The fish you don't know you eat.

25% of fish caught in the ocean don’t land directly on our plates. They’re churned into something called fishmeal.
China has become the world’s fish farm. The country produces 60 percent of the world’s farmed fish, and a growing appetite for farmed seafood both in China and abroad is fueling this booming industry. But it is an industry that has hidden costs, and it takes a lot to feed these farms. Can it last?

Story by ANNIE RUETER, MELANIE WOODS, OSCAR BEARDMORE-GRAY and RYAN PATRICK JONES
It’s a brisk December afternoon on Donghai Island off China’s southern coast, and it’s time for Ye Deguang to feed his prawns. The farmer walks along a raised pathway that joins four of his 17 ponds packed with South American white prawns.

“Prawn prices are low in the summer, so we breed more fish in the summer and build sheds to breed prawns in the winter,” he says.

He steps through an entrance in a white tarpaulin cover that’s been draped across each pond to keep the water warm during the mild winter, and tosses out scoops of small brown pellets. They float on the surface until they are gobbled up by hungry prawns.

Ye’s farm is one of many that cover China’s southern coastline and blanket Guangdong Province like a patchwork quilt. The country has more than 32,000 square miles of fish farms in total—about the size of South Carolina.
A worker mixes feed on Ye De Guang’s farm in southern China. Photo by Ryan Patrick Jones

The region is driving China’s aquaculture industry, which has rapidly industrialized over the past three decades, exporting billions of dollars of seafood around the world. The farmed products end up in restaurants, grocery stores and on dinner plates in countries like the United States and Japan.

![Aquaculture production in China, 1960 to 2016](chart.png)
To feed their prawns, salmon and grouper, farmers like Ye can either feed them smaller fish, or give them commercial feeds that contain fishmeal and fish oil made from ground-up, wild fish caught at sea.

Fishmeal and fish oil provide farmed fish with a natural source of high-quality protein that mimics their normal diet in the wild. Chinese fish farms require massive amounts of it. The country is the world’s largest importer of fishmeal—it imported more than one third of all fishmeal produced in 2018—and is a significant producer in its own right.
"Fish In Fish Out" ratios, a measurement used to compare the amount of wild fish it takes to produce an equivalent weight of farmed fish. (Read our methodology.) *Illustration by Luella Sun*

Some Chinese fishmeal comes from byproducts of fish processing, including heads, fins and organs. But most Chinese fishmeal is made from what are commonly referred to as “trash fish.”
These fish are too small to have commercial value as human food and are often caught as juveniles before reaching maturity.

“The demand for both fishmeal and so-called trash fish is putting increasing pressure on our marine resources,” says Yvonne Sadovy, a marine biologist and professor at Hong Kong University who has studied the South China Sea for more than 25 years.

Sadovy and other experts warn that catching wild fish to feed farmed fish is an unsustainable practice that contributes to overfishing and further depletes fish populations.

“There are many people who consider aquacultured fish—farmed fish—as a sustainable solution to the global fishing crisis,” says Sadovy. “But it’s not solving problems of overfishing our resources. It’s actually making those problems worse.”

A day on the trash fish docks

The trash fish unloaded at Bohe Port and other ports along China’s 11,000-mile coastline once had little commercial value. But in recent decades, these fish have become a valuable raw material for fishmeal.

The boats docked at Bohe use a controversial fishing technique called pair-trawling. Two fishing boats drag a cone-shaped net between them, catching everything in their path, including unintended larger species such as dolphins, sharks and rays.
Because of the unintended “bycatch,” this technique is restricted in several parts of the world, but in China, trawling still accounts for about half of its domestic catch.

Wu Min has worked at Bohe Port for more than a decade, buying and selling fish caught by trawlers. He sells trash fish to both local farmers, who feed it directly to their farmed fish, and also to companies that process it into fishmeal.

“No matter how much fish we catch, it’s not enough,” Min says. “These past few months have been okay, but how it will be in the future is uncertain.”

Min blames the number of fishing boats for declining catches.

“To make a long story short, there are more boats than there are fish. That’s the situation,” says Min.

A history of China’s fisheries
The South China Sea is one of the world’s most productive fisheries, producing more than 10 percent of global catches in recent years. But a growth-at-all-costs mentality and poor fisheries management have caused a 70-to-95 percent decline in fish populations over the past several decades.

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<tbody>
<tr>
<td>1949</td>
<td>Fishing sector began to industrialize following end of Chinese Civil War.</td>
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<tr>
<td>1950</td>
<td>Boats in China’s waters totalled 78,000.</td>
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<td>1977</td>
<td>Period of massive growth in the fishing sector began.</td>
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<td>1979</td>
<td>Fishing boat licenses introduced.</td>
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<td>1985</td>
<td>Government introduced the No. 5 Central Document, a policy aimed to accelerate marine fisheries development. Sparked massive growth in China’s fisheries economy.</td>
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<td>1992</td>
<td>China became the world’s largest fishing nation.</td>
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<td>1998</td>
<td>Engine-powered boats in China’s waters total 473,000.</td>
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<td>1999</td>
<td>Government outlined first efforts to significantly regulate its fisheries by introducing “zero growth” policy: Catch was not to exceed the previous year’s.</td>
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<td>1999</td>
<td>Annual seasonal fishing bans introduced in South China Sea to mitigate environmental impacts.</td>
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<td>2000</td>
<td>“Negative-growth” strategy further discouraged high catches.</td>
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<td>2002</td>
<td>China became largest exporter of fish products.</td>
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<td>2002</td>
<td>Vessel buyback program implemented to reduce the number of fishing vessels in Chinese waters.</td>
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<tr>
<td>2010</td>
<td>China accounted for 60 per cent of all aquaculture production worldwide.</td>
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<tr>
<td>2015</td>
<td>Fish populations in South China Sea were 10 percent of 1960 numbers.</td>
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<td>2016</td>
<td>Chinese government introduced radical new “Five Year Plan” focused on fishery management.</td>
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<td>2017</td>
<td>Seasonal fishing moratorium in South China Sea from May 1 to Aug. 16 was the longest since fishing bans were introduced.</td>
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<td>2017</td>
<td>Chinese Ministry of Agriculture stopped fishing operations for more than 4,000 boats and destroyed over 30,000 illegal fishing tools and nets.</td>
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<tr>
<td>2018</td>
<td>New regulations limited trash fishing to protect 15 endangered species.</td>
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Zhou Wei, a senior oceans campaigner with Greenpeace East Asia, says overfishing of large predator species including yellow croaker and tuna has disrupted the equilibrium of the food chain.

“A healthy food web ... has a balance of fish species from the top to the bottom,” says Zhou. “If we remove all the fish from the top level then ... the food web [loses] balance and the whole ecosystem becomes unhealthy.”

The intensity of China’s commercial fishing puts pressure not just at the top of the food chain, but at the bottom too. As large predators become sparser, Chinese fishermen have increasingly targeted trash fish for fishmeal, many of which are juveniles.

A 2016 Greenpeace East Asia report estimated that at least one third of of the 13 million tons of fish caught in China’s waters in the previous year were trash fish.

The demand for trash fish to feed China’s farms drives fishermen to go to great lengths, even using illegal gear including electric nets and small-mesh nets.
Almost all of these fish are destined to be processed into fishmeal. Photo by Caroline Graham

Sharks and endangered fish are accidentally caught in trash fish hauls, according to a Greenpeace survey of 22 coastal Chinese ports. “If the fishermen catch everything from the sea, that also becomes a trouble to the biodiversity and the whole ecosystem,” Zhou says.

Industry says fishing not main cause of dwindling population

Some industry experts say the fishmeal industry is not responsible for dwindling fish populations. Neil Auchterlonie is the technical director of the International Fishmeal and Fish Oil Organization (IFFO), an industry lobby group whose members account for 60 percent of all fishmeal and fish oil produced worldwide.

He recognizes there are challenges when it comes to managing fisheries in Southeast Asia, including China. However, he says fluctuations in fish populations come from “environmental factors,” including the availability of food, water temperature and impact of ocean currents.
Trash fish is processed into fishmeal pellets. *Photo by Annie Rueter*

“There’s a lot of debate in the scientific community about how these stocks are managed and what sustainability actually means in terms of fisheries,” Auchterlonie says. “I think in many ways some of those arguments are not based on reality. The reality is that we need more food. And this is a good way of supplying it.”

Auchterlonie says that the majority of fish caught to make fishmeal are species that humans do not want to eat. But Greenpeace disagrees. The environmental advocacy organization sampled trash fish throughout China and found that nearly 40 percent were edible commercial species that could be consumed by humans if allowed to grow to maturity.

“These fish could be massive sources of protein, inexpensive food for people and sources of livelihood, but instead they feed other fish or they’re brought in to rot on the dock,” Sadovy says. “It’s a terrible waste of good quality protein.”
Committing to green development

Beijing recently introduced new measures to reduce the fishing of trash fish. Since August 2018, regulations specify a minimum body size for 15 commercial fish species and also mesh size requirements for fishing nets.

The policies are part of a wider push by the Chinese government to improve fisheries management and rebuild fish stocks.

“More and more people care about the environment now,” said Cao Ling, a leading expert on Chinese fisheries and aquaculture at Shanghai Jiao Tong University. “Pollution and resource depletion is already at a very critical time, so the central government realizes that.”

But Cao says that despite ambitious goals, there is a gap when it comes to enforcing the rules. She says regulations like those on body size and mesh size are not being enforced consistently across the country.

“The central government has issued very comprehensive and extensive measures, but when it comes to the local level, the implementation is still very poor,” says Cao.
China’s decentralized system of governance is one of the biggest obstacles to enforcing rules intended to better manage fisheries, according to Zhou from Greenpeace. The central government in Beijing sets policy goals, but the provinces are tasked with implementation.

“If the local government doesn’t [enforce regulation] measures, the fishermen would think they have the chance to not follow the law,” says Zhou.

Zhou says another challenge is that the government is reluctant to upend an industry that many people rely on for their livelihoods.

“Clearly we need to cut the fishing capacity, but when we cut the fishing capacity, what can the fishermen do in the future? What other jobs can they take in the future?” asks Zhou.

**Globalization of fishmeal industry**

Catching trash fish is part of a highly profitable, multi-billion dollar feed industry in China. Feed is the most expensive aspect of fish farming, and Guangdong Evergreen Feed Industry is a key national player. Its parent company has an annual revenue of more than $1.5 billion and has centralized the production process, owning every step—from the trawlers at ports like Bohe to the fishmeal factories, farms and seafood processing plants.

Chen Yuchi is the son of Evergreen’s founder and president, Chen Dan. Now the company’s manager of overseas operations, the younger Chen grew up alongside the family company based in Zhanjiang—a southern Chinese port city of 8 million where the population and economy have boomed in the past few decades.

He says the company is prioritizing global expansion to secure sources of fishmeal.
Chinese companies are purchasing fishing rights in foreign countries, including quotas from the Peruvian anchovy fishery—the world’s major supplier of high-protein fishmeal.

“Superprime” Peruvian fishmeal is some of the highest quality fishmeal available and Chinese manufacturers are buying it up. In 2017, a full 85 percent of the fishmeal produced in Peru was exported to China, where it is cut with Chinese fishmeal, which is often a lower-quality product made from the entire fish, including bones, rather than just the protein-rich flesh. Evergreen and other fishmeal producers do this to make a higher-quality product that meets demand, while also maintaining their high profit margins.
In 2017, Evergreen opened an $86 million tilapia and shrimp facility in partnership with the government of Egypt. Located at the mouth of the Nile River, it’s Egypt’s largest aquaculture facility. Evergreen is also working to secure a similar deal in Saudi Arabia, with plans to build a reported $300 million integrated feed and farming complex in the Saudi desert.

“We’ve got the confidence,” Chen says. “I’m gonna grow no matter what. This is China, and as a company we’re going to spend, we’re going to go outside.” He is exploring ventures in countries including Kenya, Indonesia, and Malaysia. The company’s aim is to create an “overseas Evergreen” within three to five years. “If I’m not there, I’m gonna be there soon,” he says. “And sooner or later I’m gonna get it.”

West African countries such as Senegal And Mauritania are a new avenue for Chinese fish feed companies.

“Once I’ve fed enough of my 1.5 billion people,” says Chen, “I’m going to feed the rest of the world.”
Peru produces more fishmeal than any other country in the world. A natural abundance of anchovy along the South American country’s coast has given the aquaculture industry easy access to the key ingredient needed to produce high-quality fishmeal. But the rapid expansion of the fishmeal industry resulted in serious pollution, environmental degradation, and a near collapse of fish stocks. In an effort to reverse damage and adjust to climate change the government is reimagining the industry.

*Story by CAMERON BULLEN, JONATHAN VENTURA, MONIQUE RODRIGUES, RITHIKA SHENOY, SEBASTIAN ROMERO TORRES and STEPHAN KROENER*

Isla Blanca lies just off of the coast of the Peruvian city of Chimbote. This brilliant white island gets its characteristic color from guano, the excrement of seabirds such as cormorants and pelicans and a key ingredient in fertilizer. Chimbote, which was once a major world source for guano, was at the heart of a region known as the “Pearl of the Pacific.”

Today, the island is a stark reminder of days long past when the area was popular with tourists and known for ecological diversity and natural wonders. But now, the birds are disappearing, marine life is dying and even the tourists are gone.

On the surface, the town, which is 250 miles from the capital city of Lima, retains its historic beauty. It is one of the reasons father Jaume Marco Benaloy fell in love with the city 10 years ago when he moved to Chimbote from Spain. He arrived as a missionary and says that despite what looked like a beautiful coastline, people were disconnected from the sea.
Father Jaume Benaloy looks at White Island from the top of a hill in Chimbote. *Photo by Jonathan Ventura*

“When I looked closely at the sea—so polluted—I felt pain in my body,” he says. “What happened here? There is something that is not working. From that moment, I felt that I had to help in some way to turn the city around.”

The coastline is degrading because of pollution, which is exacerbated by the $1 billion fishmeal and fish oil industry. Rapid growth of fish factories came at a cost—high levels of pollution had a profound impact on sealife, especially in the city of Chimbote, home to large guano bird populations who would now have to compete with the industry for their main source of food.

The city’s coast is lined with rows of piers directly linking factories with ocean water teeming with Peruvian anchovy—or anchoveta as it is known locally. This little fish, only about eight inches long when mature, has been a game changer not only for the Peruvian economy, but also for the fishmeal industry globally. Abundant, oily, and rich in protein, it is the most-caught species of fish in the world, and the one preferred for high-quality fishmeal and fish oil.
Lack of water treatment and poor regulations around industrial development are two of the reasons why this once-pristine coastline is now polluted. For decades, factories in Chimbote have been accused of dumping their untreated waste directly into the bay.

Romulo Loayza, a biology professor at the National University of Santa in Nuevo Chimbote, often takes his students to sample sludge at the bottom of the ocean, and assures that it is residual waste from fishmeal factories.

According to Loayza, there are around 53 million cubic meters of sludge below the ocean surface, and in some parts it is more than two meters in height.

Building the industry

Almost a century ago, the fishmeal industry thrived off the Pacific coast in the U.S. In 1937, at its peak, 790,000 tons of California sardines were hauled out of the Pacific and ground into fishmeal and fish oil, or canned for human consumption. John Steinbeck described “silver rivers of fish” pouring from fishing boats in his novel *Cannery Row*.

By 1968, poor regulations and overfishing resulted in a collapse of the California sardine stock. The state then announced a ban on fishing the species, but even with the restrictions the population never recovered.

Amidst the decline, investments started shifting south, with an eye toward the protein-rich Peruvian anchovy. Daniel Pauly, director of the Institute for Oceans and Fisheries at the University of British Columbia, describes the industry’s relocation as a kind of fly-by-night operation. “[Plants that were operating in California] were dismantled, put on boats, and brought to Peru, and secretly reassembled. And all of a sudden they started producing fishmeal.”
Chimbote was the ideal city for the new fishmeal industry. The Humboldt Current, a cold ocean current that runs along the South American Pacific coast, creates the perfect sea conditions for anchovy populations to thrive. And, because Chimbote had been the site of a prosperous international guano trade, roads and railways used to get the valuable bird excrement to markets abroad for use as fertilizer were already in place. The fishmeal industry used the existing infrastructure to quickly start up operations.

In 1970, Peru produced 2.25 million tons of fishmeal, and caught a world-record 12.4 million tons of anchovies. But that year is also remembered as a record-low for the
guano bird population. As guano trade declined the fishmeal industry expanded, undermining “the guano base economy of Peru,” says Pauly.

On the brink of collapse

After settling into the city of Chimbote, the fishmeal industry grew rapidly. In the 1960s, vessels would head out to sea to rake in as much fish as they could, as quickly as possible.

“It was what we would call an Olympic race,” says Ricardo Ghersi, former advisor to the Minister of Production, the government branch that oversees the fishing and industrial sectors. He says that in about 17 days, the anchovy stocks for the entire year would be gone.

Then, in 1972, Peru suffered one of the most destructive El Ninos of the century. El Ninos—the series of climatic changes that affect the equatorial Pacific region every few years—are characterized by unusually warm, nutrient-poor water off northern Peru and Ecuador. That year, the waters of the typically cold Humboldt Current rose to 77 degrees, and torrential rains caused floods. The sudden change in temperature, combined with overfishing, decimated the anchovy stocks.

The government responded to this near-collapse by introducing regulations. In 1992 they restricted the total annual catch in an attempt to rein in expansion and ensure that the species could reproduce for the next fishing season. In 1996 the government further
tightened regulations by limiting the number of authorized fishing vessels. But these measures were not enough to mitigate the impacts of the industry combined with climate change, which increases the frequency of El Nino years.

In 1997 an El Nino almost caused another collapse. This time, the federal government acted fast to restrict fishing by rapidly establishing new regulations aimed at companies.

Then in 2008, a law imposed fishing quotas on individual companies. Now the government’s research branch—Institute of the Peruvian Sea, or IMARPE—monitors the coast during fishing seasons. The same branch also establishes no-fishing zones in areas containing juvenile anchovies, which are identified by size.

Since the introduction of these regulations, Peru’s fishery has become more stable. The country avoided a total industry collapse and now produces 19 percent of the world’s fishmeal, more than any other nation. A full 80 percent of that production is exported to China to feed its vast and growing aquaculture industry.

Chinese businesses aren’t just importing fishmeal, they are also big players in Peru’s industry. In 2006, China Fishery Group, now known as CFG Investment SAC, moved into Peru. In 2013, they bought the Peruvian fishmeal company Copeinca. CFG-Copeinca now has the largest combined catch quota, which means they are allowed to catch more fish than any Peruvian-owned company.

**Civic fight**
Local citizens and activists have mobilized to clean up their community from the impacts of the fishmeal industry. They launched a volunteer organization called Chimbote de Pie—which means “Chimbote Standing Up”—to fight back against contamination in the city and force the industry to clean up after itself.

Grassroots efforts began in 2014, when locals noticed that pelicans were entering the city in droves. The animals were starving due to a lack of food. Chimbote de Pie started investigating the problem and members learned how contaminated the ocean was.

“It was like a landfill,” says Béberly Enríquez, a lecturer at nearby San Pedro University. She was born and raised in Chimbote, but never felt a connection to the sea before she began this work. “The only thing that they would teach us in school was that there was a very contaminated sea and that it wouldn’t ever recover.”
In 2014, massive numbers of pelicans started arriving on the shores of Ferrol Bay. Photo reproduced with the authorization of Bebérly Enríquez

Garbage, waste from ships, and the oil from the flesh of fish, blood, scales and bones, which are all unused in fishmeal production, coat the ocean floor. Local pressure from organizations including Chimbote de Pie led to important changes, including a centralized pump that pushes now-treated waste six miles further out to sea.

“Thanks to the civic fight—and now to the management from the authorities and the private companies as well—we’re managing to stop [the contamination]. But there’s still a lot to do,” says Father Benaloy, a leading activist. “Chimbote de Pie will continue to fight until it is possible to stop all the polluters and we’re able to say that we managed to recover the Ferrol Bay.”

While the new government regulations will help curb further environmental pollution, they fail to address the damage already caused.

“In the case of Chimbote, the situation is much, much worse than you imagine,” says Ghersi, the former advisor to the Minister of Production. “Chimbote has been receiving effluent from the industry for 50 or more years. It has been said that, for the seafloor to
go back to what it was, at least 60 or 70 years must pass, and that’s with all the contaminant activities disappearing.”

Some beaches in Chimbote are still full of garbage produced by boats that navigate in Ferrol Bay. *Photo by Sebastian Romero*

The long game Ghersi describes is one Benaloy, Enríquez and Romulo Loayza, a biology professor at the National University of Santa in Nuevo Chimbote, understand. They remain concerned that despite improvements some factories continue to dump unfiltered waste into the ocean. Loayza says that while the major industry players have cleaned up their acts, there is still concern that effluent is flowing untreated into the ocean from smaller factories and illegal fishmeal processors in the area.

**Climate change**

Climate change is making the regulation of anchovies even more important for the survival of the fish stocks. El Nino years, like the ones that almost collapsed the anchovy population in 1972 and 1997, have been increasing in frequency due to climate change. Experts also believe the series of warm ocean waters, which skirt the equatorial Pacific region, will continue to intensify.
To alleviate these mounting pressures, comply with regulations, and ensure the long-term economic sustainability of their industry, the large fishmeal companies are developing new methods that are both more efficient and more environmentally sustainable.

For example, CFG-Copeinca has recently teamed up with the World Wildlife Fund to reduce harm to animals like sea lions and sea birds. A program has also been established to specifically address bycatch—when a species of fish or sea animals other than the target species is caught. The program provides training to crew members on how to identify and release animals that were unintentionally caught. “We already have crew members who have shared their experiences: releases of turtles, gulls. There is a lot of enthusiasm,” says Nathaly Pereira, manager of the program with CFG-Copeinca.

Another company, TASA, has a control room to monitor its fleet in real time. “We even self-impose no-fishing zones when we detect juveniles in certain areas,” says Javier Igarashi, TASA’s quality manager. “Therefore, we have a close relationship with the authorities so that fishing—and in that case our resource, anchoveta—is sustainable over time.”

Pauly, who has edited two books on Peruvian fisheries, says Peru is doing a decent job in managing its anchovy stocks.

“Outside an El Nino event, the Peruvian fisheries are relatively well-managed, at least for anchovy, because now it is forbidden [to completely deplete the] fish stock,” he says. “So when the stocks decline, they stop fishing.”
But what is troubling to Pauly is the unpredictability of climate change. He says if El Nino events continue to increase, then the stocks of anchovies could decline permanently. And when the anchovy declines it affects all the species that depend on it for survival.

Along the coast of West Africa, global demand for fish is endangering a long-established way of life. Many people in Senegal and Gambia depend on fish for both food and income. But a recent influx of foreign-owned fishmeal factories is threatening that livelihood—spurring locals into a fight for their future.

Story by ABI HAYWARD, DUSTIN PATAR and REHMATULLAH SHEIKH

Metal strikes metal on Sanyang Beach in Gambia. Abdou Kunta Fofana hefts a mallet over his head before bringing it down again and again, hitting screws holding a pipeline in place. His muscles strain with the effort and sweat beads on his forehead as he stands in rushing tide, oblivious to the water soaking his jeans.

“We do not want this factory!” he shouts, breathing hard. The hammer comes down again.

Within a matter of minutes, a small group of men dig the black plastic pipe out of the sand, forcing it from concrete holdings, and discard it, triumphantly, into the ocean.

The wastewater pipe connected the ocean with the Nessim Fishmeal Factory, one of three Chinese-owned fishmeal production facilities built along the 50-mile Atlantic coastline of Gambia, the smallest country in West Africa. The factories buy small fish, including sardines and bonga shad, from local fishermen, and process it into fishmeal—creating a waft of putrid odor that permeates the area, and producing an effluent that pollutes the sea.

These and other foreign-owned factories along the West African coast are creating conflict within local communities and economies, and inspiring the young people who live near them to take action.
Productive fishery draws both industry and the ire of locals

Fueled by global demand, fishmeal is a growing industry in West Africa. Today, three million people work in the region’s fisheries, which generate $2.5 billion each year from legal catches. The area has one of the most productive fisheries in the world, thanks to a natural upwelling system in which cold water rises from ocean depths and flows down along the northwest coast, bringing with it rich stocks of fish.

There are four major upwelling currents permanently swirling around the world and creating some of the world’s most productive fisheries. These systems are the Humboldt and California (in the Pacific Ocean) and the Canary and Benguela (in the Atlantic Ocean).
As coastal winds push warm surface water away from land, cold, nutrient-rich water is pulled up from ocean depths. The nutrients in the water feed tiny plankton, which are in turn eaten by thousands of small fish, including anchovies and sardines.
These forage fish are a vital part of the ecosystem, simultaneously limiting populations of lower-level species, such as plankton and jellyfish, while also serving as a food source for a diverse array of predators, including seabirds, mammals, and other fish. While not diverse, these small fish are voluminous. Just 13 species of these fish average 16.5 million tons of the world’s annual catch. They are the key ingredient in fishmeal.

Fishmeal factories started operating in West Africa during the 1970s and 1980s, when some coastal countries signed fishing agreements with the Soviet Union in exchange for investments in the region. At first the industry struggled to gain a foothold—the first factories in Mauritania closed due to low profits.

Decades later, the industry took off. In neighboring Senegal, for example, fishmeal production in 1967 totalled just 2,000 tons. By 2016, the yield had increased sevenfold, to 14,000 tons, according to data from the UN’s Food and Agriculture Organization.

As the industry became more lucrative, the first fishmeal factories started production in Gambia.

“The very first evening, when they started their engines, it was a shock to everybody,” says Lamin J.J. Jawla, a business owner who runs a tourist resort down the beach from the Nessim factory in Sanyang. “The stinking smell hit the village. It was a smell we have never experienced in our lives.”

Then in July 2018 the factory was closed down for almost six months because it was not meeting environmental standards mandated by Gambia’s National Environment Agency (NEA). The factory was dumping untreated waste on some of Sanyang’s fields and community gardens, where residents grow vegetables. Within a day, residents say their tomatoes changed color and a foul odor made it difficult to breathe.

While several studies have exposed the harmful effects fishmeal effluent has on fish and other animals in the ocean, there has been little research on its health effects on humans. A 2006 study in Kerala, India, however, identified a range of health concerns linked to exposure of untreated fishmeal factory effluent in local water sources. The study found that residents were suffering from respiratory, skin, and gastric diseases, and that factory pollution had created “an area of severe environmental crisis.”

While our team was reporting in Joal, Senegal, many locals said they believed the effluent from the fishmeal factory was negatively affecting their health. In response, we collected samples of wastewater being discharged from the Omega fishmeal factory directly into the ocean, and tested the outflow in a laboratory at the University of British Columbia. We found toxic levels of four heavy metals—Cadmium, Thallium, Selenium and Vanadium—well above safety guidelines set out by a number of international health organizations. In the case of Selenium, toxicity levels were more than 2,000 times the "Immediately Dangerous to Life or Health" levels established by the Centers for Disease Control and Prevention. We have repeatedly reached out to Omega for comment, but have received no response.
The community responded by staging a peaceful protest, which temporarily stalled factory operations. The Gambian environmental agency issued the company an ultimatum: stop processing until wastewater is properly treated. By the end of the six months, the company had taken heed and built a wastewater treatment plant. The NEA was satisfied with the water samples they tested, and Nessim got the go-ahead to continue operating.

But not everybody is satisfied. “We’re not even complaining anymore,” says Fofana, the mallet-wielding protester who helped remove the Nessim pipeline in Sanyang. “We are fighting.”

An online petition started in February this year calls on the Gambian government to close all three of Gambia’s fishmeal factories. It lists close to 3,000 signatures.

“All the people here don’t want the factory, because we have seen what it already does,” says Fofana. “It’s not good for our health, it’s not good for our plants, it’s not good for our birds, it’s not good for our fish. It’s not good for nothing.”

The monochrome Nessim Fishmeal Factory looms large behind the brightly-colored fishing boats of Sanyang, as teenagers play soccer with a destroyed wastewater pipe standing in for soccer goalposts. Photo by Abi Hayward
Foreign investors drive lucrative fishmeal business

Locals are even less inclined to accept the downsides of fishmeal production knowing that the facilities are operated by outsiders—foreign business owners capitalizing on the region’s natural resources, but without ties to the community.

The Nessim fishmeal factory is Chinese-owned. “The reason I chose Africa as my investment location is the source here is cheap,” says owner Du Qi Chao. “The price of fish is cheap.”

Du owns two other fishmeal factories outside of Gambia. He says the fishmeal produced by the Nessim factory is exported not only to China, but also to Russia, Turkey, and some other countries in Europe.

Some locals feel that foreign stakeholders are using local resources without regard for local interests. “They do what the foreigners want,” says Fofana. “They don’t do what the citizens want.”

Sharif Bojang is known throughout Sanyang as the person who supported bringing the fishmeal factory to their village. Bojang was the youngest chair of Sanyang’s Village Development Committee, a government-recognized body, before the fishmeal factory came to town.

“I didn’t do it, you know, in ill faith. I did it to support the development of my community, as I did with the other projects,” says Bojang, who counts a library, school, and community center among the projects he has backed. “If development is to come to my community, I will support that development.”

He got involved in the fishmeal factory, where he is now a supervisor, when the company needed local workers. Bojang condemns the activists who dug up the pipe, but he’s in an awkward position because Sanyang is a close-knit community.

“I am in between the community and the factory,” he says. “It’s very difficult for me sometimes.”
Fishermen in Senegal use horse-drawn wooden carriages and colorful wooden fishing canoes called pirogues. Photo by Farah Nosh

A way of life

In the north of Senegal, the first rays of the morning sun touch the sands of Joal Fadiouth, where the tide brings with it a fleet of fishermen in colorfully-painted wooden canoes brimming with the morning’s catch. Waiting on shore is a small army of women who buy and process fish. As soon as the first bucket makes landfall, the beach comes alive. This bustling scene, a riot of color, is the lifeblood of Senegal’s fishing industry.

Down the road, local fish processor Mariane Tening Ndiaye gets a call from her buyer. Ndiaye has been drying and smoking fish her whole life, just like her mother and grandmother before her. Nowadays she is struggling to compete with the higher price factories can pay for fish destined to become feed.

“They are more powerful than us,” she says of the factories buying up the catch.
Buying and smoking fish gives Mariane Tening Ndiaye economic and political power. But as fishmeal factories take more and more of the catch, her livelihood and place in society is threatened. 

*Photo by Farah Nosh*

Though women like Ndiaye are losing business to the fishmeal industry, some locals are benefiting from the new economy. “Those who sell their fish to the factories are in favor of them to stay, because [the factories] buy large quantities of fish at a very good price,” says Dodou Kote, a fisherman.
Stoking division

In the south of Senegal lies Abene, a quaint town popular with European tourists, home to emerald paddyfields and twisting turquoise river systems, as well as a close-knit community that was shocked when a fishmeal factory started up operations recently.

The Chinese-owned Société des Produits Halieutiques barely operated for one month in April 2018 before peaceful community protests led Senegal’s Ministry of Environment and Sustainable Development to suspend the factory’s operations. But some members of the community welcome the positive aspects of development that the factory has promised, such as new roads, hospitals, and schools. This has caused divisions in the community, even within families.

Momodou and Seny Sonko are brothers. They sit on an open veranda, sharing fish and rice from one metal bowl, arguing about the controversial factory in their town.

Seny asks why Momodou and the youths never complained when the factory first came to town. Momodou retorts that they didn’t know it would be a fishmeal factory at that time, saying that the owners claimed it was an ice-making plant. They agree on one thing: it smells bad.
The future

Fish is not only central to the working lives of people in the region, it’s also a vital source of protein. “If there is no fresh fish, we eat dried fish,” says Ndiaye, the fish processor from Joal Fadiouth.

The national dish of Senegal is thieboudienne, a hearty plateful of spicy tomato rice topped with vegetables and bony fish, often sardinella. But with a growing West African fishmeal industry exporting overseas, the star ingredient is being diverted from these communities.

“The system as a whole cannot produce an infinite number of fish,” explains Daniel Pauly, a marine biologist and director of the University of British Columbia’s Sea Around Us project. “So if you take them for exports for fishmeal, then they are not available to be eaten as food for humans.”

That change could have health consequences in a region reliant on the sea for protein. Meat is expensive and bean crops in sub-Saharan Africa are increasingly threatened by climate change as the Sahel desert creeps southwards.

“If a product is eaten by humans and eaten by animals, humans should go first,” says Pauly. “But these humans happen to be African, and they never go first.”
The growth of the fishmeal industry comes at a time when West African fisheries are already under pressure from overfishing, a problem made worse by illegal fishing. Six West African nations—Mauritania, Senegal, Gambia, Guinea Bissau, Guinea, and Sierra Leone—lose a staggering $2.3 billion in revenue annually as a result of illegal, unreported and unregulated (IUU) fishing, according to a 2017 study published in Frontiers in Marine Science.

“Gradually, we are determined to address those challenges,” says Banja Bamba from Gambia’s fisheries ministry. “It is happening not only in the high seas, but in our rivers.”

Regulations to combat illegal fishing exist, but are weakly enforced. Bamba says that countries, including Gambia and Senegal, are increasingly working together to crack down on enforcement.

The lucrative draw of fishing for fishmeal only adds to this problem. “Maybe in 10 to 20 years, we have no sardinella,” says Alessane Samba, the former head of research at Senegal’s Oceanic Research Institute.
He warns that depleting fish at the bottom of the food chain, such as sardinella, could lead to a collapse of the marine ecosystem.

Research shows that such dark predictions could come true. A 2019 report from Sea Around Us found that 88 percent of West African fish stocks had biomass below sustainable levels and 6 percent of them had collapsed entirely.

Unfortunately, Pauly knows these numbers too well. The marine biologist predicted the collapse of the sardinella fishery further down the coast, off Namibia. By the turn of the century, jellyfish filled the void of the sardinella in the ocean ecosystem, and the fishery never recovered. Pauly says that this was the first system where fish were replaced by jellyfish.

When marine ecosystems are pushed to their limits, the results can be devastating. Off the coast of Namibia, the once-rich fish stocks of the Benguela upwelling system have almost completely disappeared. Overfishing of sardines, and later anchovies, resulted in a series of collapses. Marine biologists report a 90 percent decline between the 1960s and early 2000s.

Small pelagic fish including anchovies and sardines are the bedrock of an upwelling food web. When they are removed, it results in ecosystem upheaval. Near Namibia, jellyfish filled the void when the pelagic population was disappearing. No longer suppressed by fish, the jellyfish prospered, growing to more than 13 million tons—four times the weight of the earlier population.

The small fish haven’t recovered, in part because jellyfish consume their eggs. Scientists say that with better fisheries management, situations like this can be avoided.

Oceanic researcher Samba says the collapse of sardinella in Senegal would have the worst impact on the poorest people. Families that depend on the small fish for both food and work could really suffer. He advocates a radical response to the threat.

“The only solution I see is to close all fish feed factories,” he says. “There is no benefit to us. It’s foreign owned and it’s all exported.”

But Pauly notes that the solution is not so simple and trying to turn back the clock could lead to unintended consequences.

“What would the Senegalese government offer to young people that are fishing?” asks Pauly. “Go work in Silicon Valley or go work where? There’s no other job. So they have to let them continue to operate.”

Bamba says the factories are here to stay, “I think the right thing to do was not to give them approval in the beginning, but having done that, now you have to support them.”
For people like the protesters in Gambia and Senegal, however, resistance seems like the only way to protect their health, their economy, their agriculture—and especially their fish.

Ndiaye puts it simply: “If there is no fish, there is no future.”

As the pressure on the ocean’s resources intensifies, aquafeed companies—big and small—are searching to find new ways to provide the protein fish need to grow. Many of these alternatives are promising, but can they ever replace fishmeal?

Story by ANNIE RUETER and OSCAR BEARDMORE-GRAY

Fish farms are the fastest-growing food production method in the world and the fish feed industry, which relies on small fish around the world to feed those farms, has come under increasing pressure to find alternative nutrition sources. A recent study in the science journal *Nature* predicted that the demand for fish feed “will eventually surpass ecological supply of forage fish” and called for “alternative feed sources.”

Wing Yin Mo, an environmental scientist, is trying to offer just that. He has developed a fish feed made from food waste—including expired items from grocery stores and discarded food and scraps from restaurants.

“We have lots of food waste in Hong Kong and China,” says Mo, who is completing his postdoctoral studies at Hong Kong Education University. He says 3,600 tons of food waste is sent to landfills every day in Hong Kong. “I am trying to recover those resources as much as possible.”
Mo’s alternative feed aims to address two problems at once—the need for fishmeal and too much trash. Nearly 40 percent of Hong Kong’s municipal garbage is food waste. Using some of that for feed could both reduce the amount of garbage and relieve pressure on the South China Sea’s wild fish stocks that are currently caught for fishmeal.

For small-scale fish farmers in particular, Mo says his product is an environmentally and financially sustainable choice, since his formula uses about half the amount of fishmeal as commercial feed, at about half the price. Typically, fish feed is the largest cost for farmers, so cheaper feeds can have a big effect on bottom lines for local fish farmers.

But Mo’s research is only in its preliminary stages. He acknowledges that the formula still needs improving, and that more collaboration and support will be required to make his product scalable.
Win Ying Mo has developed a pilot project in Hong Kong that uses food waste as an alternative protein source for fishmeal. Photo by Annie Rueter

Global incentive to develop alternatives

As more and more of the world’s people rely on farmed fish for meals, innovators around the world are working to find sustainable alternatives to produce the feed needed to sustain farms long-term. The World Wildlife Fund has been pressuring the fishmeal industry to develop alternative sources of protein for fish feed.

“It’s time for the commercialization of these sustainable alternatives, so we can achieve sustainable and affordable food in a way that is ethical, economical and environmentally respectful,” said Marcela Navarro, co-founder and CEO of Project X, an independent company first launched as a project by WWF.

According to a recent report commissioned by Project X, the global feed industry is one of the 10 industry sectors particularly harmful to biodiversity and climate due to its high levels of greenhouse emissions.
WWF affiliate Project X is partnering with fish feed giant Skretting to find ways to make more sustainable feeds. *Photo by Project X*

To respond, Navarro and her team launched a challenge earlier this year to help identify innovations that will enable the fishmeal and fish feed industry to shift toward more sustainable alternatives. Norwegian company Skretting, which is the largest producer of salmon feed in the world, partnered with Project X to create the FEED-X challenge.

Their aim is to shift 10 percent of the world’s feed production to alternative ingredients by 2025. FEED-X invites and incentivizes innovators to develop more sustainable fishmeal alternatives and technology for producing feed for shrimp and salmon—two of the world’s most popular seafood products—on a marketable scale.

“To feed the 9.7 billion people on this planet [by 2050],” says Navarro, “we need to look into non-traditional innovations and collaboration models to achieve the results we need, at the pace the planet needs it.”

**Novel ingredients on the rise**
The push for industry to replace forage fish with alternative ingredients isn’t new. For the past 30 years, the percent of farmed fish eating fishmeal has declined as the $69 billion aquafeed industry increasingly turned to novel ingredients.

Skretting, for example, developed aquafeed for salmon without using fishmeal or fish oil more than three years ago. The feed’s source of omega-3 fatty acids, typically found in forage fish like mackerel and anchovies, comes from marine algal oil. The acids are essential for brain development and human health.

The company behind Skretting’s algal oil project, Veramaris, recently opened a $200 million facility in Nebraska. Now, major European retailers, including UK-based Tesco and French supermarket chain Match, are selling salmon raised on algal oil-based feeds, and are encouraging salmon suppliers to use alternative ingredients.

Another possible protein substitute are soybeans. Most soybeans go toward animal feed, but they are also the most commonly used vegetable protein in fish feed. However, relying on soy to replace forage fish poses challenges of its own. A recent study by Rainforest Foundation Norway found the three main soy suppliers to the Norwegian farmed salmon industry “are linked to illegal deforestation, land conflict, soy on Indigenous territories, illegal pesticides and slave-like labor conditions, through their supply chains.”
Insects are an increasingly popular alternative to fishmeal. Photo by Enterra Feed Corporation

Since most farmed fish are carnivorous, one alternative to forage fish in fishmeal is another source of animal protein—insects.

Taplow Feeds, based in Canada, has been using bugs to supplement fishmeal in its pet and aquafeeds for more than a decade. The company sources the grubs from Enterra Feed Corporation, also based in Canada, who grow black fly soldier larvae on food waste. The insects then get processed into grubs, protein meal or oil suitable for fish diets.

“If we can take what is currently a waste stream and turn it into food, it’s actually not a bad idea in my view,” says Brad Hicks, vice president of Taplow.

Insect meal has high-quality protein, vitamins and amino acids and produces minimal greenhouse gas emissions. They may have potential, but it’s not a magic bullet. Even Hicks acknowledges the relatively new industry cannot supply enough quantity to replace fishmeal, and there are limits on how much insect meal can be incorporated into feeds.
“At this stage of industry development, it’s really not feasible [to completely replace fishmeal with insect meal],” Hicks says. “Insect meal is not going to replace fishmeal tomorrow or the day after. We are talking years and years.”

But finding substitutes for forage fish seems inevitable. Even the leading fishmeal and fish oil industry group acknowledges the need for alternative ingredients even if it maintains that fishmeal and fish oil will forever be a key part of the aquafeed industry.

“The way that we see the rise of the novel ingredients is that they’re very much needed to help provide that additional volume for feed for agriculture and aquaculture,” says Neil Auchterlonie, technical director of IFFO—The Marine Ingredients Organization. But “fishmeal and fish oil are always going to be part of [the feed] because they are [a] very effective and practical means of supplying that nutrition.”

Over the past three decades, the industry has significantly decreased its “Fish In: Fish Out” ratios, a measurement used to compare the amount of wild fish it takes to produce an equivalent weight of farmed fish.

According to the IFFO’s most recent figures, the ratio is now better than 1:1—in other words, it takes less than a pound of wild fish to produce a pound of farmed salmon or trout. So today, according to industry numbers, there is a net gain in protein, which is a huge improvement over the ratio in 2000, when it took 2.5 pounds of wild fish to produce one pound of farmed salmon.
Fisherman Lueng Kam Wah supplements with an alternative feed produced using food waste but still relies heavily upon wild fish to feed his farm. *Photo by Yuxian Wang*

**What consumers can do**

Globally, there are more than 30 different aquaculture certifications, standards, and schemes intended to guide consumers’ choices when purchasing seafood.

Criteria vary, and some of them evaluate the source of feed for farmed fish as part of the assessment.

“We look at both the source of the fishmeal and how efficiently it is processed into fish protein on the other end,” said Alasdair Lindop, the science lead on aquaculture at Ocean Wise in Vancouver. “[We] make sure [the fishmeal] is from a wild fishery that’s already been assessed as sustainable. And then we are looking at the energy transfer—we want it to be as close to a ratio of one to one, so one kilo of fish in, to one kilo of fish out,” he said.

Lindop says that many fish consumers do not know that most farmed fish need fishmeal to grow, and he urges shoppers to choose sustainably-sourced seafood.
“From a layman’s point of view, I don’t think fishmeal is something that people understand well,” he said. “But I think that’s across all kinds of agriculture. I don’t think people think too much about what you’re feeding [cows] or chickens.”

Link: https://globalreportingprogram.org/fishmeal/