Commercial Open Ocean Aquaculture Operations and Their Future Prospects

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Key questions that will determine the future prospects for open ocean aquaculture (OOA) are the attitude of government, the technology that is developed to enable development, and the market for seafood products.

In many ways, government attitude and regulation is the most critical of these, because governments have to allocate space in public waters for marine aquaculture to take place. Thus, there must be the political will to enable the industry to develop, which, in turn, requires acceptance by voters that it is a wise and necessary use of the resource. Such acceptance is not guaranteed and depends on a nation's economic imperatives. China, which is by far the leading aquaculture nation in the world, has clearly determined that aquaculture is an economic imperative. Chen (2006) pointed out that "cage fish farming" saves water, land, and energy. By contrast, in the United States, people have not yet accepted these benefits or that aquaculture is a wise or necessary use of the resource. In many cases, it is thought that floating aquaculture will get in the way of other activities that are considered more important. Moreover, OOA is not really necessary in the United States because the country can afford to import all the seafood it needs.

The future prospects for OOA in the United States are not good until or unless a way can be found to make the case more strongly favorable. There are three levels on which such a case can be presented:

1. *Focused:* Create new businesses in coastal communities that need and want economic development.
2. *Broad social and economic:* Provide more affordable seafood and reduce an $8 billion U.S. seafood trade deficit.
3. *Visionary:* Farm the sea as we farm the land, thereby using the vast ocean resource more effectively than is the case presently, thus relieving pressure on the land.

The visionary approach has not yet been given sufficient attention by the OOA industry or by its critics. Much criticism of OOA is based on a presumed lack of sustainability, and a longer term visionary goal puts such criticism in perspective. For example, it is expected that by 2030, the world population will increase from 6.0 billion to 8.3 billion; food calories consumed per person will increase from 2,800 kcal/yr to 3050 kcal/yr; and there will be a need for an additional 1 billion metric tons of cereal crops, requiring 120 million ha more farmland to grow them. The sources of land and freshwater required for such an expansion remain uncertain. Currently, 24% of the Earth's land is cultivated, and most of the rest is desert, ice, mountains, or cities. Top soil

is eroding as deforestation takes place to clear more land for farming. The food supply is being further reduced by the increasing use of agricultural crops to produce biofuels. Aquifers are being depleted in China, India, and the United States.

It seems that the world and its people are set on a course that is unsustainable, with little to suggest a political will to do anything about it until the crisis strikes closer to home. Thus, the "Visionary" goal may present the strongest and most profound reason for the development of OOA because: (a) the oceans could offer a solution or serve as a relief valve; (b) current attempts to farm the oceans, albeit easy to criticize, could be the start of a change in ideas about ocean productivity and the Earth's capacity to support increasing human demands; and (c) development of a broad based marine agronomy could rescue humanity from its presently unsustainable trajectory.

Presently, capture fisheries produce less than 2% of total weight of the world's food, 6% of the protein, and about 16% of the animal protein. Notwithstanding that in some parts of the world, fisheries are essential for the nutritional wellbeing of local people their contribution to our food supply in general is modest. In fact, relative to the 68.6% of the world's surface covered by oceans, capture fisheries contributions could be considered wholly inadequate. In contrast to the land, where only about 24% is cultivatable, almost the entire ocean surface is potentially productive without the need for fresh water.

The idea that the oceans may one day be farmed to supply man's needs is not new, although no one has yet provided an answer. If the oceans are to be farmed like the land, production must be based on farming plants as the primary source of biomass, which may then be processed into value added products ranging from human food to industrial chemicals. Ideas on how this might be done include the following:

- Fertilizing ocean waters with iron (Fe), which is the limiting nutrient in many ocean areas. This would increase primary productivity and, in turn, secondary and tertiary production that could be harvested.
- Increasing nutrient levels by artificial upwelling of deep, nutrient rich ocean waters using wave actuated pumps or Ocean Thermal Energy Conversion (OTEC) systems.
- Farming of macrophytes (seaweeds) could be greatly expanded. Presently, there are almost 14 million mt of seaweed farmed globally each year in coastal waters, mostly in China and other Asian countries.
- Farming of floating seaweeds (e.g., *Sargassum* spp.) would eliminate the need for attachment structures and therefore be possible in deep ocean water. Some *Sargassum* species fix atmospheric nitrogen, thus reducing or eliminating the need to apply fertilizer.

In the same way as yesterday's family farms provided the basis for the development of modern agriculture, today's OOA farms should be seen as the first stages in a more intelligent use of the sea that will one day lead to a much larger and more broadly based marine agronomy. These pioneering new businesses provide the physical, commercial, and technological platforms on and around which future developments will occur.