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PREFACE

The 21st International Seaweed Symposium: seaweed science for sustainable prosperity

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The 21st International Seaweed Symposium (ISS) took place in Bali, Indonesia, from April 21 to 26, 2013. For more than six decades, the ISS have been the foremost international symposia for individuals and organizations involved with seaweed research and applications. Over the years, ISS have provided a renewed forum for scientists, technologists, business people and resource managers to present their latest research results, exchange ideas and network to develop synergies for strengthening this important bioresource sector.

This year was no exception, as 580 participants from 50 countries, and 33 exhibitors from six countries, presented and discussed many aspects focusing on the theme of this year's edition "Seaweed Science for Sustainable Prosperity". This theme recognized the fact that scientific research plays a fundamental role in the development of seaweed cultivation, harvesting, processing and commercialization, as well as in the well-being of many coastal communities. The 21st ISS was held in Bali, in the heart of the Coral Triangle where seaweed farming employs tens of thousands of coastal people. There is a clear and present need for expanding research and development to enable environmentally, economically and societally sustainable seaweed industry commercialization, not only in the Coral Triangle but also in other regions throughout the world, either alone or integrated with other aquaculture activities. One of the goals of the 21st ISS was to catalyze support for such endeavours.

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The program was a rich learning experience and provided opportunities for stimulating discussions. It was developed by the National Organizing Committee (NOC), with the help of the members of the International Seaweed Association Council (ISAC). We would like to thank, in particular, Safari Azis (Chair of the NOC), Made Arthajaya (Vice Chair), Tris Wismiarsi (Secretary), Iskak Indrayani (Treasurer), and the 32 other members of the NOC.

There were four plenary presentations:

(1) Dr. Shaojun Pang (China) covered "How much we have achieved towards improving the farming of seaweeds and what remains to be accomplished towards sustainable prosperity in China",
(2) Dr. Helmi Faisal Zaini (Indonesian Minister for Development of Disadvantaged Regions) talked about "The seaweed industry of Indonesia",
(3) Dr. Iain Neish (Indonesia) talked about "Seaweed science for sustainable prosperity—from research to reality", and
(4) Dr. Ik Kyo Chung (South Korea) offered his perspectives on "Seaweeds in the era of climate change".

Twelve mini-symposia (52 presentations) covered the whole realm of where seaweeds play crucial roles: bioactive extracts; integrated multi-trophic aquaculture; environmental and social impacts of seaweed farming; physiology and systematics; biofuels; seaweeds as food and feed; population ecology; human and natural impacts on seaweed beds; agricultural applications of seaweed extracts; cultivation of tropical red seaweeds; phycopathology and diseases; and cultivars and molecular biology of commercial species. Twenty eight contributed paper sessions (171 presentations) and 151 posters in two sessions covered a suite of topical and varied subjects such as: seaweed biogeography and productivity; cultivation techniques; diseases and grazers; bioactive substances; alien, invasive and bloom species;

aquaculture impacts, bioremediation and integrated multi-trophic aquaculture; seaweed resources and harvesting impacts; seaweed diversity and biogeography; ecophysiology; postharvest and processing; hydrocolloid extracts; non-hydrocolloid extracts; climate change and natural seaweed biomass; socio-economic impacts of seaweed farming; molecular biology and systematics; biofuels; reproductive biology, ecology (population and community); and seaweeds as food and feed.

The mid-symposium excursions were an opportunity to see seaweed farming in action, as Bali was the birthplace of extensive commercial seaweed farming in Indonesia about 30 years ago. There was also time to discover the rich Balinese culture, during the mid-symposium excursions and several very enjoyable cultural evening events, under a no less enjoyable tropical climate and with the much appreciated Balinese hospitality.

On Sunday, April 21, 2013, before the 21st ISS really started, the ISAC had its triennial face to face meeting. ISAC is the governing body of the ISA with 12 elected members conducting business electronically in between each ISS. Three members had their mandate expiring with the 21st ISS: Pete Bixler, Michael Friedlander and Peter Salling. To all three, we express our gratitude for their commitment to the ISA. The commitment of Pete Bixler has been, in fact, exceptional during the existence of the ISA: Vice-President from 2001 to 2004, President from 2004 to 2007 and Past-President from 2007 to 2010; but, most importantly, he was the longest serving Treasurer from 1998 to 2013. Not only was he the Treasurer of the ISA, but he was also a quiet benefactor of the ISA (maybe he should be called the "phycocolloid daddy", instead of the "sugar daddy", of the ISA!). In recognition of his long standing involvement with the ISA, Pete Bixler was made honorary life member of the ISA at the banquet of the 21st ISS. Three new members joined the ISAC: Stefan Kraan, who became the Vice-President for 2013–2016, Daniel Robledo and Gonzalo Soriano, who accepted to fill Pete's very big shoes and became the new Treasurer. Iain Neish became the Past-President for 2013–2016, while Alejandro Buschmann became the President and Thierry Chopin was renewed as Secretary for the same period.

We should also remember our colleagues who passed away recently, among them Klaus Rotmann, Guillermo Garcia Reina and Benson Dakay.

At the closing ceremony, the University of British Columbia (Vancouver, Canada) awards were given to the best three student oral presentations and the Universitas Bakrie (Jakarta, Indonesia) gave three awards for the best three student posters. We thank the two committees of judges, and their Chair Grevor Gerung, who were in charge of the very difficult evaluation process, as students delivered remarkable oral presentations and beautiful and informative posters. The winners received certificates, their award cheques, and for the first time a gift certificate of €200 from Alexandrine Cheronet, Senior Publishing Editor in Environmental Sciences at Springer, the publisher of the ISS Proceedings. During the week of the 21st ISS, the ISAC officers worked with Alexandrine Cheronet on a special deal for ISA members. People attending an ISS become de facto members of the ISA for the next three consecutive years until the next ISS; during that period of time, they will have free online access to the *Journal of Applied Phycology*, in which the ISS Proceedings have been published as special issues. The deal is effective now for the ISA members between 2013 and 2016 and the people attending the 22nd ISS will be offered the same valuable membership benefit between 2016 and 2019.

Now, we should approach a topic dear to our heart: how can we put seaweed aquaculture, and the ecosystem services it renders, on the radar outside of the converted phycological community? It is estimated that this year, or very soon, aquaculture will account for over 50 % of the world's seafood consumption, the rest coming from capture fisheries. If this is true for what the Food and Agriculture Organization of the United Nations designates as "food fish", i.e. finfish, crustaceans, mollusks and other aquatic animals for human consumption, seaweeds were the first group of organisms to pass the 50 % farmed/wild harvest threshold in 1971 (Chopin 2012a). Presently, 95.5 % of the world seaweed supply comes from aquaculture (FAO 2012). Seaweeds constitute the largest group of organisms cultured at sea since 2004 (Table 1). With a world production estimated in 2010 at 19.0 million tonnes (with a value of US$5.7 billion; FAO 2012), seaweeds represent, in fact, the majority of the total world mariculture production (50.9 %; Chopin 2013).

Now, how much of this is known in the western world? Unfortunately, not much because 98.9 % of seaweed aquaculture is concentrated in 7 Asian countries (China, Indonesia, The Philippines, South Korea, North Korea, Japan and Malaysia). Moreover, seaweeds are often short changed in seafood statistics by national and international agencies. How can we, then, change this unfounded animal-biased perspective so rampant in the western world, where we hear so much about fish aquaculture, whereas it only represent 9.1 % of the total world mariculture production? How can we inform aquaculturists, scientists, regulators, decision makers and the general public that there are other types of aquaculture systems in the world and that seaweed aquaculture not only provides the raw material for a multitude of everyday life applications, but also provide significant ecosystem services such as nutrient biomitigation, oxygen provision, carbon sequestration and reduction of ocean acidification (Chopin et al. 2012)? As scientists, we have a key role to play in demonstrating the societal relevance of our preferred organisms. This should, in fact, ease the securing of funding for our research and the training of undergraduate and graduate students.

Keeping in mind the production numbers presented in Table 1, it is interesting to compare them to the distribution

Table 1 Evolution of the world mariculture production of major species groups from 1996 to 2010 (FAO 2010, 2012; Chopin 2012a, 2013)

Major mariculture species groups	Production (%)				
	1996	2000	2004	2008	2010
Molluscs	48.0	46.2	43.0	42.7	37.2
Seaweeds	44.0	44.0	45.9	46.2	50.9
Finfish	7.0	8.7	8.9	8.9	9.1
Crustaceans	1.0	1.0	1.8	1.8	1.8
Other aquatic animals (sea urchins, sea cucumbers)	–	0.1	0.4	0.4	1.0

of the abstracts at three major conferences of the World Aquaculture Association (WAS) held the same years as the last three ISS: in 2007, the WAS conference was in San Antonio (USA) while the 19th ISS was in Kobe (Japan); in 2010, the WAS conference was in San Diego (USA) while the 20th ISS was in Ensenada (Mexico); and in 2013, the WAS conference was in Nashville (USA) while the 21st ISS was in Bali (Indonesia). With around 9 % of the world mariculture production, fish are the topic of 60–66 % of the abstracts; molluscs, with around 40 % of the world mariculture production, attract 16–21 % of the abstracts; crustaceans with only 1.8 % of the world mariculture production attract 12–14 % of the abstracts (Table 2). By regrouping abstracts on microalgae (0.8 %), freshwater plants (0.6 %) and seaweeds (0.6 %), a combined 2.0 % was reached for algae and aquatic plants, whereas seaweeds represented around 46 % of the world mariculture production in 2007 (FAO 2010). Doing the same exercise in 2010, a combined 4.6 % was reached for these three groups of organisms. This more than doubling was mostly due to abstracts on Integrated Multi-Trophic Aquaculture (IMTA) and biofuels. In 2013, 0.7 % of the abstracts were dedicated to microalgae, 2.9 % to freshwater plants and 1.9 % to seaweeds, for a combined 5.5 %, while seaweeds represented around 50.9 % of the world mariculture production in 2010 (FAO 2012). This time the bulk of the 5.5 % was related to IMTA and aquaponics, which is a freshwater variation on the IMTA theme.

Why are seaweed presentations so underrepresented at international aquaculture conferences? Would that mean that seaweed aquaculture does not have as many environmental, economic and societal issues as animal aquaculture [physiology, growth, nutrition, feeds, genetics, breeding, husbandry, health and diseases, environmental variability (including climate change and ocean acidification), contaminants, fouling, product qualities, production, processing, waste management, regulations, policies, economics, marketing, location, societal acceptance, etc.]? Seaweed aquaculture also has its share of issues, but, more fundamentally, it is an attitudinal problem: it is time we get out of the phycological ivory tower and "preach" at other meetings to educate people who do not know much about seaweeds because of our deeply-rooted zoologically-biased education system, particularly in the western world.

We still have a lot of work to do to increase this low 5.5 % representation and increase scientific and public awareness of the roles, ecosystem functions, uses and values of seaweeds in many everyday activities and in solving global issues. We have a huge educational role to play to help bring a more balanced and ecosystem-based management approach to aquaculture development and to "convert" the western animal-dominated aquaculture sector (including aquaculturists, scientists, regulators and decision makers) to make it recognize that it needs to take advantage of the ecosystem services of seaweeds. If aquaculture is to make a major

Table 2 Distribution of the abstracts, according to the major mariculture species groups, at the World Aquaculture Society (WAS) conferences in 2007, 2010 and 2013 (*FW* freshwater)

Major mariculture species groups	2007 WAS conference (% of 1198 abstracts)		2010 WAS conference (% of 1211 abstracts)		2013 WAS conference (% of 1244 abstracts)	
Finfish	66.3		59.7		64.1	
Molluscs	15.9		20.7		17.6	
Crustaceans	14.2		12.2		11.8	
Algae and aquatic plants	0.8 microalgae		1.4 microalgae		0.7 microalgae	
	0.6 seaweeds	2.0	2.2 seaweeds	4.6	1.9 seaweeds	5.5
	0.6 FW plants		1.0 FW plants		2.9 FW plants	
Other aquatic animals (sea urchins, sea cucumbers)	1.6		2.8		1.0	

contribution to the efficient and responsible food production systems of the future, far more production and applications of inorganic extractive seaweeds and aquatic plants, and organic extractive animals, must be developed in a more integrated and evenly distributed manner throughout the world (we have to spread seaweed aquaculture worldwide instead of having 98.9 % of it concentrated in seven Asian countries).

Seaweeds remain a relatively untapped resource with a huge potential—as edible food, food ingredients, cosmetics, agrichemicals, fishmeal, biomaterials and bioenergy molecules—while being significant transitory nutrient and carbon sinks that could be the objects of trading credits in recognition of their ecosystem services and as economic incentives to make aquaculture practices evolve. Moreover, the vast majority of seaweed species has yet to be screened for various applications, and their extensive diversity ensures that many new algal products and processes will be discovered.

However, it is important to recognize that some biotechnological issues and societal constrains remain, particularly in the western world, and a long-term responsible and gradual interdisciplinary implementation strategy should be adopted. It will be up to us to bring aquaculture into a new ERA of Ecosystem Responsible Aquaculture. We need to go beyond what Max Doty called "marine agronomy" in the 1970's and clearly delineated in the Proceedings of the 9th ISS more than 30 years ago (Doty 1979). The aquaculture "Blue Revolution" of the 1980s needs to become greener; it is now time for the "Turquoise Revolution" (Chopin et al. 2010). This greener approach not only targets practices in the marine environment, but also in the freshwater environment, and in open-water as well as in closed containment operations. Instead of talking about agronomy (in Greek, "the laws of the [land] fields") in marine or freshwater environments, it may now also be the time to talk about "aquanomy" ("the laws of the aquatic fields"; Chopin 2012b), especially if we want to produce large amounts of seaweeds as crops, understand how to do it and manage this farming activity, including its environmental, economic and societal impacts.

It is time to walk the talk and recognize the implications—notably regarding marine spatial planning and our societal production, food and energy habits—of the policies and scale-up trajectories we are elaborating for the future of an ever growing and hungry population. Humans will soon not be able to continue thinking of mostly land-based agricultural solutions for securing their food, as well as provisioning many other derived products, but will have to turn increasingly to responsible aquanomy to manage their "aquatic fields". Depending on our choices, we will be able to elaborate grandiose projects or more realistic ones with concrete and manageable deliverables and palpable benefits at local or regional scales.

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