Of Fish and Men

An Analysis on Aquaculture's Future Promise

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Introduction

Cod, salmon, crabs, tuna, and shrimp. These are some of the choices that we often consider when shopping for seafood at the nearest market. It is a common alternative to the usual pork, chicken, or beef fare. But is there anything more to seafood? More than you might assume. Fish stock, as they are normally referred to collectively, is increasingly becoming a major food source for the world. And, for many developing countries, it is a very important dietary source. "Fish provides the primary protein needs of 950 million people" (Gupta 2004, p.410). Here then is where the cusp of the problem lies. The bounty of seafood products available to consumers has been a deceptive indicator of the actual surviving population in the seas today. And, as the world increasingly demands more and more seafood on their plates, the pressure on wildlife population also increases. Aquaculture, the rearing or farming of aquatic species under controlled conditions, has been proposed as the solution to take pressure off wild stocks and address the growing gap between demand and supply.

Figure 1: Seafood at Pike Market, Seattle

In the proceeding sections, I would like to discuss the current state and trends in the world's fisheries. Then, I would like to briefly discuss the rise of the aquaculture industry and the present condition that it is in. There are many debates regarding its social and environmental impacts. I will elaborate on the major issues and discuss the costs and benefits normally associated to aquaculture. Despite its advocates' claims of poverty alleviation and solution to hunger, I would argue that aquaculture's expansion is not pro-poor. But regardless of this fact, evidence shows that economic pressures will guarantee its tremendous growth in the near future.

Current State of the World's Fisheries

John Volpe accurately describes man's relationship to the oceans in saying that "the seas are the last vestiges of our hunter-gatherer past" (Volpe 2005). This is true because man has managed to successfully domesticate, tame, and cultivate the select land-based plants and animals that it needs for sustenance. Agriculture has become a high-scale scientific and mechanized industry. And similarly, animal husbandry has evolved into a very

sophisticated level. Therefore, it has been viewed that these sources of food production is very near or has already reached its limits. Because the oceans are relatively less accessible, marine wildlife has been protected from systematic exploitation…at least until the last few decades. Since then, advances in methods used by capture fisheries have opened up the deep seas to similar utilization. This includes the use of radar and sonar for easier tracking of fish schools and the application of industrial fishing vessels with built in factories for quick processing. These developments made harvesting fish from the ocean a more efficient process. And, the result is that fish stocks in the wild have been significantly reduced due to over-fishing. Theory suggests that the maximum sustainable yield that can be cropped from a fishery comes when the biomass of a target species is about 50% of its original levels (The Economist 2003b). But most marine fisheries are below this threshold. According to 2003 data, the biomass of large predator species in a new fishery is reduced on average by 80% within 15 years of the start of exploitation. In some long-fished areas, it has halved again since then.


Figure 2: Bluefin Tuna

Growing world population has also contributed to increased pressures on ocean wildlife. And, as people get richer, they eat more fish (The Economist 2003c). "Fish consumption doubled between 1973 and 1997, according to a joint study by two leading think tanks, the International Food Policy Research Institute and the WorldFish Center" (Mann 2004). This rising demand makes it even more difficult for wild populations to keep up. And, this obvious trend has led some to believe that the ocean is destined for a classic 'tragedy of the commons'[1]. Historically, management of the natural resources in the seas has proven to be very difficult. Although, there are international agreements that exist, its enforcement have not been met with much success because there are no clear boundaries and fish populations migrate heavily in international waters. In 1991, for instance, several countries arranged to reduce their catches of swordfish from the Atlantic. Spain and the U.S. complied with the limitations (set at 15 percent less than 1988 levels), but Japan's catch rose 70 percent, Portugal's landings increased by 120 percent and Canada's take nearly tripled (Safina 1995).

The Role of Aquaculture in Fish Production

In this environment of declining catches and increasing demand, aquaculture has stepped in as a candidate solution. Aquaculture is the farming of aquatic species including a variety of fish (i.e., tilapia, cod, salmon, tuna), crustacean (i.e., shrimp and crabs) and ocean flora (i.e., seaweed and algae). The methods of aquaculture have existed and been

[1] This 1968 theory by Garrett Hardin argued that common ownership of a resource cannot succeed, as the innate human desire to maximize individual benefits will inevitably cause overuse of a common resource leading to ultimate resource degradation (Boggs 2000)

applied by local fishermen in China as early as the 14th Century. However, it is important to note that these methods have been done in subsistence levels wherein fish are raised and harvested mainly for household or domestic consumption. Subsistence aquaculture is distinct from what has occurred over the last three decades wherein fish farming has been executed in large-scale, ranch style productions for high volume output mostly directed at national or international markets. This shift has introduced what can be referred to as *industrial aquaculture*. Data from the World Watch Institute (2003b) shows that the percentage of global production of fish and seafood coming from aquaculture has increased from 3.9% in 1970 to 27.3% in 2000. This is supported by recent statistics provided by the U.N. Food and Agricultural Organization which shows that aquaculture has continuously contributed to a larger share of fish produce (Table 1).

Table 1: FAO 2004, World Fisheries Production Statistics (in million tons)

	1998	1999	2000	2001	2002	2003
Capture Fisheries	87.7	93.8	95.5	92.9	93.2	90.3
Aquaculture Farms	30.6	33.4	35.5	37.8	39.8	41.9
Total World Fisheries	**118.2**	**127.2**	**131.0**	**130.7**	**133.0**	**132.2**

In 2002, total world aquaculture production (including aquatic plants) was reported to be 51.4 million tons by quantity and US$60.0 billion by value (FAO 2004). As a food source, farmed fish produce is increasingly becoming a very important commodity. According to Lester R. Brown, board chairman of the World Watch Institute, fish farming is poised to overtake cattle ranching as a food source by 2010 (Futurist 2001). Other figures indicate that this might have already occurred. In 2002, worldwide production of beef was estimated at 49.7 million metric tons while farmed fish produce was at 52.7 metric tons (WWI 2003a).

The Blue Revolution

Along with the increasing importance of aquaculture are promises to take pressure off wild stocks, generate a net surplus of seafood, and provide financial opportunity for economically marginalized groups (Volpe 2005). The rapid expansion of the aquaculture industry that is projected to take place soon has been termed the 'Blue Revolution'[2]. This is in deliberate parallel to the Green Revolution that happened in the agricultural sector in the 1960s and 1970s. That period has been attributed to huge increases in productivity and yields from various plant species (most especially staples such as wheat and rice) due to technological advances. The high yield crops, controlled water supply, and improved farmer management skills ushered in by the Green Revolution has led to a 30% plus increase in maximum yields and are responsible for 20 – 50 percent of the total, increased productivity (Lomborg 2001, p.63). The argument is that today's methods won't be able to produce the volume of fish needed for tomorrow. Therefore, fisheries need to undergo the same level of transformation that occurred in the agricultural sector in order to produce

[2] The term 'Blue Revolution' has been used and applied in several articles, journals, and literature. But, the original coinage of the term is unknown.

enough to supply the world's growing demand for seafood. Otherwise, the seas will be destroyed.

There are several signs that indicate that this transformation is already underway. First and foremost is the rise of large, commercial industries dealing with fish production. Aquaculture is gradually but continuously moving away from subsistence levels into commercial scale production. Mechanization and factory farming will soon become a common practice. Even now, there are new apparatuses being deployed for the purpose of large scale sea ranching. The University of New Hampshire has created the first fish farm to ever operate on the open sea (Mann 2004). Through the Open Ocean Aquaculture Project, they have created a radio controlled ocean cage (to house mobs of fish) that is suspended beneath the ocean surface (please see Figure 3). The idea is to "launch the enormous motorized pens with lab-bred baby fish, hitch months-long rides on ocean currents and arrive at their destinations filled with mature animals, fattened and ready for market" (Mann 2004). Furthermore, in some countries that have invested in technology development and applications, such as Norway and Japan, the marine aquaculture industries represent a substantial sector of the economy (NCR 1992).

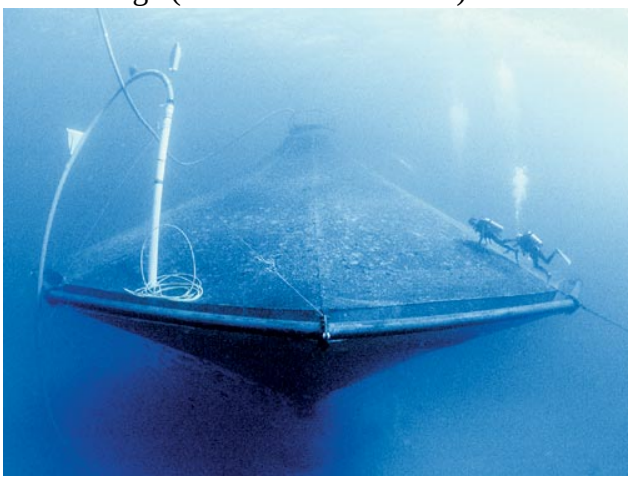

Figure 3: A prototype sea ranch in the coast of Hawaii

Secondly, normal yields from aquaculture harvest are being pushed beyond the natural limits with the use of biological and scientific methods. Hormones, advanced chemical feeds, and antibiotics are highly utilized in fish farms across North America and Europe. Also, the genetic-modification of fish has been done in order to increase the size of the farmed specie while reducing the amount of time it takes to grow. For example, transgenic[3] salmon injected with anti-freeze genes have been produced in order to make them thrive in environments that are not normally suitable (please see Box 1: Salmon Farming on page 8). This then expands the salmon's range of cultivation. Tilapia, a freshwater fish, is another species that is being produced at the genetic-modification stage.

Debates Surrounding Fish Farming

Although the advocates of expanded aquaculture present it as the only alternative, there are many disagreements around the issue of fish farming. First and foremost is the negative ecological impact. Aquaculture is a practice associated with water pollution. Inland ponds need to be emptied and replaced on a regular basis. And, this process leads to the flushing of highly contaminated water into rivers, streams, and lakes. For example, salmon grown in offshore pens in Norway create about the same amount of waste as Norway's 4 million

[3] Transgenics refer to species that have genes transferred from another species. Researchers introduce desirable genetic traits into fish in order to create hardier stocks.

people (Futurist 2001).

Figure 4: Greenpeace protests against the contribution of the World Bank to the shrimp aquaculture industry (Valencia, Spain: 21 November 2002)

Habitat destruction is another accusation pointed at the industry. In this case, shrimp aquaculture is considered as the primary culprit for the destruction of coastal habitats, especially mangroves. According to Greenpeace, in many countries in Asia, rice paddies are quickly being converted into shrimp ponds which are seen as being more lucrative. In the Indian state of Tamil Nadu, where 60% of the population is landless, thousands of hectares of land have been set aside for shrimp farms despite concerns over threats to the livelihoods of 25,000 families (Greenpeace 2005). Many environmental organizations have actively objected to the diversion of natural resources due to aquaculture (please see Figure 4).

Some fish farms have also developed a reputation as breeding grounds for infection and diseases. Because some fish pens are not completely isolated from natural bodies of water, there is a high possibility of parasites jumping from farmed fish to the ones in the wild. A recent study by the University of Victoria found that migrating fish started out generally lice-free but became heavily infected after passing the a fish farm in British Columbia (Science 2005).

Although the ecological concerns are disturbing, there is an even bigger issue related to aquaculture's impact on the environment…the danger of contaminating the seas with genetically-modified fish. This is regarded as a serious issue because escaped GM fish can better compete with the wild for food sources because of their added genes. And, they might displace wild populations while, at the same time, not being able to reproduce themselves. According to Charles Mann:

> "Farmed animals are selected to grow quickly but not to breed successfully - that's done in a lab. Wild fish breed exuberantly but have evolved to grow more slowly so they can ride out drops in the food supply. Laboratory studies suggest that ravenous farmed salmon could monopolize the food supply, then fail to spawn". (2004)

Therefore the whole species is in jeopardy.

Finally, aquaculture is seen as an inefficient means of food production. The production of farmed salmon results in a net loss to the world's total fish production, as it takes four pounds (1.82 kg) of ocean fish, turned into feed, to yield one pound (.45 kg) of salmon (WWI 2003a). This is mainly due to feeds from carnivorous farmed raised fish such as

salmon and tuna are harvested from the oceans. Fish farms need protein feed, and about 17% of ocean fish, an over-harvested wild resource, becomes food for captive-bred fish (Johnson 1998).

Arguments Against the Claims of Aquaculture

In spite of the myriad of consequences, advocates of aquaculture still believe that it is necessary to develop, advance, and expand the industry because it is crucial to keep food supply in line with demand. Otherwise, the shortfall will lead to hunger. And the direst consequences will be burdened by poor people from developing countries. In other words, "improved aquaculture techniques are needed to feed the world" (McGinn 1998).

However, *I would argue against the claim that the growth of industrial aquaculture is pro-poor*. If we take a more critical look, it is easy to notice that there are many flaws to the linkage proposed between increased production, hunger and poverty reduction.

First of all, attacking the problem of hunger and poverty in the supply side is a narrow approach. Increasing production is not a sufficient solution unless demand for the product is stabilized or reduced. At present, the demand for fish stocks will continue to increase even if the supply is met. Major metropolitan areas around the world want and expect to have reasonably priced sushi…not just Tokyo. This is because consumer incentives are distorted when it comes to purchasing decisions. This distortion in consumer behavior can be attributed to two main factors:

1) Consumers do not burden the ecological and environmental costs of non-sustainable aquaculture. At least, it is not incorporated in the pricing of the fish sold in markets. As industrial aquaculture expands, the negative ecological and environmental effects will most likely shift towards unregulated areas and countries. Therefore, people from poorer nations will disproportionately end up incurring the cost of externalities from unsustainable practices.

2) Highly subsidized fishing industries have been a long-standing tradition. The continued production and harvesting is possible only due to the support from taxpayer money. For example, in 1997, the EU provided $1.4 billion to the fishing industry and Japan $2.9 billion (Gupta 2004, p.410). At a global scale, this financial support is even more staggering. To catch $70-billion worth of fish, the fishing industry recently incurred costs totaling $124 billion annually. Subsidies fill much of the $54 billion in deficits (Safina 1995). These artificial supports include fuel-tax exemptions, price controls, low-interest loans and outright grants for gear or infrastructure. Subsidies distort consumer behavior

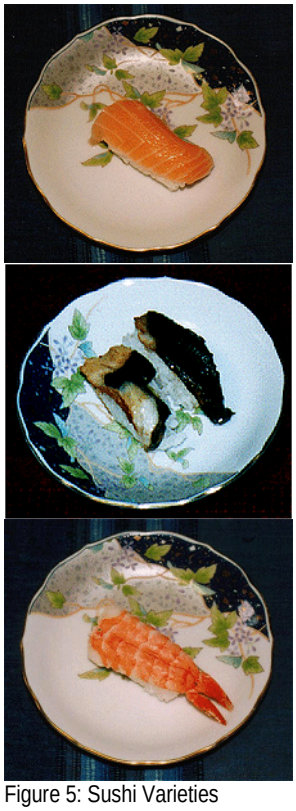

Figure 5: Sushi Varieties

because the real cost of bringing fish to market is not reflected and the prices charged are artificially depressed.

Secondly, more recent understanding in theories of poverty and development has directed a shift against the Malthusian[4] view of poverty into a market-failure explanation of its causes. Most notable is the work of Amartya Sen on "Poverty and Famines" (1944). In his approach, he asserted that more important than the lack of supply is the distributional problems associated with food security. People, even in poverty stricken areas, suffer from hunger not because there is not enough food, but because the poor has been priced out of the market or does not have the purchasing power to make subsistence products available to them. This very same analysis can be applied to a future where industrial aquaculture has managed to expand at the proposed levels. Unless poor people have the purchasing power to meet their demands, the unfavorable result will be that they will not be able to afford seafood products that are available in the market.

Box 1: Salmon Farming

The Salmon King (excerpt only)

Sea ranching demands a fast-growing fish for all seasons. A company called Aqua Bounty has engineered the perfect catch.

This year, if all goes well, the FDA will approve the company's AquAdvantage salmon for human consumption - the first genetically engineered fish to get that stamp. (A half-dozen other agencies need to give a nod before the new salmon makes it into the kitchen.) Thanks to clever lab work, AquAdvantage fish reach market weight in 18 months, rather than three years.

Aqua Bounty's innovation builds on previous research into flounder. Unlike other fish, flounder thrive in frigid water because they have special "antifreeze" proteins in their blood. To control the production of the protein, the gene is accompanied by a promoter, a bit of DNA that turns it on and off. When days grow short, the promoter goes to work and the gene starts cranking out antifreeze. Aqua Bounty realized that the promoter could activate any gene, including the one that controls growth in salmon. (Actually, they ended up using the promoter from another antifreeze-making species, ocean pout.)

Thus, the DNA that turns on the pout's antifreeze spigot gives AquAdvantage a seasonal growth spurt. Salmon normally produce growth hormone only during summer. In winter, they stop secreting it to reduce the need for food. Scientists glued the promoter to a growth hormone gene, so it would be activated in winter, then introduced the resulting genetic construct into the fish. The resulting salmon have two active growth hormone genes: the original, which induces the fish to grow when days are long, and the new one, which does the same during the rest of the year. (Mann, 2004)

Finally, the Blue Revolution is purported to bring the promise that the Green Revolution delivered. But, it can also share its folly. Credit should go to where it is due. But the same thing can be said about blame. The Green Revolution in the 1960s and 1970s had also aspired for goals of poverty alleviation and reducing hunger through increased production. However, higher yields per acre did not necessarily deliver the promised prosperity to developing countries. The assumption that higher yields will lead to increased income for poor farmers and therefore a way out of poverty did not materialize. In retrospect, we can see that linkage did not work because farmer revenues rose but profits did not. Although the new, genetically modified, higher-yield seeds increased production, it was accompanied by an increased reliance on pesticides and petro-chemicals. In order to reap the potential of the new seeds, farmers rapidly increased their use of mineral fertilizers, pesticides and irrigation. Between 1970

4 Thomas Malthus' 1798 publication, *An Essay on the Principle of Population*, identified the geometric role of natural population increase in outrunning subsistence food supplies.

and 1990, fertilizer applications in developing countries shot up by 360 percent while pesticide use increased by 7 to 8 percent per year (FAO 1996). For many poor producing regions, the rise in cost of inputs negated the increase revenue from extra output. Therefore, without addressing the economic implications of higher production output, purely technology-driven solutions will be an insufficient tool for fighting poverty. Genetically modified salmon falls short as a solution to hunger.

Recommended Solutions

"Those who do not learn from the past are destined to repeat it"
- George Santayana

This well-known maxim should be kept in mind when it comes to the expansion of aquaculture. In light of the many arguments against the claims that aquaculture is pro-poor, there are several recommendations that can be made in order to increase the likelihood that the Blue Revolution shares the gains but not the mistakes from the Green Revolution.

At the policy level, the most important tangible action that can be taken is to make sure that subsidies do not prop up the expansion of industrial aquaculture. Otherwise, the aforementioned market distortions and the warped consumer incentives are exacerbated. Secondly, neo-liberal policies for privatization and free markets are not the solution. It will only serve to hasten the exploitation of the seas for profit and increase the international competition for disadvantaged fish farmers from developing countries. The profit gains will mainly accrue to players that manage to take advantage of economies of scale since they will have the capital to invest and the volume necessary to stay afloat even if profits per unit shrink (Rosset 1998). Finally, it is important to realize the fact that aquaculture has one important advantage over open-access fisheries: it can be more easily governed (The Economist 2003c, p.21). This is then an avenue for enforcing established better-management practices (BMP) to keep the industry sustainable.

Conclusion

As fish stocks become an ever more increasing source of world food supply, it is critical that more attention is paid to the underlying industry. The manner in which it evolves during the next decade will have social and environmental impacts that are not negligible. It is hard to deny that aquaculture has a lot to offer. The industry has much room to grow and technological innovations can still help improve productivity. However, over-exuberance and over-confidence in fish farming as a solution to world problems warrants some caution. When addressing poverty and hunger, historical examples have illustrated that the relationship between food supply and food security is not direct. Therefore, aquaculture's grand promise needs to be viewed with a healthy skepticism. Otherwise, we are setting ourselves up for another disappointment.

BIBLIOGRAPHY

Boggs, L.P., 2000. *Community Power, Participation, Conflict and Development Choice: Community Wildlife Conservation in the Okavango Region of Northern Botswana*. Evaluating Eden Discussion Paper No. 17. London: International Institute for Environment and Development.

FAO, 2004. The *State of World Fisheries and Aquaculture*. Available Online: http://www.fao.org/documents/show_cdr.asp?url_file=/DOCREP/007/y5600e/y5600e00.HTM [Accessed on May 2, 2005].

FAO, 1996. *World Food Summit: Food For All*: Towards a New Green Revolution. Available Online: http://www.fao.org/documents/show_cdr.asp?url_file=/DOCREP/x0262e/x0262e06.htm [Accessed on May 26, 2005].

Futurist, 2001. *Fish Farming Gains on Cattle Ranching*. Volume May/June 2001, Issue 35.

Greenpeace International, 2005. *Aquaculture Threat to Food Security*. Available Online: http://archive.greenpeace.org/oceans/globaloverfishing/aquaculturethreat.html [Accessed on May 25, 2005].

Gupta, J. 2004. *Global Sustainable Food Governance and Hunger: Traps and Tragedies. British Food Journal*, Vol. 106, No.5, pp. 406-416.

Johnson, D. 1998. *Seafood That Never Seas the Sea*. Futurist. October 1998, Vol. 32, Issue 7, p14, 2p.

Lomborg, B. 2001. *The Skeptical Environmentalist: Measuring the Real State of the World*. Cambridge: University Press.

National Research Council, 1992. *Fish Farming: Aquaculture Recommended as Demand for Fish Climbs*. Marine Aquaculture: Opportunities for Growth. Washington DC: National Academy Press.

McGinn, A. 1998. *Blue Revolution*, Worldwatch Institute, Available Online: http://www.worldwatch.org/ [Accessed on May 3, 2005]

The Economist. 2003a. *A New Way to Feed the World*. 8/9/2003, Vol. 368 Issue 8336, p9, 1p, 1c;

The Economist. 2003b. *Ocean's Eleventh Hour?* 5/17/2003, Vol. 367 Issue 8324, p72.

The Economist. 2003c. *The Promise of a Blue Revolution*. 8/9/2003, Vol. 368 Issue 8336, p19, 3p, 2 graphs, 2c;

Rosset, P. 1998. *World Hunger: 12 Myths, Lessons from the Green Revolution*. 2nd Edition. Oakland: Grove Press.

Safina, C. 1995. *The World's Imperiled Fish*. Scientific American. Nov95, Vol. 273 Issue 5, p46, 8p.

Science, 2005. *Fish Farm Hazards*, vol 308, Issue 5719, April 8, 2005.

Sen, A. 1984. *Poverty and Famines: An Essay on Entitlement and Deprivation*. Oxford: University Press.

World Wildlife Fund, 2005. *Aquaculture Featured Projects*. Available Online: http://worldwildlife.org/cci/aquaculture.cfm [Accessed on May 2, 2005]

Mann, C.C. *The Bluewater Revolution*. Wired Magazine. Issue 12.05. May 2004.

World Watch Institute, 2003a. *Factory Farms of the Sea*. August 18, 2003. Available Online: http://www.worldwatch.org/press/news/2003/08/18/ [Accessed on May 15, 2005]

World Watch Institute, 2003b. *Matters of Scale Factory-Fish Farming*. September/ October 2003. Available Online: http://www.worldwatch.org/pubs/mag/2003/165/mos/ [Accessed May 18, 2005].

Volpe, J.P., *Dollars Without Sense: The Bait for Big- Money Tuna Ranching Around the World***,** Bioscience, April 2005, Vol. 55 Issue 4, p301, 2p