

## Oceans: The New Frontier for Aquaculture and More?

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The need for aquaculture to grow at 7-10% annum to supply seafood worldwide implies available land and water. Presently, the majority of aquaculture occurs in freshwater, which constitutes 2.5% of the total water on the globe. Of freshwater supplies, groundwater (30.1%), lakes and rivers (1.2%) are also needed for population growth and agriculture. Ice, currently, comprises the remaining 68.7%.

Freshwater is the most precious resource on earth. Clearly, growth will have to occur in the oceans. This is the last frontier and constitutes 96.5% of the world's water. Ample areas exist for expansion of human activities into the far future. Historically, population has moved to cities and the coasts. Protection of marine areas is occurring as reserves and will expand in the future as has been the case on land.

Required for this shift is the model of expansion in the U.S. Colonists were able to survive with help from those familiar with this new environment. Adoption of farming techniques and new crops adapted to this environment allowed rapid expansion. As farming communities grew, so did towns and cities. This model has begun in the oceans. Pioneers familiar with this challenging environment exist. They will lead the development from shore to offshore. As farms expand, service centers will be needed. These will form a hub or offshore city, designed with human ingenuity to withstand the sometimes harsh environment, but no less challenging than space.

Along with the shift to ocean farming, will be a change in the diet. Plant and animal production will develop along the diet currently found in Japan and other island nations. The healthy diets of these countries will enhance life and health.

Salmonids are the main marine fish and oysters the main shellfish. They are showing faster growth than the leading freshwater species: Chinese carps. In addition, fast growth is occurring with other shellfish, crabs, shrimp, and algae. Tilapias are also showing fast growth, to become the number one cultured species by most opinions. The main species, Nile tilapia, is a freshwater species and is quickly occupying available freshwater resources of lakes (cage culture), ponds and rivers. Much of the new growth in tilapia culture is targeting developing countries, eager to trade pollution for income.

Developed countries are experiencing slow to negative aquaculture growth, due to environmental regulations and higher costs. Future growth in finfish will need to add species lower on the trophic level than species now cultured, such as salmonids and tuna-like fishes. The reasons are eliminating the need for fish meal and fish oil (which is a net reduction in fish produced and reduces food sources for other marine animals), and reducing wastes by polyculture of species utilizing wastes. Marine herbivores and omnivores are numerous, such as rabbit fish and sciaenids and in need of commercialization. Fortunately, shellfish are filter-feeders and at the bottom of the food chain. They are perhaps the best species by sustainability (actually clean the water as well as requiring non-polluted sites, and require no fish meals or oils) and are very healthy for human diets. Human populations along the coast have for centuries depended on shellfish for the majority of their diet. These areas also suffer from pollution and developing them would also clean the environment. One can only hope the shellfish fisheries of the Chesapeake bay will recover along with the bay.

Marine aquaculture will expand from areas now producing marine species: Chile and SE Asia. Areas producing are primarily in sheltered

coastal sites. These will be fully utilized and expansion will need to move into deeper waters and net pens that will submerge to withstand storms. Areas of high hurricane/cyclone frequency are unfortunately in the tropics of SE Asia and the Americas. Thus, development will occur above and below these regions and in tropical regions not affected (Pacific islands, for example). Salmonid success is in part due to the colder water required and the lack of cyclones.

In addition to the objective reasons for these developments, a desire by the populations to purchase these products is necessary. The consumer ultimately determines the species and production systems. With increased knowledge of impacts and benefits from proposed changes, this shift should occur. Governments will need to be responsible for education and encouragement by favorable regulations that protect the environment while allowing responsible developments. The continental conversion of grasslands to crops did require an environmental cost, but was essential to human development. A similar analysis is needed for marine aquaculture. In fact, a more favorable profile for marine aquaculture might improve the environment of the grasslands. Conversion of areas needed for wetlands and pollution from fertilizers and runoff may be avoided. Governments also will need to fund research and extension as they have so successfully in agriculture.

Another key entity that needs to become involved are universities, especially those sea grant designated in the U.S. and similarly in other countries. Aquaculture research is primarily through universities and has been overly concerned with supporting the existing aquaculture whether profitable or not. Much money and effort has been spent for instance on supporting a declining channel catfish industry in the southern states in the U.S. At present political will and power does not exist to shift funds from this dysfunctional activity. Universities also need to produce the marine farmers, extension agents and expertise for marine aquaculture. Very few programs are taking up this task, and rather spending large sums on studying climate and human impacts on marine systems. These studies (while vital) are used by environmental groups to block development. A counter argument for development has not received commensurate support and research. These changes will require leadership at the highest levels in a top down approach. At stake is the future of not only the oceanic fish stocks, but future human and economic growth.

Research thus should add aquaculture development, as a sustainable enterprise, to the debate on the future of oceans. New species, diets, and culture systems need funding and attention. With scarce funds, this may mean directing personnel and programs away from stagnant aquacultures in freshwater. Another need is the development of species and systems that incorporate ecological principles of polyculture

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and integrated culture. High inputs of energy and fish meal and fish oil are not sustainable. Diets need to further eliminate or reduce the use of terrestrial grains and oils. These are high in omega 6, currently excessively high in comparison with omega 3 from algae. Algae carbohydrates, oils and sugars should be investigated. They form the natural diet of many low trophic level species and their culture is rapidly developing for bioenergy and omega 3 sources. The byproducts of these industries will be substantial and available.

Without this scenario, ocean stocks will be decimated to the point of no return by the commons principle and by economic incentives to harvest the last of desirable species such as Blue fin tuna. Hunger and malnutrition will increase, with its political impacts on instability. Pollution from agricultural overexploitation and ill-advised

exploitation will increase and cause disease and extinctions of species and ecosystems. No less than the future of mankind is at stake in moving into the next frontier: oceans.

The new optimism inherent in this approach would negate the negative opinions currently en Vogue that the oceans, and the earth as oceans comprise more than 2/3s of the planet, are dying from overexploitation, pollution, and climate change. Privatizing and developing the vast suitable marine areas for aquaculture would reduce pressure on fish stocks and allow better control. Focusing on preserving areas of pristine and ecological importance would follow. Discussions, if started now, would enable planning and government involvement with the private sector on this vital subject of interest and need for the future of the planet's food supply and the health of the ocean and fish stocks.