Editorial

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Seaweed resources of the world: a 2020 vision

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In this modern age, seaweeds (macroalgae) are deemed to be "sexy" and seem to be used for almost anything and everything. The traditional range of applications spans sea vegetables to raw materials used as sources of gels in processed foods (i.e. phycocolloids, such as carrageenans, alginates and agar), to fertilizers and biologically active extracts for the stimulation of microbes, plants, animals and humans. Claims for bioactivity and efficacy vary widely. The prefix "anti-" (as in: -oxidant, -inflammatory, -bacterial, -fungal, -viral, -cancer, etc.) appears liberally applied to the list of benefits of (any and all) seaweeds and their derivatives and perhaps, in the absence of human trials, is a tad over-hyped? Are the benefits real, is there an element of "snake-oil salesmanship" hyperbole or is it wishful thinking? Is there a circular argument that seaweeds are wonderful, therefore they must be good for you? Are there multiple "proofs" of efficacies which will withstand the tests of time where other fields face a replication crisis? When will the vast amounts of *in vitro* data be subject to *in vivo* evaluation (not to mention the need for independent clinical trials). The real bioavailability of active, seaweed-derived components and hence their true benefits needs a great deal more work, especially for human applications. This is not unlike determining the bioavailability of the nutritional components of other foods as well, because research involving the human gastrointestinal tract is painfully complicated. Plenty of scope for work by recent and future entrants to the field of applied phycology!

Seaweeds are a well-known polyphyletic "ragbag" and there is not a "one size fits all" scenario for seaweed claims; "not all seaweeds are the same". Specific seaweeds (and their extracts) have specific properties and therefore applications. It follows that not all seaweeds can be used for all of the perceived and/or claimed benefits. Likewise not all seaweeds are part of a superfood group. Not all seaweeds are beneficial (e.g. introduced invasives and nuisance brown/green/red tide species)! Unfortunately, many in the public and some authors in the field of applied phycology do not critically assess which seaweeds should be used for which benefits. Many of us may not even be able to identify and/or know where certain seaweeds may be found in the field by region, habitat or season? One often reads that "seaweeds", or their extracts, can do x, y, or z, but – reader beware – specific seaweeds, and their derived compounds, have specific properties and applications, some being very specific and hence their "value". When it comes to communicating about seaweeds, applied phycologists should seek to emulate Einstein: "Everything should be made as simple as possible, but no simpler". Our field and industry is mature and should have learned enough to work around this nuance even when talking to the media and science community. A simple antecedent may help – "some" or "certain" are obvious starting points for a sentence that attempts to address the 10,000 (or more) species that fall under the seaweed banner. People are sceptical of any panacea or silver bullets. This is an area where multidisciplinary collaborations amongst marine ecologists, medical professionals, food scientists, phycologists and others would be well served in the interests of health and wellness for humans, plants, and animals, and of course, our planet.

Most certainly, seaweeds are generally thought to be good for us and the environment. But which specific ones are to be used for the most appropriate or highest value from their goods and services, and for which specific application(s)? What is the best value-added use for any given red, brown or green seaweed? What is the maximum economic return that can be derived from a unit mass of a given seaweed biomass? Also, which studies provide the best value to humankind? Are some seaweeds best left undisturbed in their natural habitat for the inherent ecosystem services they provide (e.g. nurseries and refugia for economically valuable species of fish and crustacea, to providing hydrodynamic barriers absorbing wave action and acting as a blue carbon sink)? Are there examples of best practice that can be highlighted for the benefit of new entrants to the science of seaweed resource utilisation? Will currently exploited resources be available for use by future generations? It is likely that our understanding of the value of seaweeds in the environment and their applications will fundamentally change into the future, hence safeguarding biodiversity must also be considered in any sustainable business case.

Answers to all of the above questions, as well as potential and real-world applications, rely on foundational knowledge in order to provide a balanced, critical understanding of the global nature and distribution of various seaweeds, their biology and abundance. Can sufficient seaweeds be obtained through collecting beach-cast wrack or manual or mechanical harvesting? Is the exploitation of biomass acceptable for their perceived and real economic benefits? Are there socio-economic benefits to be derived by coastal dwellers and traditional owners, first nations people in many cases, as stewards of their coastal seaweed resources? Are the current methods of biomass removal sustainable from environmental, resource or economic points of view? Are there enough tested and reliable data to allow responsible and sustainable access to given seaweed resources for their industrial exploitation? Are some of the present claims regarding environmental sustainability merely "green-washing" as a commercial expediency? Are seaweed harvesters and farmers, at the start of the value-chain, given enough compensation for their efforts considering the nature of the manual work involved and the fact that some processed seaweed products have tremendous fiscal value (in particular those used in biotechnological and pharmaceutical or cosmeceutical applications)? Have we learnt sufficient lessons from the history of the millennia of terrestrial agriculture in order to transpose principles and best practices to harvesting or the phyco-economic production of selected seaweeds and their cultivars in the sea or on-land? Are there too many, or too few, regulations governing balanced industrial access to, and processing of, seaweed raw materials? Do the benefits to humankind outweigh the negatives, where they may exist? Utilised as sustenance in times of starvation, are we overlooking, as a society, the potential of seaweeds in the daily diet as a fundamental food or ingredient?

However, before any of the above questions can be answered with a degree of reliability, do we even know which seaweeds are where, when and how much biomass is present? Do we understand variability of macroalgal biomass and their biologically active components from a seasonal, geographic or climate change standpoint? Can we accurately assess the standing stock and seasonality of a given resource?

Many of the published, applied studies on the multiple benefits of specific seaweeds and their extracts do not address how sufficient biomass is to be obtained reliably and sustainably by different methods of harvesting or cultivation, nor the necessity for governing rules and regulations. These can range from a chaotic free-for-all, to highly regulated scenarios including taxation on the volumes of biomass removed or in some cases complete conservation of benthic marine flora from commercial and individual use. What about seasonality and the ever-shifting impacts of climate change? Will exploited resources be available for use by future generations? Should wild seaweed resources only be used as seedstock for cultivation, either extensively in open, coastal waters, or intensively in on-land simple lagoons or complex pond infrastructure?

How are seaweed strains selected or imported and improved in the processes of domestication? High-value, industrial uses of target seaweed species requires predictable availability of large volumes of biomass which must be delivered to consistent quality standards and time schedules. Can these be provided? Should biorefinery principles be mandatorily applied to the industrial processing of seaweed biomasses, instead of the all too common model of one biomass, one product (requiring only a small portion of the collected biomass), resulting in a large, single waste stream? Of course one person's waste is another's resource and hence we return to the fundamental principle of biorefining and sequentially removing items of value from a given biomass. Will seaweed biorefineries become a common sight soon?

Fortunately, *Botanica Marina* is providing the vehicle for a series of special issues on the important topics of global distribution, availability and sustainability of the major seaweed resources of selected geographies. In this first issue specifically: Chile, Malaysia, Italy, Mexico and Alaska provide excellent examples. Also included in this series are articles by subject-matter experts on emerging applications for specific seaweeds in ultra-high value and socially important applications for ingredients ranging from phycogastronomic creations by the world's top chefs to the provision of treatments for human diseases which big pharmaceutical companies choose not to address as those markets affected by such ignored afflictions are not considered financially lucrative enough.

Once upon a time there were publications of various editions of a book called: *Seaweed Resources of the World*, co-edited by Masao Ohno, Alan T. Critchley and Danilo Largo. These were initiated and published as training manuals for fisheries scientists by the Japanese International Collaboration Agency (JICA). This foresight was rewarded, and the book was re-published multiple times for students attending JICA training courses in Southeast Asia. This new *Botanica Marina* series is entitled: *Seaweed Resources of the World: A 2020 Vision*. 2020 was chosen as an evocative, iconic date in the up-coming calendar, as well as referencing the clarity of 20:20 vision, which after so much experience we should all have. Right? Maybe not. The series is guided under the auspices of Editor-in-Chief, Matt Dring (United Kingdom) and internationally distributed Guest

Editors: Alan T. Critchley (Canada), Anicia Hurtado (The Philippines), Leonel Pereira (Portugal), Melania Cornish (Canada), Danilo Largo (The Philippines), and Nicholas Paul (Australia). The series is dedicated to the work of Ohno *Sensei* who still works with seaweeds and their cultivation at Usa Marine Station, Kochi University, Japan.

The new series brings together invited reviews from across the spectrum of applied phycology. Some of the authors contributed to the first *Seaweed Resources* book, some are their students, now early career scientists, future leaders of applied phycology following in their mentors' footsteps. These authors are globally distributed and experts in the fields of resource identification, assessment, development and applications within their specific geographies.

The special issue series specifically addresses concerns over seaweed resource distribution, sustainable access, utilisation, ecological and socio-economic benefits, plus up-to-date reports on traditional, emerging and cutting-edge applications of selected seaweed species and their cultivars by various regions of the globe.

It is anticipated that individually the reviews contained within the *Botanica Marina* special issue series will add substantially to the body of knowledge around global seaweed resources, their responsible exploitation and specific, high-value applications. Taken together, the reviews will assist applied phycologists and managers of marine resources to make better informed decisions in relation to seaweed resources and their utilisation at various scales (i.e. from personal, artisanal to industrial) in order to maximise valorisation with regards to their environmental, socio-economic and commercial services for the benefit of all mankind – both now and in to a sustainable future.

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