The Unnoticed Reef Builders

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Acetabularia crenulata LAMOUROUX

Laurencia poetii HOWE

Most divers, photographers and snorkelers ignore a vital part of the reef life when diving. Many people, attracted by the movement of bright colored tropical fish, crustaceans lurking under rocks or the spectacular forms of colorful corals, overlook the starting point in the food chain, the plants. Without plant life to convert food energy from sunlight, there would be no animals. Herbivores require plants for their source of energy and in turn are preyed upon by carnivores — and this sequence or chain ultimately affects and includes humans.

Throughout the world, seaweeds have been utilized for centuries by humankind. Some species of marine algae form the base of multimillion dollar industries, both in the USA and more often abroad, involving alginate, carrageenin and agar production. Such algal extracts are found in many commercial foods that require stabilizers or emulsifiers (chocolate milk, ice cream, tooth paste); others are used in cosmetics, lotions, soaps, insecticides and medicines. They are also used as clarifying agents in the production of beer.

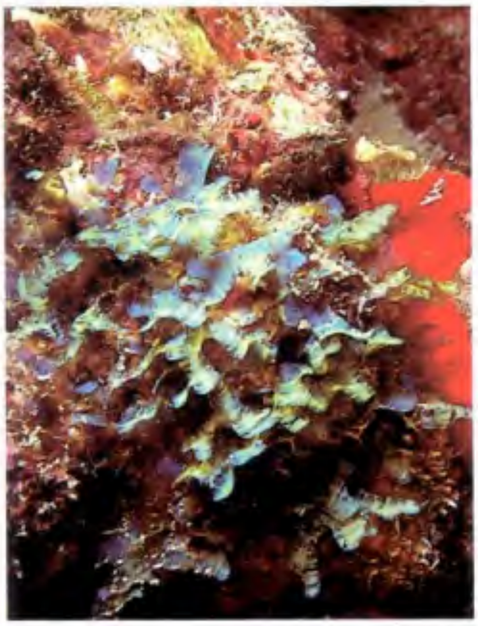
Although whole algae are eaten only occasionally in the continental USA (algal "sea sprouts" may become available in some Florida groceries soon), they have long been utilized in the Orient and Hawaii as an important food source. In the Far East, they are farmed commercially and served in sandwiches, crackers, soups and many other foods. They are dried and used as fodder for cattle, fertilizers (due to a very high potash content) and soil conditioners in Europe.

Since algae are involved in many aspects of our daily lives, let us take a closer look at the marine plant kingdom. Any diver or snorkeler is aware of the vast contrast between the terrestrial and marine environments. The plants of these two realms are as totally different as the habitats in which they live. The most dominant and successful photosynthetic organisms on land are the vascular plants; however, these abundant terrestrial organisms are, with few exceptions, absent in the oceans. Instead, tropical seas are inhabited by an enormously diverse group of non-vascular plants collectively referred to as algae.

More than 90% of all marine plants are algae (seagrasses, which are vascular plants, are the exception), ranging in occurrence from low growths on upper intertidal rocks to depths of more than 900 feet. Whereas most land plants possess chlorophyll as their dominant photosynthetic pigment and reproduction is generally accomplished by seed production (exceptions are fungi, mosses and liverworts), the larger seaweeds most often encountered in tropical waters belong to three major phyla which are characterized by various combinations of specialized pigments.

The Chlorophyta (Greek: *chloros* green + *phyton* = plant) or green algae, such as *Acetabularia, Halimeda, Bryopsis* and *Anadyomene*, are believed to be the predecessor of land plants and also have chlorophyll as the dominant pigment.

Polycavernosa debilis FREDERICQ and NORRIS



Dictyota bartayresii LAMOUROUX

Phaeophyta (*phaios* = Greek for brown, hence brown algae such as *Sargassum, Turbinaria* and *Dictyota*) possess the dominant brown pigment fucoxanthin. The Rhodophyta *(rhodon* = roses) are the red algae comprising the largest and most diversified group (with more than 4,000 members, such as *Amphiroa, Laurencia* and *Titanoderma*) and contain large quantities of the red pigment phycoerythrin.

Identification of the group to which a particular alga belongs is not solely dependent on the color, which can be highly variable and affected by environmental factors such as shading, depth and various other conditions. However, color is a very practical starting point, as long as one appreciates that there may be numerous exceptions and variations.

Along with their unique and striking colors, algae can be quite complex in terms of structure (internal and external anatomy) and the presence of very intricate life cycles. Unlike most land plants, some algae can have one appearance during their gamete-forming phases (i.e. during sexual reproduction, requiring male and female structures) and completely different forms in the asexual or spore-producing reproductive phases. This kind of life history is referred to as alternation of generations. These separate phases sometimes appear similar to each other; however, some are so different in form that plants have been given two or more separate names by scientists who did not recognize them as phases of the same species.

Algae are important in the oceans not only for their food value — for example, in the Caribbean they are the predominant contributor of beach sand. The major tropical sediment producer is the green alga *Halimeda* which consists of calcified segments connected by flexible filaments looking much like a miniature prickly pear cactus without spines. When the alga dies or when parts are ripped or torn away by storms or rough seas, the segments slowly erode and disintegrate to form sand grains. The sparkling white sand beaches of the Caribbean and many other areas in the world are largely the sun-bleached calcium-carbonate skeletons of algae.

Some species, such as *Dictyota* (a brown alga, although sometimes showing a distinct bluish fluorescent color), have been found to possess toxic chemicals that deter predators from ingesting large quantities. Many chemists have been working with seaweeds because of their ability to synthesize or incorporate certain very different and unique chemicals that have shown potential use as new pharmaceutic agents or have other economic value.

The calcareous red algae are one of the most important groups in the world's warm oceans. Without certain species of calcareous reds, most reefs would not exist. People generally think of coral reefs as composed only of corals, but that is only part of the picture. We prefer the term "biotic reefs" or just reefs when referring to these complex marine structures, since the coral animal's role is mainly that of providing the bulk material, similar to bricks in construction. A large pile of loose bricks does not really build any structure — the cement holding everything together is actually what makes it

Sargassum polyceratium MONTAGNE

Mark and Diane Littler measure primary production rates of marine algae.

all work, and algae are the principal cementing agents of tropical reefs.

In fact, many corals are not solely animals, but possess microscopic algae (called zooxanthellae) in their soft tissues. This is a symbiotic relationship benefiting both host and resident that is required for the survival of many reef building corals.

Another example of reef-building is observed in the crustose coralline algae, such as *Titanoderma,* which lives on older dead coral heads or on coral fragments and slowly cements the large fragments together by depositing calcium carbonate within their growing tissues. Other corallines are so resistant to wave shock and the shearing power of huge breakers that they are the only organisms that can withstand the tremendous power of the waves on oceanic islands. Within extremely high energy systems, corallines can form an "algal ridge" which absorbs wave energy and thereby protects the more delicate corals, fleshy algae and sponges that inhabit the protected lagoons or back reef habitats. Many species, such as *Amphiroa,* which are hard stoney algae that form small branching heads, also act as cementing agents as well as providing sedimentary materials on the reef.

Foliose algae (fleshy upright forms) provide essential habitats for many small invertebrate animals and fishes — for example, nesting areas where animals deposit eggs and live out their juvenile life phases. Other animals find protection from predators within miniature algal forests; some species have developed cryptic coloration and blend with the plants so a predator has difficulty locating them. Consequently, the marine plants comprise very important nursery grounds for many of the sea's benthic animals.

As a result of many years of research, we have developed a scientific theory that enables one to make predictions concerning the survival mechanisms and ecology of a given marine plant by just examining its external growth form. The basis for this theory is as follows: If an alga is very thin and sheet-like, such as *Anadyomene,* or finely filamentous, as in the case of *Bryopsis,* it usually has a high photosynthetic rate, rapid growth, a high caloric value (energy content) and can be an early colonizer of newly disturbed substrates.

Conversely, algae such as *Sargassum* or *Turbinaria,* which are both tough and leathery, tend to be less palatable to herbivores, are slower growers, have lower caloric values, do not normally colonize new substrates rapidly and have lower photosynthetic rates. An even further extreme is shown by the group of calcareous crusts, such as *Titanoderma,* which are rock hard (and therefore very difficult for fish to graze), very slow growers, slough off outer layers of surface cells (continually eliminating any other organisms from settling and growing upon them) and tend to show very low caloric contents and photosynthetic rates.

Caulerpa racemosa J. AGARDH

The point is that a whole spectrum of complex costs and benefits exists which is related to survival and often revealed by simply observing an alga's growth-form or shape. This approach has been used for long-term biological monitoring to indicate the presence of large-scale environmental changes in the case of natural disturbances or human-induced events, to predict how an unknown community might develop and function, as well as for numerous mariculture applications.

Algae come in an incredible array of spectacular shapes, sizes and colors and provide very exciting subjects as yet unexploited by the underwater photographer. While most people ignore these fascinating plants, we hope to bring them to the attention of the diving public and to help improve understanding of the vital role marine algae play in the biotic reef system.

About the Authors

Drs. Mark and Diane Littler are marine scientists who have developed a unique husband and wife working relationship. Their mutual interests and aspirations in the field of marine botany provide the foundation from which two jointly productive research careers have been based. Backed with an array of credentials and research accomplishments, the Littlers have established themselves as experts in the study of marine algae.

Their research has taken them around the globe, including field work in the Belize Barrier Reef Islands, French Polynesia and the Galapagos Islands. They have collectively published more than 80 research papers in scientific journals, made numerous contributions to textbooks and presently hold editorial positions with three internationally renowned journals.

Mark Littler is presently chairman of botany and senior botanist with the Smithsonian Institution in Washington, D.C.

Diane Littler has been a research associate with the Universities of Hawaii and California and currently is a research associate at the Smithsonian Institution. In addition to her abilities as a marine scientist, Diane Littler has developed a proficiency in underwater photography — a sample of her work will be featured in their soon-to-be-released field guide to tropical marine algae.

As a team, the Littlers' current research interests are directed towards the stability of marine ecosystems, the productivity and evolution of marine plants and the analysis of plant morphology as a method of predicting its ecological role in the reef community. They have been instrumental in formulating some of the most recent theories in marine botany, including the evolutionary and ecological significance of algal form/function relationships.

They recently generated excitement in the scientific community with their discovery of what is, to date, the deepest plant life ever collected from the ocean. This crustose red alga was found in the Bahamas at a depth of 880 feet. A description of the finding was published in the journal Science. Discoveries of this type are important because they extend the depth distribution limits of marine plants and challenge established theories concerning the minimum light levels necessary to maintain plant growth.

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