Diversification Of The Aquaculture Sector

Seaweed Cultivation, Integrated Multi-Trophic Aquaculture, Integrated Sequential Biorefineries

Large-scale kelp cultivation in Sungo Bay, China, is integrated with the cultivation of oysters, scallops, abalones and sea cucumbers.

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Summary:
To retain sustainability as the world's need for seafood grows, aquaculture's business models will likely have to change from "one species/one process/one product" to a streamed bioeconomic web involving different industry sectors. Evolving aquaculture practices will require a conceptual shift toward understanding the working of food production systems rather than focusing on monospecific technological solutions. As aquaculture expands to open-ocean operations, deployment footprints should make sense from environmental, economic and production perspectives, and also have an acceptable societal impact.

It may be surprising to some that fish aquaculture represents only 9% of all mariculture. Shellfish aquaculture represents 43%. At 46%, seaweed aquaculture represents the largest portion of the total. But 99.8% of the 15.8 mmt of seaweed cultivated annually come from China, Indonesia, the Philippines, Korea and Japan.

During the last few years, there has been renewed interest in the mariculture of seaweeds and their uses – something that should make phycologists and ecologists rejoice, as this group of organisms has been misunderstood, unappreciated and underused over the centuries. We now have an opportunity to explain what seaweeds are, and the many applications, benefits and services they can provide.

While everyone wants the seaweed sector to develop, some biotechnological issues and societal constraints, particularly in the Western world, should be recognized and a long-term responsible and gradual implementation strategy adopted.

Breaking Down Clichés

The Western marine biology community has been dominated by people who received primarily zoological training, often reinforced by monospecific specialization at university, instead of developing an ecosystem approach to marine knowledge. Not surprisingly, knowledge of seaweeds and their functions and services in/to ecosystems is limited and remains at universities and research institutions that have wisely kept diverse expertises.

To expand our outlooks, we must first recall there is more than fish in the oceans! Oceans cannot function with only fish, and our seafood solutions cannot come from only this group of organisms. To better manage marine environments, we need to revisit the concept of marine agronomy, learning from mistakes made in agriculture over the centuries to do a better job with aquaculture.

It is interesting to note that traditional agricultural practices, such as crop diversification, rotation and fallowing, are now being transposed to aquaculture practices. From an ecological point of view, diversification also means cultivating at more than one trophic level, adding organisms of different and lower trophic levels (sea-

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weeds, shellfish, crustaceans, echinoderms, worms, bacteria, etc.) to mimic the functioning of natural ecosystems.

This is what is happening with the development of integrated multi-trophic aquaculture (IMTA). Evolving aquaculture practices will require a conceptual shift toward understanding the workings of food production systems rather than focusing on monospecific technological solutions.

Sensible Changes

It is important to understand that changes rarely happen overnight. There is no shortage of interesting ideas for seaweeds and other species at the small demonstration scale, but problems generally appear when people realize the consequences of scaling up. The deployment footprints required should make sense from environmental, economic and production perspectives, and also have an acceptable societal impact.

We should also stay away from the idea that since around 71% of this planet is covered by oceans, there is plenty of space for aquaculture development. Although aquaculture will probably expand into more exposed and open-ocean locations due to the reduced availability of suitable new nearshore sites, it is doubtful we will see farms in the middle of oceans for simple logistics and weather reasons. Moreover, present international laws of the sea are not that comforting for owners of private equipment found at sea.

The vagueness of territorial jurisdictional competence regarding the exclusive economic zone in different countries, and certainly in international waters, has been a major impediment to progress in offshore aquaculture. If moving to the open ocean has been considered a means for moving away from environmental and public perception issues in the coastal zone, it should not encourage an "out of sight, out of mind" attitude, as open-ocean development will also come under scrutiny by an increasingly educated public.

There will be a point when reasonably accessible and manageable open-ocean ecosystems eventually reach their assimilative capacities. Instead of taking the position that open-ocean hydrodynamic conditions will be appropriate for dispersion and reduced environmental impacts, the open-ocean aquaculture sector will also have to capitalize on recapturing the by-products of fed aquaculture and engineer efficient IMTA systems with their built-in biomitigative functions – soon and not as an afterthought in the 2050s.

New Paradigm, New Seascape

With a new paradigm in the design of efficient food production systems, there are no simple solutions, but one thing is certain: The human population is increasing, and as standards of living increase, people aspire to have more proteins in their diets.

People need balanced and responsible diets, and food will have to increasingly come from aquatic production systems. As was the case on land, where the acquisition of food by hunter/gatherer societies had to evolve toward agriculture practices and signifigant landscape changes, we will have to accept an evolution in seafood procurement and seascape.

We are in the middle of this transformation, and this may be why people are uncomfortable, and unable to sit back and analyze without being emotional. Let us not forget that we are still in the infancy of modern, intensive aquaculture and that some agricultural practices have taken cen-

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turies to develop into better, not necessarily yet best, management practices.

Marine Spatial Planning

Beyond the biological, environmental, technological, engineering, economic, marketing and regulatory issues of aquaculture development, a basic question will be that of societal acceptance. Are we ready to evolve in our use of this planet's "last frontier" and finally deal with the concept of zoning portions of the oceans for large aquaculture parks as sustainable food production systems for a human population seeking ever more seafood?

Despite all the campaigns and movements, the global human population continues to grow and eat more seafood than ever. Are we investing in the principal, in fisheries and aquaculture, to only harvest interest every year so as to not reduce/eat the capital for long-term sustainability? Are we ready to put some savings aside in the form of marine protected areas, not only for their natural beauty, but also their ecosystem functions, such as breeding grounds, nursery habitats and food production areas?

The question of readiness for marine spatial planning could also be applied to emerging projects of wind and biofuel farms. In fact, combining IMTA with wind, underwater turbine and/or biofuel farms in large multipurpose integrated food and renewable energy parks could be a means for reducing their cumulative footprint, while integrating green energy with food and fuel production and processing.

Our business models will have to change from "one species/one process/one product" to a streamed bioeconomic chain or web approach among different industry sectors. On one hand, a wide range of bio-based, high-value food and feed products/ingredients/supplements, biopolymers, fine and bulk chemicals, agrichemicals, biostimulants, pharmaceuticals, cosmeceuticals, nutraceuticals, functional foods, biooils, botanicals and pigments. And on the other hand, lower-value commodity energy from biofuels, biodiesels, biogases, bioalcohols and biomaterials and heat/power – all produced within reduced footprint requirements.

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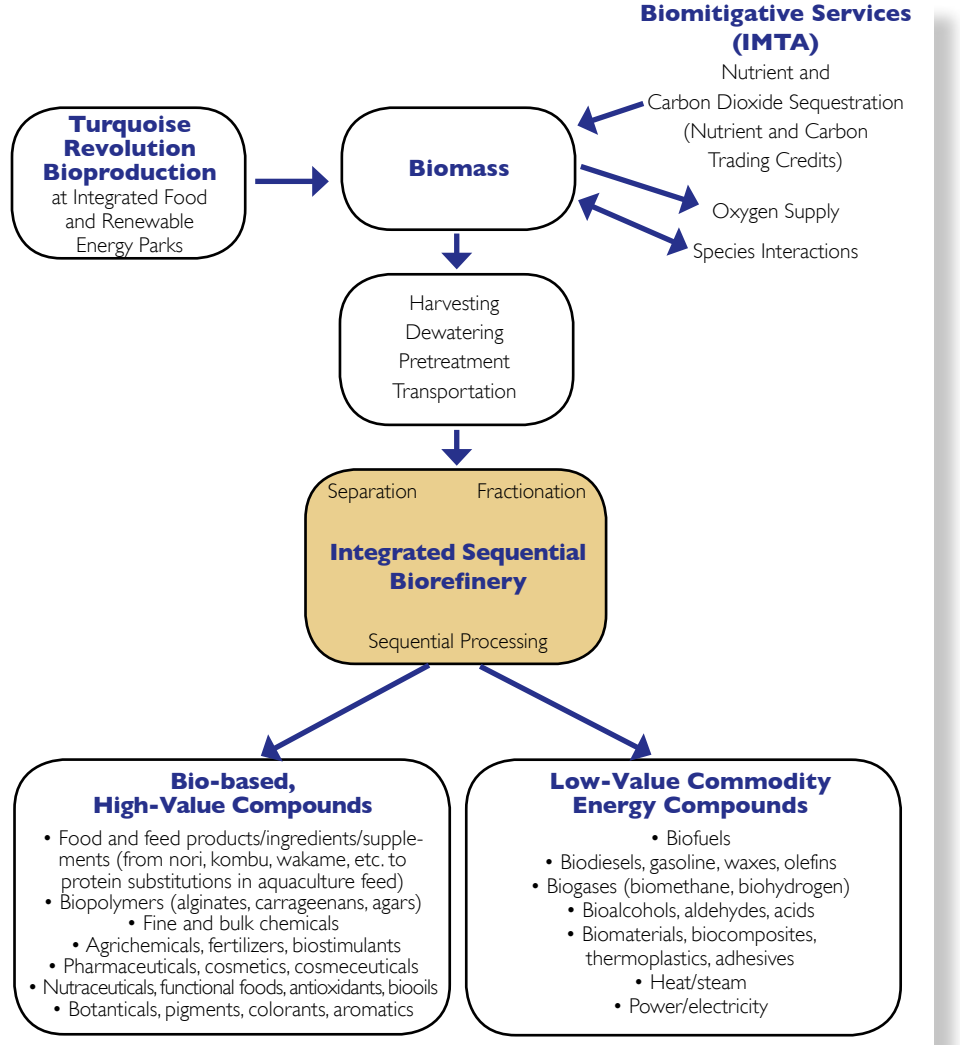

Figure 1. The concept of an integrated sequential biorefinery reflects the integrated use of biomass, food, feed, chemicals and energy produced by multipurpose integrated food and renewable energy parks in an integrated multi-trophic aquaculture setting that provides biomitigative services.

The physiological, biochemical and production performances of the different organisms will have to be improved to make the systems even more efficient, profitable and competitive. The aquaculturists and different multisector end users will need to become interdisciplinary in their approaches and learn to collaborate while aiming at the lowest resource and energy inputs.

Functionalities will have to be maintained, as much as possible, along the process for optimal use/valorization of the multipurpose biomass, and not necessarily the maximization of just one end product, as some co-products could reveal themselves as the real drivers of the emerging integrated sequential biorefinery concept (Figure 1). Market volumes/values, biomitigative services and public acceptance will have to be considered and included in models.

Walk The Talk

If the "not in my back yard" and similar attitudes continue to prevail, especially in the Western world, we will not be able to secure our food, chemicals and energy in an intricately interconnected ecosystem-responsible manner, despite ongoing rhetoric regarding alternative technologies and solutions.

We will not be able to ensure our self-sufficiency, but will become dependent on other food, chemical and energy "masters," who may no longer be in the Middle East, but the Far East. It is time to walk the talk and recognize the implications – notably regarding marine spatial planning and our societal production and food habits – of the policies we are elaborating for the future.