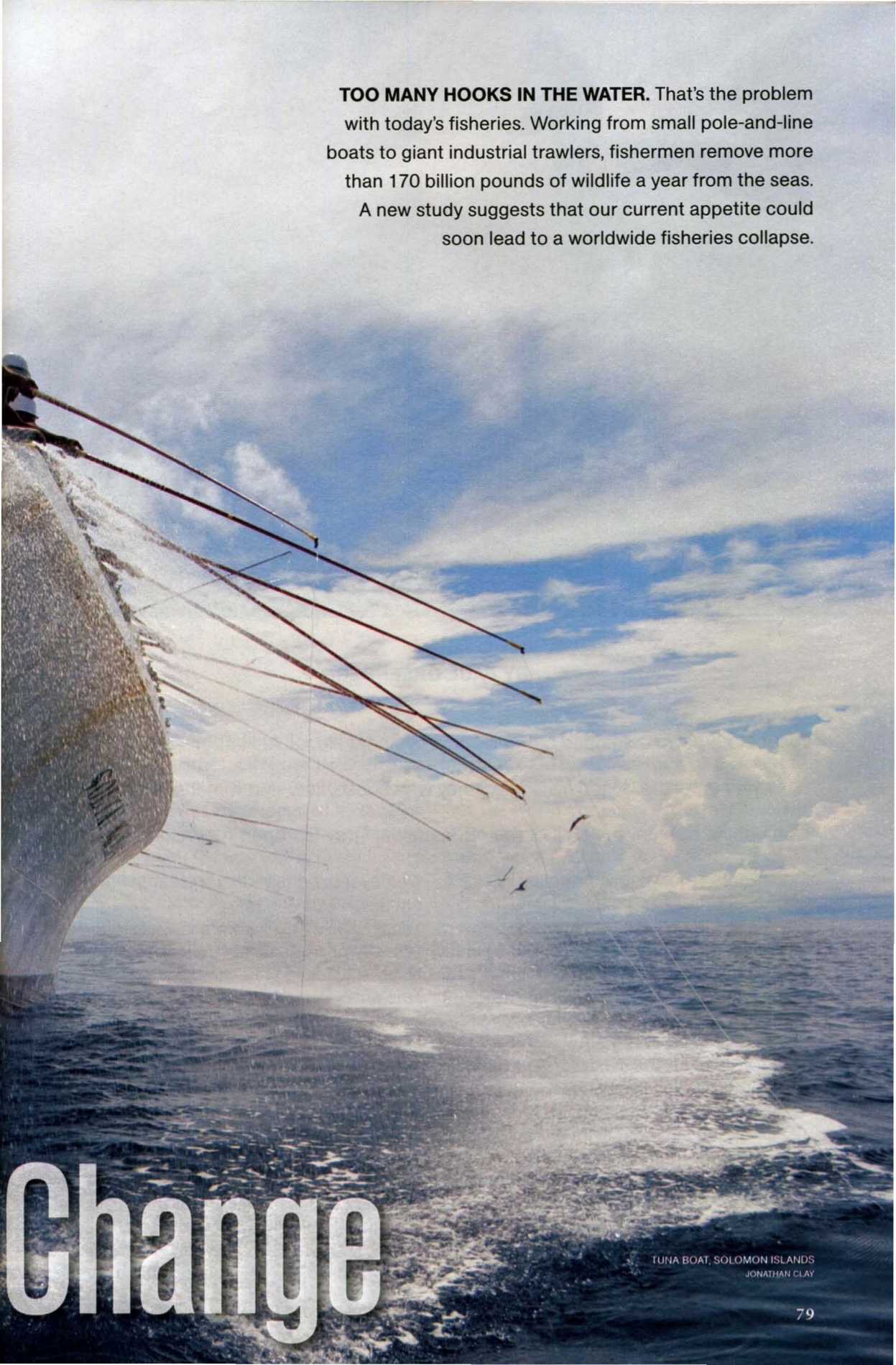




Time for a Sea

A large tuna boat is shown from a low angle, with its white hull and deck visible on the left. Numerous fishing lines extend from the boat into the dark blue ocean. The sky is filled with white and grey clouds. In the distance, several birds are flying over the water. The overall scene depicts a busy fishing operation.

**TOO MANY HOOKS IN THE WATER.** That's the problem with today's fisheries. Working from small pole-and-line boats to giant industrial trawlers, fishermen remove more than 170 billion pounds of wildlife a year from the seas.

A new study suggests that our current appetite could soon lead to a worldwide fisheries collapse.

# Change

TUNA BOAT, SOLOMON ISLANDS  
JONATHAN CLAY



**BY PAUL GREENBERG**

Just before dawn a seafood summit convenes near Honolulu Harbor. As two dozen or so buyers enter the United Fishing Agency warehouse, they don winter parkas over their aloha shirts to blunt the chill of the refrigeration. They flip open their cell phones, dial their clients in Tokyo, Los Angeles, Honolulu—wherever expensive fish are eaten—and wait.

Soon the big freight doors on the seaward side of the warehouse slide open, and a parade of marine carcasses on pallets begins. Tuna as big around as wagon wheels. Spearfish and swordfish, their bills sawed off, their bodies lined up like dull gray I beams. Thick-lipped opah with eyes the size of hockey pucks rimmed with gold. They all take their places in the hall.

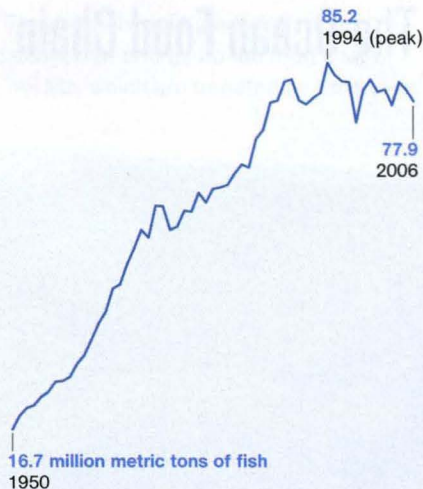
Auctioneers drill core samples from the fish and lay the ribbons of flesh on the lifeless white bellies. Buyers finger these samples, trying to divine quality from color, clarity, texture, and fat content. As instructions come in over cell phones, bids are conveyed to the auctioneer through mysterious hand gestures. Little sheets of paper with indecipherable scribbling are

slapped on a fish's flank when a sale is finalized. One by one fish are auctioned and sold to the highest bidder. In this way the marine wealth of the north-central Pacific is divided up among some of the world's most affluent purchasers.

Every year more than 170 billion pounds (77.9 million metric tons) of wild fish and shellfish are caught in the oceans—roughly three times the weight of every man, woman, and child in the United States. Fisheries managers call this overwhelming quantity of mass-hunted wildlife the world catch, and many maintain that this harvest has been relatively stable over the past decade. But an ongoing study conducted by Daniel Pauly, a fisheries scientist at the University of British Columbia, in conjunction with Enric Sala, a



Fish don't stand a chance nowadays. Factory ships like this Lithuanian trawler off Mauritania roam the world, hauling in massive amounts of fish and freezing the catch along the way.



### GLOBAL MARINE CAPTURE

During the past 50 years the annual world seafood catch has more than quadrupled, as fishing fleets have added new technologies and ventured into previously unexploited regions.

National Geographic fellow, suggests that the world catch is neither stable nor fairly divided among the nations of the world. In the study, called SeafoodPrint and supported by the Pew Charitable Trusts and National Geographic, the researchers point the way to what they believe must be done to save the seas.

They hope the study will start by correcting a common misperception. The public imagines a nation's impact on the sea in terms of the raw tonnage of fish it catches. But that turns out to give a skewed picture of its real impact, or seafood print, on marine life. "The problem is, every fish is different," says Pauly. "A pound of tuna represents roughly a hundred times the footprint of a pound of sardines."

The reason for this discrepancy is that tuna are apex predators, meaning that they feed at the very top of the food chain. The largest tuna eat enormous amounts of fish, including intermediate-level predators like mackerel, which in turn feed on fish like anchovies, which prey on microscopic copepods. A large tuna must eat the equivalent of its body weight every ten days

to stay alive, so a single thousand-pound tuna might need to eat as many as 15,000 smaller fish in a year. Such food chains are present throughout the world's ocean ecosystems, each with its own apex animal. Any large fish—a Pacific swordfish, an Atlantic mako shark, an Alaska king salmon, a Chilean sea bass—is likely to depend on several levels of a food chain.

To gain an accurate picture of how different nations have been using the resources of the sea, the SeafoodPrint researchers needed a way to compare all types of fish caught. They decided to do this by measuring the amount of "primary production"—those microscopic organisms at the bottom of the marine food web—required to make a pound of a given type of fish. They found that a pound of bluefin tuna, for example, might require a thousand pounds or more of primary production.

In assessing the true impact that nations have on the seas, the team needed to look not just at what a given nation caught but also at what the citizens of that nation ate. "A country can acquire primary production by fishing, or it can

# The Ocean Food Chain

LEVEL

4

## TOP PREDATORS

Slow to reproduce, these fish are among the most energy demanding in the sea.



### ATLANTIC BLUEFIN TUNA

Because overfishing has cut the population of this fish to a fraction of its original abundance, conservationists urge a fishing moratorium.

### ORANGE ROUGHY

The orange roughy fishery in the Southern Hemisphere was heavily exploited in the 1980s. The largest of these deep-sea fish live a century or more.



### ATLANTIC SALMON

Most Atlantic salmon sold in the U.S. come from aquaculture operations, where they are fed fish meal, adding to the pressures on wild fish.

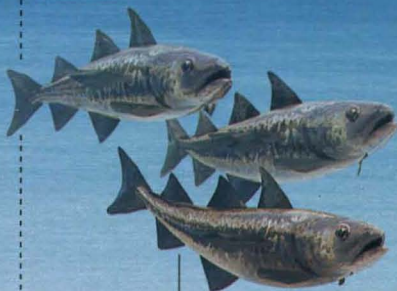


LEVEL

3

## INTERMEDIATE PREDATORS

These species are vital for keeping lower-level fish populations in check.



### ALASKA POLLOCK

Although its biomass has declined in recent years, this species (often sold as fish sticks) remains the largest U.S. fishery by volume.



### ATLANTIC HERRING

Important prey for seabirds, ocean mammals, and other fish, the Atlantic herring was overfished in the 1960s but is now recovering.



### JAPANESE FLYING SQUID

Preyed upon by albatrosses and sperm whales, the Japanese flying squid lives only a year or so but can replenish its population quickly.



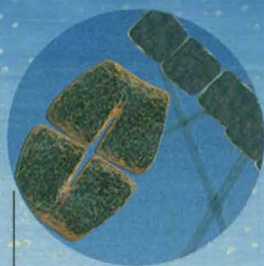
Phytoplankton and algae drive ocean ecosystems. They capture solar energy through photosynthesis and, when eaten by zooplankton, transfer that energy up the food chain. Small fish eat zooplankton and in turn are eaten by big fish, which are targeted by fishermen.

LEVEL

2

### FIRST-ORDER CONSUMERS

Able to reproduce quickly, these species account for much of the ocean biomass.



#### ZOOPLANKTON

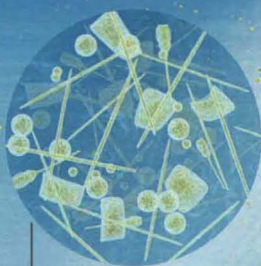
These tiny animals feed on phytoplankton and are eaten by fish and baleen whales.

LEVEL

1

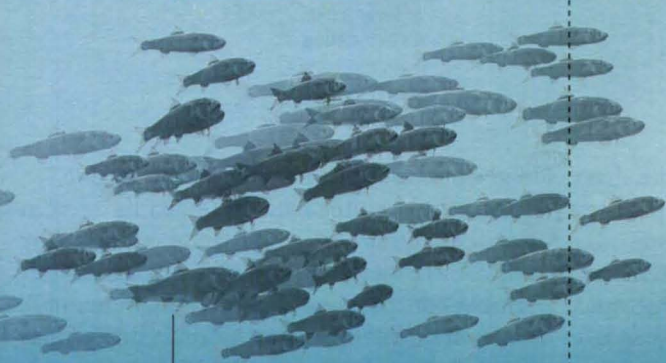
### PRIMARY PRODUCERS

Organisms at the lowest level capture solar energy through photosynthesis.



#### PHYTOPLANKTON

Microscopic, plantlike organisms are so abundant in the sea that they are responsible for half of Earth's photosynthesis.



#### PERUVIAN ANCHOVETA

The world's largest fishery by volume, anchoveta are often ground up for animal feed. El Niño events drive big ups and downs in their populations.

#### AMERICAN LOBSTER

Since the population of its main predator, cod, was overfished and collapsed, the American lobster has rebounded.



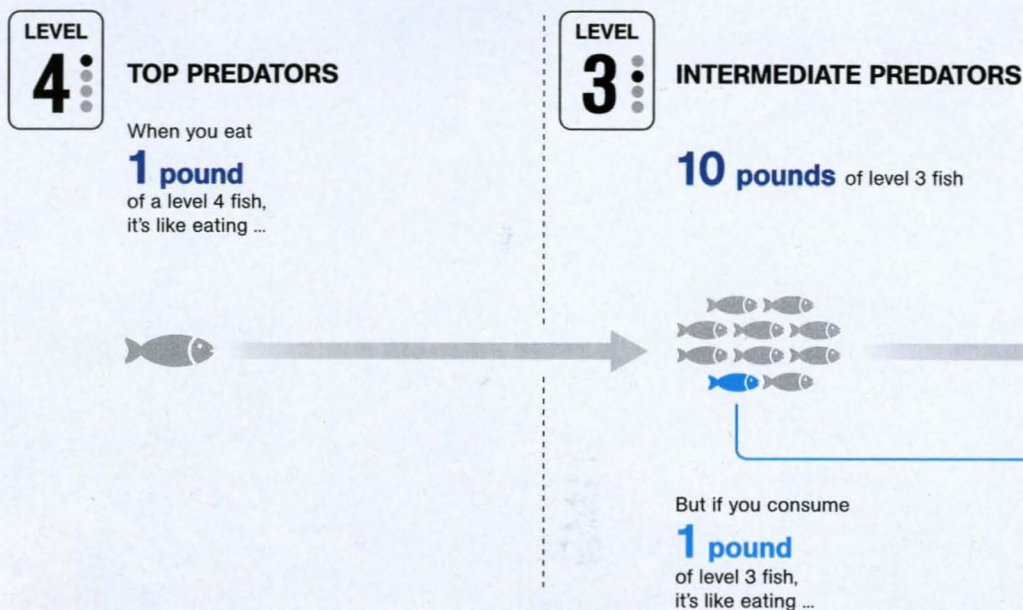
#### ALGAE

Popular as food around the world, red algae seaweed species need only water and light to thrive.



MARIEL FURLONG, NGM STAFF, AND ALEJANDRO TUMAS  
ART: HERNAN CAÑELLAS  
SOURCES: ENRIC SALA; SEA AROUND US PROJECT,  
UNIVERSITY OF BRITISH COLUMBIA FISHERIES CENTRE,  
BARTON SEEVER

# What We Eat Makes a Difference



acquire it by trade," Pauly says. "It is the sheer power of wealthy nations to acquire primary production that is important."

Nations with money tend to buy a lot of fish, and a lot of the fish they buy are large apex predators like tuna. Japan catches less than five million metric tons of fish a year, a 29 percent drop from 1996 to 2006. But Japan consumes nine million metric tons a year, about 582 million metric tons in primary-production terms. Though the average Chinese consumer generally eats smaller fish than the average Japanese consumer does, China's massive population gives it the world's biggest seafood print, 694 million metric tons of primary production. The U.S., with both a large population and a tendency to eat apex fish, comes in third: 348.5 million metric tons of primary production. And the size of each of these nations' seafood prints is growing. What the study points to, Pauly argues, is that these quantities are not just extremely

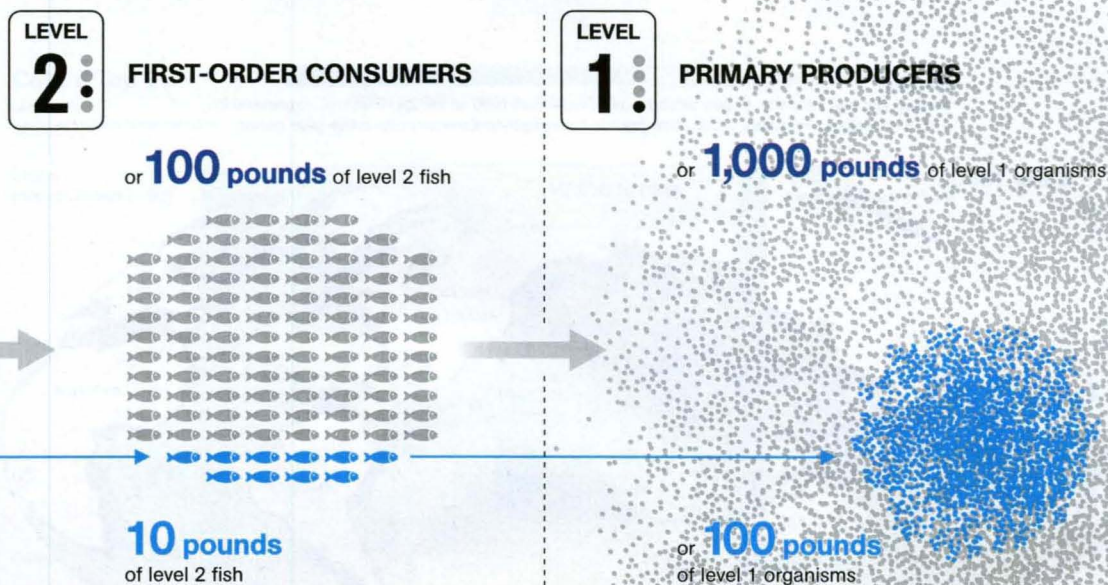
large but also fundamentally unsustainable.

Exactly how unsustainable can be seen in global analyses of seafood trade compiled by Wilf Swartz, an economist working on Seafood-Print. As the maps on page 86 show, humanity's consumption of the ocean's primary production changed dramatically from the 1950s to the early 2000s. In the 1950s much less of the ocean was being fished to meet our needs. But as affluent nations increasingly demanded apex predators, they exceeded the primary-production capacities of their exclusive economic zones, which extend up to 200 nautical miles from their coasts. As a result, more and more of the world's oceans had to be fished to keep supplies constant or growing.

Areas outside of these zones are known in nautical parlance as the high seas. These vast territories, the last global commons on Earth, are technically owned by nobody and everybody. The catch from high-seas areas has risen to nearly ten times what it was in 1950, from 1.6 million metric tons to around 13 million metric tons. A large part of that catch is high-level, high-value tuna, with its huge seafood print.

*Paul Greenberg is the author of Four Fish: The Future of the Last Wild Food.*

A top predator requires exponentially more energy to survive than does a fish at a lower level of the food chain. When wealthy nations catch or buy top predators, they increase their impact on the ocean compared with poor nations, which tend to eat smaller fish.



The wealthier nations that purchase most of the products of these fisheries are essentially privatizing them. Poorer countries simply cannot afford to bid for high-value species. Citizens in these nations can also lose out if their governments enter into fishing or trade agreements with wealthier nations. In these agreements local fish are sold abroad and denied to local citizens—those who arguably have the greatest need to eat them and the greatest right to claim them.

Although supermarkets in developed nations like the U.S. and Japan still abound with fish flesh, SeafoodPrint suggests that this abundance is largely illusory because it depends on these two troubling phenomena: broader and broader swaths of the high seas transformed from fallow commons into heavily exploited, monopolized fishing grounds; and poor nations' seafood wealth spirited away by the highest bidder.

Humanity's demand for seafood has now driven fishing fleets into every virgin fishing ground in the world. There are no new grounds left to exploit. But even this isn't enough. An unprecedented buildup of fishing capacity threatens to

outstrip seafood supplies in all fishing grounds, old and new. A report by the World Bank and the Food and Agriculture Organization (FAO) of the United Nations recently concluded that the ocean doesn't have nearly enough fish left to support the current onslaught. Indeed, the report suggests that even if we had half as many boats, hooks, and nets as we do now, we would still end up catching too many fish.


Some scientists, looking at the same data, see a different picture than Daniel Pauly does. Ray Hilborn, a fisheries scientist at the University of Washington, doesn't think the situation is so dire. "Daniel is fond of showing a graph that suggests that 60 to 70 percent of the world's fish stocks are overexploited or collapsed," he says. "The FAO's analysis and independent work I have done suggests that the number is more like 30 percent." Increased pressure on seafood shouldn't come as a surprise, he adds, since the goal of the global fishing industry is to fully exploit fish populations, though without damaging their long-term viability.

Many nations, meanwhile, are trying to

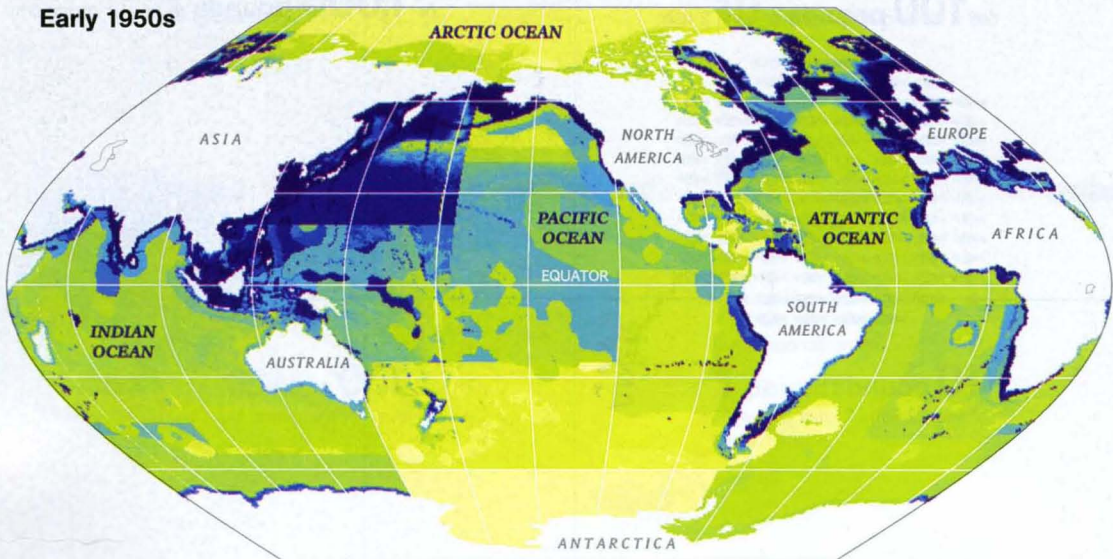


# Where Fish Are Caught

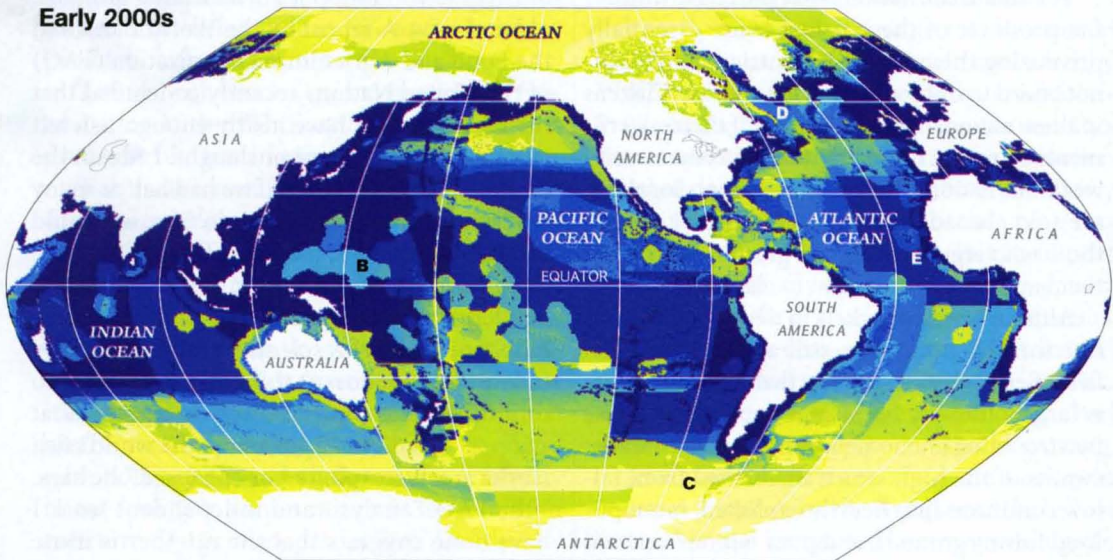
The opening of new fishing grounds during the past half century has caused a boom in the world catch, as fleets with increased range and capacity have spread out across the open seas. Now the consequences of overfishing are apparent in every ocean.

LOW  HIGH  
Harvest intensity: ocean catch by half-degree cell (930 sq mi; 2,410 sq km), expressed in terms of primary production (metric tons of phytoplankton) over a five-year period

Early 1950s



Early 2000s



## HARVESTING PATTERNS

### A: Southeast Asia

The popularity of sushi has taken a toll on tuna stocks. Several species are showing signs of decline.

### B: Exclusive economic zones

Created in 1982, the zones have slowed the growth of fisheries within 200 nautical miles of nations' coasts.

### C: Global south

After fleets moved into waters around Antarctica, Chilean sea bass stocks were quickly depleted.

### D: North Atlantic

A thousand years of fishing by everyone from Vikings to modern Spaniards has driven cod to near collapse.

### E: Eastern Atlantic

European fleets have targeted Africa's coasts. Leaders selling fishing rights may ignore costs to local food supplies.

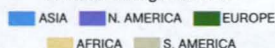
# Who Catches and Who Consumes

Wealthy nations once obtained most of their fish by fishing. Today they're more likely to buy a swordfish than to catch it. Japan purchases more than twice as much fish as it catches, while Peruvians, the number two seafood producers in the world, consume barely any at all.

## Catch: Top 20

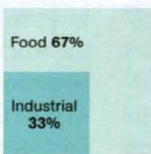
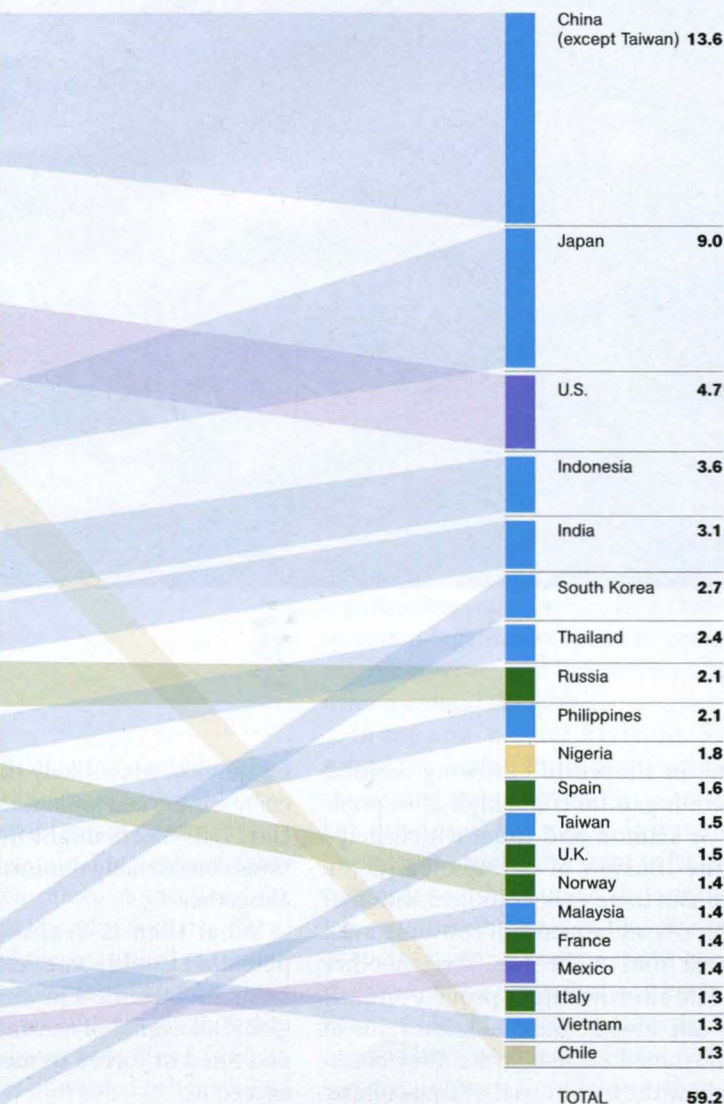
LANDINGS  
(MILLION METRIC TONS OF FISH)

Annual average 2001-05



## Consumption: Top 20

LANDINGS  
(MILLION METRIC TONS OF FISH)



### TOTAL CONSUMPTION

Annual average 2001-05

Not all of the fish that are caught are eaten. A third of today's catch is used for industrial purposes, such as the manufacturing of paints and cosmetics or feed for farm-raised salmon, tuna, and even pigs and chickens.

MAPS: MARTIN GAMACHE, NGM STAFF  
CHARTS: MARIEL FURLONG, NGM STAFF, AND ALEJANDRO TUMAS  
SOURCE: SEA AROUND US PROJECT, UNIVERSITY OF BRITISH COLUMBIA FISHERIES CENTRE



compensate for the world's growing seafood deficit by farming or ranching high-level predators such as salmon and tuna, which helps maintain the illusion of abundance in the marketplace. But there's a big problem with that approach: Nearly all farmed fish consume meal and oil derived from smaller fish. This is another way that SeafoodPrint might prove useful. If researchers can tabulate the ecological value of wild fish consumed on fish farms, they could eventually show the true impact of aquaculture.

Given such tools, policymakers might be in a better position to establish who is taking what from the sea and whether that is just and sustainable. As a global study, SeafoodPrint makes clear that rich nations have grossly underestimated their impacts. If that doesn't change, the abundance of fish in our markets could drop

off quickly. Most likely the wealthy could still enjoy salmon and tuna and swordfish. But middle-class fish-eaters might find their seafood options considerably diminished, if not eliminated altogether.

What then is SeafoodPrint's long-range potential? Could some version of it guide a conservation agreement in which nations are given a global allowance of oceanic primary production and fined or forced to mend their ways if they exceed it?

"That would be nice, wouldn't it?" Pauly says. He points out that we already know several ways to shrink our impact on the seas: reduce the world's fishing fleets by 50 percent, establish large no-catch zones, limit the use of wild fish as feed in fish-farming. Unfortunately, the seafood industry has often blocked the road to reform.



## Demand for seafood has now driven fishing fleets into every virgin fishing ground in the world. There are no new grounds left to exploit.

### EMPTY SEA, FULL MARKET

Hundreds to thousands of pounds of salmon move through Seattle's Pike Place Market each day, much of it caught in Alaska's well-managed waters. While affluent nations may practice good fisheries management at home, they often rely on poorly monitored developing countries for much of their seafood. The result could be empty fish markets in the poorest places.

are to recover and multiply in the years ahead. What Pauly and other conservation biologists now believe is that suggestions must be transformed into obligations. If treaties can establish seafood-consumption targets for every nation, they argue, citizens could hold their governments responsible for meeting those targets. Comparable strategies have worked to great effect in terrestrial ecosystems, for trade items such as furs or ivory. The ocean deserves a similar effort, they say.

"Barely one percent of the ocean is now protected, compared with 12 percent of the land," Enric Sala adds, "and only a fraction of that is fully protected." That's why National Geographic is partnering with governments, businesses, conservation organizations, and citizens to promote marine reserves and help reduce the impact of fishing around the globe.

SeafoodPrint could also give consumers a map around that roadblock—a way to plot the course toward healthy, abundant oceans. Today there are dozens of sustainable-seafood campaigns, each of which offers suggestions for eating lower on the marine food chain. These include buying farmed tilapia instead of farmed salmon, because tilapia are largely herbivorous and eat less fish meal when farmed; choosing trap-caught black cod over long-lined Chilean sea bass, because fewer unwanted fish are killed in the process of the harvest; and avoiding eating giant predators like Atlantic bluefin tuna altogether, because their numbers are simply too low to allow any harvest at all.

The problem, say conservationists, is that the oceans have reached a critical point. Simply changing our diets is no longer sufficient if fish

In the end, neither Pauly nor Sala nor the rest of the SeafoodPrint team wants to destroy the fishing industry, eliminate aquaculture, or ban fish eating. What they do want to change is business as usual. They want to let people know that today's fishing and fish-farming practices are not sustainable and that the people who advocate maintaining the status quo are failing to consider the ecological and economic ramifications. By accurately measuring the impacts nations have on the sea, SeafoodPrint may lay the groundwork for effective change, making possible the rebuilding of the ocean's dwindling wealth. Such a course, Pauly believes, could give the nations of the world the capability, in the not too distant future, to equitably share a truly bountiful, resurrected ocean, rather than greedily fight over the scraps that remain in the wake of a collapse. □