

# Farming the Sea

By Colin Woodard  
Special Correspondent

Ocean aquaculture has been an unfolding international experiment, troubled by a decade of environmental controversies. Now this technology may finally be on the path towards sustainability.

Beached on land, the salmon cages used in Passamaquoddy Bay's aquaculture industry look like a fleet of delicate alien spacecraft awaiting repairs. A half dozen of the huge, ring-shaped floats—each more than six meters in diameter—are strewn across the pebbly beaches of Deer Island in New Brunswick, Canada, a hardscrabble community lying in the middle of the bay.

When repairs are finished and their nets are reattached, the floating sea cages will join hundreds of others anchored on the shores of this tide-scoured bay on the U.S.-Canada border, their nets teeming with Atlantic salmon destined for North American dinner tables. But the cages are cast into waters that swirl with controversy about the potential environmental impact of the world's rapidly expanding ocean aquaculture industry.

Globally, marine aquaculture has more than doubled in size over the past decade, while aquaculture as a whole now accounts for more than 30 percent of the world's fish supply, according to the Rome-based U.N. Food and Agriculture Organization. Salmon, shrimp, and mussels raised by aquaculture enterprises are now cheaper in most markets than the same species caught in the wild, and researchers say the same may apply to cod, halibut, and red snapper in the not too distant future.

But the industry also has experienced growing pains, most of them associated with raising shrimp and salmon, two of the most lucrative species. Asian shrimp ponds were implicated in the destruction of mangrove forests, which are key nursery habitats for many marine creatures. Escapees from U.S. and Canadian salmon farms have furthered the decline of Atlantic salmon in the wild where natural stocks are overfished and close to extinction. Both

industries suffered enormous losses from disease outbreaks like infectious salmon anemia and Taura syndrome in shrimp.

### Environmental Impacts

"Some types of aquaculture have minimum or even positive impacts on the environment, but just as in terrestrial agriculture, there are some types of farming that cause serious problems," says Rebecca Goldberg, senior scientist with Environmental Defense, a nongovernmental organization in New York, and author of several reports on the industry.

The vast majority of the world aquaculture industry farms with little impact on the environment. Freshwater carp, catfish, and tilapia are plant-eaters and usually are raised in special ponds where the fish help convert potentially harmful organic wastes into edible fish meat. Shellfish like mussels, scallops, and oysters filter algae and plankton from seawater, reducing the risk of runaway algae blooms that can trigger the creation of oxygen-depleted "dead zones."

But the farming of other species—particularly shrimp and carnivorous fish like salmon—can be extremely destructive, as residents of Maine and New Brunswick have learned firsthand.

The Passamaquoddy Bay area, with its six-meter tides, clean water, and undeveloped coastline, became the epicenter of North America's Atlantic salmon industry. Starting with a single experimental cage on Deer Island in 1978, the industry had expanded to 125 salmon farms with annual sales approaching \$100 million by 2000. It now employs several hundred people on both sides of the border and, in easternmost Maine, pays the average worker \$39,000 per year, more than twice the average income there.

But there also have been frequent outbreaks of diseases and parasites in the crowded cages, each of which holds tens of thousands of fish. Outbreaks of infectious salmon anemia forced the destruction of 1.2 million fish in 1998 and 2.3 million in 2002. Farmers tried to keep the fish healthy by feeding or bathing them in antibiotics and pesticides, some of which have been shown to be toxic to lobsters and other marine life in laboratory settings.

Studies by the Atlantic Salmon Federation—an early proponent of the industry—showed that the proportion of farmed salmon in local wild salmon runs increased from 5.5 percent in 1983 to 90 percent in 1990. The farmed salmon can out-compete their wild cousins, but are not genetically adapted to return to their birth stream to breed and thus do not reproduce and rebuild the stocks. As further evidence that aquaculture was disrupting the ecological balance, residents blamed the farms for a perceived increase in shoreline algal growth, claiming that feces and uneaten food falling from the cages was triggering the blooms. When the industry tried to expand down the Maine coast, some local communities rebelled, refusing to grant site permits, for fear of pollution.

### Solving Problems

Globally, however, the aquaculture industry is beginning to sort out many of its problems, says Leroy Creswell, an aquaculture researcher at the University of Florida Sea Grant Office and past president of the World Aquaculture Society. "Aquaculture has been paying for the sins of terrestrial agriculture in that it's being held to a much higher standard," he says. "But aquaculture wants to be a sustainable industry and they're doing everything they can to make sure they are a nonpolluting industry with a high-quality product."

In Norway, which pioneered salmon farming in the late 1960s, many of the problems afflicting farms in the United States, Canada, and Chile have been overcome, explains Ole Torrissen, associate director of the Institute for Marine Research in Bergen. Before being released into the cages, every fish is given a vaccination shot, virtually eliminating the need for antibiotics. As a result, antibiotic use in Norwegian salmon and trout farms has fallen from 50,000 kilograms in 1987 to less than 500 kilograms today, even as production has increased by more than tenfold. Increased attention to currents at potential farm sites has eliminated nutrient pollution problems. The currents carry the falling feces and wastes to open water, thus keeping concentrations at acceptable levels.

The fish raised in Norwegian aquaculture also use feed more efficiently than European poultry and pig operations. "Salmon farming is definitely the most

sustainable meat production you have in Europe," Torrissen says, though he notes the problem of salmon escapees has yet to be solved.

Marius Holm, a researcher at the Bellona Foundation, Norway's most influential environmental group, agrees. "If you compare salmon to other meat productions, it's not bad at all," he says, seated in a briefing room at the foundation's Oslo headquarters. Norway has set "the direction salmon farms in other parts of the world are going to go."

Meanwhile, Norwegian farmers are moving on to cod, a fish whose populations have been decimated by overfishing in much of the world. The first commercial cod farm opened last year, stocking 5 million juveniles. Next year, Torrissen says, the industry expects to harvest them, putting between 10,000 and 20,000 metric tons of cod on the market. In the United States and Canada, researchers say they are on the verge of making cod, halibut, flounder, and other species commercially viable for farming.

### New Technology

But if the U.S. ocean aquaculture industry is to grow, it will probably have to move away from the shoreline, says Leroy Creswell. "Unless you're raising shellfish, you're just never going to get a permit to raise fish right along the coastline," he says, noting the stiff resistance such proposals often receive from shoreline property owners, fishermen, boaters, and environmentalists. The solution, he says, is to go either inland or right out to sea.

In Florida—where high property costs make coastal shrimp-growing ponds cost-prohibitive—some shrimp farmers have followed the lead of freshwater aquaculturists and moved inland. Pacific white shrimp, Creswell says, are now being raised in mineral-rich fresh water pumped from deep aquifers under inland Florida, with intensive water recirculation systems. "There is zero discharge, and the cost of production is much lower," he says. The main obstacle for the U.S. industry's inland expansion is competitive economics. Can U.S. aquaculture enterprises produce fish that are competitively priced against cheap imports from China and other Asian countries, where environmental standards are lax and labor costs low?

For most marine species other than shrimp, future farming may take place inside submerged ocean cages moored in federal waters several kilometers from land.

The new cage technology—much of it being perfected by researchers at the University of New Hampshire (UNH)—allows fish and shellfish to be grown in fully enclosed cages moored nine or ten meters down, beneath surface wave activity and the hulls of passing ships. Stationed in deep water with strong currents, the ocean farm's wastes and other pollutants are unable to reach harmful concentrations, as they do in calmer bays and coastal waters, researchers say, making for a more sustainable industry. The sturdy cages are thought to be relatively escape-proof and, tended and monitored by automated feed buoys, they appear to be cost-effective.

"So far the demonstration projects that are going on show that there is virtually no environmental impact at any distance and that wastes are not accumulating below the pens," says Linda Chaves, aquaculture coordinator at the National Oceanic and Atmospheric Administration (NOAA), which is drafting legislation to allow fish farmers to lease farming sites from the federal government. "Offshore farming looks really promising."

UNH researchers involved in the Open Ocean Aquaculture Project have been working with halibut, cod, haddock, summer flounder, and blue mussels, with funding from NOAA. Other researchers are raising cobia in submerged cages off Puerto Rico, while a commercial farm in Hawaii is marketing Pacific redbfin grown in deepwater cages that drift with the currents. U.S. authorities hope that investing in offshore research will help meet Washington's goal of expanding the U.S. fish farming industry by fivefold by 2025. The Department of Commerce objective in setting that goal is to meet the growing demand for seafood on American dinner tables, a demand that exceeds the capacities of wild fisheries.

### Continuing Concerns

Environmentalists remain concerned about the sustainability of an industry that continues to focus on carnivorous species raised in fish farms, which

consume food made partly from fish caught from the wild. "There simply aren't enough fish [in the seas] to grind up and make fish meal and oil for feed," Environmental Defense's Rebecca Goldberg says. "And virtually all of the fish [used for aquaculture feed] could be used for human consumption in developing countries.... Aquaculture is a net consumer of wild fisheries."

It is true that the mariculture industry focuses on relatively expensive—and profitable—carnivorous species like shrimp, salmon, and cod. While these fish can be grown more efficiently than cattle or pigs, they still remain too expensive for the world's poor. Because farmed salmon and shrimp are fed meals and oils made from small, edible schooling fish like mackerel, caplin, sardines, and anchovies, opponents point out that the farms are competing with the world's poor for some of these food species.

The practice of feeding the carnivorous species on smaller fish also has raised a human health concern. Some recent studies have found that farmed fish from some sources have higher concentrations of chemicals—some of which are known or suspected carcinogens, principally PCBs—than are present in wild fish. It is possible that farmed fish raised on a diet of smaller species may develop a concentration of these chemicals. U.S. government regulators have suggested that pregnant or nursing mothers should limit their consumption of certain species of farmed fish. In addition, they have suggested that consumption of possibly harmful chemicals can be reduced if the skin and fat of the fish is not eaten. Further research on these findings is likely soon.

With further concerns about aquaculture's environmental impacts, Goldberg agrees that offshore farms will have fewer than their coastal cousins, but she is concerned that offshore farms may be built on a scale that will become ecologically harmful. "There's no question that the model for aquaculture production in [offshore waters] is going to be very similar to that of the chicken and hog farming we have today, where you put a lot of animals in one place and bring in a lot of feed," she says. "Are we essentially going to be building a new [industrial scale] hog industry three miles off our shores?"

Linda Chaves of NOAA says she does not expect offshore ocean aquaculture to become an environmental problem anytime soon. "To produce 600,000 metric tons of fish one would need about 250 square kilometers of surface area, which isn't much when you consider we have millions of square kilometers" available for use in U.S. territorial waters, she notes. "But if environmental issues do appear, we will certainly be taking them into account."

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