

Seaweed Aquaculture Provides Diversified Products, Key Ecosystem Functions

Part I. Lesser-Known Species Group Tops Mariculture Output



When harvesting nori, specialized boats go under the nets. The red seaweed *Porphyra yezoensis* is processed into wrappers for sushi rolls and nutritious snacks.

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Summary:

Seaweeds play key roles in Earth processes and are the world's largest mariculture crop. They are primary producers and links in the food webs of coastal and estuarine ecosystems, and are used in many applications that affect our everyday lives. About 220 species of seaweeds are cultivated worldwide, primarily in Asia. It has been estimated that the productivity of seaweed communities is equal to or greater than that of the most productive terrestrial plant communities.

Seaweeds belong to one of the less known and appreciated groups of marine organisms on this planet, while playing key roles in Earth processes and being the largest mariculture crop. They are used in many diverse applications, making them part of our everyday lives.

You may start your day with seaweeds in your orange juice, where a microscopic mesh of carrageenans extracted from red seaweeds keeps the pulp in suspension. You may also end your day with seaweeds, as your toothpaste would be a liquid without alginates extracted from brown seaweeds.

Roles In Nature

Did you know that every second molecule of oxygen we inhale was produced by micro- or macroscopic algae, and every second molecule of carbon dioxide we exhale will be reused by these algae? Algae initiated an irreversible global change that led to the current oxygen-rich atmosphere, and by transferring atmospheric carbon dioxide into organic biomass and sedimentary deposits, they now act as a carbon sink that slows down global warming.

Seaweeds are key primary producers and links in the food webs of coastal and estuarine ecosystems, where they participate naturally in nutrient recycling and waste management. Coral reefs would not have been formed without the help of seaweeds. Many of the white "sandy" beaches in tropical regions are, in fact, made of fine debris of dead, calcified green seaweeds.

Image Issues

Unfortunately, seaweeds are often seen as rather unpleasant organisms. They are very slimy and slippery, and can

make swimming or walking along the shore an unpleasant experience.

Seaweeds have also recently attracted media coverage in reports of outbreaks of "green tides" and fouling species, which are considered nuisances. It is important, however, to emphasize that green tides are not the cause, but the consequence of coastal eutrophication, which needs to be addressed by long-term integrated coastal zone management.

Seaweeds Are...

A simple definition of seaweeds is not that simple, because this heterogeneous group is only a fraction of an even less natural assemblage, the "algae." Algae are a diverse group of organisms that share only a few characteristics. They photosynthesize and provide oxygen. They do not make flowers, and their anatomy is relatively simple, with no roots, stems, leaves or vascular tissues, and simple reproductive structures.

With progress in molecular techniques, we realize this "mixed bag" contains species spread over most kingdoms of organisms, encompassing microscopic microalgae like the unicellular phytoplanktonic forms and macroscopic macroalgae like the giant kelps that grow taller than trees. Algae colonize the oceans, freshwater streams, trees (associated with fungi in lichens), stones, snow in high-altitude glaciers, geothermal sources and even deserts.

The largest of all algae, the giant kelp, *Macrocystis pyrifera*, can grow to up to 50 m long. One of the fastest-growing organisms on Earth, the kelp can grow as much as 61 cm daily. The smaller sugar kelp, *Saccharina latissima*, can reach 11 m in length, with a growth rate as high as 2 cm/day. It has been estimated that the primary productivity of seaweed communities is equal to or greater than that of the most productive terrestrial plant communities.

Although often called "marine plants," not all seaweeds are plants. The most used and cultivated, the brown seaweeds, now belong to the Chromista kingdom. If green and red seaweeds can



Seaweeds in a tide pool in the Bay of Fundy, New Brunswick, Canada. The kelps are already farmed and others are candidates for future aquaculture development.

still be considered plants, they do not have much in common. The well-known green seaweed sea lettuce (*Ulva*) is closer at the molecular level to a spruce tree than to the well-known red seaweed nori (*Porphyra*), even if their morphology is very similar, and they are found close to one another on the shore.

Needless to say, the classification of algae is still the source of constant changes and controversies among scientists. The fact that the 36,000 known algae represent only about 17% of the existing algal species is a measure of our still-limited knowledge of this group of organisms, despite their key roles on this planet.

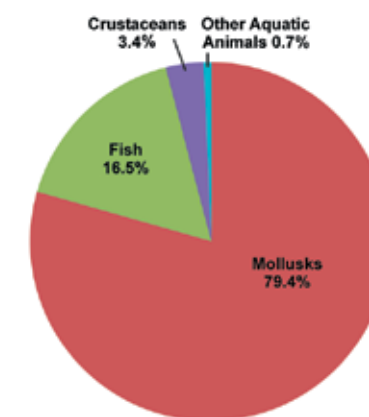
One of the key reasons for regularly ignoring seaweeds, even in coastal studies, is the very problem of their identification, as very few people, even among scientists, can identify them correctly. The production of seaweeds has probably been underestimated, since it may approach 10% of that of all the phytoplankton. However, that is taking place in 0.1% of the area occupied by phytoplankton, and this coastal zone area is crucial.

Seaweed Mariculture

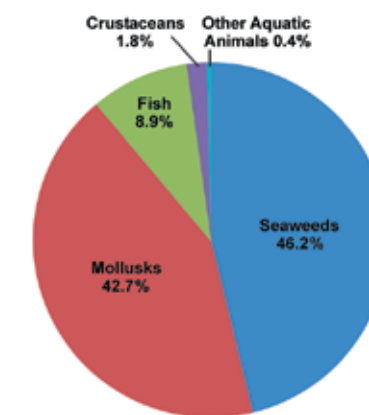
There are approximately 10,500 known species of seaweeds. Around 500 have been used for centuries for human food and medicine, directly or indirectly as extracted phycocolloids such as agars, carrageenans and alginates. However, only approximately 220 species of seaweeds are cultivated.

The largest group of organisms cultured at sea is seaweeds. Their production represents 46% of the total world mariculture, while fish aquaculture represents only 9%. Almost all the 15.8 mmt of cultivated seaweeds – worth U.S. \$7.4 billion annually – come from China, Indonesia, the Philippines, Korea and Japan. Unfortunately, seaweeds are systematically short changed in seafood statistics, which tends to limit the Western world's knowledge of seaweeds (Figure 1).

It is estimated that this year, aquaculture will account for over 50% of the world's consumption of food fish, defined as finfish, crustaceans, mollusks and other aquatic animals for human consumption. About 94% of the world seaweed supply presently comes from aquaculture, and seaweeds were the first group of organisms to pass the 50% farmed/wild harvest threshold in 1971. This occurred in 1986 for freshwater fish, in 1994 for mollusks, in 1997 for diadromous fishes and in 2010 for crustaceans. Marine fish production is still far from achieving this threshold.



The FAO Representation



The Complete Picture

Figure 1. World mariculture production of major species groups, 2008.



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