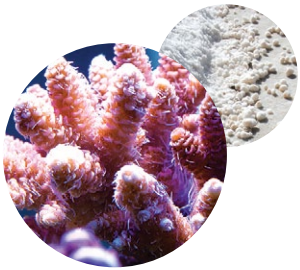
COMPLETE
REEF CARE PROGRAM

Complete solution for
optimal coral health, accelerated coral growth
and enhanced coral coloration

Red Sea

Reef Foundation Program



The Foundation Elements (Ca, KH & Mg)

A successful coral reef aquarium is dependent upon maintaining the appropriate water parameters that in turn provide the stable environment required by the corals. Although all the elements found in natural seawater have an important role in providing the optimal water parameters, a few of them have a more significant role in the overall stability. These elements are the foundation of the reef environment and they include the three major elements, Calcium (Ca), Magnesium (Mg) and Bicarbonates (HCO_3). These 3 elements have a major effect on the water chemistry (pH stability, Alkalinity, sea water ionic strength) and on many of the coral's biological processes (skeleton formation, ions exchange, photosynthesis).

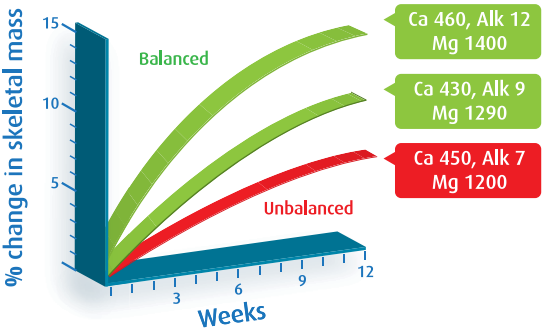
Skeletogenesis

Skeletogenesis is the process by which special cells within the corals soft tissue, combine the foundation elements together with Strontium and Barium from the surrounding water to form the building blocks of coral skeletons.

Corals build approximately 90% of their skeleton by combining Ca and CO_3 ions from the water to form Aragonite ($CaCO_3$). The rest of the skeleton is made up from Magnesite ($MgCO_3$), Strontianite ($SrCO_3$), Calcite (a more brittle crystal structure of $CaCO_3$), Fluorite (CaF_2) and other minor and trace minerals.

In unbalanced conditions such as low levels of Mg and/or Sr the skeleton will develop with a higher proportion of Calcite making it more brittle and more susceptible to damage.

The foundation elements complement each other in the formation of coral skeleton and if not available in the correct ratios one of them will quickly become the limiting factor of healthy coral growth.

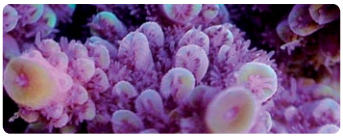


Seriatopora guttattus growth rates in different CA^{2+} (ppm) and Alkalinity (°dKH)

Coral Growth

Corals need to invest energy in transporting the foundation and other elements necessary for skeletogenisis from the surrounding water through their soft tissue. Elevated levels of the foundation elements create a more positive ionic pressure enabling passive diffusion of the elements through the soft tissue making this process much more efficient (less energy required per gram of skeleton). Therefore balanced elevated levels of the foundation elements will result in accelerated coral growth rates.

In mature systems where accelerated growth is not desired or when aiming to enhance coral coloration by reducing the levels of algae nutrients, lower balanced levels of the foundation elements should be maintained.



Optimal levels of the Foundation Elements

Unlike the natural reef environment, where there is an immense reservoir of the foundation elements, the reef aquarium is an artificial environment that is constantly affected by chemical changes and therefore the foundation elements must be monitored and replenished constantly. Furthermore, research has shown that the optimal levels of these elements should be maintained according to the variety and maturity of the specific coral population.

Choose the optimal levels according to the most demanding species in your aquarium.

Optimal levels of salinity KH, Ca & Mg according to type of aquarium:

Aquarium Type	Salinity (ppt)	Alkalinity (dKH/meq/L)	Ca (mg/L)	Mg (mg/L)
Soft Corals	33	8.2 / 2.9	430	1280
LPS Corals	33	12.1 / 4.3	440	1310
SPS Corals, Frags / Clams - Accelerated growth	35	12.6 / 4.5	465	1390
SPS Corals - Mature / Low nutrient / Enhanced coloration	35	8.2 / 2.9	430	1310

Reef Foundation Supplements & Test Kits

Supplements

Reef Foundation A – Contains Calcium, Strontium & Barium in the ratios as found in coral skeleton. [1ml will raise the Ca level of 100 liters (25 gal) by 2ppm]

Reef Foundation B (Alk) – is a complex of carbonate and other buffers present in seawater that maintain proper alkalinity and pH. [1ml will raise the alkalinity of 100 liters (25gal) by 0.036 meq/l (0.1dKH)]

Reef Foundation C (Mg) is a blend of Magnesium salts. [1ml will raise the Mg level of 100 liters (25gal) by 1ppm]

Reef Foundation ABC+ Contains Calcium, Strontium, Barium, Bicarbonates, Magnesium, Potassium, Boron, Iodine & Bromine formulated in the exact ratio as found in the coral skeleton. This unique powder supplement simplifies the daily dosing of more than just the foundation elements and is recommended for aquariums up to about 300 liters / 75gallons.

Reef Foundation A, B & C are available as liquid supplements in 500ml bottles and include a measuring cup for easy dosing. 1kg powder supplements are available for larger aquariums.

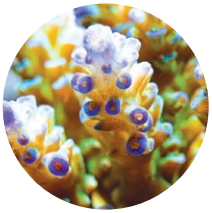
Test Kits

The **Foundation test kits** include **Calcium, Alkalinity & Magnesium** as individual tests and the Reef Foundation Pro kit which combines the 3 individual tests in one convenient to use kit. All of the foundation kits include analytical grade glass vials and an easy to use, single hand, high precision Titrator.

Test Name	Element	Accuracy	Range	Test Type	No. of Tests
KH/ Alkalinity Pro	KH	0.05 meq/l	∞	Titration	75
Calcium Pro	Ca	5 ppm	∞	Titration	75
Magnesium Pro	Mg	20 ppm	∞	Titration	100

Algae Management Program

Coral's Symbiotic Zooxanthellae Algae



Understanding the role played by the symbiotic Zooxanthellae algae and their relationship with the coral is essential for successful implementation of the algae management program.

In nature corals host Zooxanthellae populations at densities of 0.5 - 5 million/cm^2 that are located inside the coral soft tissue. The corals derive approx 85% of their energy from the Zooxanthellae and produce the remaining 15% in their soft tissue by metabolizing coral nutrients (Carbohydrates, Amino and Fatty acids) that are available in the surrounding water. This energy fuels all of the corals' metabolic processes such as protein production and skeletogenisis.

The Zooxanthellae use the strong sunlight on the tropical reef as their primary energy source and pass on up to 95% of their photosynthesis products (Carbohydrates, Amino and Fatty acids) to their coral host, utilizing the balance for their own metabolic processes. The coral host provides the Zooxanthellae with nutrients, nitrogenous compounds, phosphates and CO_2. It is this symbiotic relationship, involving the recycling of nutrients, that is the key to the ecological success.

Another aspect of this symbiosis relates to photo-protection from strong radiation. In nature, the Zooxanthellae protect the corals from intense UV radiation by absorbing the light energy and shading the delicate inner layers of the coral soft tissues.

In nature the Zooxanthellae population is controlled by the algae nutrients (nitrates and phosphates) excreted by the coral, however in an artificial reef aquarium the amount of algae nutrients accumulate rapidly and if left uncontrolled will induce an over-density of the Zooxanthellae populations.

The high nutrient induced over-density of the Zooxanthellae population disturbs the natural balance causing competition between the Zooxanthellae and the coral for the available resources such that without additional nutrition the coral may become undernourished. Furthermore the increase in Zooxanthellae population causes the corals to become darker with a deep brown tint that obscures the natural vivid pigments of the coral. Higher Zooxanthellae population densities within the acceptable range will however provide the coral with the energy required for accelerated coral growth.

Reducing the algae nutrients in the water will reduce the Zooxanthellae population to the level that can only be supported by the algae nutrients supplied directly by the coral.

Under these conditions the coral will receive less energy from the Zooxanthellae and will have less protection from the UV radiation. In this situation, if suitable coral nutrients (Carbohydrates, Amino acids and Vitamins) are readily available in the water, the soft tissue of the coral can increase its internal production of energy and assuming the necessary trace elements are available in the water, the coral will increase its natural UV protection by enhancing pigmentation of the soft tissue which is seen as enhanced coloration

Algae Nutrient control

Micro-biological reduction of algae nutrients (nitrates & phosphates) occur naturally in all anoxic areas of the aquarium (inside live rocks, porous filter media and substrates). Supporting the natural processes by regular dosing of a suitable carbon source and mineral co-factors provides an easy and reliable method of incremental control of the algae nutrient levels to safely control both the presence of nuisance algae and the population of the symbiotic Zooxanthellae.

Supplements

NO_3:PO_4-X

NO_3:PO_4-X is a unique complex of carbons that are used by nutrient reducing bacteria. Each carbon in the complex is utilized by different strains of microorganisms while ensuring the specific Carbon:Nitrogen:Phosphorus ratio required for each stage. The complex includes other organic bonded elements that are important stimulators in each stage of the reduction process. These metal and non-metals elements ensure steady bacterial propagation and complete nitrate reduction to nitrogen gas and the absorption and utilization of phosphate by the bacteria.

The fine control of the nitrate and phosphate levels provided by monitored dosing of NO_3:PO_4-X guarantees the gradual changes and accurate maintenance of the nutrient levels, preventing destruction of the Zooxanthellae population that can cause UV shock and starvation of the corals.

Unlike some other low-nutrient regimes, correct use of NO_3:PO_4-X will maintain all of the micro fauna that are beneficial for the reef.

NO_3:PO_4-X is also recommended as a complete carbon source for use with carbon based de-nitrators.

NO_3:PO_4-X is available in 500ml and 1000ml bottles and includes a measuring cup for easy dosing.

Test Kits

Algae Management Test Kits

Red Sea's **Nitrate & Phosphate Pro Test Kits** with an easy to use colorimetric comparator, provide the high accuracy required for the accurate dosing of NO_3:PO_4-X enabling complete control of algae nutrient levels. The Algae Control kit combines the two individual tests in one convenient to use kit.

Test Name	Element	Accuracy	Range	Test Type	No. of Tests
Nitrate Pro	NO_3	0.125 ppm	0-64 ppm	Comparator	100
Phosphate Pro	PO_4	0.02 ppm	0-5 ppm	Comparator	100

Comparison of various methods for Nitrate & Phosphate reduction:

Reduction methods	NO_3 reduction	PO_4 reduction	Controlled reduction	Essential equipment	Technical comments
NO_3:PO_4-X	Yes	Yes	Yes	Protein skimmer	Researched and tested formula that includes all of the necessary elements for the balanced and controlled, long term reduction of both NO_3 & PO_4 without the need for reactors or replacement media.
VSV (Vodka + Sugar + Vinegar)	Yes	Yes	Yes	Protein skimmer	Rapid reduction of NO_3 and PO_4 however over the long term, a lack of essential elements will reduce effectiveness and may lead to the collapse of the bacteria population. System can produce H_2S which is toxic for corals and fish.
Vodka or Ethanol	Yes	No	No	Protein skimmer	Rapid reduction of NO_3 but does not reduce PO_4. If not combined with additional PO_4 reduction the N:P ratio will be disturbed leading to outbreaks of cyanobacteria. Over the long term a lack of essential elements will reduce effectiveness and may lead to the collapse of the bacteria population. System can produce H_2S which is toxic for corals and fish.
De-Nitrators	Yes	No	No	De-Nitrification reactor	Rapid reduction of NO_3 but does not reduce PO_4. If not combined with additional PO_4 reduction the N:P ratio will be disturbed leading to outbreaks of cyanobacteria. Carbon Systems: Inherently unstable and difficult to regulate. System can produce N_2O and H_2S which is toxic for corals and fish. Over the long term a lack of essential elements will reduce effectiveness and may lead to the collapse of the bacteria population. Sulphur Systems: Relatively low maintenance however they easily become clogged and can cause sudden pH drops.
NO_3 / PO_4 removers	Yes	Yes	No	Media reactor	Rapid but uncontrolled reduction of NO_3/PO_4 that can easily cause stress to corals. Some products such as Zeolite/ Ferric Hydroxide ion exchangers typically release undesirable cations. Lower quality products may also release undesirable metals (Al, Fe).
Refugium	Yes	Yes	No	Refugium	Low maintenance but slow and uncontrolled NO_3/PO_4 reduction. In the event of collapse of the algae population allelochemicals (toxins for corals) are released to the system.

Coral Coloration Program

Red Sea's research has identified 31 minor and trace elements that in addition to the foundation elements are present in the skeleton and soft tissue of all corals. The Coral Color supplement family divides these elements into four groups (**Coral Colors A, B, C & D**) that are related by the biological functions they perform and are also associated with the production of specific color pigments in the soft tissue of stony corals. These pigments can only be produced if the specific elements required for the bio-chemical process are available in the correct concentration. All 31 elements are required by all stony corals irrespective of the actual color the coral displays.

Supplementing to a measured uptake

Coral Colors supplements have been formulated such that the ratio of the elements in each supplement is the same as that found in the skeleton and soft tissue of corals. Our research has identified a constant ratio between each of the Coral Colors and the overall consumption of calcium, which is proportional to coral growth and metabolic activity. This provides an easy and safe method of dosing all Coral Colors Supplements based on a measured calcium uptake.

Coral Colors A, B & C each contain a leading element (Iodine, Potassium & Iron) that is accurately measurable with Red Sea's unique Coral Colors Pro test kits. For more advanced LPS and SPS aquariums Colors A, B & C can therefore be dosed precisely according to the total demand of the reef for these elements.

Test Kits

Coral Colors Test Kits

Iodine Pro Test Kit – 50 high accuracy colorimetric tests with an accuracy of 0.01 ppm for the precise dosing of Coral Colors A supplement

Potassium Pro Test Kit – 40 high accuracy titration tests with an accuracy of 3 ppm for the precise dosing of Coral Colors B supplement

Coral Colors Test kit (I,K,Fe) combines 3 individual tests in one convenient to use kit for the precise dosing of Coral Colors A, B & C supplements.

Test Name	Element	Accuracy	Range	Test Type	No. of Tests
Iodine Pro	I_2	0.01 ppm	0-0.09 ppm	Colorimetric	50
Potassium Pro	K	3 ppm	150- 450 ppm	Titration	40
Iron Pro	Fe	0.05 ppm	0-0.5 ppm	Colorimetric	45

Coral Colors Supplements

Supplements

Coral Color A - Complex of halogens (Iodine, Bromine and Fluorine). The halogens act both as antioxidants and oxidative agents within the soft tissue and mucus layer of corals, reducing the possibilities for coral bleaching. In active reef system these elements are depleted very quickly due to their high oxidative abilities and reactivity with organic materials. Iodine and bromine are related to the pink chromo-protein (pocciloporin)

Coral Color B - Complex of Potassium and Boron. Potassium has an essential role in the transportation of coral nutrients within the soft tissue including the nutrients provided by the Zooxanthellae. Potassium and boron have a significant effect on the alkalinity inside the coral soft tissue and play a role in the formation of aragonite in the coral skeleton. Potassium is related to the red chromo-proteins.

Coral Color C - Complex of 8 "light" metals that includes Iron, Manganese, Cobalt, Copper, Aluminum, Zinc, Chrome and Nickel. Essential micro-elements with fundamental roles in many bio-chemical metabolic processes including respiration and production of energy, chlorophyll and photosynthetic catalysts. C elements are related to the green/yellow chromo-proteins.

Coral Color D - Complex of 18 trace elements. These 18 elements (out of all the trace elements in NSW) participate in different metabolic processes inside coral skeleton and soft tissue. D elements are related to the blue/purple chromo-proteins.

All Coral Colors Supplements are available in 500ml bottles and include a measuring cup for easy dosing.

KH Coralline Gro

Supplements

Coralline algae will grow naturally, without any special supplements in all reef systems optimized for hard corals. To promote coralline algae in fish only or soft coral aquariums the alkalinity needs to be maintained at approximately 3 meq/L (8.4 °dKH) and specific minor and trace elements need to be readily available.

KH Coralline Gro is a complex of carbonate buffers, potassium and trace elements such as iron formulated in the ratio taken up regularly by the coralline algae. KH Coralline Gro should be used instead of Reef Foundation B (buffer) supplement during the cycling of all new marine aquariums and on an ongoing basis in fish-only or soft corals systems. KH Coralline Gro should be dosed according to a measured drop in alkalinity with Reef Foundation KH/Alkalinity Pro test kit.

KH Coralline Gro is available in 500ml bottles and includes a measuring cup for easy dosing.

Coral Nutrition Program

Most of the corals in reef aquariums are considered to be photosynthetic as they recieve the majority of their energy requirements from their photosynthetic, symbiotic Zooxanthellae algae. In nature these corals derive approx 85% of their energy from the Zooxanthellae and produce the remaining 15% in their soft tissue by metabolizing nutrients that are available in the surrounding water.

It is therefore essential to provide a balanced mix of the carbohydrates, vitamins, amino & fatty acids to meet the corals energy demands. The amount of coral nutrients required will be dependent on the type of corals stocked. The nutritional requirements of SPS corals in particular are also dependent on the levels of algae nutrients (nitrate & phosphate) in the water. In reduced algae nutrient systems e.g. when using Red Sea's NO_3:PO_4-X, the amount of energy the corals receive from the Zooxanthellae is significantly reduced and therefore higher levels of coral nutrients must be provided to meet the corals energy demands.

Due to undesirable interactions between the various components necessary to meet the complete nutritional requirements of the corals, Red Sea's Reef Energy nutrition program is divided into 2 complimentary products.

Supplements

Reef Energy A is a unique formulation of carbohydrates, amino acids, fatty acids and suspended proteins flocks that are available for direct consumption and absorption by the corals. Every component has been proven to be utilized in the metabolic processes of coral protein production and soft tissue regeneration and therefore does not introduce any unnecessary organic material to the system. Reef Energy A stimulates extension of the polyps and soft tissue helping the coral to optimize nutrient consumption by expanding its surface area for absorption.

Reef Energy B is a highly concentrated complex of Vitamins & Amino acids that were found to be the limiting factors in the nutritional demands of corals and other invertebrates. This complex replenishes the exact vitamins and MAA (marine amino acids) produced by Zooxanthellae. Vitamins are important precursors in the synthesis of chromo proteins while the amino acids are their building blocks. All of the components of Reef Energy B come from marine sources and are emulsified in a unique medium that enhances their solubility and absorption of the vitamins and acids by the corals.

Reef Energy A & B are available in 500ml bottles and include a measuring cup for easy dosing.

Enhanced Coloration or Accelerated Growth?

It is widely accepted that there is a narrow spectrum of water conditions that are suitable for keeping corals. Red Sea's research into the long term physiological demands of SPS, LPS & Soft Corals in the reef aquarium has shown that enhanced coloration and accelerated growth require significantly different water conditions.

It is relatively easy to maintain the conditions for accelerated coral growth. Maintaining the conditions for enhanced coloration is more demanding in that it requires a higher level of attention to the water parameters. It is theoretically possible but not recommended to achieve both accelerated growth and advanced coloration simultaneously as the system will always be on the edge of instability.

The complete Reef Care Program provides advanced reef keeping solutions for all levels of hobbyists, with detailed instructions on achieving optimal water parameters for all types of reef aquarium.

Recommended water parameters for accelerated coral growth

- Algae nutrient levels of 1 – 2 ppm nitrate and 0.1 ppm phosphate; to maintain a relatively high population of Zooxanthellae that will provide enough energy to the corals for growth.
- Boosted and balanced levels of the Foundation Elements [Alkalinity 12.6dKH / 4.5meq/L, Ca 465ppm, Mg 1390ppm] to properly utilize all of the extra energy
- Availability of the minor and trace elements (Coral Colors) taken up by the corals during growth [I2 0.06ppm, K 410ppm, Fe 0.15ppm]
- Sufficient coral nutrients (Reef Energy) to supplement the energy supplied by the Zooxanthellae [2ml of Reef Energy A & B per 100Liter/25gal]

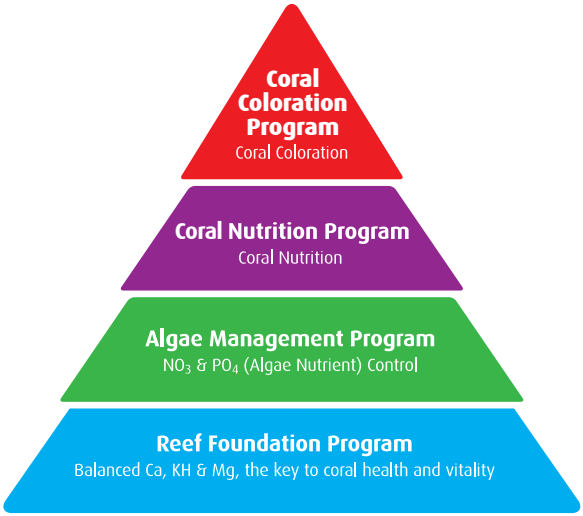
Recommended water parameters for enhanced coloration

- Algae nutrient levels of 0.25 ppm nitrate and 0.02 ppm phosphate; to maintain a reduced level of Zooxanthellae, reducing the brownish tint of the corals and inducing the protection response of enhanced coloration.
- Reduced levels of the Foundation Elements [Alkalinity 8.2dKH / 2.9meq/L, Ca 430ppm, Mg 1310ppm]to lower the energy demand from coral growth
- Availability of the minor and trace elements (Coral Colors) used in the soft tissue for increased coloration [I_2 0.06ppm, K 380ppm, Fe 0.15ppm]
- Increased coral nutrients (Reef Energy) to provide the additional energy that the coral needs to receive from the environment [4ml of Reef Energy A & B per 100Liter/25gal]

Complete Reef Care Program

Complete solution for:

- Optimal coral health
- Accelerated coral growth
- Enhanced coral coloration



The complete Reef Care Program is the result of years of research into the physiological demands of SPS, LPS & Soft Corals in the reef aquarium. The program has been divided into 4 distinct but complimentary sub-programs according to the various biological processes that take place.

- **Reef Foundation Program** – Provides biologically balanced levels of the foundation elements (Calcium, Carbonates and Magnesium) that ensures the optimal water conditions for a sustainable, vibrant coral reef.
- **Algae Management Program** – Controlled nitrate & phosphate reduction that prevents nuisance algae and provides the fine control of Zooxanthellae populations that significantly affect coral growth rates and coloration.
- **Reef Nutrition Program** – Provides the carbohydrates, vitamins and amino acids that fuel all metabolic processes of corals.
- **Coral Coloration Program** – Provide the essential minor and trace elements that are part of the coral skeleton and soft tissue and are specifically important for SPS corals to display their natural pigments.

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