on reef #2 on 10/23/02 bringing the total urchins placed on reef #2 to 278, a potential density of 3.2/m². No Diadema urchins were placed on the control reefs. The translocated populations were evaluated for number and placement of surviving urchins 10 times on reef #1, and 11 times on reef #2 over various intervals during the period from September 8, 2001 to February 5, 2003.

NURC (NOAA’s National Undersea Research Center) was contracted to perform a rapid habitat assessment of the four project reefs on 08/31/01 and 09/01/01, before translocation of the urchins and again on 09/18/02, about one year after translocation of the urchins to document the ecological changes that might occur on these reefs.

Initial survival after translocation of the juvenile Diadema urchins was very good. Survival rates for the juvenile urchins were 81 and 93 percent on experimental reefs #1 and #2 over the first month of the project. Survival declined to about 45 percent on both reefs after about three months and the slowly declined to about 20 to 25% after 17 months. On experimental reef #1, survival after 17 months was 27%. The average density over this 17 month period was 1.6 urchins/m², and the final density on 02/05/03 was 1.2/m². On experimental reef #2, survival was 20% after 17 months, the average density was 1.0/m², and the final density on 02/05/03 was 0.6/m². The slow decline of the translocated Diadema population was due to predation on the urchins and lack of recruitment of enough juveniles to maintain the population.

No urchins were placed on control reefs #3 and #4. (A small population of Diadema urchins, about 6 to 8, was present on reef #4 before and during the study.

Results of the ecological assessments

NURC carefully assessed the ecology of all four reefs before and one year after translocation of the Diadema urchins. The ecological effects of

Continued on page 3
of coral tissue at the point of interaction with macro algae. These data show that coral cover increased significantly on the experimental reefs and decreased significantly on the control reefs. This was the first time since the decline of the reefs began 20 years ago, that human manipulation of the ecology of a Keys coral reef reversed the decline of coral cover and decreased the growth of macro algae that shroud the reefs. Whatever the dynamics of corals, algae, and urchins, this demonstrates that the presence of the urchins results in recovery of coral cover. And this is the bottom line for recovery of the coral reefs of the Keys.

Juvenile coral density

The presence and density of juvenile corals is a measure of the success of settlement and survival of larval and juvenile corals on a reef area. The total mean density (#/m², number per square meter) of juvenile stony corals on the experimental reefs went from 6.17 to 15.3/m², an increase of 151% in one year. On the control reefs, the total mean density of juvenile corals went from 6.57 to 9.94/m², an increase of 54.5%.

Although juvenile corals increased on both experimental and control reefs, the experimental reefs, with the translocated urchin populations, had a much greater increase. This indicates that the presence of the urchins changed the ecology of the experimental reefs to favor the settlement and/or survival of juvenile hard corals.

Percent crustose coralline algae

The presence of crustose coralline algae is very good for the reefs. Unlike foliose algae, crustose coralline algae coats the rock surfaces and presents a smooth, hard substrate free of foliose algae, sediment and algae turf. This is a substrate that attracts settlement and survival of juvenile stony corals. In fact, it has been shown that lettuce coral, A. agaricites, is stimulated to settle by the chemical secretions of coralline algae.

On the experimental reefs with the urchins, crustose coralline algae cover went from 7.5% to 19.0%, an increase of 159.5% in one year. On the control reefs without the urchins, stony coral cover went from 7.75% to 8.25%, an increase of only 0.5%.

Obviously the presence of the urchins greatly stimulated growth of coralline algae on the experimental reefs as these algae increased three fold.

Brown foliose algae

This is the type of algae that competes directly with corals for space and light. It grows much faster than coral and diminishes coral cover where it occurs on the reefs. These brown algae are typically in the genera Tubinaria, Lobophora, Dictyota and Padina. The pattern of change in brown foliose algae was more complex. On the experimental reefs...
Coral Reef Restoration: Returning the caretakers to the reef

Continued from page 3

reefs with the urchins, brown foliose algae cover went from 10% to 5.13%, a decrease of 45% in one year. On the control reefs without the urchins, brown foliose algae cover went from 4.5% to 5.9% an increase of 31%. These combined figures for both experimental reefs and both control reefs don’t tell the complete story. On experimental reef #1 that had the most extensive coral growth and the largest population of urchins, brown foliose algae cover declined from 11.0% to 1.75%, an 84% decrease. Control reef #4, with its small natural population of urchins, started the project with only a 3.0% brown foliose algae cover and ended the year with a 1.0% cover. Experimental reef #2 had a 6.0% decrease in brown foliose algae and control reef #3 had a 1.9% increase.

The reduction of brown foliose algae on the experimental reefs, especially reef #1, and the increase on control reef #3 show without a doubt that the presence of the urchins greatly diminishes this competitive algae on the reefs. Its presence in low quantities on control reef #4 only supports this conclusion because of the presence of low numbers of adult urchins on this reef before and during the study.

Considerations on restoration of the long-spined sea urchin, Diadema antillarum to the reefs of Florida Keys

It is obvious that the restoration of Diadema to the coral reefs of the Florida Keys would be immeasurably beneficial to the ecology of the coral reefs and to the future economy of the Keys and all of South Florida. It may be that in time Diadema will repopulate the reefs of the Keys naturally. But as we wait for this to occur, and it has already been two decades, our coral reefs continue to decline. If it is possible to enhance the recovery of Diadema on Florida reefs through human effort, it must be done soon.

There are two main pathways that should be followed that may aid restoration of Diadema to the reefs.

The first is the translocation of juveniles of Diadema from areas where they are at high risk of mortality from storms and predation, to small, complex reef areas. We have demonstrated that the act of translocation causes little, if any, direct mortality. Development of small reef areas with pre-plague population levels of urchins will allow for effective reproduction of the urchins by placing them in close proximity to each other, and create reef areas where corals can grow without intensive algae competition.

The second avenue is to work with hatchery techniques to produce larvae and juveniles from captive brood stock of adult Diadema. This process would be more costly but would have the advantage of controlled production with release in specific areas at specific times of large numbers of late larval and juvenile urchins.

There is little that can be done locally to reverse or mitigate the effects of global warming or pollution from far off sources such as the rivers that empty in the Gulf of Mexico, but it may well be possible, through restoration of the long-spined sea urchin, to greatly reduce the algae growth that is smothering our reefs. The value of a successful Diadema restoration program can be measured by the value of our coral reefs to the economy of the Keys and South Florida. It could be that efforts to restore Diadema to Florida reefs may not succeed. The potential for restoration, however, is great enough, and the need for restoration of this herbivore so critical, that it is imperative that we at least make a strong effort to return Diadema to our reefs.

Editor’s Corner

Continued from page 1

with a low pH, such as 3, has a hydrogen ion activity of 0.001 mol/L while a solution with a higher pH, such as 8, has only 0.00000001 mol/L of hydrogen ions. Since 0.001 is a larger number than 0.00000001 the solution with a pH of 3 has a much greater hydrogen activity, making it more acidic.

Pure water (H2O) consists of two hydrogen ions (H+) and one hydroxide ion (OH-) with the formula of H2O = H+ + OH-. If there are equal numbers of hydrogen and hydroxide ions than, by definition, the pH is neutral and its value is 7 (the concentration of both hydrogen and hydroxide ions is 10-7). Pure water is one example of a neutral liquid. The pH of a liquid can be either acidic, basic (also called alkaline) or neutral depending upon the concentration of the hydrogen ion. A basic solution has a concentration of hydrogen ions less than 10-7 while in an acidic solution the hydrogen ion concentration is greater than 10-7.

While the words acidity and alkalinity look like they are adjectives for acidic and alkaline, they are not. This has, in my opinion, resulted in some of the confusion and misinformation about pH, as well as alkalinity and acidity.

Alkalinity is the acid-neutralizing capacity of a water. Namely, it is a measure of the buffering ability of the water. Water with high alkalinity can accept a lot of hydrogen ions before the pH starts to drop. Conversely, acidity is the measure of the ability of a water to accept a base (caustic) solution before the pH increases. Both alkalinity and acidity are commonly expressed in terms of mg/L of calcium carbonate (CaCO3), a much different scale than that of pH. Thanks for reading.

Future Events and Conferences

Dr. Timothy A. Hovanec: will be speaking at the Brooklyn Aquarium Society Jan. 9, 2004 at the New York Aquarium on Surf and Water 8th Street, Brooklyn, NY. More information at www.brooklynaquariumsociety.org

Aquaculture 2004: March 1-5, 2004, Honolulu, Hawaii. More information at www.was.org


Aquaculture 2004: June 4-6, 2004, Chicago, IL. More information at www.oceanario.pt