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Message from the President: Dr. Céline Rebours

Dear ISAP Members,

I am happy to introduce this Newsletter as the second of my term as President of ISAP and the second edition issue 2-2018. During this year, the MC members have been actively working on several issues.

1. With the secretary/treasurer of the ISAP, Valeria Montalescot, we are today working on registering the society as a foundation in the Netherlands to establish the society legally and facilitate its management. On behalf of ISAP, I signed Memoranda of Understanding with The North Sea Farm Foundation (https://www.noordzeeboerderij.nl) in order to have a permanent address and a legal status in the Netherlands. In addition, we are also working on modernizing the website to facilitate memberships management and facilitating the access to the journal.
2. The Training Course organized in Tunisia by Dr. Ktari Leila and her colleagues was a success. I am very glad that ISAP support was utilized effectively for such a well-organized course. Several news on our social media pages reported on the training course activities. In addition, you will find a detailed report on the conduct of this training course on the ISAP website: (https://www.appliedphycologysoc.org/training-workshops-1).
3. Our 7th ISAP Congress to be held in Japan in April 2020. You will receive more detailed information on this event during 2019.
4. To follow up on the ISAP activities, besides our webpages, I would like to remind you that we have a Facebook page and a LinkedIn group for ISAP. If you are not yet registered, I would like to invite you to register yourselves through the links that you will find on ISAP Website (https://www.appliedphycologysoc.org/) and at the end of this newsletter.
5. I would like to also remind you also that ISAP Members who are in good standing with their dues have free access to the electronic version of the Journal of Applied Phycology through the ISAP Website. If you are not yet a member, please do not hesitate to register in order to take advantage of this offer by Springer.

As I mentioned in the previous version of the newsletter, all ISAP members can actively participate in the activities of the society. We would appreciate your ideas, feedback on ISAP, news, and announcements of interest for ISAP Members. We would also be delighted to receive articles that could be published in our next Newsletter during spring 2019. For the matters, please contact either the Editor of the Newsletter, Sasi Nayar or the ISAP Secretary/Treasurer, Valeria Montalescot. Their contact information's are given at the end of the newsletter.

As the new year is approaching, I would like to take this opportunity to wish all the ISAP Members nice holidays season as well as a successful new year in their researches and/or business in applied phycology.

With my warm regards

Céline Rebours

President, International Society for Applied Phycology

Message from the Editor – Sasi Nayar

Dear ISAP Members,

This being the last issue of the newsletter for this calendar year, and with the festive season and holidays upon us, I take this opportunity in wishing you and your loved ones a Merry Christmas and a Happy and Prosperous New Year 2019.

To maintain a good balance in the newsletter, the Editorial committee selects a contribution each on microalgae and macroalgae pertaining to applied phycology for each issue. We intend to publish our first issue for 2019 in April followed by the second issue in December. It is worth pointing out that the allocation of the ISSN number by the National Library of Australia requires us to publish two issues of the newsletter a year. We would love to receive contributions from our members, particularly early career researchers, graduate and undergraduate students for the next issue. For the April 2019 issue, we will appreciate receiving your contributions by email to sasi.nayar@sa.gov.au no later than the 15 March 2019. I am hoping to receive a good number of diverse articles that we can publish in our forthcoming issues as well. Your editorial committee is also working on a 'guide to authors' or a style guide to assist authors in preparing and submitting articles for our newsletter. We expect to have this ready in the new year with the hope that it will streamline the process into the future.

The editorial team is therefore delighted to present you with this issue of the newsletter with two excellent articles. The first article by Seger and Hallegraeff is an interesting account of the application of clay minerals in fin-fish aquaculture to mitigate the impacts of harmful algal blooms. The authors highlight their on-farm experience in South Korea and Australia on large-scale application of clay in not only aggregating algal cells that contribute to harmful algal blooms but also in binding ichthyotoxins produced by these blooms in the vicinity of commercial fin-fish farms. The second article by Augyte and co-authors highlight the significance of kelp aquaculture in enhancing ecosystem services. This article reviews global efforts in kelp farming followed by a focus on the Gulf of Marine and Long Island Sound. Ecosystem services resulting from kelp farming include food, carbon sequestration, nutrient remediation, production of cosmeceuticals, nutraceuticals and pharmaceuticals, bioenergy, habitats, and nursery grounds as well as the creation of ecologically engineered structures.

I would specifically like to thank Rémi Nghiem-Xuan, Alexandra Busnel, Antoinette Kazbar, Valeria Montalescot and Céline Rebours for their efforts with the publication of this issue. We hope you enjoy reading this issue and please do not hesitate to share with your colleagues and your library.

Sasi Nayar

Editor of the ISAP Newsletter and Social media administrator

Protecting finfish aquaculture from harmful algal blooms: ichthyotoxin adsorption by clay minerals

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Summary

Harmful algal blooms pose a significant threat to a globally expanding aquaculture industry through the production of potent fish-killing toxins (ichthyotoxins). Extensive economic damages to the finfish aquaculture sector (up to US $800 million for single events) have highlighted the urgent requirement for the development of effective mitigation strategies. The largely unknown chemical nature of most ichthyotoxins has necessitated the development of novel bioassay systems, the most recent breakthrough being the development of a fish gill cell line assay, allowing for the direct exposure of fish gill epithelial cells to live algal samples. Employing this assay, we here briefly summarize our recent work on the use of clay minerals to mitigate fish-killing impacts. We focus on the direct adsorption of ichthyotoxins to clay particles, a novel aspect of clay treatment that promises refinement and increased efficacy of existing clay application regimes.

Introduction

The microscopic algae of the world’s oceans are an essential component of the marine ecosystem, forming the basic trophic level on which the rest of the food-web relies. Rapid proliferation (so-termed blooms) of this group during favorable conditions may, therefore, be considered beneficial to fisheries productivity. However, blooms of certain microalgae have been implicated in mass mortalities of cultured finfish and shellfish. The 80+ different algal species responsible for these deleterious effects are remarkably diverse. While some algal species pose risks to cultured fish through indirect effects caused by the sheer number of algal cells (*e.g.* oxygen depletion or physical damage to fish gills), others are known to produce potent toxic compounds. The latter can be grouped into two broad categories: those that bio-accumulate and cause negative human health effects upon ingestion of contaminated seafood (true toxins of human health significance) and those that impact finfish (ichthyotoxins). An apparent global increase in the occurrence of fish-killing algal blooms combined with recent range extensions of harmful species has led to an increased exposure of a globally expanding aquaculture industry. Economic damages are in the order of millions of dollars (up to US $800 million for single events; Hallegraeff et *al.*, 2016) and the requirement to better understand bloom dynamics, as well as fish-killing mechanisms to formulate effective management strategies, has never been greater.

A formidable challenge to research

While the algal toxins of human health significance are well understood due to their relative chemical stability and consequential bioaccumulation, the exact nature of most true ichthyotoxins has remained elusive. Their short-lived nature (tendency to degrade within hours), in some cases (e.g. *Chattonella marina*; Figure 1) involvement of reactive oxygen species (half-lives of seconds to nanoseconds), and their largely unknown exact chemical structure has provided a formidable challenge. Previous research focused on the use of various bioassays in an attempt to quantify fish-killing impacts. Early work included direct exposure of live fish (inconsistent species and sizes), followed by the search for surrogate assay systems designed to improve repeatability and avoidance of lengthy ethics approval processes. This approach has been limited in that the assay organism (e.g. brine shrimp, red blood cells, non-toxic algal species) often masked the true impact of ichthyotoxins within allelopathic effects and/or required extraction of algal biomass within organic solvents.

Figure 1: Bluefin tuna mortality from a *Chattonella marina* bloom event in 1996 in Port Lincoln, South Australia (Courtesy: the late Barry Munday, UTAS School of Aquaculture).

A major breakthrough has been the recent development of a fish gill cell line (RTgill-W1) assay (Dorantes-Aranda et *al.*, 2011). The fish gill is the first site of impact when fish are exposed to harmful algae: positive pressure during respiration forces algal cells directly across the gill epithelium, promoting cell lysis and release of intracellular ichthyotoxins, a process well documented to substantially increase ichthyotoxic effects (Dorantes-Aranda et *al.*, 2015). Subsequent damage to the fish gills severely impairs respiration, creating a positive feedback loop wherein stressed fish engulf increasing amounts of contaminated water in response to impaired gill function; ultimately leading to suffocation. The RTgill-W1 assay allows for the direct exposure of live algal samples to the fish gill epithelium cell line, thereby removing any artifacts otherwise introduced during toxin extraction processes.

Mitigating fish-killing impacts

The multi-million-dollar impacts of fish-killing algal blooms have highlighted the urgent requirement for effective mitigation strategies. Tactics currently being practiced in fish farm waters include cessation of fish feeding, towing away of cages from affected areas, perimeter skirts to protect against algal surface slicks, aeration or airlift upwelling to dilute harmful algal concentrations, or clay flocculation to reduce numbers of harmful algal cells.

Clay flocculation

First pioneered by Shirota (1989) in Japan and Yu et al. (1994) in China, clay dispersal aims to promote the generation of rapidly sinking clay-algal aggregates that entrain additional cells during their descent. In Korean waters, where this approach has been extensively practiced for the last two decades (Figure 2), clay application has been claimed to reduce overall fisheries damages of yearly recurring *Cochlodinium polykrikoides* blooms by up to 80% (Park et *al.*, 2013). Several laboratory experiments investigating the efficacy of this approach have reported excellent cell removal efficiencies (up to 100%), dependent upon clay type, target species, algal concentration, turbulence and clay loading (Park et *al.*, 2013; Seger, 2017; Sengco et *al.*, 2001). Modification of clays with surfactants (Gemini, sophorolipid) or flocculants (Polyaluminium chloride) can greatly increase cell removal and lower required clay concentrations by up to an order of magnitude.

Figure 2: Routine field application of clay in Korean fish farm waters (Namhae Island, South Korea). Inset: Chain of *Cochlodinium polykrikoides* cells entrained in a clay matrix.

The Northern Territory experiences

Our own interest in the application of clay was first peaked when a distraught Barramundi farmer in the Northern Territory, Australia successfully mitigated a farm threatening *Prymnesium parvum* bloom (Body, 2011; Figure 3).

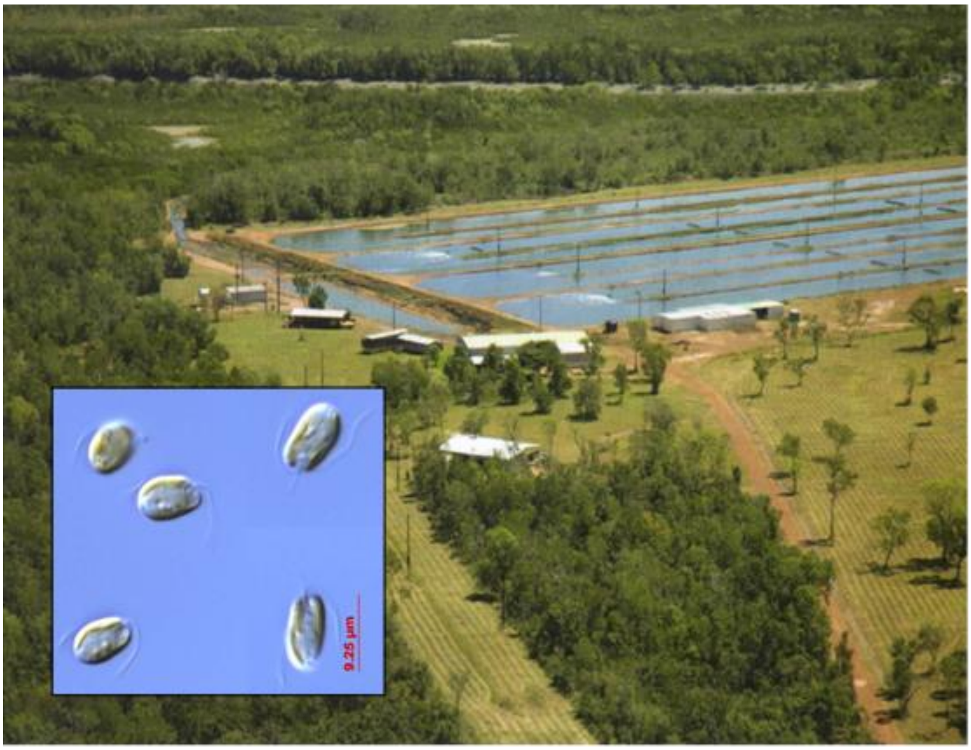

Figure 3: Pond based Barramundi (*Lates calcarifer*) aquaculture in the Northern Territory, Australia (Body, 2011) impacted by ichthyotoxic *Prymnesium parvum* (inset).

After having lost an entire pond of fish (*Lates calcarifer*) to the toxic alga and faced with developing blooms in the adjacent ponds, the farm manager researched strategies to reduce elevated phosphate concentrations in his ponds. *Prymnesium parvum* is well known to exhibit increased ichthyotoxin production during either nitrogen (N) or phosphorus (P) limitation but is only weakly toxic when nutrients are supplied in the ratio N:P of 16:1 (Redfield ratio), when it can be outcompeted by other, non-toxic algal species. With this in mind and left with no other treatment options, the farm manager applied a specialized phosphate adsorbing clay (Phoslock^{TM}) in an unprecedented last bid effort to save his livelihood. His unconventional approach successfully altered the pond nutrient ratio, stabilized dissolved oxygen levels and effectively mitigated the developing *P. parvum* bloom (Body, 2011).

To better interpret these field observations, we conducted a series of laboratory experiments aimed at mitigating the ichthyotoxic effects of the Northern Territory *Prymnesium* strain by manipulating nutrient regimes through Phoslock^{TM} clay treatment. Quantifying fish-killing potential with the RTgill-W1 cell line assay, we were able to establish that clay treatment not only significantly reduced toxicity towards the gill cell line in live *Prymnesium* cultures but also lysed cell preparations (complete elimination of cytotoxic effects; Seger et *al.*, 2015). This adsorption of dissolved ichthyotoxins appeared to offer a much greater, immediate benefit from clay application than either nutrient manipulation or algal cell flocculation alone.

Toxin adsorption by clay minerals

The adsorption of toxic compounds to clay minerals is not a novel observation. In the agricultural sector, clay adsorption of commonly used pesticides and herbicides has long been an area of concern and it has become a common precautionary practice to add clays to stock feeds of cattle grazing in pastures where they might be exposed to fungal aflatoxins.

Previous work in the aquatic environment has shown that brevetoxins (from *Karenia brevis*), cyanobacterial microcystins and hemolytic activity of *Prymnesium parvum* ichthyotoxins could be completely removed or significantly reduced through treatment with bentonite clay (summarised in detail in Seger, 2017). The unknown nature and complex mechanism of action of most other ichthyotoxins, paired with the remarkable physicochemical diversity of clay minerals have necessitated intensive screening experiments, as each clay-algal system appears unique.

The development of the RTgill-W1 cell line assay has allowed us to generate an extensive library identifying the most effective clay types by screening several kaolin, bentonite, Korean loess and zeolite type clays for removal of ichthyotoxins from all major fish-killing algal species, as well as reactive oxygen species-mediated lipid peroxidation precursors and suspected end-products (Seger, 2017). Clay concentrations required to completely eliminate gill cell-damaging impacts are algal concentration, clay type and particle size specific. Clay treatment proved effective at concentrations as low as 0.1 g L^{-1}, orders of magnitude lower than clay loadings reported to negatively impact benthic filter feeders (Seger et *al.*, 2015b).

The Korean experience

In 2015, the opportunity presented itself to take the gill cell line assay to South Korea to actively participate in government run routine clay dispersal operations targeting annually recurring *Cochlodinium polykrikoides* blooms off Namhae Island. Working closely with scientists from the National Institute of Fisheries Science, we collected samples from both the clay treated area in the immediate vicinity of the fish farm, as well as upstream control sites to quantify *Cochlodinium* cell density and ichthyotoxicity (Seger et *al.*, 2017).

Clay dispersal effectively reduced *Cochlodinium* cells to below levels considered dangerous to finfish aquaculture (<300 cells mL^{-1}), but exacerbated toxicity towards the gill cell line RTgill-W1 by up to 32% when compared to untreated control sites (depth dependent). Coincidentally, US $1.4 million fish were lost at the Namhae site. Exact replication of field observations under controlled laboratory conditions revealed rapid lysis (within 5 minutes) of *Cochlodinium* cells after clay treatment as the cause of exacerbated ichthyotoxicity (Figure 4). Application of identical, but finely ground clay, however, completely eliminated ichthyotoxicity.

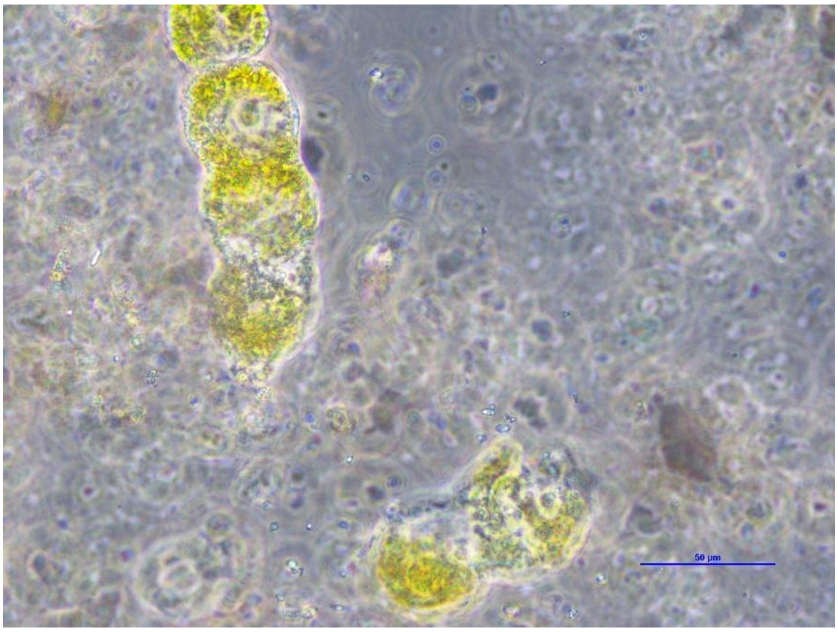

Figure 4: Lysis of *Cochlodinium polykrikoides* cells immediately after clay treatment.

Conclusions

Fish-killing algal blooms pose a significant threat to a globally expanding aquaculture industry. As the Northern Territory Barramundi farm experience has shown, effective guidance on available mitigation strategies is urgently required. Clay treatment has historically been employed in South East Asia to flocculate harmful algal cells, yet the adsorption of fish-killing algal toxins to clay minerals appears to present a much greater, immediate benefit. The development of the gill cell line RTgill-W1 assay has greatly facilitated the determination of species-specific minimal effective clay loadings (as little as 0.1 g L^{-1} required to completely remove toxic effects) and will no doubt continue to be a valuable tool in the future study of fish-killing algae. Our work indicates that selecting clays based on their ichthyotoxin adsorptive capacities presents an opportunity to fine tune current clay dispersal practices and significantly improve treatment efficacy.

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Enhancing marine ecosystem services via kelp aquaculture

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For centuries, humans have harvested different seaweeds for food, medicinal purposes, feed, and more recently as raw materials for industrial processes. Currently, wild harvested seaweed account for less than 5% of the total worldwide supply (FAO 2018). The majority of seaweed production is provided via aquaculture, with 99% of the production taking place in Asia including China, Korea, Japan, Indonesia, and the Philippines, worth US $11.7 billion annually (FAO 2018). Although seaweed aquaculture is a fast expanding industry, the global demand for seaweed-based products is surpassing the supply. Such demands necessitate either domesticating new species or further expanding the productivity of the existing leading seaweeds. According to the FAO, only a few species dominate seaweed farming, including two brown kelps, Saccharina japonica and Undaria pinnatifida (Buschmann et al., 2018). To meet the present market requirements and to contribute in reducing the over-exploitation of wild stocks, experimental trials worldwide have assessed the performance of newly farmed seaweeds as potential products, particularly kelp species that have been traditionally harvested from wild populations (Figure 1).

Figure 1: Sugar kelp, *Saccharina latissima* harvest on a longline. (Photo: C. Yarish & J.K. Kim)

Chile has carried out pre-commercial research on the cultivation of the giant kelp, *Macrocystis pyrifera* showing that it is feasible to cultivate the species at large scales (Camus et *al.*, 2018). Chile has also invested in producing significant quantities of the kelp *Lessonia trabeculata* on long-line cultures (Edding and Tala, 2003). In North America and Europe, the sugar kelp, *Saccharina latissima*, has been cultivated at commercial scales and shows potential as an ideal candidate to be used for larger off-shore, seaweed farming operations. This species has already been cultivated in both monoculture as well as in integrated multi-trophic aquaculture operations at both open water sites and in land-based systems in several European countries (Peteiro and Freire 2011; Sanderson et *al.*, 2012; Azevedo et *al.*, 2016; Peteiro et *al.*, 2016.) In the northeast United States, *S. latissima* farming is currently becoming a fast-growing maritime industry (Kim et *al.*, submitted), with more than 50 commercial farms, and several nurseries and processing facilities have been established in the Gulf of Maine and Long Island Sound (Figures 2, 3, 4 and 5). Regulatory requirements are being put in place for farm installation and safe food handling and processing. Meanwhile, creative chefs are developing new recipes incorporating kelp into the American diet (Figure 6).

Figure 2: Kelp seedstring being deployed on off-shore farm longline. (Photo: C. Yarish & J.K. Kim)

Figure 3: Seeding kelp on a longline. (Photo: C. Yarish)

Figure 4 & 5: Sugar kelp, *Saccharina lastissima*, harvest. (Photo: C. Yarish & J.K. Kim)

Figure 6: Tasting event featuring the local culinary chef, Jeff Trombetta with kelp delicacies. (Photo: S. Augyte)

Although the economic value of kelp farms is predominantly based on marketable harvested biomass, it is critical to consider the ecosystem services kelp farms provide to the near-shore coastal environment.

Social and ecological benefits derived from kelp farming could have potential economic benefits that to date have been underestimated. Just like natural kelp beds, kelp farming could aid as a significant climate buffer via CO_2 capture and release of O_2, thus, contributing to Blue Carbon production. Research shows that kelp farms can provide a buffer against changes in pH on localized scales and thus could play a role in mitigating ocean acidification. Furthermore, in a recent example, Kim et *al.*, (2015), showed that kelp farmers might also benefit from the Nitrogen and Carbon Credit Trading Programs by translating hectares of the farmed crop to carbon and nitrogen sequestration, adding economic value to the kelp farming activity.

In addition to carbon sequestration, kelp farming contributes to nutrient cycling, removing nutrient excess and improving water quality. Seaweed farming with the addition of shellfish farming in eutrophic waters, such as the urban estuary of Long Island Sound, has been shown to absorb excess organic and inorganic nutrients, contributing to rebalancing local ecosystems (Rose et *al.*, 2015, Kim et *al.*, 2015). As such, it represents a clear opportunity in urbanized areas to create and expand business ventures by revitalizing working waterfronts from depleted fisheries. The commercial production of kelp not only provides bioenergy in the form of food, biofuel, medicinal, and pharmaceutical products, it also provides seasonal habitat, nursery grounds, and refuge for an array of finfish and invertebrates. The spatial complexity added by these temporal habitats can enhance diversity by hosting numerous species, many of which have commercial and recreational value (Hasselström et *al.*, 2018). Aside from harvest, kelp farmers could provide sports fishing and diving services, potentially bringing people closer to the coastal ocean (Figure 7). These additional ecosystem services are socially appealing and worth further evaluation.

Another aspect that needs further exploration is the ability of kelp farms to function as ecologically engineered structures. Ecological engineering seeks to design sustainable ecosystems that consider and integrate human society with its natural environment, as opposed to what we call "traditional civil engineering" (Mitsch 2012; Kim et *al.*, 2013). Despite the long history of shoreline constructions, until relatively recently, there was limited research on the ecological impacts of armoring coastlines, especially when compared to research on the effect of urbanization in terrestrial habitats. Because of the structural complexity added to the water column, kelp farms can contribute towards coastal protection by dampening waves, modulating particle transport, and overall influencing bulk water flow. Contrary to typical seawalls, ripraps or gabions (all armoring structures), kelp farms can be integrated into natural marine ecosystems, even contributing to the indirect restoration of the marine environment while still providing coastal protection services.

Figure 7: Diving around kelp beds. (Photo: D. Bailey & P. Caiger)

In the general context, aquaculture tends to carry a negative connotation. The United States, for instance, has a seafood deficit and imports over 90% of all seafood consumed in the country, while its vast coastline could be used to develop sustainable aquaculture practices on local scales. Public concerns appear related to environmental health issues as well as "not in my backyard" mentality where landowners are reluctant to see aquaculture gear in coastal areas (Bacher 2015; Osmundsen and Olsen 2017). Nonetheless, the development of new and sustainable ecosystems, even if seasonal, could have a variety of indirect but positive outcomes. To advocate for its full potential, kelp farming must overcome the negative connotation and promoters need to educate the public on its many benefits. Contrary to traditional land agriculture or some finfish aquaculture, kelp farming requires no freshwater, no pesticides, artificially-added fertilizers or other chemicals such as antibiotics or hormones, sometimes used to improve yields. The absence of additives not only marks a key difference between agriculture and traditional fish farming regarding production cost but also emphasizes the *eco-friendliness* of seaweed farming, at least as it stands today. Consequently, seaweed cultivation for either bio-energy, fodder or any other intended uses could be key for large and environmentally friendly global improvements, providing humanity with the opportunity of increased sustainable food production (Bjerregaard et *al.*, 2016; cottier-cook et *al.,* 2016).

Off-shore seaweed aquaculture is a potential new strategy to meet the growing demand for biofuels and feed derived from seaweed. The US has the largest Exclusive Economic Zone (EEZ) zone in the world with waters that have limited user conflicts and can produce large amounts of seaweed biomass. The MARINER program through the ARPAe, Department of Energy is leading the way to fund projects for the EEZ zone that would support algal cultivars adapted to low-nutrients and high wave action located off-shore. The techno-economic feasibility and practicality of growing large amounts of seaweed are currently being modeled. Both temperate species of *Saccharina* and *Macrocystis*, as well as tropical species including the red alga *Eucheuma* and the brown bloom-forming *Sargassum,* are being tested for these studies. Overall, the many ecological benefits of seaweed farming including maintaining and improving environmental and water quality while contributing to global food security with little to no net environmental degradation. On the contrary, it can offset some of the environmental problems facing near-shore coastal ecosystems by mitigating nutrient pollution, helping regulate localized ocean acidification, mitigating climate change, and providing habitat for marine organisms. Finally, with global climate change driving retreats in the range of kelp distribution and an overall decrease in kelp productivity worldwide, there is a push to find kelp cultivars that are thermally tolerant and could potentially be used for restoration of disturbed marine ecosystems.

Acknowledgments

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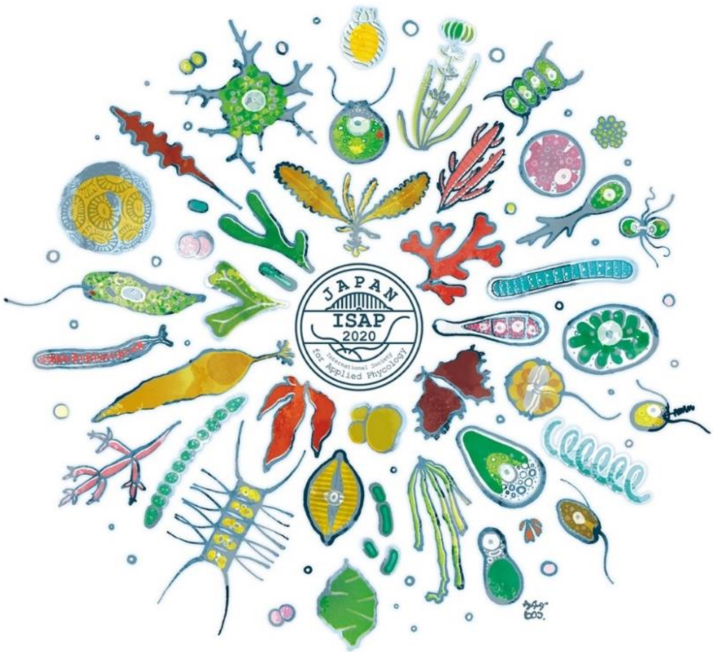
News and views

The new ISAP Logo for the 7th Congress

The new logo for the 7th ISAP Congress has just come out. We wish to see you all there.



The 7th ISAP Congress will be held in Chiba, Japan. Additional information has been posted on the ISAP webpage, Facebook page (https://www.facebook.com/AppliedPhycology1/) and the congress webpage in the coming days.

The 9th International Conference on Algal Biomass, Biofuels and Bioproducts. 17-19 June 2019, Boulder, CO, USA

The 9th International Conference on Algal Biomass, Biofuels and Bioproducts (AlgalBBB 2019) will take place in Boulder (CO, USA) where we will continue to provide an exciting atmosphere to discuss the latest research and technologies and to interact with leaders in the field.

More information and application at https://www.elsevier.com/events/conferences/international-conference-on-algal-biomass-biofuels-and-bioproducts

2019 International Conference on Natural Science, Engineering, and Technology (ICNSET 2019), January 19-21 2019. Sapporo, Japan

The main objective of ICNSET is to provide a platform for researchers, academicians, practitioners, as well as industrial professionals from all over the world to present their research results and development activities (aquaculture science is included). This conference provides opportunities for the delegates to exchange new ideas and application experiences face to face, to establish research relations and to find global partners for future collaboration.

More information at https://icnset.org

ACI's 9th European Algae Industry Summit, 10-11 April 2019. Lisbon, Portugal

How to Market Algae Products & Applications whilst Working Together as an Industry and Attracting Durable Investments. This conference will explore the ongoing developments of the algae industry. This new edition will focus on how to market the various algae-based products & applications, with case studies from key actors of each segments bringing forward their experience.

The conference will also take an in-depth look into two important themes: how can the industry work together towards standardization & regulation for products, and specifically food products; and on the other hand, how to attract investments and create beneficial partnerships. These two topics will be discussed through interactive panel discussions, to ensure a positive exchange with all industry actors involved.

Submission at: https://www.wplgroup.com/aci/event/european-algae-industry-summit/

4th International Conference on Food and Biosystems Engineering, 30 May-2 June 2019, AgiaPelagia-Heraklion, Crete Island –Greece

Following topics related to microalgae and macroalgae will be presented: Food Product Engineering and Functional Foods, Food and Agricultural Waste Engineering, Extraction Technology for natural antioxidants and Phytochemical, Industrial Fermentations and Biotechnology, Water and Wastewater Management and Irrigation Engineering. Novel Bioremediation Technologies.

All these subject from the 30 May to 2 June 2019, find more information at https://fabe.gr/en/conferences/4th-fabe2019/

Call for Project: European Commission, research, and innovation
TOPIC: Alternative proteins for food and feed

Proposals shall identify and assess new or alternative protein sources for food and/or feed and develop/validate efficient production and processing approaches to convert/integrate them into high quality, safe, healthy, and sustainable products or ingredients. This proposal could include Microalgae and Macroalgae as a source of alternative proteins for food and feed.

More information at http://ec.europa.eu

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