The Potential of Seaweed Culture in South Africa

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"Seaweed" is the common name for countless species of marine plants and algae that grow in the ocean as well as in rivers, lakes, and other water bodies. Seaweeds, also referred as macroalgae is in fact macroscopic multicellular marine photosynthetic organisms usually classified into three groups: Rhodophyta (red algae), Phaeophyta (brown algae) and Chlorophyta (green algae). Macroalgae are benthic organisms with a cosmopolitan distribution within the photic zone of the oceans that play an important role in marine communities as primary producers and in the transference of energy to higher trophic levels of aquatic ecosystems.

The success of seaweed aquaculture in South Africa is due to a number of natural and human (industrial) factors. The development of the seaweed aquaculture industry has paralleled the growth of the abalone industry and has been successful largely because of bilateral technology transfer and innovation between commercial abalone farms and research institutions. In South Africa seaweeds have been used commercially as feedstock for phycocolloid production, for the production of abalone feed, and the production of Kelpak®, Afrikelp® and SEAGRO® which are plant-growth stimulants used in the agricultural sector. Additionally, *Ulva* is being investigated for large-scale biogas production. The South African seaweed industry provides a template that could be used by other coastal African nations to further their undeveloped aquaculture potential. The present uses of seaweeds include as human foods, cosmetics, fertilizers, and for the extraction of industrial gums and chemicals. They have the potential to be used as a source of long- and short-chain chemicals with medicinal and industrial uses.

What are microalgae:

By direct translation from Latin, microalgae are "little seaweeds." However, defining microalgae further is not simple, because the microalgae represent a taxonomically diverse group of organisms, rather than a single, phylogenetic category. A functional definition of microalgae might be "photosynthetic single-celled or colonial microorganisms"; however, most of these microbes are able to grow without light if dissolved sugars are provided.

Microalgal cells range in size from one micrometer—roughly the size of a bacterium—to several hundred micrometres (1 µm)—barely visible to the naked eye. Colonies and chains of some microalgal cells can attain a length of several centimetres (2.5 cm = 1 in.). This group of organisms contains remarkable morphological diversity, with shapes ranging from simple spheres to the ornate, silica shells of one group, the diatoms. Many microalgae are motile, propelling themselves with flagella, by amoeboid

motion, or by gliding on extruded mucilage. Microalgae are found in an astonishing range of habitats, such as in fresh, saline, and hypersaline waters, in polar ice, in soil, attached to plants and animals, and even in symbiotic relationships with fungi (e.g., lichens) and animals (e.g., corals). Historically, many of these organisms have been claimed and named by both zoologists and botanists; therefore, taxonomy has been, and remains, problematic. From the perspective of aquaculture, there are common characteristics that warrant their consideration as a functional group; the foregoing definition will suffice for this discussion. As "microalgae" is a functional rather than phylogenetic group, a list of taxa that would reasonably fit within the category is necessary. Higher level systematics of these groups are under revision; hence, only the class level is specified. The diversity of the group is underscored by the presence of both prokaryotic (not containing a nucleus, Cyanophyceae, or cyanobacteria) and eukaryotic (nucleated) taxa. The eukaryotic groups are thought to have arisen from the incorporation of photosynthetic prokaryotes (or, subsequently, photosynthetic eukaryotes) within protozoan-like host organisms. This hypothesized process is referred to as the endosymbiosis theory. Evidence from both electron microscope studies of microalgal cells (usually focused upon numbers and types of membranes within the cell) and more recent molecular sequencing work indicates that endosymbiotic creation of "new" organisms may have occurred a number of times in evolutionary history, leading to the diversity in morphology and physiology seen today. This diversity, especially in terms of physiology, provides opportunities for the current and potential use of these organisms in the aquaculture industry.

South African Seaweed:
Approximately 800 species of seaweed are found on the South African coast, but only seven species are common and useful enough to be collected commercially. These are collected in 23 specially designated zones along the SA coast, which-along with all

other marine resources – are controlled and managed in accordance with ongoing scientific research by the Department of Forestry, Fisheries & The Environment.
Kelp, the name given to large brown seaweeds, is collected where it grows in the cooler waters of the West Coast (Cape Agulhas north to the Namibia border at the Orange River Mouth). Kelp is the mainstay of the local seaweed industry and, since the 1950s, two kelp species (*Ecklonia maxima* and *Laminaria pallida)* have been gathered from the shore where they wash up after storms. They are then dried, milled, and exported mainly for the extraction of alginate, a gel-forming substance that is used in a variety of products including cloth dyes, toothpaste, processed foods and even welding rods.

At Kommetjie in the Cape Peninsula, fresh *Ecklonia maxima* is harvested for the production of a liquid, plant-growth stimulant that is exported to many countries where it is used in agriculture and horticulture. The patented extraction process and the effectiveness of the product make this a flagship operation of the SA seaweed industry. Since 1990, the development of abalone farms has led to increasing demand for freshly harvested kelp fronds (leaves) as feed for these valuable molluscs. More than 6 000 tons of kelp fronds, worth about R 4.5 million, are cut every year. As a result, considerable research effort is being invested in determining just how much kelp can be safely harvested and what methods should be used to minimize ecological effects of harvesting. Meanwhile, the Government has set Maximum Sustainable Yields (MSY) for each of the seaweed rights zones.

The stringy red seaweed, *Gracilaria gracilis,* grows in the sheltered water of Saldanha Bay and periodically washes up on the beaches in the area. It is collected, dried, and exported for the extraction of the agar it contains, fetching more than R 12 000 per dry tone. Agar is a gel that is used in food and cosmetics and as an irreplaceable medium for growing bacteria and fungi in pathology studies. The *Gelidium* species, which contains high-quality agar, is harvested from intertidal shores in the Eastern Cape. The dried *Gelidium* fetches more than R 20 000 per dry ton on the overseas (mainly Far East) market. However, supplies of these seaweeds are rather limited in South Africa, with annual yields seldom exceeding 600 tons. Although still small, the seaweed industry is sustainably managed and provides permanent jobs for several hundred workers and part-time employment for many more. Additionally, poor coastal communities, for example at Buffelsjagt, Saldanha Bay and St Helena Bay in the Western Cape, and several communities in the Eastern Cape, hold the rights to collect kelp in order to supplement their income.

Current Aquaculture production of seaweed:
The seaweed industry worldwide uses approximately 8.0 million tons of wet seaweeds (fresh weight) annually, with a majority of it derived from aquaculture, as the demand for seaweed polysaccharides, like agar and carrageenan, and other seaweed-based products exceeds the supply of seaweed raw material from natural stocks. At present there are approximately 200 species of seaweeds used worldwide, of which the following species or genera are intensively cultivated: *Laminaria japonica, Undaria pinnatifida, Porphyra* sp., *K. alvarezii, Gracilaria* sp., *Monostroma* sp. and *Enteromorpha* sp.

Seaweed cultivation not only provides an alternative to seaweed resources which have

been overexploited but also facilitates the selection of germplasm with desired traits. Different alternatives, such as simple and cost-effective cultivation methods, use of selected material as seed stock, and good farm management, are some common practices to enhance the economic prospects of seaweed cultivation. Furthermore, *in vitro* cell culture techniques have also been employed as they facilitate development and propagation of genotypes of commercial importance.

Commercial seaweed cultivation has been carried out successfully for over 60 years in countries like Chile, the Philippines, Indonesia, Japan and China, and production has increased sharply.

Integrated Aquaculture:
Research on seaweed biofilters for treating effluents from mariculture practices started in the mid-1970s. Since the start of the 21st century research in this field has attracted considerable interest and is now one of the most novel applications of seaweed. The integration of seaweeds with marine fish culture has been examined and studied in Canada, Japan, Chile, New Zealand, Scotland, South Africa, the USA etc. Species like *Ulva* sp. and *Enteromorpha* sp. have been identified as ideal candidates for filtering fish effluents due to their capacity to rapidly absorb and metabolize nitrogen, removing up to 80% of dissolved ammonium in aquaculture wastewaters, their high growth rates, low epiphytism susceptibility, and their worldwide distribution.

Alginate:
Alginate, also called alginic acid is a compound found within the cell walls of brown seaweeds of *Ascophyllum, Durvillaea, Ecklonia, Laminaria, Lessonia, Macrocystis and Sargassum*. However, most of the alginate extracted is obtained by harvesting these seaweeds from natural populations. These species cannot be grown by vegetative means but must go through a reproductive cycle involving an alternation of generations. For alginate production, this makes cultivated brown seaweeds too expensive when compared to the costs of harvesting and transporting wild seaweeds. Alginate is considered extremely safe as it is almost naturally extracted from the cells as a polysaccharide. The alginate is often combined with water to create a viscous gum paste, perfect for creating moulds of dental impressions, hands, feet, or other small-scale items. Alginate has a unique ability to hold upwards of 200-300 times its own weight in water, making it a naturally gelling substance. Alginate has an incredibly wide range of applications, on a local and global scale, mostly in the food and medical industries. Two of the most common applications are in the consumer products of Gaviscon and Rennies, both of which need Sodium Alginate as its key ingredient.

Conclusion:
Although the harvesting of seaweeds has long been of considerable importance in South Africa due to the existence of large stocks of native Kelp (*Ecklonia maxima* and *Laminaria pallida),* the exploitation of seaweeds is still very recent in Aquaculture production systems. Seaweed exploitation and cultivation could be an important economic source for the region if market studies and assessment of commercial interests in investment are undertaken before funds are committed.

Some pictures are from Google Images.
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