

smaller granules in another. This is not a problem if 100 percent of the bag contents is used at one time, but separation can result in solutions of varying chemical ionic composition when only a portion of the container's contents is used to make a sea salt mix. A quality sea salt manufacturer, such as Instant Ocean, will eliminate the potential for separation by pre-treating the chemicals—running them through a machine to crush or powder the chemicals. This treatment results in all the chemical compounds being nearly the same size, so that they do not separate during shipping.

c. Choice of chemical compounds.

The choice of chemical compounds can be crucial to the quality of the sea salt. Most chemicals are available in various grades of quality. To work down the scale of quality, there are grades such as Certified, Reagent, Food, Industrial, and Agriculture, to name a few. The higher the quality grade, the greater the purity of the chemical. At the top of the quality ranges, every batch of the chemical has been analyzed and there is a guarantee of exactly what is in the compound. The higher the quality, naturally, the more expensive the chemical.

For synthetic sea salt manufacturers, it follows that there is a compromise between making a sea salt that is affordable but that still contains as high a quality of the various chemicals as possible. No one can make a sea salt from 100 percent certified or reagent chemicals; the resulting product would be just too expensive. In general, a food-grade or equivalent chemical for the major compounds, such as sodium chloride, is sufficient. Compounds that are used in much smaller quantities can be reagent grade. However, some budget salts use low grades of nearly all the chemicals, so the resulting product may not dissolve quickly or it will contain impurities or a large amount of organics. Furthermore, lower-grade chemicals will vary more widely from

Table 1. Mean Concentration of the Major Ions or Constituents of Natural Seawater and Instant Ocean® Synthetic Sea Salt		
Ion	Natural Seawater	Instant Ocean
Sodium (Na ⁺)	10.781	10.780
Potassium (K ⁺)	0.399	0.420
Magnesium (Mg ⁺⁺)	1.284	1.320
Calcium (Ca ⁺⁺)	0.4119	.400
Strontium (Sr ⁺⁺)	0.00794	.0088
Chloride (Cl ⁻)	19.353	19.290
Sulfate (SO ₄ ⁻)	2.712	2.660
Bicarbonate (HCO ₃ ⁻)	0.126	.200
Bromide (Br ⁻)	0.0673	.056
Boric Acid (B(OH) ₃)	0.0257	—
Fluoride (F ⁻)	0.00130	.001

batch to batch. This fact means that the final sea salt product will also vary from batch to batch, which is a sign of poor quality control.

d. Matching natural seawater

The decision by a synthetic sea salt (SSS) manufacturer of how precisely to make its salt match NSW varies. At a minimum, a quality sea salt should not be deficient in the major cations and anions associated with NSW (see Table 1). Some sea salts (those that are for reef aquaria) are supplemented with extra calcium or strontium, for instance, because these elements are removed from the water by various reef building organisms. This type of variance from NSW is generally a good thing. Other sea salts are advertised as having extra levels of trace elements in their mix or packaged in a separate bottle to be added. This approach can be viewed as a plus or a minus, depending on the hobbyist's point of view. Many trace elements are nutrients at very low concentrations (parts per billion or less). However, these same elements are toxic at slightly higher concentrations (parts per million). Unfortunately, there is little solid research on the role, beneficial or detrimental, of most trace elements in aquaria. Trace elements in natural seawater and synthetic sea salts are discussed in detail in a later section of this paper.

Many sea salts have more buffering capacity compared with natural seawater, because pH is one aspect of a marine aquarium that will change more quickly than in the ocean, due principally to nitrification in the closed aquatic system. The chemistry of nitrification, the oxidation of ammonia to nitrite and then to nitrate, releases hydrogen ions into the water. The ion concentration consumes alkalinity and eventually causes the pH to drop. A more complete discussion of pH and alkalinity is presented in the next section.

Probably more important than matching NSW exactly is consistency from batch to batch, achieved in the mixing and blending steps of manufacturing. A superior sea salt will exhibit identical quality from batch to batch and from month to month, so that the end user can be assured of obtaining a consistent product. While this point may seem obvious, reports have shown that the blends of several salt manufacturers differ significantly from batch to batch. This variation is a sign of lax manufacturing and poor quality assurance.

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Advancing the Hobby of the Marine Aquarist

Aquaculture of Caribbean Corals for Restoration

by Craig A. Watson, School of Forest Resources & Conservation, University of Florida

In 2004, the United States Navy began redoing an old seawall in their harbor at Key West and quickly discovered that much of it was covered with corals. Some of the colonies measured several feet in diameter while others were much smaller. Working closely with the National Oceanic and Atmospheric Administration (NOAA) and the staff of their Florida Keys National Marine Sanctuary (FKNMS), teams attempted to salvage as much of this material as possible. They moved the larger pieces intact to several nursery and restoration sites nearby, and also sent word to several research entities that had expressed interest in corals.

The University of Florida's Department of Fisheries and Aquatic Sciences operates the Tropical Aquaculture Laboratory (TAL) in Ruskin, Florida, about 25 miles south of Tampa. The primary mission of the facility is to conduct research and extension education to assist the state's ornamental aquaculture industry, which has for some time been expanding its production to include marine species.

The TAL had already begun a partnership with The Florida Aquarium in Tampa, exploring aquaculture of Caribbean corals from the Keys. A collaborative team, working with the FKNMS director, developed a project that would look at two basic questions concerning aquaculture of corals for restoration: First, would corals produced in inland, indoor facilities survive if transplanted back into the wild? Second, could a process be developed for issuing a health certificate that would alleviate concerns that aquacultured corals might introduce disease if taken into the wild?

In April of 2006, parent colonies of seven species of corals were obtained from the FKNMS. The team divided the colonies into three equal pieces to supply coral fragments for three test sites: fragments immediately transplanted to a restoration site on Western Sambo reef, just off Key West; fragments to be grown in outdoor, flow-through seawater tanks at Mote Marine Laboratory's Summerland Key facility; and fragments to be grown in a greenhouse at the TAL, using a recirculating system and Instant Ocean® seawater.



Coral fragments being reared for reintroduction to the wild.

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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.

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SPECIAL EVENTS

- **Dallas/Fort Worth Marine Aquarium Society's Next Wave 2009**
January 24, 2009
Fort Worth Botanic Garden
Ft. Worth, TX
www.dfwmas.org/next-wave2009/registration.html
- **Third Annual Mid-Michigan Marine Club Frag Swap**
January 25, 2009
Fraternal Order of the Eagles Hall
Lansing, MI
www.michiganreefers.com/forums/showthread.php?t=66710
- **Marine Aquarium Expo**
April 3-5, 2009
April 3-April 5, 12 PM-6 PM
OC Fair & Event Center
Costa Mesa, CA
<http://marineaquariumexpo.com>



Bringing the
ocean home.

Ten fragments one inch square were made from each species for each test site. The team then attached each fragment to a concrete disk roughly three inches in diameter and half an inch thick, using a two-part Z-Spar marine epoxy. They attached a number to each disk, to permit tracking the progress of each fragment. They then immediately placed the fragments for the open-water segment of the trial on the rock surface of Western Sambo reef, where the grounding of a ship had severely damaged the reef. The remaining numbered fragments were placed in their tanks at Mote and the TAL.

The system at the TAL is simple, consisting of two long fiberglass culture tanks, a large sump, a one-ton chiller unit, a 3/4 horsepower pump, and current-generating Carlson surge devices for each culture tank. The fragments and their bases are raised so that they receive the direct blast of water from the surge device. The sump has a six-inch-deep (9.5 cm) bed of crushed coral to assist in maintaining hardness and alkalinity.



Preparation of coral fragments.

The water is made by mixing Instant Ocean® sea salt with reverse osmosis water, and a 50-75 percent water change is performed each month. Temperature has been maintained at 78 – 82° F (25.5 – 27.7° C), salinity at 33 ppt, and total hardness at 400 mg/l or greater. Weekly water-quality measurements include total ammonia, nitrogen, nitrite, nitrate, pH, total hardness, and total alkalinity.

The greenhouse is covered with shade cloth that allows approximately 10 percent of the sunlight to reach the culture tanks. Algae is controlled by using snails, and Peppermint shrimp are used to control *Aptasia sp.* Beyond the

NEW Packaging for Instant Ocean Sea Salt® and Reef Crystals®

Look for the new Instant Ocean Sea Salt® and Reef Crystals® packaging in stores soon. Instant Ocean Sea Salt and Reef Crystals are available in boxes, bags and pails from 10–200 gallons. For more information on specific sizes and product information, call **800-822-1100** or visit www.instantocean.com.

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Bringing the ocean home.

regular water changes and the crushed coral in the sump, there are no other additives or supplements introduced into the system, and growth and survival at the TAL has been consistent with expectations.

In December of 2006, the team reintroduced to the Western Sambo site 59 fragments from the TAL and 29 from Mote Marine Laboratory (MML). One fragment of each species from each site was sacrificed for histological analysis. Altogether, four fragments from TAL and 34 from MML did not pass health assessment (either because they failed as single fragments or they failed as a species), and those were not reintroduced.

Current research at the TAL and the Florida Aquarium includes long term monitoring of the Western Sambo restoration site, to continue the comparison of growth and survival in the three separate culture scenarios. In addition, researchers at the University of South Florida will be evaluating the flora and fauna of the mucous layers of these corals, using polymerase chain reaction (PCR) techniques. Meanwhile, researchers at Florida Atlantic University will be analyzing the genetic variations in two of the species in culture – *Montastrea cavernosa* and *Diploria clivosa*. This research is being

funded by the Florida Fish and Wildlife Conservation Commission through their Florida Wildlife Legacy program.

Although it is too early to judge the long-term outcome of these programs for reintroducing fragile corals into their natural habitats, preliminary data is showing positive results. We are optimistic and will enhance our efforts for higher levels of success.

Craig Watson joined the University of Florida in 1988. He was appointed director and research coordinator for the University's Tropical Aquaculture Laboratory in 1997.

MACNA XX

MACNA XX speaker Bruce Carlson, with Walt Smith and others, as they raffie off Marineland's new Marine Series aquarium and stand to banquet attendees.

Part 5: Science Behind Synthetic Sea Salts

From the Labs of Instant Ocean

Visit www.instantocean.com to read the earlier installments of this continuing article.

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5. Characteristics of a Quality Synthetic Sea Salt

a. Dissolvability
From a perception standpoint, dissolvability would seem to be the most important aspect of a synthetic sea salt. After all, customers want a sea salt that dissolves fast when mixed with water. However, producing the fastest dissolving salt that has all the right ions in the right concentrations is not as easy as it might seem. The reason is that some chemical compounds do not dissolve as fast as others. Furthermore, not all manufacturers use high quality chemicals in their sea salt. Chemicals of lesser quality contain more impurities. While such chemicals are cheaper, the impurities can cause turbidity problems in the final product.

Conversely, a manufacturer who wants a sea salt that dissolves really quickly could put more sodium chloride in the mixture, and perhaps less sodium sulfate and/or magnesium chloride—chemicals that may not dissolve as quickly. A salt of this type would not match natural seawater (NSW) in all ionic aspects, but it would dissolve quickly. That a salt dissolves quickly, therefore, does not necessarily mean it is the best salt for use in your aquarium.

b. Homogeneity of the mixture
The homogeneity of the mixture refers to the uniformity of the final product in the bag or bucket. Are the salt grains nearly all the same size or are there chunks of chemicals in the mix? The granules of the chemical compounds used to make sea salts are of different sizes. If left at their original sizes, the different compound granules will tend to separate during shipping from the manufacturer to the store and to the end-user's home. Separation means that the bigger granules accumulate in one zone of the package and the

Salinity, Specific Gravity and Units

The scientific definition of salinity is tedious and has been the subject of debate and measurements since first defined by Knudsen in 1902 (Pilson 1998). We need not get into the messy details and can settle, instead, for a practical definition: Salinity is the weight in grams of all the inorganic material dissolved in one kilogram (or 1,000 grams) of seawater. The units for this value can be ppt, g/kg or the symbol "‰/oo" (many oceanographers prefer a unit-less description of salinity due to grams/grams). Salinity is typically measured in an aquarium with an instrument called a refractometer. Thus, the sum of the values in the first column of values in Table 1 (page 4) represents the average salinity of the world's oceans, which is 35.169 ‰/oo.

A second method of measuring saltiness is by specific gravity and the use of a hydrometer. This method, in simple terms, measures the density of water and compares it to some standard. The standard is, by definition, the specific gravity of absolutely pure water at a temperature of 3.98°C which is 1.0000. As ions dissolve in water, the density of the water increases. At a salinity of 35.169‰/oo and a water temperature of 3.98°C, the specific gravity of seawater is 1.026 g/cm³. At the more normal temperature of a marine aquarium (25°C or 77°F), the specific gravity will actually read 1.023 g/cm³. Temperature affects specific gravity because water becomes less dense at its temperature increases. However, the effect is minor at normal aquarium temperatures.

While salinity and specific gravity measure different things, there is a relationship between the two: If you know one, you can generally calculate the other, as long as you know the water temperature. Fortunately, one need not do the calculation, because there are tables available that convert salinity to specific gravity (or vice versa). Furthermore, many of the instruments used to measure one value include a measurement scale for the other.