



The End of the Line

Fish are the last wild food, but our oceans are being picked clean. Can farming fish take the place of catching them?

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JOSH GOLDMAN RUNS A FISH FARM, but the hangar-size facility in the western Massachusetts town of Turners Falls looks a lot less like a farm than a factory. Thousands of one-third-pound barramundi — an omnivorous fish native to Southeast Asia and Australia — swim in a 36-ft.-diameter tank that resembles a supersize kiddie pool. They spend their days fattening up on feed pellets under the watchful eyes of factory workers — farmers, if you must — who grade them for size. After

several weeks of careful feeding, the fish are moved via an industrial waterslide — the pescalator, Goldman calls it — to a larger tank in the plant's next cavernous room. The assembly line runs until the barramundi have been raised to market weight, about 2 lb., after which they're sent off to white-tablecloth seafood restaurants and sustainability-minded retail outlets across the U.S.

From the moment the barramundi are hatched, from eggs barely one-hundredth of an inch long to the day they're sold, they never swim in a river or sea, never hunt for food, never feel the tug of a fishing line. "We're producing great-quality fish without harming the oceans

or anything else," Goldman says of his operation, Australis Aquaculture. His barramundi aren't caught; they're manufactured. And factories like these might represent the last, best chance for fish to have a future.

Since human beings first took up the plow about 10,000 years ago, most of our food has come from the farmer's hand. We grew fruits, vegetables and grains to feed ourselves and support those domesticated animals we relied on for meat and dairy products. But there was an exception. When humans fished, we still went out into the wild, braved the elements and brought back decidedly undomesticated animals for dinner. There was a romance to fishing that was inseparable from the romance of the sea, a way of life — for all its peril and terror — suffused with a freedom that the farmer and rancher would never know. Though the fishermen who roved the Sea of Galilee in Jesus' time and the factory trawlers that scrape the ocean floor today couldn't be more different, they share a common link to our hunter-gatherer past. "Fish are the last wild food," says Paul Greenberg, author of *Four Fish*, one of the best books on the state of seafood. "And we're just realizing it."

But we may be coming to that realization too late, because it turns out that even the fathomless depths of the oceans have limits. The U.N. reports that 32% of global fish stocks are overexploited or depleted and as much as 90% of large species like tuna and marlin have been fished out in the past half-century. Once-plentiful species like Atlantic cod have been fished to near oblivion, and delicacies like bluefin tuna are on an arc toward extinction. A recent report by the International Programme on the State of the Ocean found that the world's marine species faced threats "unprecedented in human history" — and overfishing is part of the problem.

Meanwhile, the worldwide catch seems to have plateaued at about 90 million tons a year since the mid-1990s. That's a lot of fish, but even if those levels prove sustainable, it's not enough to keep up with global seafood consumption, which has risen from 22 lb. per person per year in the 1960s to nearly 38 lb. today. With hundreds of millions of people joining the middle class in the developing world and fish increasingly seen as a tasty and heart-healthy form of protein, that trend will continue. The inescapable conclusion: there just isn't enough seafood in the seas. "The wild stocks are not going to keep up," says Stephen Hall, director general of the WorldFish Center. "Something else has to fill that gap."

Something else already does: aquaculture. Humans have been raising some fish in farms for almost as long as we've been fishing, beginning with Chinese fishponds 4,000 years ago. But it's only in the past 50 years that aquaculture has become a true industry. Global aquacultural production increased from less than 1

million tons in 1950 to 52.5 million tons in 2008, and over the past few decades, aquaculture has grown faster than any other form of food production. Today about half the seafood consumed around the world comes from farms, and with the projected rise in global seafood consumption, that proportion will surely increase. Without aquaculture, the pressure to overfish the oceans would be even greater. "It's no longer a question about whether aquaculture is something we should or shouldn't embrace," says Ned Daly, senior projects adviser at the Seafood Choices Alliance. "It's here. The question is how we'll do it."

That's not an easy question to answer, because the rapid growth of aquaculture has been accompanied by environmental costs. In the past, the dense salmon farms of Canada and northern Europe helped spread disease among wild fish while releasing waste into coastal waters. Mangrove forests, which provide a valuable habitat for coastal life, have been razed to make way for Thailand's shrimp farms. Especially troubling, many of the most popular farmed species are carnivores, meaning they need to be fed at least partly with other fish. By one count, about 2 lb. of wild fish ground up to make fish meal is needed on average to produce 1 lb. of farmed fish, which leaves the ocean at a net loss. "Aquaculture's reliance on fish meal and fish oil is a major concern for marine conservation," says Sebastian Troeng, a marine expert with Conservation International.

But unless you can convince 1.3 billion Chinese — not to mention everyone else in a growing world — that they don't deserve the occasional sushi roll, aquaculture will keep growing. As it does, it will need to become more efficient and less polluting. The good news is that the industry is improving. More farmable but less familiar species like the barramundi — which yields more protein than it takes in as feed — may have to supplement popular fish like cod that haven't taken as well to aquaculture. We may even need to genetically engineer popular species to make them grow faster and bigger. And perhaps most of all, we need to accept that on a planet with a population of nearly 7 billion and climbing, we may no longer be able to indulge our taste for the last wild food. We've farmed the land. Now we have little choice but to farm the sea as well.

Aquaculture and Its Discontents

To the average shopper, farmed fish is barely distinguishable from its wild cousin — except, often, in price. Without the growth in aquaculture, many of our favorite kinds of seafood would likely be much more expensive than they are now. And chances are, you get what you paid for: farmed seafood can be inferior to wild fish in taste and may not always have the same nutritional



value. Salmon raised in an aquaculture environment, for instance, often have lower levels of cardiovascular-friendly omega-3s than wild fish, and farmed fillets would actually be gray without a pink chemical dye. And if you're eating farmed seafood, you're almost certainly getting it from overseas: U.S. aquaculture accounts for just 5% of Americans' seafood consumption. The Monterey Bay Aquarium's Seafood Watch program mostly discourages consumers from choosing farmed fish, both for health reasons and because of worries over the environmental impact of aquaculture. "There's a real difference in the regulation you might see in other countries compared with the U.S.," says Peter Bridson, Monterey's aquaculture-research manager.

At the same time, it's important to look at the big picture. For health reasons, most of us should be eating more fish. For its new dietary guidelines, the U.S. government just upped the recommended consumption of seafood to 8 oz. or more a week — which is more than twice what the average American eats — and 12 oz. for pregnant women. In a report this month, the U.N. said global food production would need to increase by as much as 100% by 2050 to meet growing demand — and seafood, as a vital protein source, will have to be part of that. Farming is unavoidable. "There may be a price split between expensive wild fish and cheaper farmed fish," says Don Perkins, head of the Gulf of Maine Research

Institute. "But seafood consumption will spread because we need it for health reasons."

To understand global aquaculture — its potential and its problems — it helps to look at the industry's track record in China, a country responsible for 61% of the world's aquaculture. China has begun exporting industrially produced catfish, shrimp and tilapia in recent years. As production pressures have ramped up, Chinese manufacturers have packed their ponds more tightly, leading to disease and pollution from fish waste. That waste can overload coastal waters with nutrients, causing dead zones that can strangle sea life. To fight the diseases worsened by crowding, Chinese fish farmers have liberally used antibiotics and other drugs, including malachite green, an antifungal agent and potential

carcinogen that was banned by Beijing in 2002 but shows up periodically in exports. "It is still a problem," says Wong Ming Hung, a biology professor at Hong Kong Baptist University.

While China remains a laggard on safety — though experts say its fish-farming industry is improving as it matures — there's no denying that aquaculture can be messy. A badly run near-shore farm of 200,000 salmon can flush nitrogen and phosphorus into the water at levels equal to the sewage from a town of 20,000 people. But for all that, fish farming's bad reputation isn't entirely deserved, especially if it's compared with farming on land.

Farmers have had thousands of years to improve agricultural methods and breed domesticated animals like cows and pigs with maximum efficiency. And industrial agriculture can be polluting: the dead zone in the Gulf of Mexico is due largely to fertilizer runoff from the Midwest. Modern aquaculture is just a few decades old, and as producers have become more experienced, they've cut down on pollution and bred more-efficient fish. Many environmental groups that once opposed aquaculture now seek to work with the industry. The World Wildlife Fund (WWF) is leading the way in this effort, helping develop sustainability standards for farmed species. "Our industry is under a lot of scrutiny, and we're doing our best to alleviate those worries," says Nell Halse of Cooke Aquaculture, a major producer in Canada and the U.S.

And no matter how much room the industry has for improvement, aquaculture usually puts less stress on the environment and requires less caloric input to yield a pound of protein than meat production. Part of that is simply a result of biomechanics and metabolism. Unlike land animals raised for food, fish are cold-blooded and live in the water, which means less of their feed is wasted — from our point of view — being burned as energy to keep warm or to build bone. Fish farmers had the bad luck to come along after industrial meat production was well established, and the new guy on the block gets more scrutiny. "We have to address the environmental and social issues," says Jose Villalon, director of the WWF's aquaculture program. "But aquaculture is a good tool to deal with food security."

One way to address those issues is to build an aquacultural system that mimics nature, in which the waste produced by farmed fish is put to use. Thierry Chopin, a biologist at the University of New Brunswick, wants to take advantage of that principle with his integrated multitrophic aquaculture (IMTA). In an IMTA loop, species like salmon and shrimp are raised less densely than in conventional aquaculture, together with seaweed and shellfish like mussels. The waste from the farmed species fertilizes the seaweed, which can be harvested for use in fish feed. The mussels, which are filter feeders, can gobble waste in the water, preventing pollution from building up. The result is more biomass and less waste — just as nature intended. "If it functions as an ecosystem does," says Chopin, "then it functions right."

Even an aquacultural system more in tune with nature still faces essential challenges, including the feed-ratio problem. When producers began raising fish intensively, they picked species that people like to eat: salmon and sea bass. But those species are high on the food chain, and raising them on a farm is a bit like trying to domesticate tigers. The aquaculture industry has gotten better at replacing fish meal with plant-based feed, but not fast enough. You're not feeding the world sustainably if you need to remove the base of the marine food chain to do it. "The question of what the fish will eat is central to aquaculture," says Australis' Goldman. "We can't grow on the back of small forage fish."

A Fish and a Dream

The answer might be simply to find a better fish, one more suited to farming. This is exactly what Goldman set out to do. He got into aquaculture in the 1980s as a college student and had a tilapia-farming operation for a few years. But while tilapia are more sustainable than many other fish because they're vegetarians, they lack the high amounts of omega-3 oils that make salmon so heart-



ATLANTIC SALMON Some 90% of what arrives at tables comes from farms—about 1.4 million tons each year



BARRAMUNDI Only about 45,000 tons are farmed annually, but production has doubled over the past 10 years



COMMON CARP Annual farm production is about 3 million tons, mostly in China



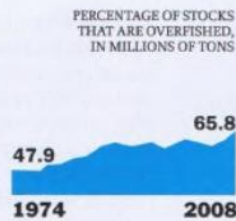
OYSTERS, MUSSELS They account for a quarter of aquaculture production—more than 12 million tons each year



SHRIMP More than 1.2 million tons are farmed each year—about 40% of the shrimp consumed globally

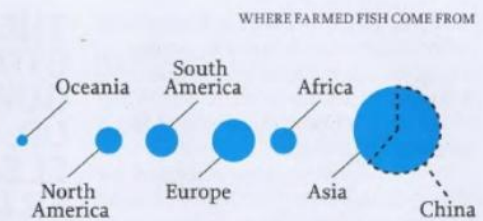
PEOPLE ARE EATING MORE FISH

Since 1960, worldwide seafood consumption has increased nearly 60%, leaving our oceans in short supply



BUT THE U.S. ISN'T DOING THE FARMING

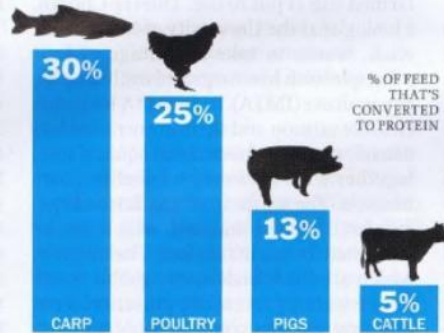
Just 5% of the seafood consumed in the U.S. comes from domestically produced aquaculture



THE U.S. HAS A "SEAFOOD TRADE DEFICIT" OF \$9 BILLION. AMONG NATURAL RESOURCES, THAT'S SECOND ONLY TO ITS TRADE DEFICIT IN OIL

FARMING SEAFOOD VS. FARMING LAND ANIMALS

Cold-blooded fish convert feed to protein much more efficiently than warm-blooded mammals—so in terms of how much feed it takes to produce nutritional body tissue, fish farming compares well with meat production



84%

of the 5 million to 6 million tons of seafood consumed each year in the U.S. is imported. About half of it comes from aquaculture

healthy. Goldman tried striped bass but found them too fussy to raise. It wasn't until a chance encounter with an Australian entrepreneur that he found his dream fish: the barramundi.

As a farmed species, the barramundi is just about perfect. It can survive in a wide variety of environments and lays eggs frequently. It has a flexible diet, and much like its fellow Australians, it is laid-back by nature, so it can endure the rigors of farming. Goldman launched Australis in Turners Falls in 2004 and was producing barramundi commercially by 2005. The fish is rich in omega-3 oils; Dr. Oz named it one of his top superfoods in 2010. Less than 20% of the barramundi's feed at Australis comes from fish meal and fish oil — a better percentage than for many farmed salmon, which can require as much as 50% of their feed from fish meal. The Turners Falls operation is an indoor, closed recirculating system, so there's little waste, little risk of disease and no threat that the barramundi will escape into the wild. Plus, barramundi tastes good, with the flaky mouthfeel of the better-known sea bass. Goldman's real challenge is convincing Americans — with their appetite for shrimp, tuna and salmon — that they should eat an unfamiliar Australian fish. "Selling it as sustainable helps," he says. "But once they try it, people like it."

Australis' barramundi has become so popular, in fact, that Goldman has expanded production — but not in Massachusetts. While the closed recirculating system he uses in Turners Falls is an environmentalist's dream, Goldman eventually wanted to reach a larger market at a

lower cost, a step that he decided required an outdoor operation on the central coast of Vietnam. That branch, where barramundi are raised in sea cages in a protected bay, isn't quite as green as Turners Falls, but it's cheaper.

Land-based systems may work for more premium species, and they offer the chance to raise fish close to cities. In New York State, for instance, a company called Local Ocean produces indoor-farmed sea bass and flounder two hours from Manhattan. But such systems are still more experimental than economical. "As much as the NGOs would have loved it, [Australis] just couldn't meet the economics of an expensive indoor environment," says Goldman.

Rise of the Frankenfish

Many NGOs would also like us all to choose farmed fish more judiciously, selecting sustainable species low on the food chain. There's not a lot of evidence that's going to happen, however. But if we won't always choose the fish that take better to farming, another option is to take the fish we like and engineer them into sustainability. Fish farmers have been doing that quite naturally for the past few years, breeding salmon and other species so they grow faster and require less fish meal — something farmers on land have done for hundreds of years with cattle, pigs and chicken. The Massachusetts-based biotech company AquaBounty wants to take that breeding process a step further by genetically engineering Atlantic salmon that can grow up to twice as fast as conventional fish. Its product, the AquAdvantage salmon, contains a

gene from the chinook salmon, a larger cousin that lives in cold northern waters. That gene activates a growth hormone, with obvious commercial benefits for farmers who want to get their fish to market weight quickly. "America imports its seafood at the cost of a huge carbon footprint," says Ronald Stotish, AquaBounty's CEO. "This could make it economical to raise land-based salmon domestically. This is sustainability."

The Food and Drug Administration convened a panel of experts last fall to review the genetically modified (GM) salmon, and they were mostly satisfied with AquaBounty's proposal. But while the FDA hasn't yet decided whether to approve what would be the first genetically modified food animal, most environmental groups are staunchly against what they've termed the Frankenfish. They worry about the possible effect on human health, and they're concerned that if GM salmon escape into the wild — as conventionally farmed salmon do all the time — they might outcompete wild salmon.

While AquaBounty has pledged to ensure that the GM salmon will be kept sterile and produced in confinement, critics fear that something will go wrong. (As a government scientist wrote in a leaked e-mail, "Maybe [the FDA] should watch *Jurassic Park*.") "Absence of evidence does not mean evidence of absence," says Zach Corrigan, fish-program director for Food & Water Watch. "The regulation isn't there."

Even if GM salmon doesn't succeed in North America, it might find a home in China or another fish-hungry country where knee-jerk resistance to transgenic technology isn't so strong. And newer, better GM fish are

being engineered in labs right now, including a transgenic trout that can pack on 15% to 20% more muscle than a conventional fish. But the very fact that we can ponder these issues shows how much our relationship with the last wild food has changed. For thousands of years, fishermen risked the elements to bring back the bounty of the sea. Fishing is the deadliest job in the U.S.: in 2009, 0.2% of fishermen died hauling in our seafood, compared with 0.01% of miners who died on the job. But that danger is also part of the allure, as the success of TV shows like *The Deadliest Catch* and books like *The Perfect Storm* demonstrates. "Fishermen are the last commercial hunters in the world," says Sebastian Belle, director of the Maine Aquaculture Association, who has seen unemployed New England fishermen take up aquaculture. "They had the excitement of never knowing what they were going to get."

With 7 billion people, however, the planet doesn't have much space for such freedom. It's not that commercial fishing will disappear; in fact, sustainable fisheries like Alaska's wild-salmon industry may even produce boutique foods, finally earning what they're worth. There's no doubt that something will be lost in the transition to mass aquaculture, as fish — the last true wild food — are domesticated to support human beings, in much the same way we tamed cattle, pigs and chickens thousands of years ago. But if we're all going to survive and thrive in a crowded world, we'll need to cultivate the seas just as we do the land. If we do it right, aquaculture can be one more step toward saving ourselves. And if we do it well, we may even enjoy the taste of it.

