The Brightwell Aquatics

NeōZeo Method

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Synopsis: Maintaining ultra-low (e.g. immeasurable) nutrient concentrations in reef aquaria and precisely-controlling the inorganic and organic substances entering the system can result in vibrant coloration of zooxanthellate corals and their allies. The method described below can accomplish this task. It should be stated from the onset that this method will only produce dramatic results if it is employed continuously, and as directed (with slight adjustments made to dosing as dictated by the appearance of the aquarium inhabitants). It is an interesting, highly-effective method of maintaining reef aquaria that is without question geared to the more "hands-on", experienced reef aquarium enthusiast.

Stated simply, this method removes undesirable nutrients and provides beneficial nutrients. To be slightly more descriptive, it:

- Extracts phosphate, ammonia, and dissolved organic material from aquarium water by direct adsorption.
- Limits production of nitrate and minimizes the presence of latent organic material in the system.
- Provides specific organic and inorganic substances for the express purpose of enhancing health, growth, and vibrant coloration of corals and their allies.

Note: It should be stated that we are not claiming to have pioneered the method described herein by titling this document "The Brightwell Aquatics NeōZeo Method"; we are simply outlining the method utilizing Brightwell Aquatics supplements and filtration media for the reference of interested reef enthusiasts. Additionally, no amount of tinkering with methods of filtration or nutrient supplementation will provide the desired results if the remaining water parameters and physical conditions are not within the proper ranges; it is presumed that temperature, pH, alkalinity, and the concentrations of magnesium, calcium, potassium, strontium, and important minor and trace elements in an aquarium are properly maintained, and that lighting and water flow are adjusted to address the needs of the aquarium inhabitants, in any system in which the NeōZeo (or similar) method is employed. For many aquarists, this is a somewhat complex system when first reviewed; we can just hear people saying "Ye gads!" (or the like) once they have finished reading this document. Be assured that the information provided below is meant to be a comprehensive introduction to the method, but that there are bound to be exceptions or conditions presenting themselves within specific aquaria that necessitate some degree of divergence from general dosing recommendations made; therefore, it is up to each aquarist to know their system well, for this method relies heavily on attention to detail (specifically the impact that individual components utilized have on the appearance of aquarium inhabitants, and this only comes with time and experience).

Throughout this document, the word "nutrient" will appear many times. It is used in the broadest possible context, adhering to the definition of a nutrient being a substance that provides sustenance.

Discussion: Maintaining a healthy reef aquarium (or any aquarium, for that matter) is largely dependant upon limiting the concentrations of nutrients such as nitrate and phosphate; in doing so, the general health of the inhabitants tends to be relatively high (presumably because more attention is being paid to water quality) and the appearance of the system remains more pristine. So-called "nuisance organisms" such as filamentous algae and cyanobacteria are rarely visible in systems with immeasurable phosphate, and stony corals maintained in such systems are generally more vibrantly-colored as opposed to being predominantly brown or a shade thereof (an appearance that is the result of the high population density of zooxanthellae in the coral tissue, caused in large part by an elevated phosphate concentration in the system). Photosynthetic organisms require a usable source of phosphorus and nitrogen if they are to survive and flourish, so some small amount of these elements must be present for these organisms, and their symbionts, to survive; the key is to provide the nutrients directly to the organisms in an appropriate form and limit their "free" concentration in the reef aquarium. There's nothing revolutionary about this concept; rather, the method in which it is accomplished (as described in this document) is somewhat new.

The NeōZeo method can be dissected into two main areas of focus: Nutrient Limitation and Nutrient Supplementation. While we will examine them individually, it is extremely important to state that this system relies on a balanced combination of the two aspects in order to provide positive results. It is extremely simple to strip the important substances out of an aquarium to the point that the aquarium inhabitants begin to suffer and perish; it is even simpler to overload an aquarium with organic and/or inorganic substances, resulting in the same fate of the inhabitants (albeit by different means).

Nutrient Limitation

As previously mentioned, controlling the concentrations of nutrients, and their precursors, in reef aquaria is extremely important; the long-term overall health of the system is highly reliant upon it. This entails extracting dissolved and particulate organic material, as well as phosphate and nitrogenous molecules such as ammonia, nitrite, and nitrate from the system efficiently and effectively. In the past, aquarists have utilized protein skimming, activated carbon, and ion-exchange resins in conjunction with the natural biological and chemical reactions taking place within sediment and porous substrates to accomplish this goal. The aspect of this method that makes it "unique" is the utilization of a family of selective zeolites for the dual purpose of extracting ammonia/ammonium and providing a substrate for the colonization of beneficial microbes. It follows that an aquarium with efficient extraction of ammonia *before it is utilized in the nitrification process* will have a very limited propensity for nitrate accumulation. Similarly, by extracting dissolved and particulate organic material from the water before it has a chance to be broken down via microbial processes and/or photodegradation, the constituents of that material are not released into the system; this is accomplished through protein skimming and the use of high-quality activated carbon. The rates of nitrogen and phosphorus input and the presence of adequate organic carbon largely determine whether or not some amount of measurable nitrate and/or phosphate persist in an aquarium; nitrate is removed via denitrification and/or the use of a sulfur reactor, and phosphate is addressed by utilizing some form of phosphate-adsorption media. The ultimate goal is to maintain microbial biomass production at such a rate that the concentrations of nitrate and phosphate never become measurable.

Biological Nutrient Limitation (Microbes and Organic Carbon)

The role that microbes play in a zeolite filtration method is extremely important: they convert nutrients existing in excessive concentrations into biomass, which is then (in the case of planktonic bacteria, or "bacterioplankton") consumed by corals and other suspension-feeding organisms and utilized in biological processes, and/or removed from the aquarium by protein skimming. The process may be thought of as nutrient recycling and export, and in that regard it provides some of the same benefits that a refugium housing macroalgae provides; the main difference is that the nutrients assimilated into microbial biomass are at least partially available to corals, which is not the case when it comes to nutrients assimilated into macroalgae tissue. A percentage of the microbes form biofilms on inanimate objects (often appearing as a brownish film on the panes of the aquarium), which can be brushed off and captured by aquarium inhabitants and skimmer intakes, again exporting nutrients from the system; we will return to the topic of biofilm shortly. Before we move on, it is likely that some readers will ask the questions, "Why is this means of nutrient export any different than the natural processes taking place within any cycled aquarium? Microbes are going to colonize the NeōZeo media regardless of seeding it. What's the big deal?" The primary difference between a "traditional" system in which biological filtration media is set into place and allowed to become passively populated with microbes and a system in which a select group of microbes is supplemented on an ongoing basis is that (again) the enthusiast maintains more control over the rate of nutrient export, and simultaneously encourages the biological processing of various substances known to negatively impact water clarity and/or the health of the aquarium inhabitants.

MicrōBacter[7] is a selective complex of microbes and enzymes specifically formulated to rapidly reduce the concentrations of organic nitrogen, ammonia, nitrite, nitrate, phosphate, and organic carbon. Used alone, the microbes and active ingredients in MicrōBacter[7] will begin decreasing the concentrations of the aforementioned substances until such time as one of them becomes limiting to the uptake of the others. It is here that the discussion turns to carbon limitation and the implications this has with regards to the ability of microbes to assimilate phosphorus and nitrogen. Covering this topic requires elementary thinking and relies on the ratios of nutrient uptake in bacteria being somewhat analogous to that of marine phytoplankton.

Using the molar ratios of 106:16:1 C:N:P (carbon : nitrogen : phosphorus) in marine phytoplankton as a model for nutrient uptake in bacteria, it follows that bacteria require considerable carbon to assimilate nitrogen and (particularly) phosphorus. In a system with low- to immeasurable-concentrations of nitrate and phosphate, there is presumably sufficient organic C present to enable bacteria to utilize the N and P that is available; resultantly, bacterial biomass is regulated by the relative abundance of N and P. Conversely, in a system with relatively high concentrations of nitrate or phosphate (e.g. one that tends to be heavily-fed), their uptake by bacteria will be *inhibited* by inadequate organic C. The solution is to supplement the system with organic C, which enables assimilation of the existing N and P into bacterial biomass. As previously described, the bacteria, and hence the N and P, are then removed from the system via filtration and/or converted into biomass of suspension-feeding organisms capturing bacterioplankton and pieces of biofilm that become dislodged from static surfaces. Addition of Reef BioFuel alleviates the N- and P-uptake limitations of the system and ultimately leads to lower concentrations of nitrate and phosphate in the system. Reef BioFuel does not pollute the system when properly administered (which will necessarily be different for each individual aquarium system); regular addition encourages more rapid assimilation of phosphate into microbial biomass.

The table below lists the Brightwell Aquatics filtration media that are applicable to this method; each requires placement into a proper filter.

Brightwell Aquatics Media	Benefit Provided
NeōZeo	Selectively removes ammonium and certain other monovalent cations and organic compounds, and provides surface for the colonization of beneficial microbes that improve water quality and become a food source for suspension-feeding invertebrates
Carbonīt-P	Rapidly extracts dissolved organic material from system
Phosphāt$_R$	Efficiently extracts phosphate from system; regenerable

Adsorptive Nutrient Limitation

NeōZeo is a blend of zeolites (naturally-occurring minerals that have specific ion-exchange properties; they essentially exchange ions of like-charge with their surrounding medium (in this case, aquarium water)) that selectively remove ammonium and certain other monovalent cations from seawater (leaving divalent cations such as calcium, magnesium, strontium, and various minor and trace elements alone), exchanging them primarily for other monovalent ions. The colonization of the media's vast surface area with the appropriate types of nutrient-remineralizing microorganisms, such as those found in MicrōBacter[7], serves to deplete existing concentrations of dissolved organic material from the aquarium. Due to the highly-porous nature of NēoZeo and the rate at which it is colonized by microbes, some degree of surface impaction with latent organic material and microbial biomass occurs with time. It is important to gently dislodge this material from the NēoZeo media by physically handling it (see the instructions that accompany the media reactor) and/or by briefly increasing the flow rate through the reactor to help blow some of the latent material into the water column. In either case, the water-borne material will be fed upon by various aquarium inhabitants and/or removed via protein skimming and mechanical filtration.

Some enthusiasts familiar with zeolite filtration may scoff, but our preferred method for housing this media is simply to place it inside a large-capacity canister filter that either has some pre-existing means of flow-rate adjustment or can be retrofitted with a ball valve on the filter discharge (which practically any filter that utilizes flexible tubing will accommodate). The water flow through the media is generally maintained at a rate of <100 gph (378.5 lph), with a brief (e.g. 3 – 5 minute) dramatic increase in flow rate (e.g. >200 gph or 757 lph) every 2 – 3 days that serves to dislodge any latent organic material that may have accumulated on the surface of the media itself. We prefer to use a canister filter for this purpose because, in our opinion, it's a cleaner approach than using an open-top reactor placed in a sump, and opens up the possibility of placing Carbonīt-P or NeōMag (our granular magnesium/calcium media) into the same vessel for added benefit; also, a filter that features flow-control built into the motor housing simplifies maintenance. Once established, occasional supplementation of MicrōBacter7 is recommended to replace those microorganisms that are lost to the water column (becoming planktonic and available for predation by corals, sponges, and other suspension-feeding invertebrates) during routine disturbances to the NēoZeo media, itself, as well as when replacing a portion of the media.

The aquarist must be cognizant of the fact that NēoZeo is an extremely-effective adsorber of ammonium, and that corals that have become accustomed to, and dependant upon, the presence of ammonium are likely to show an initial negative response to the rapid removal of this ion. As one might expect, this is an issue that is primarily encountered in aquaria that have been established for many years; in contrast, aquaria that utilize zeolite filtration from the onset are far less-likely to exhibit this sort of ammonium-related issue.

The following recommendations are based upon extensive testing and will produce the best results in most aquaria:
Weeks 1 and 2: Place 200 g each week of NēoZeo for each 100 US-gallons (378.5 L) in the entire aquarium system into an appropriate media reactor; adjust the rate of water flow through the reactor to ~25 gph (94.6 lph). Add 2.5 ml MicrōBacter7 per 100 US-gallons daily.
Weeks 3 and 4: Add 200 g each week of NēoZeo for each 100 US-gallons (378.5 L) in the entire aquarium system into the media reactor; increase water flow through the reactor to ~50 gph (189.3 lph). Add 1 ml MicrōBacter7 and Reef BioFuel per 100 US-gallons daily.
Week 5: Add 200 g of NēoZeo for each 100 US-gallons (378.5 L) in the entire aquarium system into the media reactor; increase water flow through the reactor to ~100 gph (378.5 lph). Add 1 ml MicrōBacter7 and Reef BioFuel per 100 US-gallons daily.
Once the first 5 weeks of usage has passed, adjust the dosage of MicrōBacter7 and Reef BioFuel according to the appearance of the system, the inhabitants, and as dictated by the water parameters. Refer to the instructions on each of the afore-mentioned supplements' labels for additional information. Every six-weeks, change 25% of the NēoZeo media and add 1 ml MicrōBacter7 and Reef BioFuel per 100 US-gallons daily for one week before resuming normal dosing schedule.

The Biofilm
One of the complaints often voiced by some aquarists using this method is that a short, brownish film forms on inaccessible static surfaces (as previously mentioned, it is most prominent on aquarium panes and less so on live rock and sand) that detracts from the overall appearance of what would otherwise be a "pristine" display. This film is a result of microbes populating the surface and forming a "living surface". Encouraging water flow within the main aquarium, regularly cleaning these surfaces, and utilizing adequate NeōZeo media all tend to decrease the propensity for biofilm

formation inside the display. Additionally, several species of Acanthurids will graze on this film, helping control it and simultaneously recycling some of the constituent nutrients (which decreases the need to feed).

Carbonīt-P is employed in this filtration system (as with others) to improve water quality by removing dissolved organic substances, including compounds that discolor the water. The end result is reflected by increased water clarity (e.g. no yellow tinge to the water, particularly apparent when viewed through acrylic or colorless-glass panes) and relatively high redox potential. The benefits provided by quality activated carbon are an important facet of "zeolite filtration" because the ultimate goal is limiting the presence, and therefore availability, of organic material. Theoretically, continued usage of activated carbon will help minimize the build-up of latent organic material on the surface of the NēoZeo media, prolonging the time between media replacement and enabling the microbial colony to process the remaining organic material more efficiently. Keep in mind that activated carbon will also passively and actively extract minor and trace elements from water, requiring that these be supplemented (as we will discuss later) for the benefit of the aquarium inhabitants. Carbonīt-P is a premium quality activated carbon that features high capacity for organic removal, high Iodine number, low ash content, minimal dust, and immeasurable phosphate (verified with lab-grade water analysis equipment). It is typically employed at the ratio of 1 g per gallon net in the system, and (again) may be easily housed in a canister filter. We opt to run it for 2 -3 hours each day rather than continuously; this gives a bit of a "boost" to the rate of organic adsorption taking place in the aquarium (via microbial processes and protein skimming) and prolongs the amount of time allowable between replacing the carbon.

Phosphāt$_R$ further enhances the removal of phosphate from the system and has the added benefit of removing silicate. Phosphāt$_R$ is a next-generation regenerable phosphate- and silicate-adsorption media that is far more effective at phosphate removal than alumina- or ferric-based media; additionally, it does not deteriorate (e.g. crumble or disintegrate) or release substances back into the system once it reaches exhaustion. The media may be employed in either a flow-through or fluidized-bed filter; our findings suggest that the flow-through application extracts phosphate more rapidly than does fluidizing it. In either case, the media can be regenerated up to five times (it loses efficiency each time it reaches exhaustion), increasing the cost effectiveness. With all of the afore-mentioned nutrient-control measures (in addition to protein skimming) in place, one might question the need to use a phosphate-adsorption media; as with most types of filtration media, the requirement for use is dictated by the presence of phosphate in the system. Some aquarists choose to employ this media simply to ensure that they minimize the chances that phosphate becomes a problem in their aquaria; others employ it *if and/or when* phosphate becomes elevated. In the latter scenario, it is up to the aquarist to determine whether the use of such a media will be required only sporadically until the system gets into a "balance", or will be permanently utilized to control the phosphate concentration. As with Carbonīt-P, Phosphāt$_R$ is typically employed at the ratio of 1 g per gallon net in the system; it may be housed in a 150µm bag placed inside a canister filter or area of moderate water flow, or may be employed in a fluidized-bed filter. Once the phosphate concentration has not changed for a period of 4 - 6 hours, remove and regenerate resin, then reapply if necessary or desired. In all cases, the use of a mechanical pre-filter to remove particulate organic material from water prior to its interaction with this media will prolong the effectiveness, and is therefore recommended.

Implications with Xenia and their Allies

Something that we have observed when running this method of filtration is that the population density of nutrient-loving cnidarians, such as *Xenia*, *Anthelia*, and other corals that satisfy all of their nutritional requirements via direct nutrient adsorption and zooxanthellae (e.g. *corals that do not actively feed*), tends to noticeably decrease with time; this is presumably a result of the increased rate of nutrient uptake by microbes, which in effect starves the aforementioned corals into recession. This occurrence may or may not be desirable for the aquarist, depending upon whether these cnidarians are regarded as "unwelcome and/or pestilent" or "welcome and/or revered". In either case, it is worth mentioning.

<u>Nutrient Supplementation</u>
As previously mentioned, *removing the undesirable nutrients* is only one part of the equation; equal attention must be paid to *providing the beneficial nutrients*, and to maintaining the concentrations of these substances as steadily as possible. Fortunately (for the sake of avoiding as much confusion as possible), it is practical to split the following discussion between inorganic and organic nutrients, as they can (to a large extent) be addressed as individual groups.

Note: Because every aquarium presents different chemical and biological conditions, the dosages suggested in the following sections are intended as general guidelines. *Regarding any and all of the supplements discussed in this general section, minor adjustments to dosing should gradually be made by the aquarist in order to address the requirements, and to maximize the apparent health, growth, and coloration, of the aquarium inhabitants; this will necessarily be different for every individual aquarium system.* Remember to base the specific dosage required for an aquarium on the net volume in the entire system (including sump(s), water displacement by rock and bottom substrate, etc.). We encourage aquarists to use our supplements responsibly and to always use their best judgment; if specific questions to which there are no apparent answers arise, please contact us directly.

Inorganic Supplementation
Setting the supplementation of major cations such as magnesium, calcium, potassium (we will return to this element later), and strontium aside for the time being, we are primarily concerned with providing the proper minor and trace elements to the aquarium in the proper ratios (e.g. their concentrations relative to one-another).

Supplement: Rēplenish
Impact on Aquaria: Improves overall health and color intensity of inhabitants

Of the detectable elements in seawater, 11 are minor elements (concentrations <1 ppm and >1 ppb) and 52 are trace elements (concentrations ≤ppb). Between the two groups, at least 13 elements appear to be expressly-required for the growth of primary producers such as algae, and an additional 18 are either incorporated into living tissue/skeletal material or undergo chemical interactions that cause their depletion in surface waters. These elements are important to a number of enzymatic and vitamin-synthesis reactions for plants and animals alike; additionally, they influence pigmentation, and therefore coloration, of various organisms. So, if the question of whether aquarium inhabitants really need these elements presents itself, the answer is, "Yes". At this point it is important to state that minor and trace elements are not only actively removed by some forms of filtration such as the use of activated carbon, but they are also *passively* removed as a result of their "capture" by organic material (having many receptor sites for multivalent cations) which is subsequently removed from the aquarium by protein skimming and (again) activated carbon. All of this is ancillary to the uptake of these elements by organisms residing within the aquarium. The result is a requirement for dosing these elements.

We address this requirement with two supplements that serve different purposes. The first is Rēplenish[1], which provides only those minor and trace elements (including iron) found by oceanographers to exhibit non-conservative behavior in seawater (meaning that they are depleted by biological and chemical reactions taking place within the photic zone) and that are safe for human handling. Elements are present in natural seawater ratios (e.g. the ratios in which they are present in seawater). Since they are not depleted by biological nor chemical interactions, no minor or trace elements that are not expressly needed by aquatic organisms are present in this supplement. In the

[1] Kōralle-VM may be substituted for Rēplenish owing to the fact that the two supplements contain the same elements in like ratios, though in different concentrations (Rēplenish is considerably more concentrated); additionally, Kōralle-VM provides the same vitamins present in Vītamarin-M (again, same ratios, different concentration). In this regard, Kōralle-VM may be used in lieu of Rēplenish and Vītamarin-M for aquarists looking methods to simplify the system.

NeōZeo system, Rēplenish is best administered at the rate of 0.07 ml (~1 drop) per 10 US-gallons each day (corresponding to ~0.50 ml per 10 US-gallons weekly) for the first four weeks of use. Thereafter, the dosage may be increased to 0.14 ml (~3 drops) per 10 US-gallons each day (1 ml per 10 US-gallons weekly) over the following four weeks.

Supplement: KoralColor
Impact on Corals: Improves color intensity of corals and their allies

The second supplement that provides trace elements is KoralColor, albeit for the purpose of providing elements incorporated in "Biochromes", which are biological pigments responsible for much of the observed coloration of corals, clams, and their allies. The formation and perceived appearance of these pigments is at least partially influenced by the presence of trace elements that form the basis of more complex molecules. Certain characteristics of the light source(s) used to illuminate the aquarium will also influence the observed coloration of an organism, however the actual coloration of the organisms will still be primarily dictated by the pigments present, their ratios to one another in the same tissue, and other physical, chemical, and biological factors. The general purpose of providing the elements incorporated into biochromes is not necessarily color *change*, but color *intensification*. It is not, however, uncommon for the coloration of some of the lighter, "warm-colored" pigments (such as yellow and pale orange) in corals and clams to take on a slightly "cooler" coloration (such as lime or aqua); furthermore, we have noted several of the already-green *Acropora* colonies maintained in our lab systems turning lavender towards the tips after a few weeks of dosing KoralColor (these corals had been in unchanging chemical and physical conditions for months before dosing began). The recommended initial daily dosage is 2 drops per 10 US-gallons (37.5 L). Although some aquarists may consider dosing heavily in hopes of obtaining "brighter invertebrates faster", overdosing may be detrimental to the long-term health of the aquarium inhabitants as a result of toxicity; *anything* is toxic if overdosed!

Supplement: Iodion or Lugol's
Impact on Corals: Minimizes tissue irritation caused by zooxanthellate oxygen production under intense lighting

Iodine dosing used to be a somewhat controversial subject among reef enthusiasts; on one hand there were those that saw a positive impact on zooxanthellate corals and other hermatypic invertebrates, as well as macroalgae growth (when this was desirable), and on the other hand there were those claiming that iodine was harmful to living organisms for a number of reasons. The latter opinion seems to be decreasingly defended as time progresses, since reef aquarists of all skill levels (particularly advanced aquarists) dosing iodine (as directed) in their systems *observe obvious benefits* to the inhabitants; ask just about anyone who has bona fide experience maintaining "cutting edge" reef aquaria about dosing iodine and they will confirm that they use it in one form or another because it has a positive impact on zooxanthellate corals. One of the main reasons that iodine is supplemented in reef aquaria is that it, as the iodide ion, is thought to bind with free oxygen produced by zooxanthellae to form iodate[2]. Under intense illumination and in the presence of the necessary nutrients, zooxanthellae (being photosynthetic) apparently produce oxygen at a rate that irritates the surrounding coral tissue. In "fleshy" hermatypic invertebrates (e.g. large-polyp stony corals, solitary and colonial polyps, hermatypic bivalves), this irritation is apparent as the organism contracts the tissue; it is possible that this action is shading the zooxanthellae, thereby decreasing the rate of photosynthesis and the corresponding production of oxygen. In small-polyp stony corals, the tissue may appear greatly contracted as opposed to inflated (a condition that is only apparent to the aquarist who is intimately familiar with the normal appearance of the corals in their system(s)). If this condition persists, it can result in expulsion of the zooxanthellae crop (e.g. bleaching) and/or starvation of the host organism. Even if all of this theory is eventually determined to be false, there is still some sort of visible benefit provided to hermatypic invertebrates by iodine

[2] Iodine is also essential to the molting process whereby crustaceans shed their exoskeleton for the purpose of growth. No iodine = no molting.

supplementation, so to state that iodine supplementation based on this theory is foolish until someone either verifies its' validity or ascertains the *real* reason that it is beneficial seems rather foolish. So to recap, iodine (as the iodide ion) essentially bonds with oxygen to form non-toxic iodate, relieving the need to shield zooxanthellae and enabling the host organism to open fully. Admittedly, this is a very simplified explanation for the overall process, and interested readers are referred to books and articles dealing with the chemistry of water in marine aquaria for additional details.

The predominant form of iodine in seawater is iodide. The natural seawater concentration of all iodine species combined is approximately 0.06 ppm, classifying it as a minor element. Even in this small concentration, iodine is required for survival of fishes, crustaceans, macroalgae and kelp, and hermatypic invertebrates alike. Iodine binds rapidly with latent organic material and is passively removed by aggressive protein skimming and the use of organic-adsorption products such as activated carbon and specialty resins. The combined biological and chemical depletion of iodine necessitate that its concentration be monitored and the aquarium supplemented, either as directed by the manufacturer or by the appearance of the hermatypic invertebrates in the system. The rate at which iodine is extracted from the water is determined by the stocking density of reef-building livestock, type of lighting, and other biological, physical, and chemical conditions.

The logical question that arises from this discussion is, "should I be using Iodion or Lugol's in my system?" There are differences between the two supplements, namely the ingredients used and the total concentrations: Lugol's consists of potassium iodide and elemental iodine, whereas Iodion consists of potassium iodide and stabilized iodine. The primarily advantage to dosing Lugol's over Iodion is that the former is over 8x stronger than the latter, and therefore requires less dosing to obtain the same result. Resultantly, more attention must be paid to dosing Lugol's only as directed; there's more room for error when using Iodion.

For reef enthusiasts familiar and comfortable with the use of Lugol's solution, the choice of using one supplement versus the other is essentially a matter of preference. For the remaining enthusiasts, perhaps no exercise will better prepare them for using Lugol's than immersing themselves into this system, for the simple reason that *everything* dosed is controlled so carefully and this fact will translate directly into drop-by-drop dosing of Lugol's. We have read accounts posed by some writers that iodine is toxic to marine invertebrates and that it should not be administered to marine aquaria; we tend to disagree with this theory and would like to cite years of positive experiences using Lugol's as directed in all manner of marine aquaria. The key point to retain is that Lugol's should never be overdosed, and following the directions printed on our Lugol's label will enable any hobbyist with a calculator and 30-seconds of spare time to determine exactly how much of the supplement they should be adding by estimative index. In our opinion, there is nothing to be lost by using Lugol's. On the other hand, the same general results may be obtained by using Iodion. Again, it really all amounts to personal preference and experience.

Supplement:	Kōralle-VM
Impact on Corals:	Improves and maintains health and coloration

Kōralle-VM is a multi-faceted supplement that spans the gap between inorganic organic supplements; it does this by combining the active ingredients in Rēplenish and Vītamarin-M (which will be discussed in the next section) in the same respective ratios, but at lower concentrations. The result is a simplified method of providing several of the vitamins and elements important to metabolic and neurological function of all living organisms, though the ratios in which they are present reflect those of the tissue profile of marine bivalves and of natural seawater, respectively. Upon reading this, the first thing that will undoubtedly pop into the minds of many readers is the question, "If they can combine these two supplements, then why can't they do it with a number of others and simplify this whole thing?!?" For the answer to that question, please refer back to the disclaimer near the start of this document alluding to the fact that no two aquaria are alike. Except when dosing major elements and trying to hold to natural seawater parameters, there is no way to "add everything to the pot" and come up with a supplement that will be equally beneficial to every aquarium to which it is added. Our preference is to formulate supplements by combining appropriate ingredients in ratios that are either found to be directly beneficial to aquatic organisms, or will bring about a specific change in the water chemistry; the dosing of those supplements is the variable that must be altered for every individual aquarium.

For aquarists interested in *really* tweaking the water chemistry in their system, Koralle-VM is not likely to be of much interest because they are not going to be in as much control of the parameters as they would be if using Rēplenish and Vītamarin-M individually; the possibility of using one supplement in lieu of two others is mentioned for the purpose of disclosing as much information to each interested aquarist as possible. In doing so, the aquarist can make their own decision.

Supplement:	Potassion and Potassion-P
Impact on Aquaria:	Provides potassium for formation of aragonite, incorporation into biological pigments, and replaces potassium lost to zeolitic material

In natural seawater, potassium is a non-conservative major element with a concentration slightly lower than that of calcium (~399 ppm vs. ~413 ppm, respectively). It is a component of aragonite; additionally, potassium is utilized in photosynthesis, maintaining ion (charge) balance, in the translocation of important organic and inorganic compounds (such as sugars and nutrients, respectively), and it is essential to many of the biochemical reactions taking place within plant tissues. Of particular interest to many reef enthusiasts is the fact that potassium supplementation dosing has, within the past several years, been implicated in improving the blue coloration of numerous varieties of small-polyp stony corals, presumably by being incorporated (in the presence of adequate ionic iron) into natural pigments. When we were first made aware of the color-changing that some aquarists dosing potassium observed in their SPS corals, we did a tremendous amount of research to try and determine precisely *how* this reaction could be taking place. Admittedly, the answers we came up with seemed a bit far-fetched, so we decided to start experimenting with potassium in our research systems. What we observed confirmed much of what we had heard: the corals were indeed changing color with potassium supplementation, often within the first few weeks of initial dosing. We're still not sold on the answers we came up with to the question of how this is taking place, but in this case "seeing is believing", so we continue to supplement the systems with Potassion as well as search for more plausible mechanisms that would cause this change in coral coloration.

While the aforementioned aspects of potassium supplementation illustrate some of the reasons that it should be carried out in reef aquaria, it should be made clear that potassium supplementation is *absolutely required* in systems that are utilizing zeolitic media such as NeōZeo. This is because the zeolites used are adept at pulling ammonium and other monovalent cations out of solution, as discussed previously; one of these cations is potassium. As such, the potassium concentration in NeōZeo aquaria should be monitored and supplemented as required. Each ml of Potassion will increase the concentration of potassium in 1 US-gallon (3.785 L) of water by approximately 21 ppm. In particularly large systems, the enthusiast may choose to employ Potassion-P (the powdered version of Potassion) for the sake of economy; detailed instructions about creating and dosing a stock solution of Potassion-P may be found on that product's label or on our website. In either case, utilizing Potassion or Potassion-P to increase and maintain the potassium concentration within a range of 390 – 410 ppm is relatively simple once the initial potassium concentration is known.

Organic Supplementation
This is where things "get interesting"; there are a number of organic supplements that may be added to a system in order to facilitate specific changes in, or address specific needs of, corals and their allies. Again, why aren't these supplements all combined

into one for the sake of ease and economy? Firstly, overdosing organic supplements is very easy to do and takes considerable time and resources to correct; secondly, there is no guarantee that the organics provided will be needed in the ratios in which they are present in the supplement (e.g. some may be needed in larger quantities by the corals whereas others are needed less, if at all). There are several such supplements available on the market, but again we do not do things this way. Instead, we prefer to allow the aquarist to see the exact impact that each supplement has on their system(s) *and then combine them if desired to simplify dosing for an individual aquarium*. This is, in fact, the topic of the next section ("*Combining Supplements to Simplify Aquarium Care*").

We strongly advocate the dosing of all organic supplements at night (or during the period of time in which all lighting other than moonlights are extinguished), preferably allowing at least one hour to elapse after lights have gone off before commencing with dosing. This suggestion is made for two reasons: first, research performed on reefs has repeatedly shown that the majority of feeding is done by corals and their allies at night; as such, dosing organic supplements during the day will essentially result in underutilization of the supplements, themselves, leading to an increase in nutrients in the system along with wasted time and money. Second, photodegradation of organic materials takes place when they are exposed to intense illumination, such as that present over some reef aquaria; this process impacts the substances being added to the aquarium and may decrease or eliminate their usefulness to the target organisms. In short, dose your organic supplements at night before you go to bed; the difference you observe in your system will likely be substantial and you will be able to dose less yet still obtain good results.

It is important to understand that no nutrient supplement can work miracles on an aquarium that is not sufficiently tended to, and/or in which the chemical and physical parameters are not conducive to the long-term survival of the inhabitants. For instance, please do not expect the corals in an aquarium to suddenly begin growing like weeds if the concentrations of important elements are well below their NSW concentrations when initial nutrient dosing is commenced. It is expected that an aquarium being tended to with the degree of care outlined in this document will have the proper conditions for the growth of corals and their allies already in place; what we are doing here is exercising extreme control over the biochemical aspects of aquarium husbandry.

The discussion on organic dosing touches on several topics pertaining to biochemistry; the details are by no means meant to be exhaustive, rather they are providing a broad picture of processes in which organic substances are required for the sake of understanding the roles that the various supplements play in reef aquarium husbandry.

There is one additional point that should be made before commencing with the specifics of organic dosing: it is in the best interests of the aquarium inhabitants, aquarium appearance, and aquarist to begin the dosing of any organic supplement very sparingly and then gradually increase the dosage as the appearance of the inhabitants and aquarium, in general, dictate. One recurring question that we have receive is whether we are advocating adding 5-ml of each supplement per 50-gallons of aquarium water per week; no. We are suggesting that no more than 5-ml of *combined* organic supplementation per 50-gallons per week, and this is only for those systems that are capable of processing this amount of material. Understand that each supplement consists of a different concentration of dissolved and/or particulate organic material; therefore, combining two or more supplements together will not necessarily result in the same amount of organic material being present in the resultant solution. The other thing to remember is that every aquarium will present different demands for nutrients, so providing a general suggestion for dosing is literally impossible. *This is why the appearance of the aquarium and the inhabitants should be the guide by which aquarists determine the optimal dosing for their particular system*. When increasing dosages, the obvious signs of nutrient-overload are the appearance and/or increased rates of growth of cyanobacteria, filamentous algae, and/or biofilm covering flat surfaces (which is where they're most apparent); if any of these events occur, begin *decreasing* the dosage of organic supplements until these signs clear up and the benefits to the desirable inhabitants are maintained.

Supplement: CoralAminō
Impact on Corals: Improves growth and tissue-repair

Reactions carried out at the cellular level, not the least of which are enzymatic reactions and the formation of new tissue, are dependant on having appropriate proteins, or the components thereof, available for assimilation; this statement applies to all living organisms, coral or otherwise. Focusing on corals and their allies, the afore-mentioned substances are utilized in both particulate and dissolved form. Proteins present in particulate material are obtained by corals through feeding, which essentially comprises of straining the water column for particles of suitable size and then ingesting particles that are regarded as food; the proteins may then be broken down into the constituent amino acids and utilized by the coral to create new proteins and/or be eventually converted into energy. By contrast, amino acids present in solution are actually taken in directly by corals through special receptor sites on the tissue. This process essentially eliminates one step in the formation of new tissue by providing the coral with the amino acids and then allowing it to assemble them as required, as opposed to the coral having to exert the energy required to break proteins down into the constituent amino acids first.

CoralAminō essentially combines amino acids found in tissue profiles of several genera of stony corals in the same average ratios; in doing so, it provides the building blocks for new coral tissue in the proper proportions. This leads to increased growth rates of soft tissue, which may (in a system with otherwise ideal chemical and physical parameters) be a limiting factor in overall coral growth; in other words, if all parameters are ideal yet there are insufficient amino acids available for the production of new tissue to "match" the potential for calcification, addition of these molecules can result in a substantial increase in overall growth of a colony. This has some fairly obvious implications in terms of usefulness to aquarists propagating corals. We suggest starting with a dosage of 2 drops per 10-gallons daily for the first month and then increasing the dosage as desired.

Supplement: Restōr
Impact on Corals: Improves growth and tissue-repair; may be used as an interim source of food for corals that have become partially bleached

The details regarding proteins discussed in the first paragraph of the section dealing with CoralAminō are equally applicable to Restōr. As opposed to the CoralAminō, however, Restōr consists of proteins and fatty acids, both of which are derived from marine sources (yes, this is a vague description, but the specific nature of the sources is deemed proprietary information), as well as biopigments. Restōr is primarily formulated to enhance the rate of tissue growth by providing substances that are easily assimilated into new tissue; a notable secondary benefit of dosing Restōr is the ability of corals that have lost zooxanthellae to survive on the nutrients that the supplement provides. Both of these aspects make Restōr useful in propagation operations. As with CoralAminō and indeed all organic supplements, we recommend beginning with a dosage of 2 drops per 10-gallons daily for the first month and then increasing the dosage as desired. It has been our experience that corals maintained in systems in which Restōr is supplemented tend to have noticeably faster rates of tissue growth than control systems.

Supplement: Vītamarin-C
Impact on Corals: Immune system stimulant; dramatically improves the rate of tissue growth

Vitamin C is an organic compound required for many metabolic and enzymatic reactions, and also acts as an antioxidant (essentially inhibiting the damage done to cells through the chemical process of oxidation). It is this last point that is of the greatest interest to reef aquarium enthusiasts, because the presence of vitamin C not only helps zooxanthellate organisms deal with free radicals produced during the process of photosynthesis, but it is also required for the formation of new tissue. We are really only discussing the proverbial "tip of the iceberg" here; it is probable that vitamin C performs so many essential biochemical functions that a comprehensive discussion of how it impacts corals and their allies would fill several pages. Ultimately, these benefits manifest themselves in corals as dramatically-improved tissue growth, particularly after recently-sustained injury or illness. Again, this suggests that supplementation of vitamin C in fragmenting operations would be particularly beneficial, though every reef aquarist is always trying to get their corals to grow faster so there's no sense in limiting the scope of application to "fragging". It's worth mentioning that grow-out systems regularly dosed with vitamin C tend to have improved growth rates when compared to control systems with identical environmental conditions.

Vītamarin-C is a concentrated source of vitamin C in a stabilized form to maximize the supplement's effectiveness. We advocate beginning with a daily dosage of 1 drop per 10 gallons for the initial month of use, then gradually increasing the dosage thereafter as desired. You can expect to see a significant increase in the rate of tissue growth, particularly around the base of recently-fragged stony corals, with regular addition of this supplement. In our considerable experience with this supplement, it is arguably the closest thing to "instant gratification" that can come in a bottle in terms of the speed with which it acts on corals and their allies.

Supplement:	Vītamarin-M
Impact on Corals:	Provides substances required for sustained metabolic and neurological functioning

Vitamins are compounds required in minute concentrations for vital metabolic reactions. While many vitamins are synthesized by animals, the *quantities* generated are often insufficient to facilitate all of the biochemical reactions that vitamins mediate or take part in; this requires that the animal obtain vitamins from foods or from their immediate surroundings. The quantities of the various vitamins required for a given species varies. Short-term vitamin deficiencies can typically be tolerated by most organisms, however long-term deficiencies tend to result in abnormalities, poor health, and eventually even death of the specimen. Conversely, if severely overdosed, ingested vitamins can have a negative impact on a specimen by way of toxicity, though the impact is unlikely to be permanent. Decreasing the vitamin dosage typically results in full recovery of the affected specimen. Where does this leave us with regards to corals?

As with most things pertaining to the supplementation of complex organic substances, there is no definitive evidence documented (to our knowledge) that the presence of vitamins is crucial to the health of corals and their allies, *however* one can easily draw the conclusion that these substances, by their very definition, are certainly *required* by corals and that the vitamin profiles of planktonic organisms (particularly phytoplankton), upon which corals feed, strongly suggests that there are more benefits derived from capturing these organisms than simply utilizing the non-vitamin constituents provided. If this sounds like a drawn-out conclusion, one needs only look at the health of inhabitants in a system that is being supplemented with a quality vitamin blend; the appearance of everything from fishes to invertebrates is typically better than those organisms maintained in a more "sterile" environment. Many vitamins are unstable in water (unless preserved), and some are destroyed by exposure to intense light (photodegradation); because of this, it has been our experience that vitamins are most effective when employed as a soak for foods that are (again) applied to the system at night.

Vītamarin-M is a stabilized multi-vitamin solution that is formulated to have the same vitamin ratios as that of many marine bivalves, organisms that must obtain all of their nutrition from straining the surrounding water for plankton and other suspended particles. Because we are mainly interested in the application of Vītamarin-M as it pertains to coral care, we can focus dosing instructions on its' use as a soak for planktonic suspensions. To do this, we recommend combining 1 drop of Vītamarin-M per 8 drops of planktonic suspension to be added to the aquarium and allowing the resultant solution to mix in a clean container for at least 10-minutes prior to actual dosing. Dosing Vītamarin-M directly into the water will have positive benefits on all organisms that have the ability to take vitamins in directly, but this method is generally not as effective as is the application of the supplement as a food soak.

Briefly returning to the topic of using Kōralle-VM in lieu of Rēplenish and Vītamarin-M, the question of whether the aforementioned should be added directly to the water or used as a food soak may arise, since there is some conflict in the most effective means of use. The answer is that Kōralle-VM may be utilized either as a direct addition to the water *or* as a food soak, but the latter method has been observed to provide greater benefits to corals and other suspension-feeding invertebrates. Even though Kōralle-VM is weaker than both Rēplenish and Vītamarin-M, we recommend using the same dosage discussed above for Vītamarin-M.

Combining Supplements to Simplify Aquarium Care
As time passes, we're willing to bet that a number of readers employing this method of aquarium husbandry will start to tire of adding "x-drops of this, y-drops of that, z-drops of something else" on a daily basis. The solution (pun intended) is to combine compatible supplements in the proper ratios and volumes, and dose the resultant solution to the system either manually or by employing an automated or semi-automated dosing apparatus. *The key to making this work is simply to follow the more tedious steps of dosing each supplement individually each day until such time as the impacts that the supplements have on the system and inhabitants are understood and "optimal" daily dosages are determined.* In general, organic supplements are compatible with one another, so they can be combined in the same vessel with no fear of reaction. This also holds true for inorganic supplements that *are not* heavy on iodine, iodide, or carbonates (e.g. do not combine Lugol's, Iodion, or buffers with other supplements in the same mixing vessel, as reactions may occur that impact the viability of the resultant solution). Kōralle-VM should be combined with organic, rather than inorganic, supplements if this method is employed.

If combining supplements and then dosing the resultant solution without first diluting it into a larger volume of water[3], a four-step calculation is performed (this generally takes less than 2-minutes to perform): first, the ratios of each supplement used on a daily basis is determined; second, the ratios are combined; third, the ratios are divided by the sum of ratios to obtain a percent by volume; last, the % by volume is multiplied by the desired volume of the solution in order to determine how many ml of each supplement must be used. It sounds a little complicated at first but is really a straight-forward calculation that can easily be performed on paper or even whipped up using a spread sheet application.

Begin with the supplement that is used in the *least* volume and give it a value of 1. Then divide this volume (in ml) into the volumes of other supplements being used; the quotient (the result of the division calculation) is the ratio to the first supplement that should be present in the solution. Consider the following example of dosing on a fictitious 500 US-gallon aquarium system; for now, pay attention to the first two columns.

[3] It is recommended that this approach be used with organic supplements because of the means by which they are preserved, and diluting these supplements into a larger volume of water (as in a larger dosing vessel into which water is added) both decreases the preservative concentrations and introduces microbes to the solution; the result is the possibility of microbial decomposition of the solution. See the paragraph on automated/semi-automated dosing for additional notes on this topic. Compatible inorganic supplements may be combined in a larger solution with little chance of reaction.

Supplement	Daily Dose (ml)	Ratio	% by volume	Vol Req'd (ml)
CoralAminō	5.00	2.50	0.29	147.06
Kōralle-VM	5.00	2.50	0.29	147.06
Restōr	2.00	1.00	0.12	58.82
Vītamarin-C	5.00	2.50	0.29	147.06
Totals	**17.00**	**8.50**	**1.00**	**500.00**

In this case, Restōr is used in the least amount, and so it becomes the divisor in each calculation. In this simple example, the remaining supplements are added at 2.5x the volume of Restōr (5 ÷ 2 = 2.5), so each will be present at a concentration of 2.5x the amount of Restōr used in the solution; that is to say that if 10 ml of Restōr are used in the solution, then 25 ml each of CoralAminō, Kōralle-VM, and Vītamarin-C will be used.

Next, add the ratios together; in this example, their sum equals 8.5. Divide the ratio of each supplement by the sum of ratios to obtain the % by volume. In the table above, the calculated values are shown in the fourth column. The sum of % by volume should equal 1.0; if it does not, the calculation has been performed incorrectly.

Once the % by volume has been calculated for each supplement, simply multiply those values by the desired volume of the final solution. In this example, the volume of CoralAminō required is calculated by multiplying 0.29 x 500 to arrive at ~147 ml. Again, perform a check by adding the volumes together and making certain that they total the desired volume of the final solution; they should.

In this example we have decided that the final solution will have a volume of 500 ml, but the volume can be as large or small as the user wishes according to the number of days that they want the solution to last (e.g. 17 ml total of supplements are added each day in this example; to last 10 days, a solution of 170 ml would be required). Finally, the aquarium would receive 17 ml of this solution daily; this volume is simply the sum of individual volumes of supplements that had been dosed daily.

If using the solution in a dosing vessel to which water will be added, multiply the daily dosage volume of the solution by the number of days that the dosing vessel will be in operation, then top the vessel up with purified water to the desired overall volume. Compatible inorganic supplements can be combined with purified water far in advance (if desired) without much concern for precipitation reactions. By contrast, it is recommended that organic solutions not be mixed with water in larger batches than can be dosed within a 5-day period; this suggestion is made to maximize the longevity of the active ingredients once they are diluted into a larger volume of water (which necessarily changes the chemical characteristics of the solution). If it becomes necessary to mix a larger volume of the water/solution than can be dosed in this period of time (such as when taking an extended trip and leaving the system in the care of another party), it is recommended that this "dosing solution" be refrigerated until it is required to help slow the rate of decomposition.

Please refer to the following tables for dosing compatibility guidelines:

Magnesion/-P
Calcion/-P
Potassion/-P
Strontion/-P
Ferrion
Rēplenish
KoralColor
Reef Cōde A

Table 1: Inorganic supplements that may be combined in a mixing vessel and then dosed as one solution.

CoralAminō
Kōralle-VM
MaxAminō
Microvōre
PhytōChrom
PhytōGold-M
PhytōGold-S
PhytōGreen-M
PhytōGreen-S
Reef Snow
Restōr
Vitamarin-C
Vitamarin-M
Zooplanktōs-L
Zooplanktōs-M
Zooplanktōs-S

Table 2: Organic supplements that may be combined in a mixing vessel and then dosed as one solution.

Alkalin-8.3/-P
Reef Cōde B
Liquid Reef
Elemental
Kalk+2
Iodion
Lugol's

Table 3: Supplements that should generally not be combined with other supplements in the same vessel for the purpose of dosing.

Before moving on, we would like to briefly mention an observation that may be of considerable interest to a number of reef enthusiasts. Our research systems house a diverse assemblage of corals and their allies, including several colonies of *Tubastraea* sp. ("sun polyps"). For those unfamiliar with these corals, they are azooxanthellate and feed on zooplankton and particulate organic matter captured by their tentacles (which are, in most reef aquaria, extended only at night or near "dusk"); as such, these corals require feeding if they are to survive in captivity over the long term. In our systems, however, we have opted *not* to target feed them; rather, they receive dissolved organic material provided by dosing Vītamarin-C, Vītamarin-M, CoralAminō, Restōr, MicrōBacter[7], and Reef BioFuel. The interesting observation that we have made comes with regards to the growth of these *Tubastraea* colonies: they continually grow and reproduce. This observation suggests that the corals are obtaining sufficient organic material of the proper molecular composition to not only survive, but also to reproduce. Future experimentation of this "technique" with anemones and azooxanthellate soft corals and corallimorpharians is planned, and we will publish the results on our website.

Plankton and Zooxanthellate Cnidarians
Because the ultimate goal of this complex method of reef aquarium husbandry is to provide ideal nutrient conditions for corals and their allies, it is sensible to include a section on plankton and prey capture, as we believe that the dosing of planktonic suspensions is important to long-term survival of corals maintained in captivity.

Marine Biologists have estimated that a modest percentage (varying among species) of the nutritional needs of zooxanthellate cnidarians can be met by the capture of plankton (either directly using nematocysts or via mucous layers that trap plankton and other water-borne particles), however the majority of sustenance is obtained from organic material exuded by the zooxanthellae residing within the host's tissue. Nonetheless, considerable research has been performed on coral feeding; it is clear that a *substantial* amount of plankton is captured by both octocorals *and* scleractinians (this is determined in a number of ways, not the least of which is comparing the plankton abundance of water that is upstream and downstream of coral colonies). The collective evidence illustrates that active and/or passive feeding is indeed very important to zooxanthellate corals. Despite of this evidence (and somewhat paradoxically), there is a relatively well-defined division in the opinions of experienced aquarists as to whether or not the addition of plankton to a captive reef system benefits the corals at all. Our opinion is that it makes little sense for a related group of organisms that has been in existence for several million years to have retained feeding morphology enabling them to capture water-borne particles if they did not derive some considerable benefit from doing so; this is contradictory to the opinion that zooxanthellate cnidarians don't need to feed to survive.

At the risk of enraging experts on coral biology, we are going to make some generalizations (drawn from experience and thorough research) regarding corals and prey capture; note that there are always exceptions to generalizations.

- Research indicates that even when levels of irradiance on natural reefs are high, zooxanthellate corals continue to prey upon plankton.
- We are aware of at least one study showing that predation on zooplankton is positively-related to calcification rates in scleractinians.
- Zooxanthellate corals with short tentacles (e.g. "small-polyp stony" corals) tend to capture plankton with mucous present on the epidermis rather than with the nematocysts covering the tentacles themselves.
- Zooxanthellate corals with large tentacles (e.g. "large-polyp stony" corals) tend to capture plankton directly with nematocysts; research had previously suggested that that these species are less-dependant upon zooxanthellae for nutrition (presumably as a result of this tendency towards active prey-capture) than are corals with smaller tentacles, however recent research findings do not necessarily agree with the earlier train of thought.
- Soft corals are adept at capturing both phytoplankton and zooplankton.
- Azooxanthellate corals *must* be fed if they are to survive in captivity; they tend to feed primarily on relatively-large zooplankton and organic water-borne particles.

Given the points listed above and the fact that an aquarium is an artificial environment in which the physical and chemical conditions are not necessarily conducive to long-term survival of zooxanthellate cnidarians, providing the appropriate foods can do nothing but be *beneficial* to these organisms and can help them survive in occasional suboptimal conditions. In general, it has been our experience that zooxanthellate cnidarians maintained in systems receiving regular addition of planktonic suspensions have faster growth rates and stronger skeletons than those that are maintained in even the most brightly-illuminated, yet underfed, systems. Systems housing sponges, tunicates, suspension-feeding worms and sea cucumbers, and bivalves (both azooxanthellate *and* zooxanthellate) *require* dosing with *phytoplankton* suspensions if they are expected to survive over the long-term.

We currently offer 8 different planktonic suspensions: 5 are phytoplankton suspensions and the remaining 3 are zooplankton suspensions. What groups of organisms do these suspensions target?

Zooxanthellate Bivalves
Azooxanthellate Bivalves
Tunicates
Sponges
Suspension-feeding Worms
Suspension-feeding Echinoderms
Soft (Leather) Corals

Table 4: Groups of sessile invertebrates that consume phytoplankton.

SPS Corals
LPS Corals
Azooxanthellate Cnidarians
Anemones
Corallimorpharians with prominent tentacles
Zoanthidians (*Palythoa* and *Protopalythoa* sp.)

Table 5: Groups of sessile invertebrates that consume zooplankton.

Summary
In closing, we would like to make it clear that some degree of variation in observed results attained with the employment of this "system" should be expected; we are, after all, dealing with living organisms and some variability in biology and chemistry in each individual aquarium is inherent. This system presents an interesting and effective means of maintaining marine organisms in captivity, and the results can be very impressive. Additionally, the details involved with implementing this system require that aquarists become more knowledgeable about all aspects of aquarium husbandry, and this in itself nearly always results in improved success with regards to maintaining marine organisms in captivity. We wish all aquarists choosing to implement this system our best wishes for success, and stand by to answer technical inquiries (answers@brightwellaquatics.com) as they arise.