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Seafood for Tomorrow: Sustainability and the Rise of Aquaculture in the US

By Garrett Wheeler and Sofiya Feerer

Outside of Lansing Michigan, Russ Allen is growing shrimp in giant indoor tanks. In the desert North of Las Vegas, Scott McManus is building a similar facility using recaptured and reprocessed water. McManus's system is sustainable, organic, and chemical-free.

In Ridgeway Virginia, a town known for NASCAR and the Martinsville Speedway, Blue Ridge Aquaculture has become the country's largest producer of indoor-raised tilapia. Other indoor facilities, large and small, are sprouting up country-wide. Like organic farms struggling to find their niche within American agriculture, land-based seafood cultivation represents a greener future for an industry coping with over-exploitation and ever-increasing consumer demand.

Meanwhile in our oceans, world wild fish production is estimated to have peaked and annual production is likely to hover at levels between 85 and 95 million tons. This figure considers that some stocks are currently being fished beyond maximum sustained yield (MSY), i.e., overfished – meaning those levels of production will have to be reduced, while other stocks are rebuilding or healthy – such as Atlantic and Pacific groundfish stocks and Pacific salmon, where an increase in overall production of those species is anticipated.

The increasing demand for seafood – brought on by a growing population, together with the worldwide growth in a middle class able to afford upscale fish products – will have to be met by farmed, or aquacultured, fish production.

The issue is no longer whether there is a future for aquaculture, but what forms it will take, and especially where it will primarily take place – on shore or in open waters – whether it can be conducted in a sustainable manner and whether it will complement existing wild fish production or destroy it.

Pioneered by the Chinese a few thousand years ago, growing and harvesting fish as well as crustaceans, mollusks, and aquatic plants, is not a new practice – but it is a growing one.

In the last half-century, aquaculture has gone from somewhat of a novelty to a well-established industry, with global production increasing from less than 1 million tons in 1950 to 52.5 million tons in 2008. About half the seafood consumed around the world now comes from such farms, and that number is expected to increase in the coming years.

Aquaculture facilities are located both in the ocean and on land. More than 48 percent of the world's aquaculture facilities are ocean-based, while the rest are situated in freshwater ponds, estuaries, or land-locked facilities. In the United States, the bulk of the industry is centered on farming catfish in freshwater ponds in Mississippi and its surrounding states. Nearly 80 percent of the aquaculture that takes place in US domestic marine waters produces shellfish – oysters, clams, and mussels – while the remaining 20 percent comes mostly from salmon and shrimp operations in Maine and Washington State, according to the Coastal Conservancy.

Production of farmed fish has expanded well beyond freshwater species such as catfish, tilapia, shrimp and salmon – the latter two competing with wild fish production. Sablefish, halibut, cod, crab, snapper and tuna are all species where aquaculture operations are now in place or planned for the future. Aquaculture is no longer a concern just for shrimp and salmon fishermen.

Recently, a new wave of enthusiasm toward US ocean-based operations, particularly offshore farms located in the 200 mile-wide Exclusive Economic Zone, spurred by a government agency, has gained attention. Called the "blue revolution" by its advocates – taking a

page from the "green revolution" in agriculture following World War II – the movement has garnered support from entrepreneurs as well as the federal government. For the past 40 years, the US government has offered subsidies to aquaculture developers, much as aquaculture has enjoyed generous government financial support in many other nations around the world.

In 1998, the US Department of Commerce's National Oceanic & Atmospheric Administration (NOAA) established its National Marine Aquaculture Initiative, which has granted $15 million to date for aquaculture development. Commerce's 1999 "Aquaculture Policy" promotes open-ocean aquaculture development, while the Secretary of Commerce recently allowed a Gulf of Mexico Aquaculture Fishery Management Plan that would permit up to 65 million pounds of offshore fish production in the Gulf. And, this past July, NOAA announced its "Aquaculture Technology Transfer Initiative" to "foster public-private partnerships…"

Proponents of the "blue revolution" see open-ocean farms as playing a major role in the solution to the US's $9 billion seafood trade deficit, but opponents warn of potentially devastating economic, social, and environmental consequences.

A central concern lies in the fact that, with few exceptions, ocean-based aquaculture has been accompanied by rampant environmental damage. Examples are everywhere. Dense salmon farms in Canada, Chile and Northern Europe brought disease or spread parasites to wild fish and released waste into coastal waters. Mangrove forests, which provide valuable habitats for a multitude of marine species, have been destroyed to make way for shrimp farms in Thailand and other parts of Asia. In 2009, 40,000 adult salmon escaped from Canada's largest aquaculture facility, compromising the genetic fitness of wild Atlantic stocks through interbreeding. On the West Coast, Atlantic salmon escapees from BC and Washington State salmon farms have been found in Alaska streams where they could pose a threat to native Pacific salmon populations.

In China, the country responsible for 61 percent of the world's aquaculture, increased production pressures have led to over-packed ponds, causing disease and pollution from fish waste. The waste can overload coastal waters with nutrients, causing "dead zones" unable to sustain sea life. Chinese fish farmers have responded by loading fish with antibiotics and other drugs including malachite green, an antifungal agent and potential carcinogen banned for use in China in 2002. According to *TIME* Magazine (June 18, 2011), a badly run nearshore or ocean-based farm of 200,000 salmon can flush nitrogen and phosphorous into the water at levels equal to the sewage from a town of 20,000 people.

A Safer Alternative?

One possible solution to the conundrum of offshore fish farms may be the use of land-based facilities, where problems like escapement, pollution, and disease are more easily dealt with. These technologies still need improvement, especially in terms of economic viability, but already there are a handful of US businesses cultivating fish away from the ocean. One such facility, located a few miles outside of Lansing, Michigan, may be a model for profitable, environmentally sound aquaculture that can minimize ecological harm while still turning a profit.

A recent article in the Lansing State Journal highlighted Russ Allen's Seafood Systems Inc., a company that runs a viable shrimp business using indoor tanks and a recirculation system. Allen says that if he can expand his shrimp farm operation to become a commercial size farm and processing facility, the result will be lowered costs and cheaper shrimp. "We could grow shrimp almost as cheap as we can grow chicken," Allen told the Journal. "There's huge room to grow."

Marianne Cufone, Executive Director of the Recirculating Farms Coalition, and formerly Fish Program Director for Food & Water Watch, says that "recirculating aquaculture systems (RAS)," hydroponics (growing plants in water) and aquaponics (growing fish and plants together) can provide healthy food and local jobs in an eco-friendly way, without competing with fishermen. Plus, they can operate virtually anywhere. "These can be community-based systems that provide fresh, local food to consumers, which is something we so badly need," Cufone says. "Green jobs can also be created."

RAS technology recycles water within the system, requiring only occasional supplements of new water. Aquaponic systems create a symbiotic environment, growing plants hydroponically and filtering the water which in turn recirculates to the fish. The process can be extremely energy efficient, and capable of running on solar, wind, or thermal power. Some farms convert fish waste into methane gas, which may be used to power the farm. "You really have to go see one of these systems to appreciate how amazing they are," says Cufone. "People can't believe food production can be this clean and efficient."

Unlike ocean-based aquaculture, RAS and aquaponic systems can operate without competing with fishermen for ocean space or fish. As a precaution against escapement, ocean-based facilities may be restricted to farming species native to the area, where local fishermen are after the same species. This is the case in California where non-native salmon and genetically engineered fish are banned from use in open water net pens. But that is not the law everywhere. Contained, land-based facilities, on the other hand, can theoretically grow any species in any location, without endangering wild fish populations or capture fisheries, all while allowing, for example, diners in Las Vegas to enjoy fresh fish pulled from the water just hours earlier.

Onshore systems can also produce more fish faster. According to the Recirculating Farms Coalition (RFC),

recirculating farms can raise a "market-sized fish" in nine months, instead of the fifteen to eighteen months needed by other systems. And, this is without resorting to genetic engineering. They're also extremely space efficient, varying in size from large-scale commercial farms to desk-size tanks. Additionally, the need to use antibiotics and other drugs may be eliminated because fish living in an enclosed system can be exposed to fewer parasites and diseases and have reduced stress.

A side benefit of land-based aquaculture in urban settings, aside from reducing transportation costs of food to the market, is that new aquaculture development could help to rebuild the economies of cities in the nation's rust belt. In rural areas, including the west side of California's San Joaquin Valley, the Klamath Basin, and already in parts of Florida, land-based fish farms may be a way to convert problematic agricultural lands while still keeping them in food production.

While RAS and aquaponic technology is capable of providing fresh, local seafood to communities across America without the carbon footprint associated with long distance shipping (or maintaining offshore cages), a few questions remain to be answered. For example, a problem that exists for both ocean-based and land-based aquaculture is what to feed the fish. For many of the fish in high demand, like salmon, bass, and especially tuna, because they're high on the food chain, the amount of protein it takes to feed the fish can be greater than the amount they ultimately produce.

According to the Ocean Conservancy, each year about 25 million metric tons of fish are "reduced" into fish meal – almost 30 percent of all wild fishery landings. This glaring inefficiency is leading to a new effort to find solutions. "The best place to start with aquaculture is probably with vegetarian or omnivourous fish," Cufone says. "And while there's been some success with soy as a replacement protein, most of the soy being used is geneticaly modified and that comes with its own problems. There are more natural options – some folks are using worms, algae, and even re-purposing waste for creatures that would eat such products in the wild. Ideally, we're really after a natural product to feed fish that's good for the fish and doesn't harm something else."

Another issue is whether land-based systems can be economically viable. After all, it's often thought that start-up costs tend to be higher for land-based commercial facilities than for open-ocean pens. The short answer is that land-based farms can be money-makers. "These systems are absolutely economically viable," says Cufone. "Even without the millions of dollars in grants that have gone to ocean systems we're seeing smaller scale operations be very successful." Cufone points to the economic wastes caused by operating giant cages in the open ocean, a dynamic environment where operators can't control variables like water quality or temperature. "The model is very different for community-operated, land-based farms," says Cufone.

While Blue Ridge Aquaculture's Virginia-based tilapia facility is struggling to expand production from four million pounds of fish annually to ten million, and eventually upwards of 100 million, the business has remained solvent since 1993. The company retains complete control of its operating process, operating on 100,000 square feet. Russ Allen's Michigan shrimp farm currently produces only about 100 to 200 pounds of shrimp each week, but Allen told the Lansing State Journal that if he were given more financial backing, he could grow shrimp cheaper in Michigan than in China, where labor costs make shrimp about $1 per pound.

For Allen, and the rest of the land-based aquaculture entrepreneurs looking to expand into the commercial sector, the major hurdle towards economic success is a lack of investment or subsidies from the government. Without government assistance, Allen and his colleagues must rely on commercial banks or venture capitalists, which Allen says are wary of giving loans to new, unproven businesses. Ironically, the US government has subsidized aquaculture since the 1960s, but little of that money has reached non-ocean farmers.

Interestingly enough, it has been NOAA and the open water aquaculture operators who've been making claims that land-based operations are incapable of meeting new demand or are not economically viable, or both. This is not surprising, however, since NOAA has no regulatory authority over land based operations and the statements of the open water operators seem simply self-serving, not factual.

Agency Patchwork and Authority to Regulate

As the US aquaculture industry undergoes a new period of expansion, the question of agency regulation arises: who has jurisdiction over enclosed pens in the open ocean? Should the same agency also be responsible for land-based operations?

The National Aquaculture Act of 1980 recognized that the harvests of wild fish and shellfish were operating beyond optimal yield. At the time, Congress already recognized that aquaculture could supplement wild caught fish and help reduce reliance on international imports of seafood. The purpose of the Act was to establish a national aquaculture policy and establish the Department of Agriculture as the lead federal agency. The Secretary of the Department of Agriculture is required to establish a National Aquaculture Information Center for collecting and analyzing "scientific, technical, legal, and economic information relating to aquaculture, including acreages, water use, production, marketing, culture techniques, and other relevant matters."

Currently, the regulatory framework is a confusing patchwork of agency discretion, much like the rest of US ocean policy. The Environmental Protection Agency (EPA) regulates discharge of pollutants under the Clean Water Act, while the Army Corps of Engineers presides

over devices used to explore, develop, or produce resources on or around the seabed. The Coast Guard, under the Department of Homeland Security, regulates vessel traffic and dictates safety measures for ocean-based aquaculture structures. Even the Department of Defense may be involved, reviewing proposals that could interfere with naval operations.

Claiming authority under the Magnuson-Stevens Fishery Conservation & Management Act (MSA), the New England and Gulf of Mexico Regional Fishery Management Councils have exercised regulatory oversight over ocean-based farms. In New England, the Council established evaluation criteria for ocean aquaculture proposals, while the Gulf of Mexico Council is working to develop an offshore aquaculture fishery management plan.

To make matters even more complicated, because farmed fish are ultimately sold as food, the United States Department of Agriculture (USDA) has also offered its own reports and monitoring. Along similar lines, the Food & Drug Administration (FDA) is currently evaluating the production of genetically-engineered or modified (GM) fish, and charged with approving the use of antibiotics and other drugs on the fish themselves.

Not to be outdone, NOAA recently asserted its authority to regulate aquaculture under the MSA, although the source of that authority, taken from a 1993 memorandum from NOAA General Counsel, Jay. S. Johnson, is disputed. In any case, NOAA released its official policy, an ambitious document that seeks to "integrate environmental, social, economic considerations in management decisions concerning aquaculture," in June. Despite language indicating that NOAA's policy is one concerned with stewardship and sustainability, there is no discussion given to the promise of land-based aquaculture systems, an obvious oversight given the tumultuous history of open-ocean aquaculture.

Additionally, the National Marine Fisheries Service (NMFS), the nation's fishery agency, has assumed a role promoting open ocean aquaculture development as part of NOAA's policy regime. On July 6, 2011, NMFS issued Kona Blue a permit for operations in federal waters off Hawaii; however, the agency's authority is being challenged in court by Food & Water Watch and others.

Like any piecemeal regulatory structure, these agency overlaps mean that the regulation of aquaculture is highly inefficient. For example, NOAA is an agency founded on ocean and atmospheric science and research, and may not be equipped to handle the rigors of enforcement or economic analysis. Similarly, the USDA is probably not well versed in the biology affecting marine ecosystems. But is there a better alternative?

One suggestion has been the addition of a new, comprehensive agency that would be in charge of both offshore and on-shore aquaculture. The concern that NOAA and NMFS may be overlooking the promise of land-based aquaculture could be remedied with the creation of an agency that oversees both systems, such as a "Bureau of Fisheries & Aquaculture." Indeed, such an agency could be outside of NOAA, a standalone entity within a cabinet agency, much as the US Fish & Wildlife Service is within the Department of Interior.

Of course, creating a new agency may be problematic so far as it would need to fit somewhere – the Department of the Interior, Commerce, or Agriculture all seem viable. There's also no overlooking the current political and economic climate, which may not be ripe for creating more government oversight. However, the need for more cohesive – and effective – agency regulation over aquaculture will continue to persist and magnify as the industry expands.

At the moment, no explicit laws exist on a national level to regulate aquaculture, offshore or land based, though that could change in the coming months. The noticeable lack of legislative policy has given way to the recently introduced "National Sustainable Offshore Aquaculture Act of 2011" (H.R. 2373), proposed by US Representative Lois Capps, D-Santa Barbara. That bill would set up an unprecedented regulatory framework for offshore fish farm operations, and work to address environmental, social, and economic concerns. The bill, however, only addresses open-ocean aquaculture operations, and does nothing to facilitate the permitting and development of land-based aquaculture.

Central to the Capps bill is a new permitting process mandating would-be fish growers to receive authorization from the Secretary of Commerce once they've met a series of requirements aimed at minimizing potentially adverse impacts on marine ecosystems. This is similar in concept to existing California law setting in place standards to be met for open-ocean aquaculture permitting.

The requirements in the Capps bill include identifying appropriate locations for farms, compliance with site inspections, limiting where certain fish species may be farmed, and preventing escapement, disease, and harmful waste discharge. In addition, H.R. 2373 would initiate a research program designed to solve significant data quandaries as well as address concerns with the ecological sustainability of further aquaculture development and expansion.

For those concerned with the growth of ocean-based aquaculture in the US, H.R. 2373 has been received in generally two ways. First, those who believe that ocean-based aquaculture is inevitable, and likely permanent, tend to accept the Capps bill as an appropriate step toward regulation. In the other camp are those who don't accept the premise that ocean-based farms are the future. The bill, therefore, is seen to open the floodgate toward unprecedented governmental acceptance.

In the end, both groups are skeptical of the bill and its role in the future of aquaculture development. While the bill's fate as it navigates the circuitous legislative process is far from certain, it has nonetheless aroused a discussion as to what standards should

regulate ocean-based farms, assuming they're here to stay. The bill could very well meet the same fate as several past aquaculture bills: demise at the hands of overwhelming public opposition.

Congresswoman Capps is to be thanked for bringing the issue out into the open for full public discussion; this is a welcome change from NOAA's effort to move ahead with no public oversight or Congressional policy.

Behold the Frankenfish

The latest environmental concern associated with fish cultivation is in the field of genetic engineering, where the Massachusetts-based biotech company Aquabounty Technologies, Inc. is leading the race to genetically modify fish to grow faster and larger. The company's first product, the AquAdvantage Salmon, called "Frankenfish" by skeptics, is an Atlantic salmon implanted with a gene from its larger cousin, the chinook salmon, combined with a gene from an ocean pout, an eel-like fish. Marketed as a low carbon-emitting savior to the struggling salmon industry, the AquAdvantage salmon is a controversial piece to the aquaculture puzzle, and one that could have a potentially enormous effect on the entire industry.

Last fall, the FDA convened a panel of experts to review the GM salmon; the FDA has yet to issue an approval. Concerns about GM fish are wide-ranging. Aside from possible health effects on humans who eat the fish, many worry about the possibility of escapement into the wild, and the faster growing GM salmon's ability to outcompete with wild salmon. While AquaBounty insists that GM salmon will be kept sterile and produced in confinement, a new study by Canadian researchers shows that the fish could succeed in breeding and passing their modified genes into the wild.

The Aquacultural Crossroad

With a world population pushing 7 billion and an ever-increasing demand for protein and nutrient-rich fish products, it is clear that commercial fishing alone cannot answer current and future seafood demand. However, modern aquaculture systems are still relatively new, and like any new technology they are far from perfect.

The US has now arrived at an aquaculture crossroads: one fork leads to an example set for sustainable seafood; the other is a jagged descent towards further environmental damages.

The dangers associated with ocean-farms – environmental, social, and economic – are as real as the history that illustrates their checkered past. An increase in the use of ocean-farms guarantees further damage to wild fish stocks and the fishermen whose livelihoods depend on them. Pens in the ocean are always susceptible to escapement, disease, and pollution.

Genetically modified fish also pose a threat to the environment; research now proves that they can indeed interbreed with or overtake wild species and essentially eradicate wild stocks.

Without legislation that properly regulates both ocean and land-based aquaculture, a hapless framework of policy will continue to encourage unsafe and unsustainable practices in the ocean, compromising any effort to help restore our marine ecosystems. A new, comprehensive policy could warrant responsible use of our oceans, and encourage the use of alternative aquaculture systems like those operating on land. Much like the current standards imposed on imported shrimp, a new policy could thwart US businesses from simply moving their operations overseas to avoid regulation.

Land-based aquaculture is a viable technology that can help solve many of our production and environmental problems related to sustainable seafood. Countless working examples are already operating in this country and all over the world. While business models and feed issues may still require further development, the promise land-based systems hold for the future cannot be ignored. If the US government so chooses, the prospect of a future with sustainable seafood can be realized.

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