PREFACE

When I was born in 1946 the global human population was about 1.2 billion people; seaweed farming was virtually limited to Japan; seaweeds were generally held in low esteem and the main global use for seaweeds was as raw material for the manufacture of marine colloids. As of 2014 there are more than 7 billion of us populating the planet; seaweed farming has developed all over the world; the value of seaweeds for global wellbeing is increasingly recognised and a broad array of economic uses for seaweeds is being developed.

The collection of papers presented in *Advances in Botanical Research* (ABR) is testimony to the broad scope and the diverse range of research and development that is leading to advances in the state of the art of human utilisation of seaweeds. The included papers cover topics that include seaweed biogeography and productivity; cultivation techniques; pests and diseases; bioactive substances; aquaculture impacts, bioremediation and integrated multitrophic aquaculture (IMTA); seaweed resources and harvesting impacts; seaweed diversity and biogeography; ecophysiology; seaweed extracts; natural seaweed biomass; molecular biology and systematics; reproductive biology; population ecology and seaweeds as food and feed.

Papers included in ABR report the results of essential research and development necessary to advance the state of the art in seaweed production and management of ecosystem services. Such work is essential if we are to reach the point where the true potential of seaweeds as primary producers in integrated aquaculture systems can be realised. It is estimated by Food and Agriculture Organization (FAO) that within the next few years aquaculture will account for over 50% of the world's seafood consumption. Presently, 95.5% of the world seaweed supply comes from aquaculture (FAO 2012). Seaweeds have been the largest group of organisms cultured in the sea since 2004 and they comprise about half of total world mariculture production. It is a reflection of the growth in human population cited above that there is a vast global need for aquaculture. FAO forecast demand is for added annual production of 33 M tons of animal-based aquaculture production worth at least 46 B USD by 2030. Capture fisheries cannot increase production so sustainable, integrated; algae-based aquaculture is the path towards the future.

With respect to seaweed utilisation, papers included in *ABR* reflect a wide range of advances beyond the field of hydrocolloid applications. In particular there are widespread and expanding advances in knowledge and

technologies in fields including the extraction and production of bioactive substances from seaweeds; seaweeds for direct use in food, feed and fertilisation applications; biotechnology based on polymers synthesised by seaweeds; ecosystem services such as nutrient biomitigation, oxygen provision, carbon sequestration and reduction of ocean acidification and the production of biofuels from algae including seaweeds.

ABR is about advances in botanical research and it is gratifying to see that the sluggish pace of advancement typical of the twentieth century seems to be picking up as we move into the twenty-first century.

Iain C. Neish

Macroalgae (seaweeds) are ecologically and economically important, providing essential ecosystem services and biomass for foods, phycocolloids, soil additives, animal feeds and nutraceuticals. Selection of these algal species is intensively cultured. In 2013, 11.3 million tons of fresh algae were produced commercially forming a $5.7 billion market. Asian countries, such as China, Korea and Japan, which have traditionally consumed seaweed for food, are responsible for three quarters of this production. In contrast, seaweed is very seldom considered as food in European countries. About 220 species of algae are consumed globally as food. Six genera (*Laminaria* (kombu, 40.1%), *Undaria* (wakame, 22.3%), *Porphyra* (nori, 12.4%), *Eucheuma/Kappaphycus* (11.6%) and *Gracilaria* (8.4%)) are responsible for 94.8% of the total algal production. The hydrocolloid industry is known to have the second largest consumption of seaweeds. The most common hydrocolloids manufactured from seaweeds are alginates, carrageenans and agars. In recent years, the application of macroalgae as animal feed supplement has grown. Alginates from seaweeds are used as a binder in feeds for farm animals. Laboratory investigations have also been carried out to evaluate macroalgae as possible alternative protein sources for farmed fish because of their high protein content and productivity.

Due to their rapid growth rates, ability to assimilate nutrients, such as nitrogen and phosphorous and to sequester other elements, such as heavy metals, they are also utilised for the bioremediation of waste waters, in particular from aquaculture systems. Algae have a number of characteristics that have a potential to significantly improve the sustainability of many industries. These include high biomass productivity, the possibility of utilising marginal, infertile land, salt water, waste streams as nutrient supply and combustion gas as CO_2 source to generate a wide range of fuel and nonfuel products. At the same time, eutrophication related to anthropogenic inputs

from land has led to several green tides in shallow sandy bays. There has been research to use this biomass for animal feed, composting, biodigestion and methane production, fertiliser applications, etc., but none of these approaches proved economically feasible and capable of handling the variety of situations outside a laboratory context.

The harvesting of seaweed can exert pressure on the natural stocks of macroalgae. This pressure is made more severe as several macroalgae populations are in decline due to climate change. Seaweed harvesting can potentially cause a disruption in the natural habitats of shellfish and fish. This could be minimised and better understood with long-term monitoring. Rational management appears to be a promising solution for maintaining such biodiversity. Various research groups also highlight the valuable contribution of a 'fundamental research' approach to deal with practical management issues.

More sustainable production of seaweeds using new aquaculture technologies can help commercially develop green algae and simultaneously improve the environment. Technologies, such as IMTA have bioremedial properties which help improve and stabilise nutrient fluxes in the oceans. This development of seaweeds will depend on the successful domestication of several species.

For all these reasons, it is indeed imperative to continue research in the fields of metabolism, physiology, biology of algae, relations between plant and environment, and management, to see and understand the conditions ensuring a culture of quality, to highlight compounds of interest for food, cosmetics, agriculture, bioactives and to explore them as raw material for chemistry and bioenergy.

The authors are all recognised as experts in their respective areas. From Brazil to India, from France to South Africa or from Australia to Canada, they enrich our knowledge about the incredible world of algae. Two special guests the first with a species of microalgae and the second with of coastal lichens... a simple link to algae.

I would like to thank all the contributors for their patience, enthusiasm, hard work and commitment.

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I hope you will enjoy this textbook as much as we have enjoyed putting it together.

Prof Nathalie Bourgougnon