SECOND EDITION

Updated 2011

Turning the Tide

The State of Seafood Monterey Bay Aquarium

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Monterey Bay Aquarium

Julie Packard, Executive Director

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The mission of the Monterey Bay Aquarium is to inspire conservation of the oceans.

Cover images
(outer) Giant kelp and schools of sardines at Catalina Island, California. Tim Laman / National Geographic Stock.
(inner) Live shrimp in San Lorenzo, Honduras. David Evans / National Geographic Stock.

Since the Monterey Bay Aquarium first invited visitors to peek below the surface of the ocean and discover the marvels of the sea, we've opened the eyes – and hearts – of millions of people to the incredible marine life found in our oceans.

Photo by Tom O'Neal

Sadly, ocean life today is threatened as never before. Human activities are taking their toll, and nothing exacts a greater price than the scope and scale of fishing to feed our growing appetite for seafood.

When we opened our doors in 1984, the global catch of wild fish – the last wild animals on Earth taken by people for food in vast numbers – had nearly peaked. The catch is now in decline; so is the health of ocean ecosystems.

Farmed species will soon overtake wild-caught fish as the leading source of seafood in the human diet. Yet some aquaculture operations are not without their own significant impacts on aquatic systems, further contributing to the decline in ocean health.

The Aquarium recognized the warning signs more than a decade ago, and shared the story with visitors in a special exhibition called "Fishing for Solutions: What's the Catch?" We addressed issues of inadequate fisheries management, overfishing and the bycatch of unwanted animals, destruction of marine habitats by fishing gear and aquaculture operations, and skyrocketing demand for seafood from a larger, more affluent global population.

We offered solutions, too: notably a new program launched in 1999 called Seafood Watch.

Seafood Watch has taken off from its modest beginnings and has helped spawn a growing sustainable seafood movement that's gaining momentum across the globe. To date, we've distributed nearly 40 million consumer pocket guides with seafood recommendations covering the entire United States, and put our Seafood Watch app on mobile devices including iPhone and Android smartphones. We have also partnered with the largest food service companies in North America as well as retailers and seafood distributors to help shift millions of pounds of seafood purchases to more sustainable sources.

Backed by a team of fisheries and aquaculture researchers, Seafood Watch has become a recognizable reference point for millions of conservation-minded consumers, restaurateurs and purveyors in the United States interested in purchasing seafood from ocean-friendly sources.

Our work and that of others is having a real impact, as you'll read in *Turning the Tide: The State of Seafood*. We created this report in 2009, and plan biennial updates, beginning with this 2011 edition. Our intention is to document the condition of fisheries and aquaculture in the world today, and to highlight both trends that are a cause for concern and that offer new hope for the future.

To date, Monterey Bay Aquarium has distributed nearly 40 million Seafood Watch consumer pocket guides.

There are many reasons to be optimistic.

Yes, the state of ocean life is still in decline; yes, we have reached a point when urgent action is needed to reverse declines in ocean wildlife populations – and to restore what we've lost. The good news is that fishermen and consumers, businesses and governments are charting new courses and cooperating in new ways to address the problems our oceans and fishing communities face.

Respected scientists from across the spectrum – fisheries management experts and marine ecologists – have reached consensus about how best to bring back the world's ocean fish populations. In a paper published in the journal *Science* in 2009, they agreed that while overfishing and environmental change still threaten wild fish populations around the world, there are many signs of progress.

They also agreed that several specific steps can help turn the tide. Notably, they pointed to management techniques like closing some areas to fishing, restricting certain types of fishing gear and giving individual fishermen, communities and fishing cooperatives a secure privilege to harvest a share of the annual catch.

New initiatives by conservation organizations, consumers, businesses, governments and fishermen are gaining momentum, too. International dialogues are shaping criteria for aquaculture that can be sustainable in the long term and embraced by major seafood buyers as they make purchasing decisions. In North America, most major supermarket chains have adopted principles of sustainability for their seafood purchases, and many are working with a conservation organization to put those standards into practice. Around the world, governments are acting to end destructive fishing practices like the wasteful slaughter of sharks for their fins.

Now more than ever, consumers are asking for seafood that is both healthy to eat and caught or farmed in a way that is not harmful to the oceans. Fishing communities and conservationists are crafting innovative solutions to ensure that there will be fish to catch – and fishing livelihoods – for generations to come.

Of course, beyond how many fish we catch, our oceans face growing threats from degraded coastal habitats and pollution. We must protect and restore critical coastal areas that support ocean life and reduce pollution of productive coastal waters. These issues, coupled with the growing threat posed by global climate change, can no longer be ignored. If we delay, we threaten the health of marine ecosystems and – ultimately – our own survival.

Turning the Tide: The State of Seafood is contributing to this movement by serving as a benchmark of where we are and a roadmap of where we're going. It's a story of people working together at all levels to find solutions to problems of a massive scale, and it's a story of progress and results. I believe we are truly turning the tide, and I'm confident that together we can – and will – create a future with healthy oceans.

Julie Packard
Executive Director
Monterey Bay Aquarium
December 2011

We envision a seascape where the rebuilding, conservation, and sustainable use of marine resources become the unifying themes for science, management, and society.

– Boris Worm *et al.*, 2009

The health of the oceans is directly connected to the way people catch and farm seafood.

For millennia, we have depended on the oceans for food, livelihoods and the very air we breathe. This dependence carries with it a responsibility to safeguard the living systems that support us. Numerous scientific studies show that despite the enormous size and scale of the Earth's oceans, they are increasingly affected by human activities. Most commercially important populations of ocean wildlife have been in decline for decades. Food webs are becoming less robust, and marine habitats are continuously being altered and degraded.

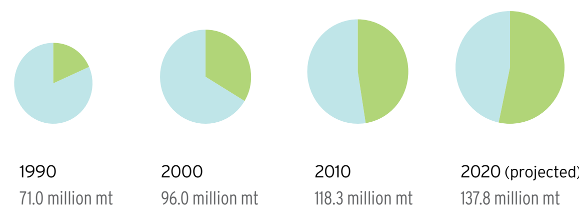
While many human activities strain the marine environment, the primary factor in the oceans' decline is our demand for seafood. The science is unequivocal and for the most part the news is not good. Through the combination of industrial-scale fishing and ineffective management, a significant number of major commercial fisheries are in need of rebuilding and many have collapsed. Other populations of ocean wildlife, from turtles to seabirds, are imperiled. As a result, total global landings of wild-caught fish have slowly declined over the past two decades. In parallel, aquaculture – the practice of farm-raising fish and shellfish – is growing rapidly and will soon eclipse wild fisheries as the main source of seafood for the world. Aquaculture poses its own set of challenges for the marine environment.

Yet there are new signs of hope – we appear to have reached a turning point. On many fronts, new data point to a brighter future thanks to the actions of informed consumers, businesses, fishermen, fish farmers and governments.

Through better science and monitoring, we understand more fully the effects that fisheries and aquaculture have on the marine environment. In several regions of the world, proactive fisheries management is preventing overfishing and allowing marine ecosystems to recover. Better fishing practices and effective regulations are rebuilding many fisheries, and stopping an underwater "tragedy of the commons."

The trend is being buoyed by growing public awareness of the need to act. From consumers, chefs, retailers and food service operators to fish farmers and fishermen, people are expressing a shared commitment to sustainable seafood – a commitment that has grown considerably over the last decade. Initiatives now underway are helping to turn the tide in favor of ocean conservation.

A milestone is approaching: Humans will soon eat more seafood from farms than from the oceans.



The increasing role of aquaculture in seafood supply (OECD/FAO 2011). Excludes fish not used for direct human consumption. See Figure 3 on page 18.

Consumers are more aware than ever of the environmental and sustainability issues associated with seafood. A recent survey revealed that Americans believe their seafood purchasing decisions impact ocean health, and they are willing to buy and pay more for seafood that is healthy and sustainable.

The media is raising these issues with the public on a regular basis. This is true in both mainstream and trade publications. As a proxy for this expanded coverage, a simple survey of the frequency of the phrase "sustainable seafood" in the print media shows a dramatic increase between 2002 and 2008.

Leaders within the conservation community have developed a common vision for a future with sustainable seafood – a vision that major seafood buyers are embracing. Mainstream companies have removed unsustainable seafood items from their shelves. Others are asking their suppliers where their seafood comes from and how it was fished or farmed. Most of the top grocery retailers and food service operators have recently developed sustainable seafood sourcing policies or guidelines that dictate from which fisheries and farms they will buy seafood.

At the same time, forward-thinking fishermen, fish farmers and seafood processors are advocating for public policies concerning fisheries and aquaculture that take the long-term view on conserving ocean resources. Innovative new technologies are emerging that can reduce the damage from destructive fishing gear or aquaculture practices.

And public health officials, as they encourage people to eat more seafood for its health benefits, are taking environmental considerations into account in recommending which seafoods are best to consume.

Turning the Tide: The State of Seafood offers an overview of the status of global seafood – wild-caught and farmed – and its connection with ocean health. The trends are clear. Marine ecosystems have been substantially impacted by human activities across the globe. Many populations of commercially valuable fish and other ocean wildlife are poorly managed. Yet there are a growing number of exceptions in cases where governments, businesses, the seafood industry and consumers have taken significant steps to guide us toward a better future. By documenting these trends, we offer a benchmark for progress on the road to a future with healthy oceans.

These pages summarize the major trends discussed in *Turning the Tide: The State of Seafood.*

Ocean Resources Are Declining

No area of the oceans remains unaffected by human activities.

According to a recent study, no area of the oceans remains unaffected by human activities, which range from commercial fishing to global climate change. More than 40 percent of the ocean is highly affected by human activities (see Figure 1 on page 11; Halpern *et al.*, 2008).

Most regions of the world lack effective fishery management.

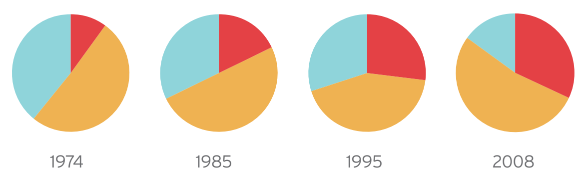
Worldwide, only seven percent of coastal governments employ rigorous scientific assessments as the basis for their fishery management policies. Only 1.4 percent of coastal governments use a transparent process to convert scientific recommendations into policy, and less than one percent provide for robust enforcement of fisheries regulations (Mora *et al.*, 2009).

Many marine species are now endangered or threatened.

The International Union for the Conservation of Nature (IUCN), the world's main authority on the conservation of species, lists many marine species as endangered. Interactions with fishing gear are the principal threat to at-risk marine vertebrates, including many species of sharks and rays, seabirds, marine mammals and sea turtles (Finklestein, 2008).

Overfishing remains a serious problem.

According to the Food and Agriculture Organization of the United Nations (FAO), the number of commercial fisheries that are overfished, depleted or recovering has steadily increased over the past several decades. A recent landmark review concluded that 63 percent of assessed stocks are in need of rebuilding (Worm *et al.*, 2009). While there are differences of opinion about the exact numbers, the trend is clear: the number of overfished stocks is on the rise. These fisheries cannot be expected to significantly increase their landings in the near future (FAO, 2011).



The State of the World's Commercial Fisheries. See Figure 5 on page 25.

- UNDERFISHED, MODERATELY FISHED
- FULLY FISHED
- OVERFISHED, DEPLETED, RECOVERING

Aquaculture management lags behind its explosive growth.

Aquaculture management varies widely by country, and there have been no global assessments of management effectiveness. Historically, where aquaculture development was profitable, governments found it difficult to control or stop runaway growth until a catastrophic mass mortality or other major problems occurred (FAO, 2006). Today there is consensus on the need for global standards and regulation to assure responsible aquaculture practices.

Despite the pervasiveness of overfishing, wild fisheries in some regions of the world are improving.

Using a combination of approaches, some regions around the world have largely prevented fishery collapses, providing a clear roadmap forward. Strong, science-based catch limits combined with better management and economic incentives can prevent overfishing and restore marine ecosystems. For example, overall landings in Alaska and New Zealand have increased substantially over the last 50 years and neither region is considered overfished (Worm *et al*., 2009).

People are increasingly carrying Seafood Watch consumer pocket guides and are willing to pay more for sustainable seafood.

Sustainable seafood pocket guides, produced by the Monterey Bay Aquarium's Seafood Watch program, help consumers make informed decisions about their seafood choices. Pocket guides provide information to evaluate the sustainability of fisheries worldwide. Since 1999, the Monterey Bay Aquarium has distributed nearly 40 million Seafood Watch pocket guides along with resource materials for chefs and businesses. Recent surveys have revealed that Americans believe their seafood purchasing decisions impact ocean health, and they are willing to buy and pay more for seafood that is healthy and sustainable (The Ocean Project, 2009; Edge Research, 2006).

Environmental groups are teaming up to help businesses find solutions.

A collaboration of more than a dozen leading U.S. and Canadian organizations, called the Conservation Alliance for Seafood Solutions (www.solutionsforseafood.org), has developed the Common Vision for Environmentally Sustainable Seafood to chart a realistic path that companies can take to develop a comprehensive corporate policy on sustainable seafood. Since its launch in 2008, more than 20 companies have signed on in support, including some of the largest retailers in the United States.

Fishery eco-certification is on the rise.

The Marine Stewardship Council (MSC) has developed standards for sustainably managed and traceable wild-caught seafood. The number of fisheries that meet MSC eco-label standards has steadily increased. Today, more than 130 fisheries are MSC-certified, representing more than five million metric tons of seafood with an estimated retail value of more than $1 billion. Additionally, 131 fisheries are engaged in the assessment process to become MSC-certified. (MSC personal communication, 2011). Aquaculture eco-certification also continues to develop and expand the range of species covered. Understanding how these developing schemes equate to the concept of 'ecological sustainability' and how they can lead to improving production practices at the farm level continues to be a priority.

Progressive companies are making responsible seafood purchasing the norm rather than the exception.

Sustainably caught and farmed seafood has moved from a niche market to a priority of mainstream retailers, restaurants and food service operators. Restaurants, retailers and wholesalers anticipate significant growth in the percentage of their seafood coming from sustainable sources within five years (Seafood Choices Alliance, 2007). Two of the largest food service companies in the U.S., Compass Group North America and ARAMARK, have made sustainable seafood commitments through agreements with the Monterey Bay Aquarium. Several leading supermarket retailers in the U.S. now have sustainable seafood sourcing policies in place; others will likely follow suit.

Sustainable seafood issues are increasingly making news.

There has been substantially greater media coverage of the issue in recent years. This is true in both mainstream and trade publications.

The State of the Oceans

Oceans cover nearly three quarters of Earth's surface and contain many of the planet's most majestic features. Earth's longest mountain range and deepest trenches all lie beneath the surface of the sea. The Mid-Atlantic Ridge, a vast underwater mountain range, is four times longer than the Andes, Rockies and Himalayas combined, and the Monterey Submarine Canyon is comparable in size to the Grand Canyon.

Within their vast expanse, oceans support tremendous biodiversity. Scientists to date have catalogued nearly a quarter-million species in the ocean (O'Dor, 2003), but they estimate that up to 10 million more have yet to be discovered (Sala & Knowlton, 2006). Oceans also play an essential role in regulating global climate. Tiny ocean plants, called phytoplankton, serve as the planet's lungs, absorbing vast amounts of carbon dioxide and converting it into oxygen and plant biomass. Photosynthesis in marine plants fixes about 50 million tons of carbon per year, roughly as much as is fixed by terrestrial plants, and produces half of the oxygen we breathe. Each year the ocean absorbs a quarter of the carbon we emit to the atmosphere (NRC, 2008; IPCC, 2007). Without these vital functions, life on Earth as we know it could not exist.

Despite their size and scale, the oceans are not immune to the effects of human activity. Around the planet, people are fundamentally reshaping the marine environment. According to a recent study, no area of the oceans remains unaffected by human activities, which range from commercial fishing to global climate change (see Figure 1; Halpern *et al*., 2008). Researchers have concluded that more than 40 percent of the oceans are highly affected by human activities. While the polar regions are currently among the least affected, retreating sea ice in the Arctic is already triggering international competition over ownership of new fishing grounds and oil and gas exploration (ACIA, 2004). Some countries are taking precautionary measures to prevent further impacts. For example, fishery managers in the U.S. recently prohibited all commercial fishing in the Arctic Ocean until we understand the potential impacts (Winter, 2009).

It is easy to miss these changes and impacts since they have developed over generations and across a vast expanse of ocean. Three centuries ago, the marine environment supported an incredible diversity of large, long-lived animals, including whales, sharks, turtles, tunas, manatees, rockfish and billfishes. Today, populations of all of these large animals have plummeted. The pace of change has continued – and in some cases accelerated – in recent decades. For example, Dr. Jeremy Jackson, a renowned marine ecologist with Scripps Institution of Oceanography, has documented the nearly complete disappearance of coral reefs in Jamaica. "Virtually nothing remains of the vibrant, diverse coral reef communities I helped describe in the 1970s," Jackson says. "Between overfishing, coastal development, and coral bleaching, the ecosystem has been degraded into mounds of dead corals covered by algae in murky water" (Olsen, 2002).

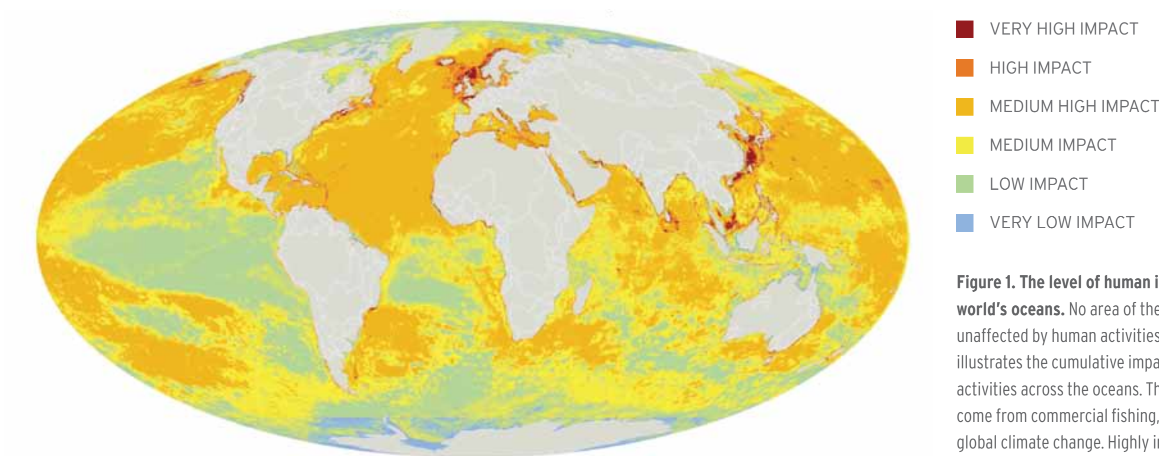


Figure 1. The level of human impact on the world's oceans. No area of the oceans remains unaffected by human activities. This map illustrates the cumulative impact of human activities across the oceans. The main impacts come from commercial fishing, pollution and global climate change. Highly impacted regions are illustrated in red and orange, covering more than 40 percent of the ocean surface; the least-impacted regions are in blue and green (Halpern *et al*., 2008).

Ambergris Caye, Belize, Central America. James Forte / National Geographic Stock

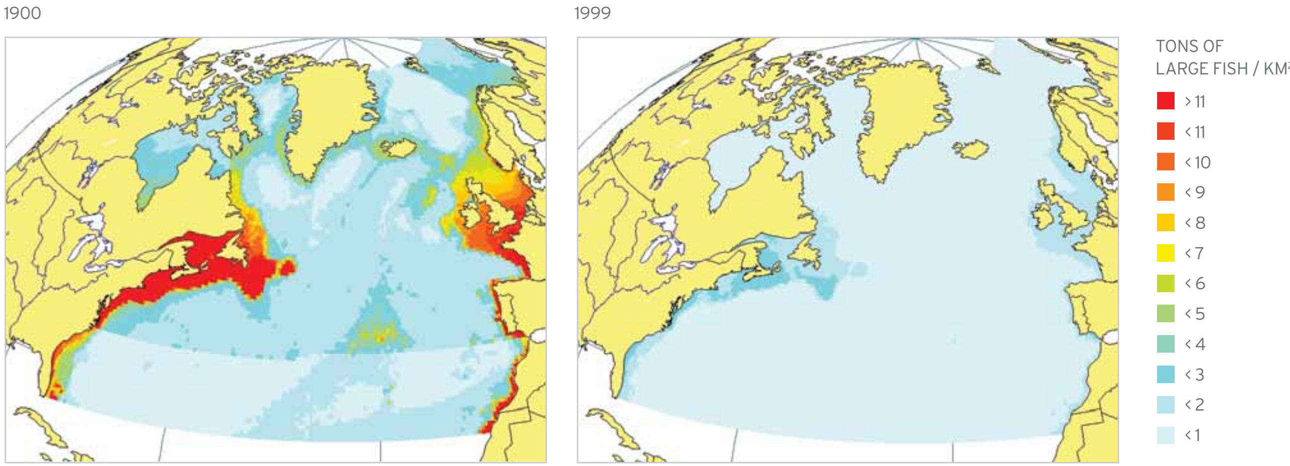


Figure 2. The number of large fishes in the North Atlantic has steadily declined since 1900. Major increases in fishing effort have led to dramatic decreases in the number of large, predatory fishes (*e.g.*, cod, halibut, haddock) in the North Atlantic between 1900 (left) and 1999 (right) (Christensen *et al.*, 2003).

Industrial-Scale Fishing

Many factors are at work, but a major culprit in the rapid deterioration of marine ecosystems is the widespread occurrence of overfishing, in large part due to the growth of industrial-scale fishing. (Industrial-scale fishing refers to fisheries that use large, mechanized fishing vessels equipped with advanced technology to find and catch fish.) The growth of industrial-scale fishing, which began in the late 1800s, has been accompanied by significant declines in the size and abundance of many fish species, along with other serious impacts on marine habitat and non-target species.

In the North Atlantic, the total amount of commercially important species, such as bluefin tuna, cod and halibut, declined by two-thirds between 1950 and 2000 (see Figure 2; Christensen *et al*., 2003). Of particular note is the Atlantic cod fishery, which helped to drive the European settlement of North America and was once an economic mainstay of New England and Canada's Maritime provinces. Its collapse in the early 1990s devastated coastal fishing communities; many have yet to recover (Frank *et al*., 2005). Similarly, since the 1960s the diversity and abundance of tunas and other top ocean predators have decreased globally by up to 50 percent and 90 percent, respectively (Myers & Worm, 2003; Worm *et al*., 2005). Experts warn that without concerted efforts to reduce overfishing and restore depleted fish stocks, more fisheries will decline and commercial landings of many species will drop, perhaps precipitously.

In addition to affecting the populations of fish we eat, fishing efforts have a dramatic effect on other ocean wildlife, such as sharks, whales, turtles and birds (Doak *et al.*, 2007; Gilman *et al.*, 2007). Of the 554 species of shark that have been assessed worldwide, 17 percent are listed as endangered, threatened or vulnerable to extinction, primarily due to fishing pressure (Polidoro *et al*., 2008). Most large whale populations are also endangered, due mainly to past commercial whaling, and six of the world's seven species of sea turtle are listed as vulnerable, endangered or critically endangered (Polidoro *et al.*, 2008). Populations of Pacific leatherback turtles have fallen by 95 percent since the 1980s (Spotila *et al*., 2000) and the greatest threat to the species now is bycatch in pelagic longline fisheries (Lewison *et al*., 2004). Unless bycatch is seriously curtailed, these largest of all sea turtles – survivors from the age of dinosaurs – could become extinct in our lifetimes.

Small-Scale Fishing

In contrast, the potential ecological impacts of small-scale fisheries remain relatively unstudied. Small-scale fisheries (defined as vessels under 15 meters long, mechanized or manual fishing gears, low relative catch per vessel, and dispersed, local ownership) account for more than half of total global fisheries production and employ over 99 percent of the world's fishermen (Berkes *et al*., 2001; Chuenpagdee *et al*., 2006). These fisheries often suffer from competition with large-scale fisheries and lack resources to monitor and manage exploited populations and ecosystems. Additionally, the cumulative impacts of small-scale fisheries can be significant. However, some characteristics of small-scale fisheries, such as the relatively basic technology, limited spatial extent and capability for effective local governance (Jacquet & Pauly, 2008), could make small-scale fisheries our best hope for the sustainable management of coastal marine resources – if they have appropriate ecosystem-based management measures in place (Pauly, 2006).

Compounding Stressors

While fishing puts tremendous pressure on the marine environment, it is important to recognize that a larger set of man-made activities is at play. The impacts of coastal development, pollution, climate change and invasive species are each compounding factors that affect the marine environment as well.

Coastal Development and Pollution

Our daily activities on land have a significant impact on the oceans. Nearly 40 percent of the world's population is concentrated in the 100 km-wide strip of coast along each continent (Millennium Ecosystem Assessment, 2005). Coastal development has slowly claimed large areas of wetlands and estuaries, reducing their ability to provide valuable ecosystem services, including their role as nursery habitats for young fish.

Human actions on land frequently result in pollution that affects ocean waters. While oil spills and other accidents receive the most attention, everyday runoff from cities and farms is the largest source of pollution. The U.S. National Academy of Sciences estimates that "the oil running off [U.S.] streets and driveways and ultimately flowing into the oceans is equal to an *Exxon Valdez* oil spill — 0.9 million gallons — every eight months" (NRC, 2002).

Other main types of pollution threatening the oceans stem from the use of agricultural fertilizer and the burning of fossil fuels. Both activities add nitrogen to the water, which can significantly alter the dynamics of the marine food web (Boesch *et al*., 2001). At its most extreme, nitrogen pollution creates expansive oxygen-depleted "dead zones" in the ocean. There are now over 400 identified dead zones worldwide (Diaz *et al.*, 2008), affecting 95,000 square miles of ocean, an area the size of New York, New Jersey, Connecticut, Massachusetts, Vermont, New Hampshire and Rhode Island combined. This figure has grown eightfold since the 1960s (Diaz *et al.*, 2008). While the recurring dead zone in the Gulf of Mexico is the most well known in the United States, the dead zone in the Baltic Sea is the world's largest. In the Baltic, deeper waters now lack oxygen year-round.

Global Climate Change

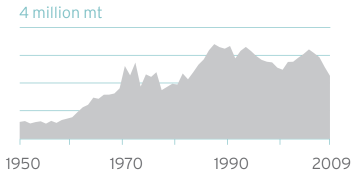
Human-induced climate change plays a critical and growing role in changing ocean ecosystem health. In the past century, the atmosphere has warmed two to three degrees Fahrenheit, altering sea-surface temperatures and raising the global sea level an average of 1.8 mm per year (IPCC, 2007). That pace is accelerating. The increased concentration of dissolved carbon dioxide in surface waters is also slowly acidifying the oceans, gradually making the water inhospitable for some animals. This phenomenon is likely to alter the oceans' natural cycles, potentially affecting their ability to provide the ecosystem services we depend upon. The full ramifications of climate change for ocean health are not well understood; however, there is growing concern that the impacts will be significant.

Invasive Species

Invasive species are a worldwide problem. Animals and plants introduced by human activity to habitats outside their natural range can displace native species, often with adverse effects on local ecosystems (Kappel, 2005). Once established, invasive species can be nearly impossible to eliminate. Over 80 percent of marine ecoregions worldwide have been affected by invasive species. There are two primary vectors globally for introduction of marine invasive species: international shipping and aquaculture (Molnar *et al.*, 2008). Marine organisms are carried in the ballast water of large ships and can attach themselves to the outer hulls of those ships, only to be released in distant ports. The FAO Database on Introductions of Aquatic Species indicates that aquaculture is the major reason for the introduction of non-native fish species to different countries.

ALL THE FISH IN THE SEA

After decades of overexploitation, nearly two-thirds of assessed fish stocks worldwide require rebuilding. With landings of wild-caught fish leveling off, aquaculture, primarily in Asia but also in Latin America, has rapidly expanded to meet the world's growing appetite for seafood (FAO, 2011).

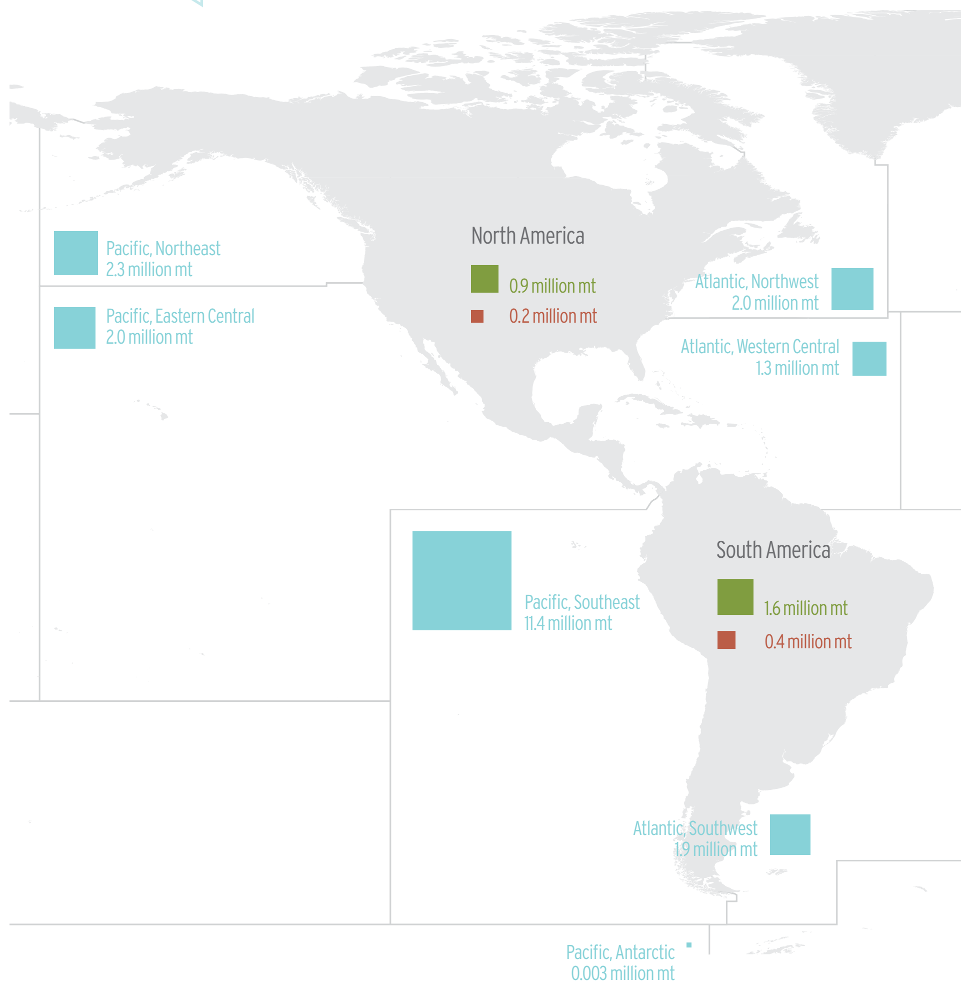


Pacific, Northeast, Annual Catch Volume
includes all species

King Salmon

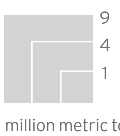
Alaska

Forward-thinking management can help maintain ocean productivity. Fisheries in Alaska are among the most well managed in the world. Thanks to proactive management and science-based catch limits, overall landings in the Northeast Pacific have increased over the last fifty years and the region's fisheries are not overfished (Worm *et al.*, 2009). The MSC-certified Bristol Bay salmon fishery is a great example of conservation-minded fishery management. See page 17 for more information on this success story.



SEAFOOD PRODUCTION BY REGION

(FAO, 2011b)

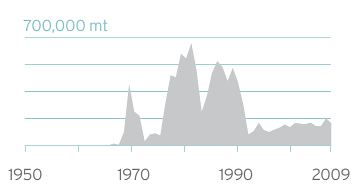


AQUACULTURE
BY CONTINENT, 2009

WILD CATCH
BY FAO OCEAN REGION, 2009

WILD CATCH INLAND
BY CONTINENT, 2009

Chilean Seabass



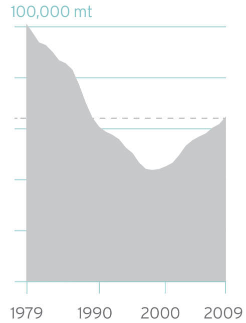
Antarctic, Annual Catch Volume
includes all species

The Southern Oceans

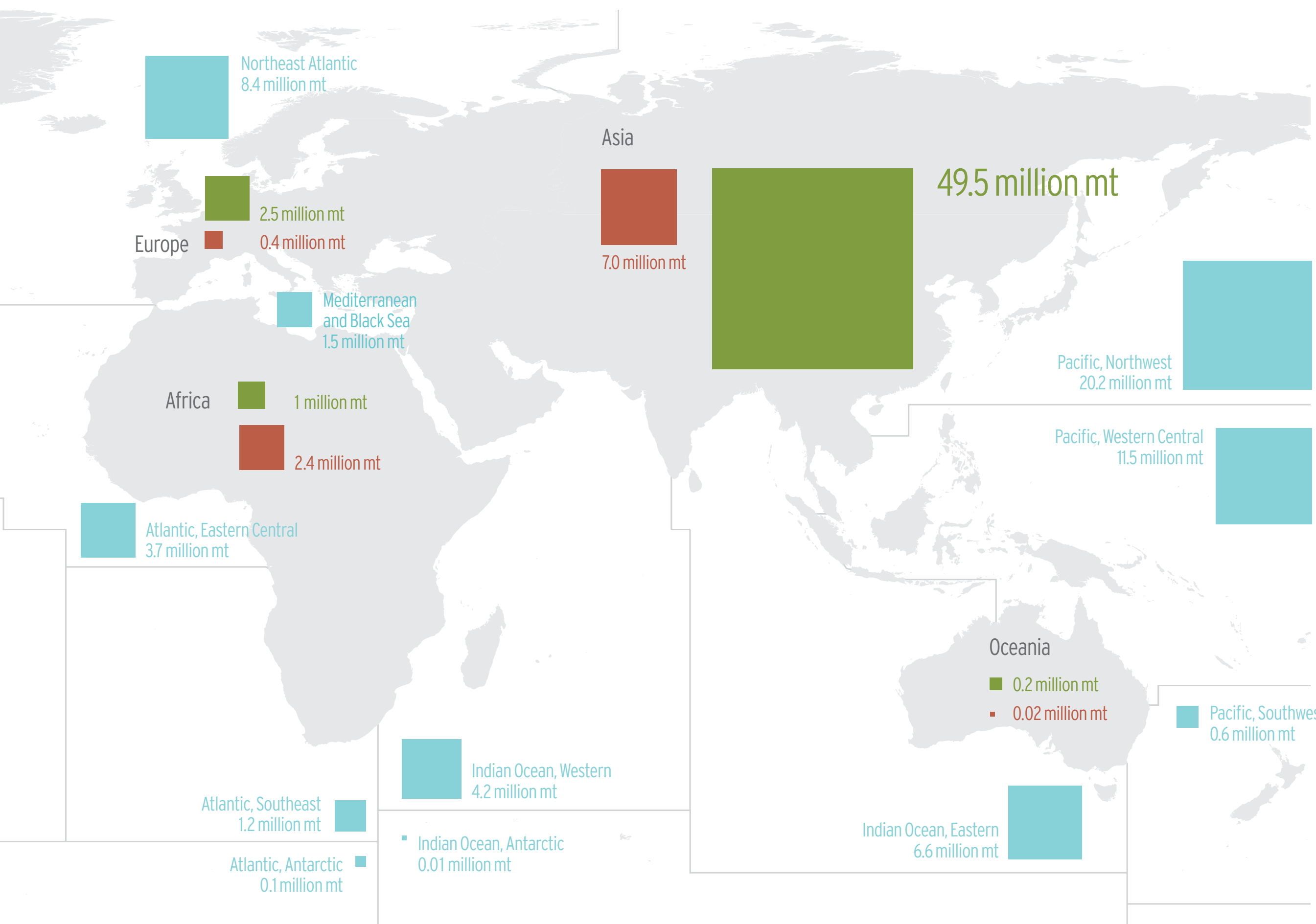
Earth's two poles are among the least visited places on the planet, and have historically been among the least fished. Apart from whaling fleets and a brief period of Soviet and Japanese interest in the 1970s and 80s, Antarctic waters had essentially remained unfished (FAO, 2011b). Today, fleets ply the ice-cold waters for species like the Patagonian toothfish, a once-obscure fish that became trendy in the 1990s after it was renamed Chilean seabass. Due to its popularity, severe illegal fishing increased, which rapidly depleted the stock. As the result of ongoing consumer campaigns, awareness of the problems with Chilean seabass has since increased, and now two small portions of the Chilean seabass fishery are MSC certified for sustainability and traceability. However, unless it is clearly labeled with the MSC logo, consumers should continue to avoid Chilean seabass until the issue of illegal fishing is adequately addressed.

The North Atlantic

Unlike the Pacific, overall fishery landings peaked in the North Atlantic in the mid-1970s. Many of the most valuable species, from swordfish and tuna to cod and halibut, were very hard hit. The Atlantic is now in the process of slowly rebuilding stocks, some fisheries more successfully than others (Worm *et al.*, 2009). For example, thanks in part to pressure from consumers and chefs, North Atlantic swordfish have recovered to healthy levels over the past few years (ICCAT, 2010). See page 43 for a success story about the role of consumers in swordfish conservation.

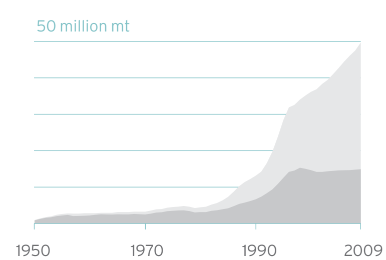


North Atlantic swordfish biomass is on the rise and the stock is at healthy levels (ICCAT, 2010). Dotted line is the biomass management target.



ASIA : THE BIGGEST PLAYER

Globally, the Asia-Pacific region captures, farms and consumes the most seafood. Asia's dominance is largely based on China's enormous contribution; it alone produces more than two-thirds of global farmed fish.



China, Total Seafood Production
(FAO, 2011b)

AQUACULTURE

WILD PRODUCTION

The State of the Seafood Enterprise

Picture a simple plate of fish.

It is hard to connect that fish to something as abstract as ocean health. Yet our demand for seafood ultimately drives industrial-scale fisheries and aquaculture. Given the direct connection between supply and demand, it is important that consumers understand the effects of their choices. Choosing seafood responsibly is one of the most important actions that individuals can take to have a profound and direct impact on the health of the oceans.

This section of *Turning the Tide: The State of Seafood* explores current trends in the types of seafood we eat, where it comes from, and the effects of our consumption on the oceans. While most seafood production has ecological consequences, some seafood is produced in an environmentally responsible fashion and a few fishing regions, like Alaska and New Zealand, have not been overfished (Worm *et al*., 2009). As governments improve their ability to manage fisheries and aquaculture, more consumers, chefs and companies are working to reduce their environmental footprint by incorporating sustainability concerns into their purchasing decisions. This trend is gaining momentum. After decades of depletion, we may be reaching a turning point in restoring abundance in our oceans.

Seafood Consumption is on the Rise

During the last century, conventional wisdom was that the oceans' far reaches supported a wealth of fisheries ripe for exploitation. Landings of wild fish rose steadily throughout the 20th century before hitting a plateau in the 1990s. Over this time period, the number of overfished stocks increased and the number of underfished and moderately fished fisheries decreased. Over the last decade, these trends have continued and the wild fisheries catch has fallen slightly from its peak (FAO, 2011). Not all the seafood we catch is eaten by people. About 30 percent of the fish caught each year is ground up into fishmeal and fish oil, commodities fed to farmed fish, poultry, pigs and livestock (Malherbe, 2005; Alder *et al*., 2008).

Over the last half-century, dramatic increases in farmed seafood have allowed global seafood consumption to increase despite the decline in wild-capture fish. In 1950, less than one million tons of fish were farmed per year; by 2009, production was more than 55 million tons, with a value of nearly $100 billion (FAO, 2011b). Despite stagnating wild

Continued on next page »

SUCCESS STORY

Bristol Bay, Alaska Salmon

Forward-thinking management can maintain fishery productivity

Pacific salmon in Alaska are among the most intensively managed species in the world, with excellent monitoring of fish populations and the fishery itself. Because salmon return to freshwater rivers to spawn, many populations in California and the Pacific Northwest have been severely depleted or eliminated due to habitat loss caused by human activities such as damming, deforestation and development. These collapses leave remaining stocks more vulnerable to fishing pressure.

The comparatively healthy river systems in Alaska combined with precautionary fishery management have resulted in salmon runs that are more resilient. Over the past 20 years, Alaska has landed roughly 10 times as much salmon as California, Oregon and Washington combined (NMFS, 2004).

The Bristol Bay region of Southwest Alaska is home to two of the most prolific sockeye salmon runs left in the world. In the last 20 years, key population indicators have been at record levels, making it one of the most lucrative salmon fisheries in Alaska. This is due largely to sound scientific management by state and federal agencies (Hilborn *et al*., 2003).

A hot debate right now is a proposal by mining companies to open a very large open-pit copper and cyanide gold-leach mine in the headwaters of Bristol Bay. If approved, the mine could result in degradation of the lakes, streams, and rivers that the sockeye salmon rely on through accidental discharge of process chemicals and byproducts.

King Salmon

A fisherman pulls in his catch in the Alaska sockeye fishery. ©Klas Stolpe / AP Photo fish landings, total world seafood supply (for direct human consumption) rose to about 117 million tons in 2009, the highest figure on record – over seven times what it was in 1950 (FAO, 2011). The FAO predicts that by 2030 the world will need an additional 37 million tons of farmed fish per year to maintain current levels of per capita consumption (FAO, 2007). While it is possible that landings of wild fish will increase as we rebuild overfished stocks, future increases in global seafood production will almost certainly come from aquaculture. Indeed, a milestone is approaching: Humans will soon eat more seafood from farms than from the oceans (Naylor *et al.*, 2009, OECD/FAO 2011).

In geographic terms, global seafood production is dominated by Asia. China is by far the world's largest producer of wild seafood, followed by Peru, Indonesia, the U.S., India, and Japan (FAO, 2011b). Asian countries collectively account for just over half of the global catch. This trend is even more dramatic for farmed fish: the Asia-Pacific region produces nearly 90 percent of all farmed fish, with China alone responsible for approximately two-thirds of the world's aquaculture.

Human Dimensions of Seafood

Fisheries and aquaculture play essential roles in the livelihoods of millions of people around the world. In 2008, 44.9 million people were directly engaged in commercial fishing or aquaculture. Eighty-six percent of fishermen and fish farmers worldwide live in Asia; China alone is home to 8.3 million fishermen and five million fish farmers (FAO, 2011). The global seafood industry generates over $190 billion annually (FAO, 2011), representing a quarter of a percent of the global economy. Fisheries and aquaculture are particularly significant in poverty-stricken regions, where they are vital to the subsistence food economy. As with other economic sectors, there are various social and labor issues surrounding the seafood industry. Because 84 percent of seafood consumed in the U.S. is imported, we need to be aware that seafood production may occur in areas with varying labor standards.

Nutritional Importance of Seafood

The nutritional profile of seafood makes it an important part of a healthy diet. Many types of seafood are high in long-chain omega-3 fatty acids, which

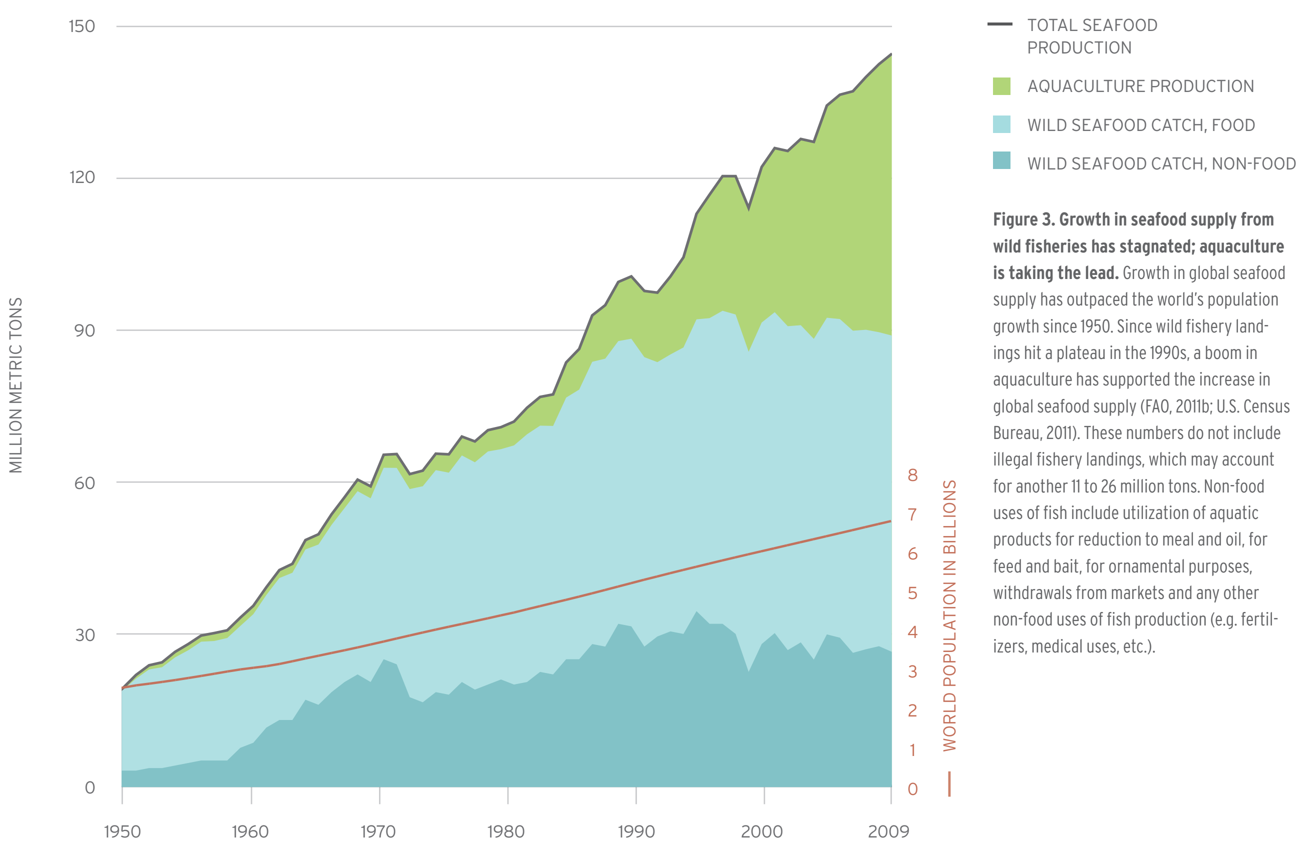


Figure 3. Growth in seafood supply from wild fisheries has stagnated; aquaculture is taking the lead. Growth in global seafood supply has outpaced the world's population growth since 1950. Since wild fishery landings hit a plateau in the 1990s, a boom in aquaculture has supported the increase in global seafood supply (FAO, 2011b; U.S. Census Bureau, 2011). These numbers do not include illegal fishery landings, which may account for another 11 to 26 million tons. Non-food uses of fish include utilization of aquatic products for reduction to meal and oil, for feed and bait, for ornamental purposes, withdrawals from markets and any other non-food uses of fish production (e.g. fertilizers, medical uses, etc.).

play a crucial role in brain development *in utero* and during infancy, and for heart health in adults. This makes seafood consumption important for all adults, and especially important for pregnant or nursing women, young children and women of childbearing age (Oken *et al*., 2005; Golding *et al*., 2009). Most Americans consume less than 50 milligrams per day of omega-3s, while the optimum benefit is thought to be attained by consuming 250 milligrams per day (Mozaffarian & Rimm, 2006; NHANES, 2009).

Contaminants in Seafood

Despite the documented health benefits, some seafood contains levels of toxins that can pose considerable health risks. Such contaminants include heavy metals (*e.g.*, mercury, which has been shown to affect brain function and development), industrial chemicals and byproducts (*e.g.*, PCBs and dioxins, probable human carcinogens) and pesticides (*e.g.*, DDT, probable human carcinogen). These contaminants usually originate on land and settle in the ocean, where they enter the food web and concentrate in larger fish species.

Seafood is the primary source of dietary mercury (CDC, 2005). Mercury levels in seafood vary by species, body size, age, and geographic region (Evers *et al*., 2007; Mahaffey *et al*., 2009). Mercury is toxic in the nervous system of humans at all life stages, but especially in fetuses, babies and young children. Elevated levels of mercury in the blood and body tissues have been linked to negative hormonal changes, reduced reproductive and motor skill function, decreased IQ, delayed learning and cognitive function, and higher incidence of premature births (Axelrad *et al*., 2007; Xue *et al.,* 2007; Driscoll *et al*., 2007; Evers *et al*., 2007; Oken *et al*., 2005).

No accepted methodology exists at this time for quantifying the risks and benefits of consuming seafood that has high contaminant levels. However, experts recommend minimizing consumption of the large predatory fish that are most likely to accumulate high levels of mercury and other contaminants. The U.S. Environmental Protection Agency (EPA) and Food and Drug Administration (FDA) specifically advise children and women of childbearing age to avoid shark, swordfish, king mackerel and tilefish and to limit consumption of albacore tuna to one serving per week. A list of seafood choices that are both good for the ocean and for human health can be found on page 21 of this report. Detailed information on contaminants in seafood can be found at www.edf.org/seafoodhealth.

Cannery workers can salmon in Bristol Bay, Alaska. Alaska Stock / National Geographic Stock

MORE THAN ONE-HALF

of total animal protein consumed in many small island developing states, as well as in Bangladesh, Cambodia, Equatorial Guinea, French Guiana, the Gambia, Ghana, Indonesia and Sierra Leone comes from fish (FAO, 2008).

3 BILLION

people depend on fish for at least 15 percent of their average animal protein intake (FAO, 2011).

25 TIMES

more fishermen fish at a small scale than at a large, industrial scale. Yet both sectors catch roughly the same amount of edible fish (Chuenpagdee, 2006).

What the World Eats

In the 1960s, the average person ate about 22 pounds of seafood each year; in 2009, the global average had risen to 38 pounds per year.[1] Over the next decade, demand for seafood is expected to grow by as much as 10 percent annually, or an additional 11 million tons per year (FAO, 2008), although the sluggish global economy has slowed the rate of increase in the last few years (FAO, 2011). Though increases in per capita consumption have not been uniform around the world, seafood is becoming more popular in both developed and developing countries. In the developed world, there is already sizable demand for seafood produced to high standards of safety, freshness, convenience and sustainability. In developing countries, especially in East and Southeast Asia, the popularity of seafood among a rapidly expanding middle class is helping to drive demand (FAO, 2008).

Globally, the most popular types of seafood include: fish farmed in freshwater ponds (*e.g.*, carp, tilapia, milkfish), farmed and wild shellfish (*e.g.*, oysters, mussels, clams), tuna, whitefish (*e.g.*, pollock, hake), salmon, and shrimp (FAO, 2011b).

[1] This volume reflects the weight of the whole fish (including the parts that are inedible, like bones).

The daily catch comes ashore near Santa Rosa, Peru. William Albert Allard / National Geographic Stock

A sustainable sushi meal. Randy Wilder / Monterey Bay Aquarium

THE SUPER GREEN LIST: CONNECTING HUMAN AND OCEAN HEALTH

Combining the work of conservation and public health organizations, the Monterey Bay Aquarium has identified seafood that is "Super Green," meaning that it is good for human health and does not harm the ocean. The Super Green list highlights products that are currently on the Seafood Watch "Best Choices" (Green) list, low in environmental contaminants and good sources of long-chain omega-3 fatty acids.

This effort draws from experts in human health, notably scientists from the Harvard School of Public Health (HSPH) and Environmental Defense Fund (EDF). The Monterey Bay Aquarium will continue to work with these organizations to balance the health and environmental attributes of seafood.

The Super Green list (current as of September 2010), includes seafood that meets the following science-based criteria:

- Contaminant levels below 216 ppb mercury and 11 ppb PCBs, as identified by EDF based on EPA National Guidance.[1,2]
- Omega-3 levels that provide at least 250 mg/d EPA+DHA (assuming 8 ounces of fish per week), identified by scientists from HSPH as providing the greatest cardiac benefit (Mozaffarian & Rimm, 2006).[3]
- Classified as a "Best Choice" (Green), according to Seafood Watch's environmental standards.

[1] The "Super Green" list is based on dietary requirements for an average woman of childbearing age (18-45, 154 pounds) eating 8 ounces of fish per week. The list also applies to men and children; children should eat age-appropriate portions to maximize their health benefits while minimizing risk.

[2] Contaminant data are from EDF, drawn from more than 250 government databases and peer-reviewed scientific studies on seafood contaminants.

[3] Omega-3 data are primarily from the USDA Nutrient Database.

[4] List updated September 2010.

[5] Many other items on the Seafood Watch "Best Choices" (Green) list provide health benefits, as consuming any amount of the omega-3s is associated with heart healthy benefits (Mozaffarian & Rimm, 2006). Other healthy "Best Choices" are low in contaminants and provide at least 100 mg/d EPA+DHA (assuming 8 ounces of fish per week), about twice the current median U.S. intake (NHANES 2005-06; D. Mozaffarian personal communication, September 2, 2009).

The Best of the Best [4]

Albacore Tuna (troll- or pole-caught, from the U.S. or British Columbia)
Freshwater Coho Salmon (farmed in tank systems, from the U.S.)
Oysters (farmed)
Pacific Sardines (wild-caught)
Rainbow Trout (farmed)
Salmon (wild-caught, from Alaska)

Other Healthy [5] "Best Choices"

Arctic Char (farmed)
Barramundi (farmed, from the U.S.)
Dungeness Crab (wild-caught, from California, Oregon or Washington)
Longfin Squid (wild-caught, from the U.S. Atlantic)
Mussels (farmed)

An Alaskan pollock fish taco. Jim Gillmore, At-Sea Processors Association / Marine Photobank

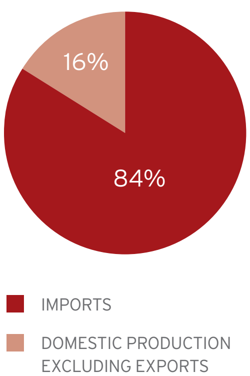


Figure 4. The U.S. Seafood Supply: Imports vs. Exports (USDA, 2011). 84 percent of the seafood consumed in the U.S. is imported. Imports include seafood that is landed in the U.S., sent overseas for processing, then shipped back to the U.S. market. The majority of U.S. seafood imports come from China (22 percent), Thailand (15 percent), Canada (13 percent), Indonesia (6 percent) and Chile (5 percent) (NMFS, 2009).

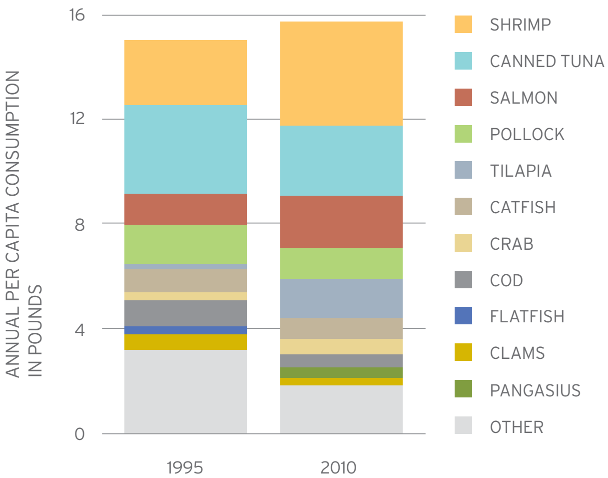
What the U.S. Eats

Per capita seafood consumption in the United States is on par with the global average. In 2007, the average American ate 40 pounds of fish and shellfish (NOAA, 2010).[1] By total volume, the U.S. is the third largest seafood consumer in the world, trailing Japan and far behind China. The U.S. depends on imports to supply its seafood. Over three quarters of the seafood in the U.S. marketplace is imported (see Figure 4; USDA, 2011). By comparison, the U.S. imports 58 percent of its oil and petroleum products (EIA, 2009). At least half of U.S. seafood imports are farmed (NOAA, 2008). In contrast, the U.S. aquaculture industry meets only one quarter of total domestic seafood demand, and most of that is catfish (FAO, 2009).

Despite the diversity of seafood products available, most Americans eat from a relatively short menu. The most popular item in the U.S. is shrimp, followed by tuna (canned), salmon, pollock and tilapia (NFI, 2011). While U.S. seafood consumption patterns have remained consistent for some items, there have been notable changes in just the past decade (see next page).

[1] This volume reflects the weight of the whole fish (including the parts that are inedible, like bones). 40 pounds of whole fish equals roughly 16 pounds of edible fish.

SEAFOOD CONSUMPTION IN THE U.S. FROM 1995 TO 2010



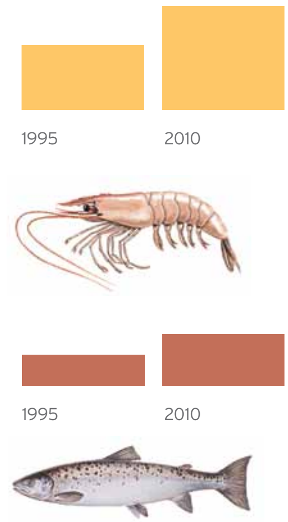
Seafood consumption patterns in the U.S. from 1995 to 2010. Top ten consumed seafoods are shown for each year. Consumption of shrimp, salmon and tilapia* has grown substantially, while consumption of canned tuna and cod has declined (Johnson, 2000; NFI, 2011).

* Per capita consumption of tilapia in 1995 is an estimate based on the relative magnitude of U.S. tilapia imports in 1995 and 2006 (FAO, 2009).

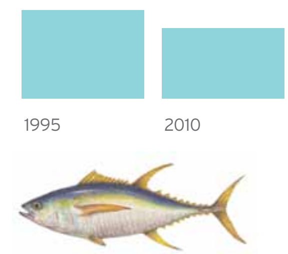
TOP TEN SEAFOOD CHOICES IN THE U.S.

#1 Shrimp	4.0 lbs
#2 Canned Tuna	2.7 lbs
#3 Salmon	2.0 lbs
#4 Tilapia	1.5 lbs
#5 Pollock	1.2 lbs
#6 Catfish	0.8 lbs
#7 Crab	0.6 lbs
#8 Cod	0.5 lbs
#9 Pangasius*	0.4 lbs
#10 Clams	0.3 lbs

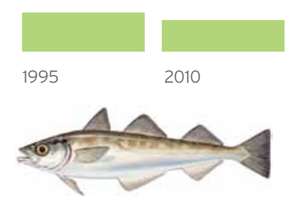
Annual per capita seafood consumption in the U.S. (NFI, 2011) *Also known as Basa, Swai.



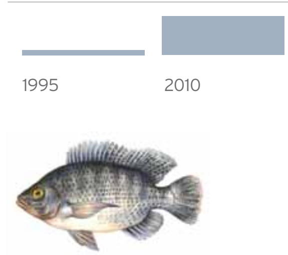
Shrimp and Salmon
A dramatic increase in consumption of shrimp and salmon has occurred, made possible by the widespread expansion of aquaculture production of these species, much of which is on the Seafood Watch red list.



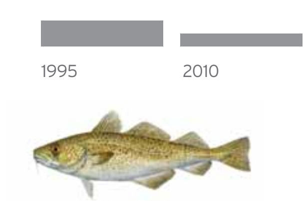
Canned Tuna
Consumption of canned tuna has decreased, due in part to consumer concerns about mercury and a decline in overall canned fish consumption.



Pollock
Consumption of pollock has continued, as it is the "secret ingredient" in breaded fish sticks, food service fish fillets and imitation crab.



Tilapia
Farmed tilapia has emerged rapidly as a top five seafood item. In the wake of the cod collapse, farmed tilapia has met the demand for mild whitefish.



Cod
Cod has experienced a dramatic fall in consumption following the collapse of major Atlantic cod fisheries.

The Impact of Fishing and Aquaculture

Growth in the demand for seafood continues to put intense pressure on marine ecosystems. This section of the report outlines trends for the four main impacts the seafood industry places on the ocean: overfishing; bycatch of other plants and animals; habitat damage from fishing gear; and the environmental effects of aquaculture. At the end of the section, we explore a fifth issue: the emergence of climate change and its implications for seafood supplies.

For each impact, *Turning the Tide: The State of Seafood* includes examples of recent innovations that represent positive trends for the future.

Overfishing

Overfishing involves catching fish faster than they can reproduce on a long-term basis. Over the last 50 years, the extent of overfishing has increased substantially (see Figure 5). Global assessments of overfishing range from 25 percent to 72 percent of fish stocks depending on the definition used, but all assessments illustrate a common trend – overfishing has increased over time (Pauly *et al.*, 2008; FAO, 2011). A recent landmark review by independent marine ecologists and fisheries scientists concluded that 63 percent of assessed fish stocks require rebuilding, and even lower levels of exploitation are necessary to reverse the collapse of vulnerable species (Worm *et al.*, 2009). While there are differences of opinion over the exact numbers, the message is the same across the assessments: overfishing remains a serious problem.

The impacts of overfishing can be dramatic, and in some cases potentially irreversible. The collapse of fisheries for Atlantic cod, beluga sturgeon and Atlantic bluefin tuna have all been striking events with dramatic economic and ecological consequences (Pauly *et al.*, 2002; FAO, 2011b).

The impacts of overfishing can also be subtle. By changing the population of one species, fisheries inadvertently alter the shape and composition of entire marine communities through a cascading effect on their predators and prey (Frank *et al.*, 2005; Heithous *et al.*, 2008). Similarly, one of the common features of overfishing is that it can lead to serial depletion. When a commercially desirable species is depleted, the industry often shifts its effort to the next most valuable species. This pattern of exploitation has resulted in a global phenomenon of "fishing down the food web" (Pauly, 1998). Scientists have documented a gradual transition in fisheries landings over the last 30 years from high-level predators, such as tuna and cod, to other species lower in the food web, such as crab, sardines and squid.

The increase in overfishing over the last half century has been driven by an unprecedented expansion in fishing effort, limited understanding of the life history of target species, and insufficient management in the face of these two factors. Governments have struggled to address the "tragedy of the commons" associated with fisheries managed in ways where individual fishermen compete against each other to catch a common resource and lack sufficient incentives for long-term conservation (Hardin, 1968). Between 1950 and 1994, fishermen doubled the number of boats, devised improved fishing gear, and invested in better fish-finding technology, often with the support of government subsidies (FAO, 2011). This growth in fishing capacity led to a steady increase in fishing effort in most regions of the ocean. Today, the global fishing fleet is twice the size needed to remove all the fish that the oceans can sustainably support (Sumaila *et al.*, 2007).

Illegal fishing is a compounding factor in the overfishing equation. It is estimated that illegal and

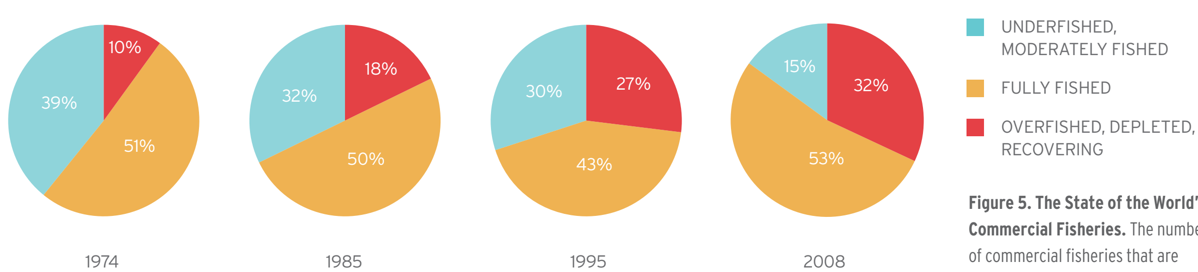


Figure 5. The State of the World's Commercial Fisheries. The number of commercial fisheries that are overfished, depleted or recovering is increasing (FAO, 2011).

Mangroves, rivers and shrimp pools in Sungai Petani, Malaysia. Tim Laman/National Geographic Stock unreported fishing currently accounts for an additional 11 to 26 million tons of landings worldwide, or around one-fifth of total global fisheries production (Agnew *et al*., 2009).

Despite the pervasiveness of overfishing, there is cause for hope. Strong, science-based catch limits combined with better management and economic incentives can prevent overfishing and restore marine ecosystems (Worm *et al*., 2009). Using these approaches, some regions around the world have largely prevented fishery collapses altogether. For example, overall landings in Alaska and New Zealand have increased substantially over the last 50 years and neither region is considered overfished (see page 17; Worm *et al*., 2009).

We have observed several examples of successful fishery management that many governments can learn from, and can point to several examples as evidence that the tools work. The challenge will be to muster the will to implement those management tools on a widespread basis. As a recent seminal paper in *Science* noted, "Management actions have achieved measurable reductions in exploitation rates in some regions, but a significant fraction of stocks will remain collapsed unless there are further reductions in exploitation rates. Unfortunately, effective controls on exploitation rates are still lacking in vast areas of the oceans, including those beyond national jurisdiction" (Worm *et al*., 2009).

Additionally, some scientists believe that, in order to truly protect marine resources, catch limits need to be lower than those typically set by fishery managers. Currently, most fishery managers set limits based on the maximum sustainable yield (MSY) of a particular species. A new, more holistic approach recognizes the importance of the entire ecosystem instead of just single species, and bases catch limits on "ecosystem sustainable yield" (ESY). This new framework reduces population collapses, allows fish populations to rebuild, increases overall food supplies for other marine wildlife, reduces fishing costs, and increases profit margins for fishermen over the long term (Grafton *et al*., 2007; Worm *et al*., 2009).

Looking to the future, a key issue will be the movement of fishing fleets from developed countries to the developing world, where effective fishery management controls are oftentimes not in place (Agnew *et al*., 2009; Worm *et al*., 2009). To address this problem, a new treaty has been approved by more than 90 nations (though it still needs ratification by each individual country). The "Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing" will be the first global treaty focused specifically on the problem of illegal fishing. While the treaty does not fix weak fishery management, it is hoped that the agreement will help block illegal fish from entering international markets (AP, 2009).

Bycatch

In addition to catching what they want, fishermen often catch species they don't want. Bycatch is the unintended capture of marine life in fishing gear. Many animals caught as bycatch — including fish, birds and marine mammals — are discarded overboard by fishermen because they are illegal or not worth enough money to land. Often, these animals are injured or killed in the process. Unfortunately, the phenomenon of bycatch threatens more marine life with extinction than invasive species, habitat destruction, fishing, pollution, climate change, noise pollution and collisions do. Sea turtles, sharks, marine mammals and seabirds are at greatest risk (see Figure 6; Doak *et al*., 2007). These animals are particularly vulnerable because they tend to be long-lived, slow to mature and produce fewer offspring than other marine life.

Bycatch is also a concern because of the sheer amount of catch that is discarded. Since animals snared as bycatch are typically thrown overboard, the overall extent of the phenomenon and its impact on ocean wildlife is difficult to estimate.

Brian J. Skerry/National Geographic Stock

SUCCESS STORY

Morro Bay Trawler Buy-Out

In Morro Bay, California, The Nature Conservancy and Environmental Defense Fund partnered with commercial fishermen in 2006 to address new regulations mandating protections of essential fish habitat. The innovative deal involved fishermen's support for closing nearly four million acres of seafloor habitat to bottom trawling in return for a buy-out of their fishing permits. With some of these permits, fishermen are now fishing with lower-impact gear under the aegis of a community-based fishing association — creating the possibility for a more sustainable fishery coast-wide.

In 2004, one FAO analysis estimated that global fishery discards amounted to 7.3 million metric tons, or roughly eight percent of landings (Kelleher, 2005). Other studies suggest discards are considerably higher (Alverson *et al*. 1994; Enever *et al.* 2007). Indeed, a conservative estimate of catch that is either unused or unmanaged is 38.5 million metric tons, or some 40 percent of landings (Davies *et al.* 2009).

Bycatch occurs with all fishing gear, but is often associated with less selective types such as longlines and bottom trawls (see "How We Fish" on pages 30–31; Kelleher, 2005). Longlines set in the upper layers of the water are used to catch large, open-ocean fish such as tuna; the lines can stretch for miles and have up to 3,000 baited hooks (Melvin *et al*., 2001). In addition to tunas, the bait on these hooks attracts a variety of animals, including other fish and sea turtles. Trawls are large nets that are pulled through the water and designed to capture everything in their path. Trawl fisheries for tropical shrimp and temperate-water bottom

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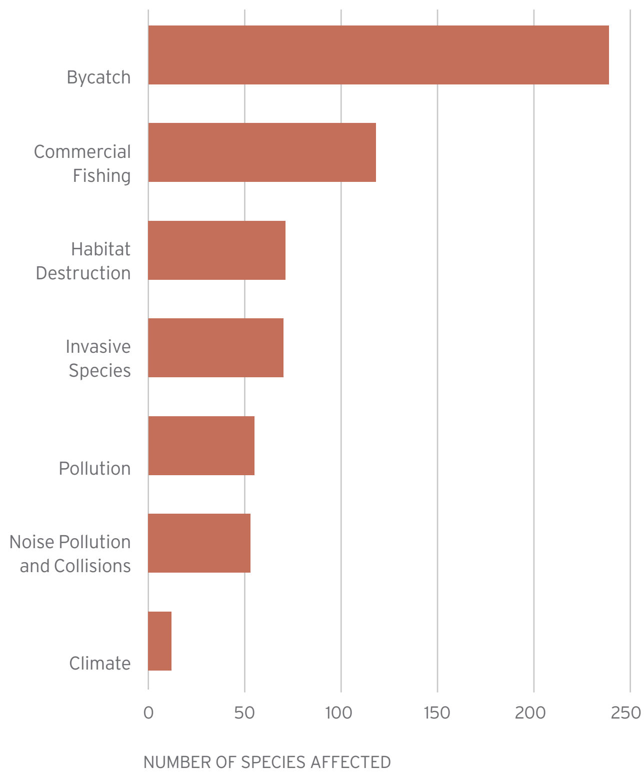


Figure 6. The relative threat of bycatch to marine species. Total number of species of cetaceans (whales and dolphins), sharks, sea turtles and seabirds in the IUCN red list database affected by invasive species, habitat destruction, commercial fishing, bycatch, pollution, climate change, noise pollution and collisions (Finklestein *et al.*, 2008).

SUCCESS STORY

Streamer Lines and Catch Shares in the Pacific Halibut Fishery
Cost-Effective Methods for Reducing Bycatch

Seabirds often flock around longline vessels, and can become snared and drown as they try to feed on baited hooks thrown into the ocean. "Streamer lines" have proven to be a cost-effective solution that has dramatically reduced seabird deaths in several longline fisheries. Brightly colored streamer lines made of polyester rope are positioned on each side of the longline. The colors and the flapping of the lines scare seabirds away from the baited hooks (Chuenpagdee *et al*., 2003). From 1993 to 2001, roughly 16,000 seabirds died each year in Alaskan groundfish longline fisheries (NMFS, 2006). In 2002, streamer lines became required gear; since then, the number of seabird deaths has decreased by approximately 70 percent (NMFS, 2006). Additionally, the Pacific halibut fishery adopted a "catch share" management system where shares of the total fishery are delegated to individual fishermen or communities. The halibut catch share system resulted in fewer hooks in the water, less bycatch and fresher product, which often means higher revenue for fishermen.

Pacific Halibut

SUCCESS STORY

Minimal Bycatch
American Albacore Fishing Association

The American Albacore Fishing Association (AAFA) represents commercial pole-and-line and troll vessels off the California coast. Unlike longlines, there is very little bycatch when albacore tuna is caught with troll or pole-and-line gear. AAFA obtained the Marine Stewardship Council certification to distinguish the sustainability of its product.

Albacore Tuna

fish, such as flounder, cod, haddock and halibut, are estimated to account for over 50 percent of total bycatch. In many bottom trawl fisheries, the amount of bycatch greatly exceeds the catch of targeted species. Globally, shrimp trawl fisheries discard on average 1.6 pounds of bycatch for every pound of shrimp that is landed; in some regions, the ratio can be over six to one (Kelleher, 2005). Shrimp trawl fisheries represent just two percent of the global fish catch but are responsible for more than one-third of the world's bycatch. In contrast, other gear types such as purse seines, handlines, jigs, traps and pots, generally have relatively low discard rates.

Spurred by innovation and regulation, the fishing industry has developed new methods to reduce unwanted bycatch. Among the most successful have been gear innovations, such as streamer lines, along with modifications in where and when the industry can fish (*e.g.*, the establishment of Rockfish Conservation Areas on the U.S. West Coast). These efforts can decrease bycatch by increasing the precision of fishing gear in catching targeted fish species.

Bycatch Takes a Toll on Endangered Species

According to a 2003 study, 133 marine populations and species have become extinct locally, regionally or globally. Fishery interactions caused the most marine losses (55 percent), followed closely by habitat loss (37 percent), while the remainder were linked to invasive species, climate change, pollution and disease (Dulvy, 2003).

Cetaceans (Whales, Dolphins and Porpoises)

Though industrial whaling is mostly a thing of the past, the effects of whaling are still evident among the endangered and vulnerable whale populations around the world. Today, accidental entanglement in fishing gear is the primary threat to cetaceans. Marine mammals are also vulnerable to being struck by ships and to ecosystem changes that affect their food supply.

Sharks

Sharks are regularly caught as bycatch in pelagic longline and many gillnet fisheries. Because they are long-lived predators that produce few off-spring, shark populations are extremely vulner-able both to bycatch and direct fishing pressure. Twenty-two species of sharks are on the IUCN's Red List of Threatened Species. In 2002, the basking shark and the whale shark were each listed under Appendix II of The Convention on International Trade in Endangered Species (CITES) – a listing that requires trade permits and monitoring of these animals to avoid their endangerment through international trade.

Sea Turtles

The primary threat to sea turtles is fishing gear (Doak *et al*., 2007). Turtles can be caught in shrimp trawls, hooked on longlines or entangled in gillnets. Like sharks, sea turtles are especially vulnerable because they can take decades to reach breeding age. Increased fishing pressure means that fewer turtles survive long enough to reproduce. Six of the world's seven species of sea turtles are listed as vulnerable, endangered or critically endangered.

Seabirds

Seabirds such as albatrosses and petrels spend most of their lives at sea and generally live longer, breed later and have fewer young than terres-trial birds. Often, seabirds undertake long annual migrations. Many seabird populations are seriously threatened by fishing activities: an estimated 61 species are affected by longline fisheries, and of those, 26 are threatened with extinction (Gilman *et al*., 2007). Of albatross species, 18 of 22 species are classified as threatened (Birdlife, 2008).

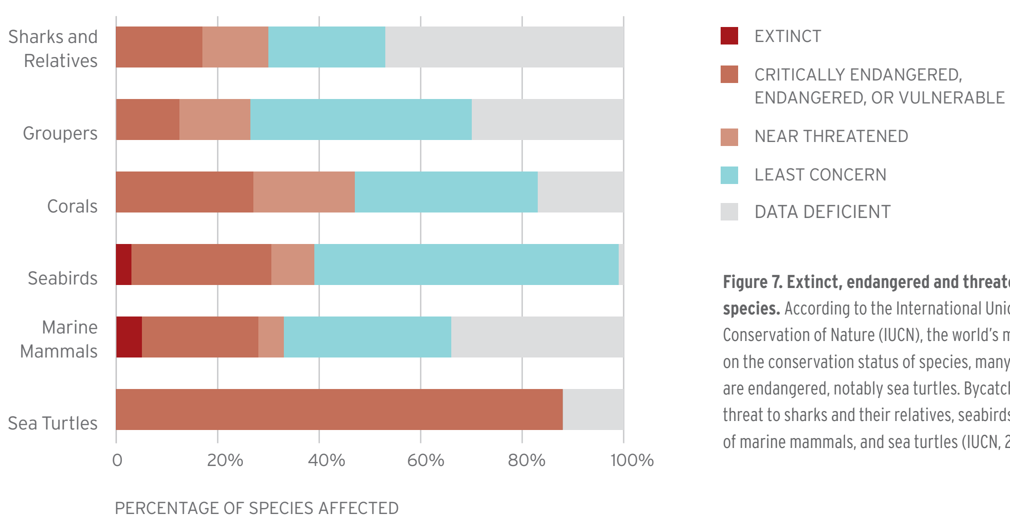


Figure 7. Extinct, endangered and threatened marine species. According to the International Union for the Conservation of Nature (IUCN), the world's main authority on the conservation status of species, many marine species are endangered, notably sea turtles. Bycatch is the principal threat to sharks and their relatives, seabirds, several species of marine mammals, and sea turtles (IUCN, 2008).

Habitat Damage

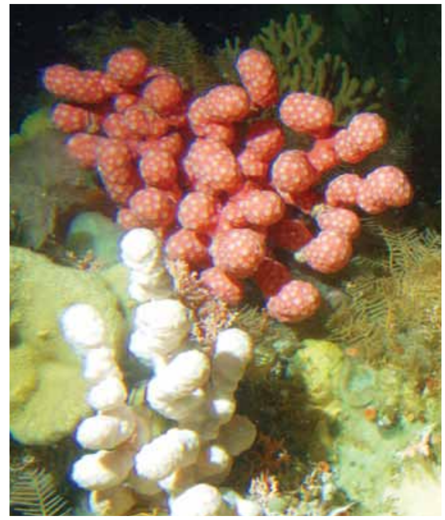
In addition to removing marine life, some fishing gear significantly affects the underwater environment. Just as clear-cutting of forests or slash-and-burn agriculture can transform terrestrial ecosystems, repeatedly dragging heavy fishing gear along the seafloor has the potential to dramatically alter the structure and functioning of the marine environment (Watling & Norse, 1998). Bottom trawling and dredging both involve large, heavy nets pulled along or just above the seafloor. In addition to catching commercially valuable animals, these gear types can destroy bottom habitats, often crushing or tearing up plant, animal, coral and sponge communities (NRC, 2002a; Roberts & Hirshfield, 2004).

Deep, cold-water coral communities are among the habitats most vulnerable to damage from fishing gear, since some corals can take centuries to grow (Shester & Warrenchuk, 2007). For example, the waters surrounding the Aleutian Islands in Alaska and the deep-water coral reefs off the coast of Florida host rich gardens of slow-growing, cold-water corals. Bottom trawling has significantly damaged both of these areas (Roberts & Hirshfield, 2004). A study by the United States National Research Council (NRC) on the impact of bottom trawling and dredging concluded that repeated trawling not only reduces the overall amount of life in the area by removing bottom-dwelling plants and animals – it can change the basic composition of the seafloor community (NRC, 2002a). These bottom ecosystems provide shelter, food and breeding grounds for many marine species.

No detailed estimates exist of the full geographic extent, intensity and effects of bottom trawling operations. One rough estimate puts the area affected by trawling at 14.8 million km^2 – an area one-and-a-half times the size of the United States (Watling & Norse, 1998). Although bottom trawling continues to be a serious concern, there are examples of fisheries that are making smart management decisions and closing ecologically sensitive areas to destructive fishing.

Continued on page 34 ››

A turtle caught in the net of a shrimp trawl. Norbert Wu / Minden / National Geographic Stock



Courtesy of NOAA Research

SUCCESS STORY

Aleutian Islands Habitat Protection

Deep-water corals and sponges are among the ocean's most long-lived creatures, and they form ecologically vulnerable and important habitats. Yet they are being destroyed in large numbers by bottom-trawling fisheries worldwide. An estimated one million pounds of deep-water corals and sponges were hauled aboard Alaskan trawling vessels annually as bycatch between 1997 and 1999 (NMFS, 2003). Alaska's Aleutian Islands in particular are thought to contain the most diverse deep-water coral assemblages in the world. In a landmark 2005 decision, the North Pacific Fishery Management Council (NPFMC) voted to permanently protect 370,000 square miles from bottom trawling in order to preserve deep-sea coral and sponge habitat. The decision implemented a new, cutting-edge approach to habitat protection: freezing the footprint of the existing trawl fishery to prevent expansion to new areas, while closing known coral locations within the footprint (Shester & Warrenchuk, 2007). The plan maintains the economic viability of the industry while protecting the region's coral beds, sponge gardens and underwater peaks (known as seamounts) from further damage. According to Dave Fraser, a trawl fisherman who fishes in Aleutian Islands, the program "is a whole new paradigm...It's not unusual for Alaska to set the gold standard for the rest of the regions around the country" (Welsh, 2005).

HOW WE FISH

Fishermen use a wide range of gear to land their catch. Every gear type has its own effects on the ocean. By selecting the right gear for the right job, the fishing industry can help to minimize its impact on the environment.

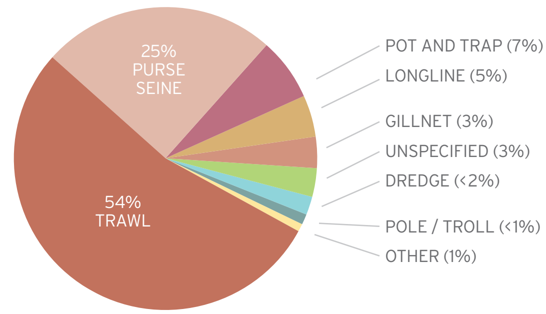
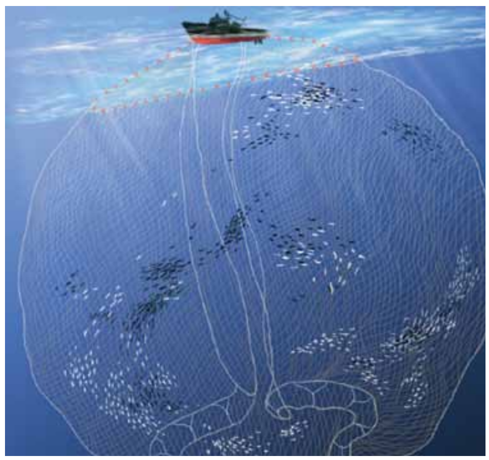
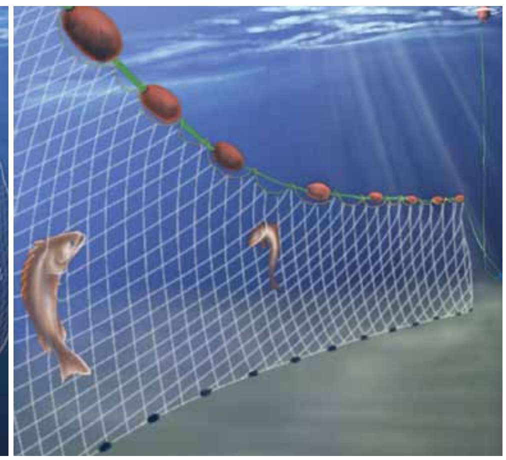


Figure 8. Types of fishing gear used in U.S. Fisheries. Most seafood in the U.S. is caught using nets dragged behind boats, such as purse seines, trawls and dredges (NMFS, 2009).



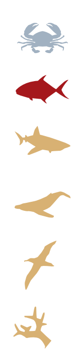


Pole/Troll
fishermen use a fishing pole and bait to target a variety of fish, ranging from open ocean swimmers, like tuna and mahi mahi, to bottom dwellers, like cod. Pole/troll fishing is an environmentally responsible fishing method and a good alternative to pelagic longlining. Unlike pelagic longlines, which catch sharks, marine mammals, sea turtles and seabirds as bycatch, pole/troll fishermen have very low bycatch rates.

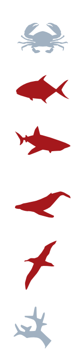
Purse Seining
establishes a large wall of netting to encircle schools of fish. Fishermen pull the bottom of the netting closed – like a drawstring purse – to herd fish into the center. This method is used to catch schooling fish, such as sardines, or species that gather to spawn, such as squid. There are several types of purse seines and, depending on which is used, some can catch other animals (such as when tuna seines are intentionally set on schools of dolphins).

Gillnetting
uses curtains of netting that are suspended by a system of floats and weights; they can be anchored to the seafloor or allowed to float at the surface. The netting is almost invisible to fish, so they swim right into it. Gillnets are often used to catch sardines, salmon and cod, but can accidentally entangle and kill other animals, including sharks and sea turtles.

BOTTOM



MIDWATER



IMPACT OF FISHING GEARS ON THE MARINE ENVIRONMENT

(Chuenpagdee *et al.*, 2003)

SHELLFISH AND CRABS

FINFISH

SHARKS

MARINE MAMMALS

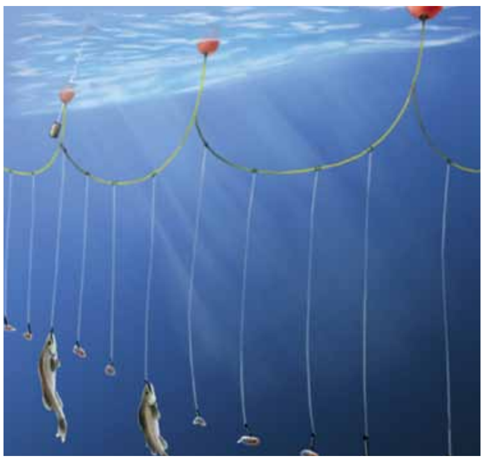
SEABIRDS AND TURTLES

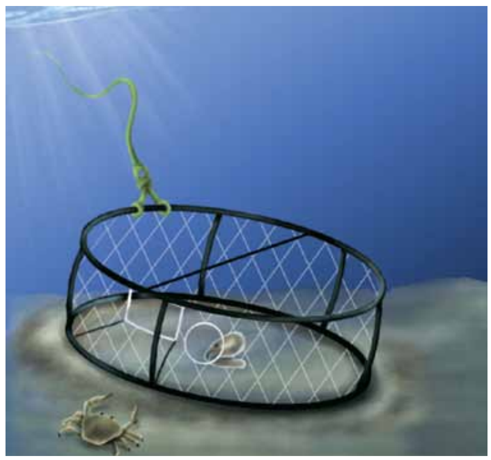
HABITAT DAMAGE

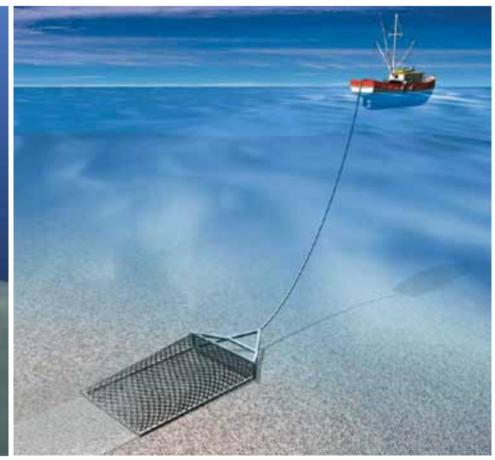
HIGH IMPACT

MEDIUM IMPACT

LOW IMPACT



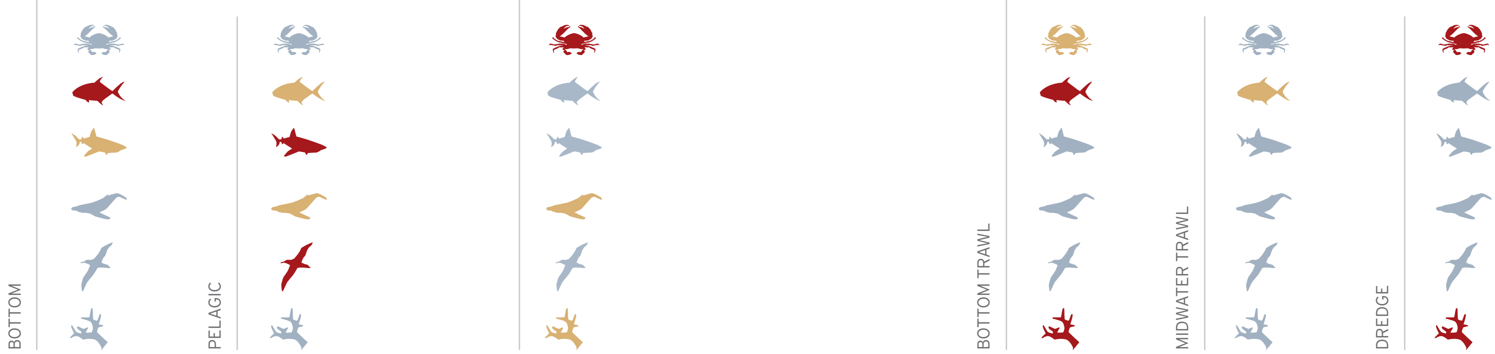




Longlining
employs a central fishing line that can range from one to 50 miles long; this line is strung with smaller lines of baited hooks, dangling at evenly spaced intervals. Longlines can be set near the surface to catch pelagic fish like tuna and swordfish, or laid on the seafloor to catch deep-dwelling fish like cod and halibut. Many lines, however, can hook sea turtles, sharks and seabirds that are also attracted to the bait. By sinking longlines deeper or using different hooks, fishermen can reduce the bycatch problem.

Traps and Pots
are submerged wire or wood cages that attract fish with bait and hold them alive until fishermen return to haul in the catch. Traps and pots are usually placed on the ocean bottom, often to catch lobsters, crabs, shrimp, sablefish and Pacific cod. They generally have lower unintended catch and less seafloor impact than mobile gears like trawls.

Trawls and Dredges
are nets towed at various depths to catch fish or shellfish. Trawl nets, which can be as large as a football field, are either dragged along the seafloor or midway between the floor and the surface. Trawlers catch fish such as pollock, cod, flounder and shrimp. Bottom trawling can result in high levels of bycatch. Dredging involves dragging a heavy frame with an attached mesh bag along the seafloor to catch animals living on or in the mud or sand; catches include scallops, clams and oysters. Dredging can damage the seafloor by scraping the bottom and also often results in significant bycatch (NRC, 2002).



FROM OVERFISHING TO REBUILDING

Overfishing has long been recognized as an environmental and socioeconomic problem, and one that has worsened globally over the last few decades. However, this trend is being bucked in several regions where efforts to restore marine ecosystems and rebuild fisheries are thriving. In places like Alaska and New Zealand, better management has prevented overfishing or allowed marine resources to recover (Worm *et al*., 2009). The key tools available to fishery managers include:

Science-Based Fishery Management
Robust Measures to Prevent Decline

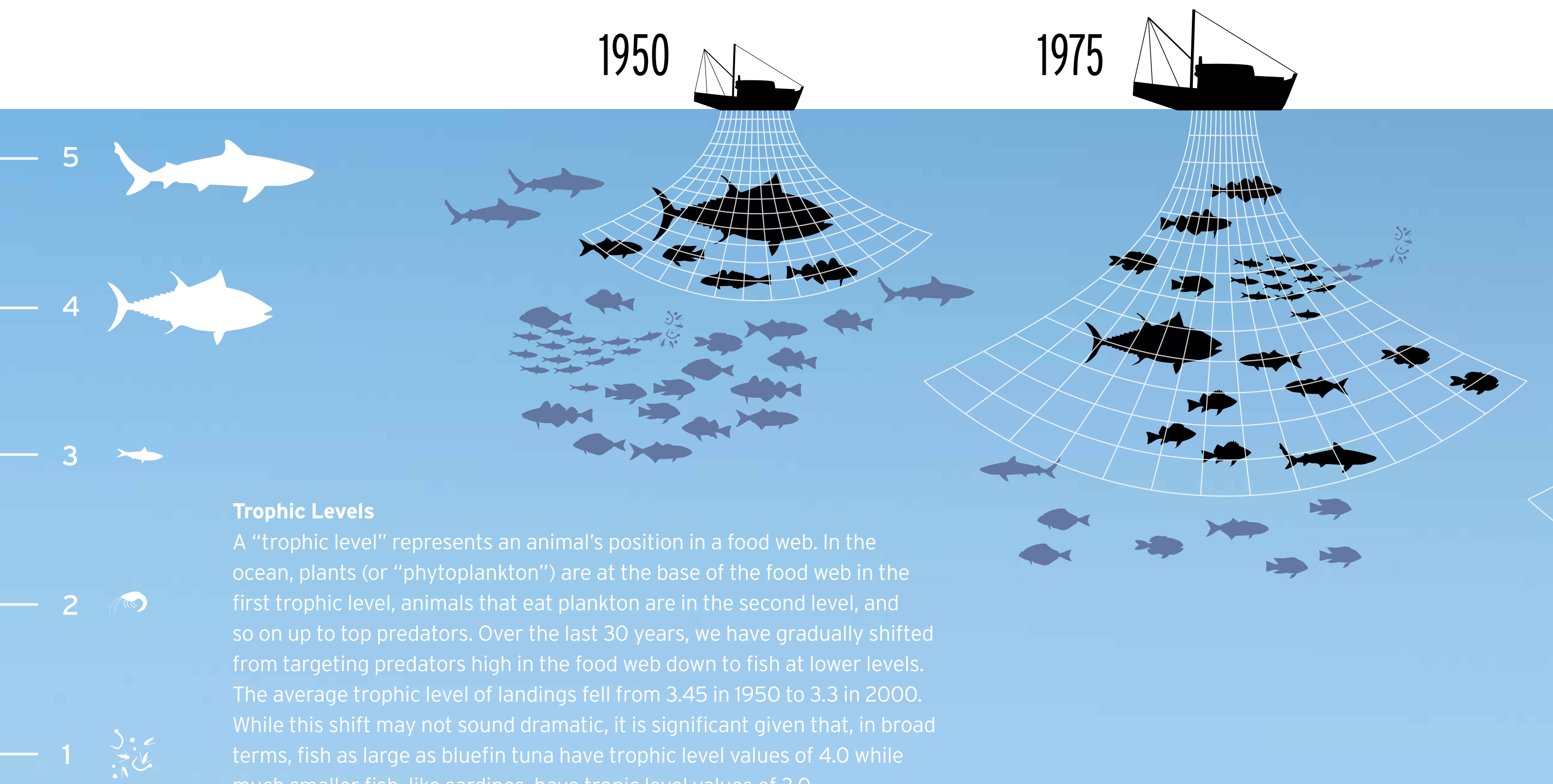
Effective fishery management systems are needed to maintain the long-term productivity and stability of marine resources. The most fundamental controls involve setting the total allowable catch (TAC) based on good science, limiting the type and quantity of fishing gear that can be used, and influencing the seasons when fishing can take place. These tools have successfully prevented the decline of fisheries in many regions of the world.

Protected Areas
Saving Critical Habitat

Like national parks on land, marine protected areas (MPAs) can be used to protect biologically rich ecosystems and help restore overfished populations. There is compelling evidence that MPAs have rapid and lasting effects. MPAs are proven to increase size, numbers and diversity in fish populations (Halpern *et al*., 2002). Even temporary closed areas can be a powerful tool in fisheries management. Currently, MPAs cover less than one percent of the world's oceans; by comparison, there's similar protection for four percent of Earth's land area. This trend is slowly changing as MPAs become more popular across the globe. Many nations have plans to protect ten percent or more of their ocean areas with MPAs over the next decade (UNEP 2008), and California is in the final stages of implementing the first statewide network of MPAs in the U.S.

Catch Shares
Economic Incentives to Prevent Overfishing

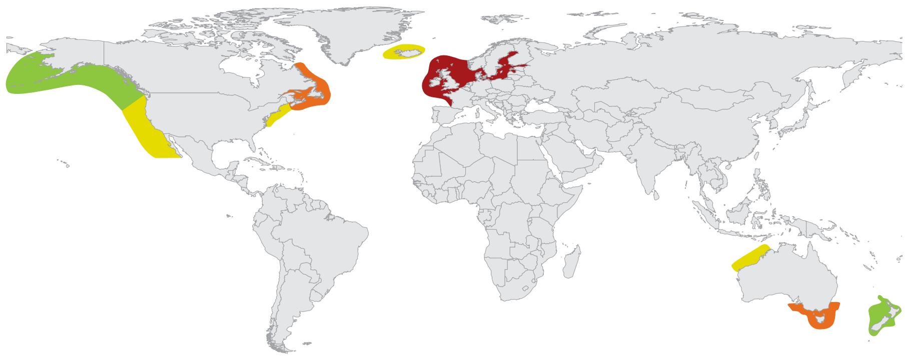
Aligning the economic incentives of fishermen toward conservation is increasingly seen as a critical component of successful fisheries. Several fisheries in the U.S., New Zealand and Iceland have adopted "catch share" systems that dedicate a share of the total fishery resource (*e.g.*, one percent of landings) to individual fishermen or communities. Establishing ownership rights can create a long-term incentive to increase the size of the fish population. In some cases, catch shares have been shown to improve compliance with laws and participation in the management process, along with the profitability of the fishery (Costello *et al.* 2008, Chu 2009, Melnychuk *et al.* 2011).



Trophic Levels
A "trophic level" represents an animal's position in a food web. In the ocean, plants (or "phytoplankton") are at the base of the food web in the first trophic level, animals that eat plankton are in the second level, and so on up to top predators. Over the last 30 years, we have gradually shifted from targeting predators high in the food web down to fish at lower levels. The average trophic level of landings fell from 3.45 in 1950 to 3.3 in 2000. While this shift may not sound dramatic, it is significant given that, in broad terms, fish as large as bluefin tuna have trophic level values of 4.0 while much smaller fish, like sardines, have tropic level values of 3.0.

Marine Fisheries and Management In Selected Regions

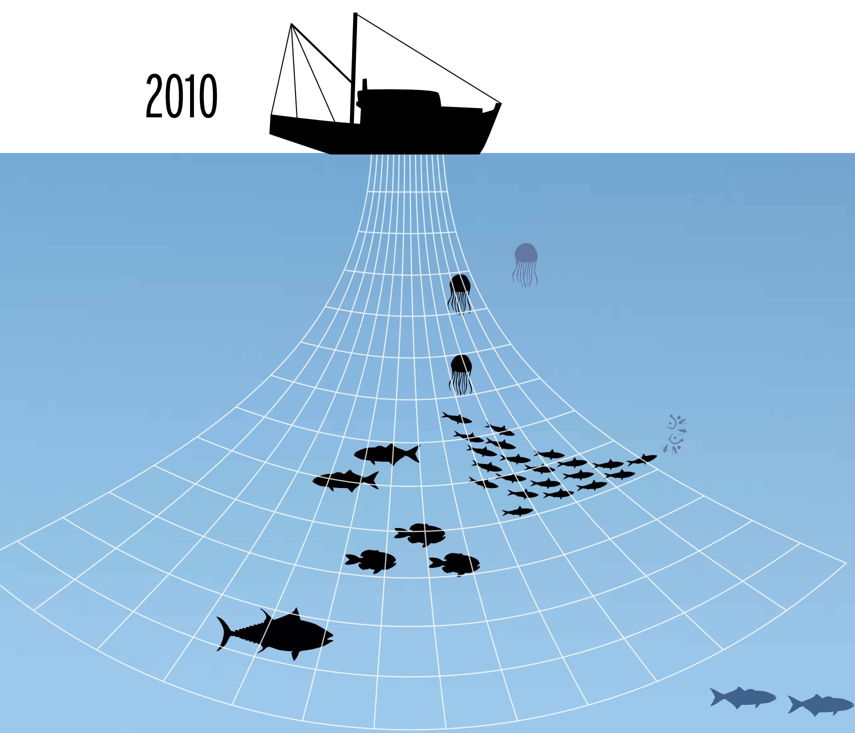
- NOT OVERFISHED
- LOW EXPLOITATION RATE, BIOMASS REBUILDING FROM OVERFISHING
- LOW TO MODERATE EXPLOITATION RATE, NOT YET REBUILDING
- HIGH EXPLOITATION RATE



Region	TAC Reduction	Catch Share	Closed Areas	Capacity Reduction	Gear Restrictions	Total Effort Reduction	Eco-Certification	Community Comanagement
Alaska	***	***	**	**	*		*	*
New Zealand	***	***		*	*		*	
California Current	***		***	**	*			
Iceland	***	***		*	*			
Northeast U.S.			**	**	*	***		
Northwest Australia			**		**			
Southeast Australia	***	***	**	*	*		*	
North Sea	***	*	*	*	*	**		*
Total Score	18	13	12	10	9	5	3	2

Figure 9. Management tools for rebuilding fisheries. Symbols indicate the contributions of a range of management tools to achieving reductions in exploitation rate: * tool contributed, ** an important tool, or *** an essential tool. Note that these examples are for industrialized fisheries. Ratings were supplied and checked by local experts (Worm *et al.*, 2009).

2010



FISHING AND THE MARINE FOOD WEB

The 1950s marked the onset of extremely rapid growth in the fishing industry. Throughout the 1950s and 60s, global fishing effort increases substantially exceeded the pace of population growth. These fisheries preferentially targeted large fish high on the trophic web.

Fisheries continued to expand in the mid-1970s, and catches started showing signs of decline in many regions. In the North Atlantic, the downward trend in fish catch accelerated until the iconic cod fishery eventually collapsed. Collapses are often accompanied by a switch in fishing effort toward species lower on the food web.

Total world fisheries landings peaked and started to decline in the late 1990s and have continued to decline by about 0.7 million tons per year (Pauly *et al.*, 2002). Today, large predatory fish biomass is 10 percent of pre-industrial levels (Myers and Worm, 2003), and most commercially exploitable fisheries up and down the food web are being fished at their limits.

Aquaculture

Just as humans changed from hunter-gatherers to farmers on land, a similar transition is taking place in the oceans. The growth of aquaculture has the potential to alleviate poverty and hunger in many regions (Subasinghe *et al*., 2009). But just as the conversion of wild land to farms can damage terrestrial ecosystems, the expansion of aquaculture – at inappropriate intensities and in inappropriate locations – can result in significant environmental impacts to aquatic ecosystems.

With so many species, locations and production systems, aquaculture creates complex environmental, economic and social impacts (Diana, 2009). In general, farming of herbivores and filter-feeders (*e.g.*, carp or mussels; see success story on shellfish aquaculture on page 36) has low environmental impacts, while farming of carnivorous species (*e.g.*, tuna, salmon) potentially has high environmental impacts (MATF, 2007). Additionally, closed, land-based systems generally have fewer impacts on marine ecosystems than open, ocean-based systems (such as net pens). Key environmental impacts of aquaculture include pollution, habitat effects, escapes, disease and reliance on wild resources (MATF, 2007).

The Use of Wild Fish in Aquafeeds

In the early days of aquaculture, there was widespread speculation that raising fish on farms would produce a "blue revolution" and ultimately reduce fishing pressure on wild species. The reality is far more nuanced, since most aquaculture operations directly affect marine ecosystems. Notably, several segments of the aquaculture industry rely on wild fisheries as a source of feed for farmed fish.

Although many types of farmed aquatic species convert their feeds into edible protein more efficiently than terrestrial livestock (Tyedmers *et al*., 2007), unlike terrestrial livestock, many of them are carnivores that naturally have a diet high in protein and oil from animal sources (Naylor *et al*., 2001). Fishmeal and fish oil are two ingredients commonly used to meet these nutritional requirements. It is estimated that aquaculture annually consumes the equivalent of more than 16 million tons of wild fish, though it is becoming more efficient in its use of this resource (Tacon & Metian, 2008). The amount of wild fish used in aquaculture diets varies widely by species. For example, in 2006, the average salmon farm needed 4.9 tons of wild fish for every ton of farmed salmon while the average shrimp farm needed 1.4 tons of wild fish for every ton of farmed shrimp (Tacon & Metian, 2008). In contrast, farmed freshwater fish such as tilapia, catfish and carp require relatively little wild fish in their diets.

Due in part to the rising cost and limited availability of fishmeal and fish oil, these feedstuffs are increasingly being replaced by other ingredients (see success story below on innovations in aquaculture feeds). The evidence suggests that a substantial portion of both fishmeal and fish oil can be replaced with plant-based sources without adversely affecting the growth rates and nutrient profile – including omega-3s – of farmed salmon (Bendicksen *et al*., 2011). As a result, the amount of

SUCCESS STORY

Innovations in Aquaculture Feeds

One of the prime issues facing aquaculture is its dependence on wild fisheries for fishmeal and fish oil, which are used to feed many farmed species. The high cost of fishmeal and fish oil – as well as their limited availability – is encouraging the development of alternative feeds (Rana *et al.*, 2009). Potential alternatives being tested or in use include plant proteins and oils, single-cell proteins, algae, and byproducts from seafood and livestock processing. Many of the major feed manufacturers are investing heavily in development of these products, while maintaining growth rates and concentrations of omega-3 fatty acids.

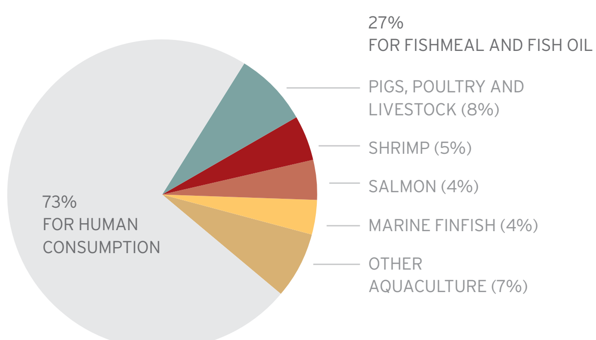


Figure 10. Uses of Wild Fish Catch. Almost one third of the world's total wild seafood catch is ground up into fishmeal and fish oil, commodities that are fed to farmed fish, poultry, pigs and livestock (Alder *et al.*, 2008; Tacon & Metian, 2008).

wild fish used in individual aquaculture operations has been dropping across the board, with significant drops for farmed salmon, trout and shrimp. Salmon was forecast to fall from 4.9 tons of wild fish per ton of farmed salmon in 2006 to 3 tons by 2010 and possibly 1.5 tons by 2020 (Tacon & Metian, 2008). While improved efficiency is encouraging, growth in aquaculture production worldwide means that overall demand for fishmeal and fish oil is unlikely to fall any time soon.

Wild fish are used not only for feed but also as a source of juvenile fish for some aquaculture operations, especially in highly profitable — and rapidly expanding — sea-ranching operations. Ranching is a specific type of farming in which wild fish are captured at a small size and grown to market size in cages in the open sea (*e.g.*, bluefin tuna ranching). Eel aquaculture, which supplies *unagi* to sushi bars, relies entirely on wild-caught juveniles. This has contributed to the collapse of wild eel stocks in Europe (ICES, 2005).

Habitat impacts of Aquaculture

Due to the diversity of farming methods and geographies, the habitat impacts of different forms and scales of aquaculture vary considerably. Because all aquaculture requires access to a reliable water supply, rapid expansion of production has been concentrated around riparian and coastal habitats. The "gold-rush" expansion of some sectors, particularly shrimp farming, has often occurred at the expense of sensitive coastal habitat. Mangrove forests in particular suffered significant losses as they were cleared for shrimp farms in the latter half of the 20th century. By one estimate, shrimp farming was responsible for approximately 38 percent of global mangrove loss with other aquaculture accounting for another 12 percent (Polidoro *et al.*, 2010).

In part because the overall ecosystem value of mangroves has been recognized and protected by international agreements such as the RAMSAR Convention on Wetlands, fewer new shrimp farms are now being located in mangroves. The wholesale conversion of sensitive habitats into aquaculture operations has diminished significantly, but competition for land remains an issue in coastal regions, and sensitive habitats are not free from the pressures of aquaculture.

Pollution

Like terrestrial farm animals, aquatic animals — when raised in high numbers and dense concentrations — produce substantial quantities of waste (*e.g.*, Da Silva *et al.*, 2010). Intensive aquaculture production is also associated with chemical use, including pesticides, antibiotics, antifoulants, and disinfectants.

Many forms of aquaculture rely on surrounding waters to dilute and break down a farm's waste products (*e.g.*, feces, uneaten food, chemical treatments, etc.). Open production systems, such as floating cages or ponds with high water exchange rates, are more likely to allow a farm's waste products to permeate beyond the farm's boundaries. Where currents and natural water exchange are low, these wastes accumulate and can have direct impacts on the surrounding environment (Bosma

SUCCESS STORY

Arctic Char

Arctic Char

An Alternative to Farmed Salmon with Fewer Challenges

Arctic char offers an alternative to farmed salmon that lacks many of salmon's environmental problems. A species native to the northern regions of Europe and North America, Arctic char is in the salmon family and possesses a similar texture and flavor (Molleda, 2008). Most char in the marketplace is raised on land in tank systems where the water is recirculated, thereby reducing the risk of disease transfer, pollution and escapes (White *et al*., 2004; Summerfelt *et al*., 2004; Molleda, 2008). Fish farmers are now experimenting with similar land-based technologies to grow other species, even salmon.

and Verdegem, 2011; Venayagamoothy *et al.*, 2011). When combined with other human wastes and agricultural pollution, they can have a significant impact on coastal or inland water bodies. However, improvements are possible.

For example, nutrients in aquaculture effluents can be recycled by other productive activities through the design of integrated systems (Bostock *et al.*, 2010). Examples of these systems are Integrated Multi-Trophic Aquaculture, in which species from different trophic levels (*e.g.* finfish, shellfish, seaweeds) are grown in combination (Troell *et al.*, 2009), and Integrated Agriculture-Aquaculture systems, that are characterized by the synergies among aquaculture and different agricultural activities (Zajdband, 2011).

Another example is that of Thai shrimp farmers, many of whom have closed their farms to outside waters (mainly to isolate their ponds from disease outbreaks). They manage their water, shrimp stocks and the farms' wastes in isolated systems that do not discharge effluent into coastal waters as they once did. The closed-farm system has potential for many aquaculture species, and offers a promising direction for the future (Bush *et al.*, 2010).

Introduced Species and Escapes

One major distinction between aquaculture and livestock farming is the potential for fish farms to be situated within the range of similar wild fish. In open aquaculture systems, such as net pens, there is a likelihood that fish will escape. Escaped non-native species can compete for habitat, disrupt wild fish during spawning, eat wild fish, and potentially establish feral populations — all major threats to native species that may already be depleted (Johnson & Johnson, 2006; Costa-Pierce, 2003). Tilapia are now one of the most widely distributed exotic fish in the world, second only to common carp, as their introduced range now stretches to nearly every continent and includes 90 different countries (Eknath & Hulata, 2009).

As they have been transported around the world in the last 50 to 60 years, tilapia have established themselves in nearly every warm-water habitat to which they have been introduced (Canonico *et al*. 2005). Similarly, in the last 10 years, the majority of shrimp farms in Southeast Asia (the world's largest shrimp-farming region) have begun growing white shrimp native to the west coast of Central America (Lebel *et al.*, 2010). The ecological implications of the escapes of these non-native shrimp are poorly understood and represent another example of how important factors like species selection and eliminating escapes are to the sustainability of aquaculture.

Even where farmed species are native, genetically distinct farmed fish can impact wild fish through interbreeding. Wild salmon populations — already threatened by habitat loss and historic overfishing — face genetic dilution from interbreeding with escapees. In the Atlantic, genetically distinct, escaped farmed salmon greatly outnumber wild salmon populations returning to rivers (Naylor *et al*., 2005), and approximately two million farmed salmon escape annually in the North Atlantic alone (Roberge *et al*., 2006). This interbreeding has been associated with the potential extinction of discrete wild salmon populations (McGinnity *et al*., 2003). As long as aquaculture operations continue to culture genetically distinct or non-native species and cannot keep them fully contained, escapes will remain a threat to wild populations and natural habitats.

SUCCESS STORY

Shellfish Aquaculture

Farmed Seafood with Minimal Environmental Impacts

Several kinds of shellfish aquaculture are recognized as environmentally responsible, including the farming of bivalves like clams, oysters, mussels and scallops. Most environmental concerns about aquaculture focus on the farming of marine finfish and shrimp, which are often intensively cultivated carnivores (MATF, 2007).

In contrast, farming shellfish has few negative impacts overall. Most shellfish feed on naturally occurring particulates; because supplemental feeds are not used, shellfish farming does not increase nutrient inputs to coastal waters (Pillay & Kutty, 2005). In fact, increased abundance of shellfish in an area is often considered to have a positive effect on water quality (Gren *et al*., 2009).

Mussels

Clam

Oyster

A half million salmon escaped from this farm in the late 1980s. Recent reports of sea lice infestations in nearby wild sea trout and salmon populations have raised questions about the impact of net-pen salmon farms in Scotland. Salmon Farm Protest Group/Marine Photobank

Spread of Disease

As with farming on land, aquaculture operations must contend with disease and parasite outbreaks. These outbreaks increase as farming effort is intensified. Global expansion of aquaculture, particularly shrimp farming, has been characterized by repeated boom-and-bust cycles: rapid growth in capacity followed by disease outbreaks and a collapse in production (Arquitt *et al*., 2006). During the period 2008–2010, the Chilean salmon sector collapsed as a consequence of a severe outbreak of infectious salmon anemia (ISA) that crippled Atlantic salmon production (Barton & Fløysand, 2010).

The situation in Chile follows years of major problems with parasitic sea lice, which affect salmon in all farming regions. In British Columbia, sea lice are associated with increased mortality of young wild salmon that migrate past salmon farms. Estimates of the precise level of mortality vary, but some models predict up to 80 percent mortality of wild salmon (Krkosek *et al*., 2007). Control of sea lice in salmon farms is improving, but the potential for commonly used anti-parasitic chemicals to become ineffective on chemical-resistant lice is one of salmon farming's greatest challenges (Brooks, 2009).

Using "cleaner fish" like wrasse to remove sea lice is one innovative solution. However, systems that raise fish outside of natural water bodies (*e.g.*, in tanks) are better at preventing the spread of pathogens and parasites (see case study on farming Arctic char on page 35).

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HOW WE FARM FISH

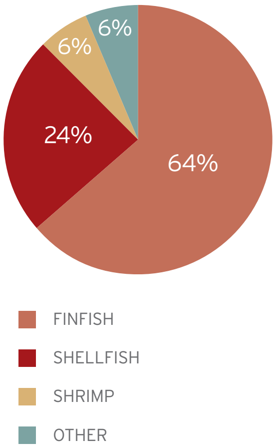
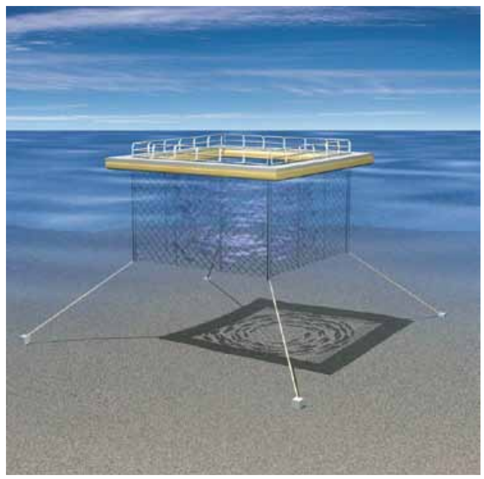
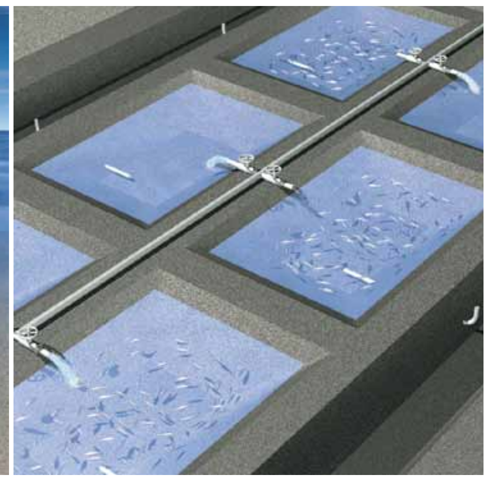


Figure 11. Species produced by the world's aquaculture operations. Nearly one-quarter of the world's fish farms produce shellfish (*e.g.*, oysters, clams, mussels, etc.), which have significantly fewer environmental impacts than other types of aquaculture (FAO 2011b).

In the next decade, the majority of fish we eat will be farm-raised, not wild.

Global aquaculture includes over 100 species, farmed in everything from traditional earthen ponds to high-tech tank systems. Each farming system has its own distinct environmental footprint. By choosing seafood from better farms and production systems, consumers can play a positive role in reducing aquaculture's potential negative impacts.





Open Net Pens or Cages
enclose fish such as salmon in offshore coastal areas or in freshwater lakes. Net pens are considered a high-impact aquaculture method because waste from the fish passes freely into the surrounding environment, polluting wild habitat. Farmed fish can escape and compete with wild fish for natural resources or interbreed with wild fish of the same species, compromising the wild population. Diseases and parasites can also spread to wild fish living near or swimming past net pens.

Ponds
enclose fish in a coastal or inland body of fresh or salt water. Shrimp, catfish and tilapia are commonly raised in this manner. Wastewater can be contained and treated. However, the discharge of untreated wastewater from the ponds can pollute the surrounding environment and contaminate groundwater.

Potential environmental risks. These impacts are based on Monterey Bay Aquarium's assessment.

ESCAPES

POLLUTION

DISEASE

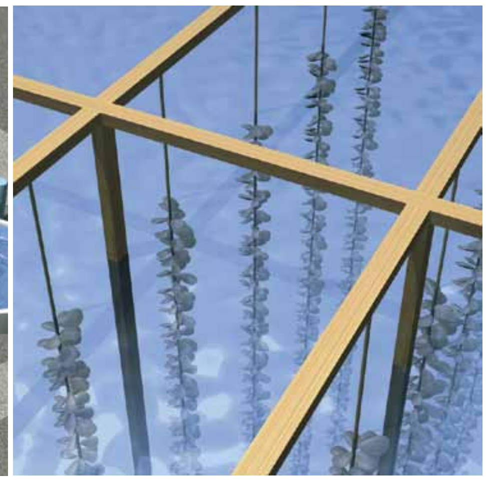
HABITAT DESTRUCTION

Raceways

allow farmers to divert water from a waterway, like a stream or well, so that it flows through channels containing fish. Farmers usually treat the water before diverting it back into a natural waterway. Some governments require strict regulation and monitoring of on-site and nearby water quality. In the U.S., farmers use raceways to raise rainbow trout. If untreated, wastewater from the raceways can contaminate waterways and spread disease. Farmed fish can potentially escape and compete with wild fish for natural resources. Escaped fish can also interbreed with wild fish of the same species, putting the health of the wild population at risk.

Recirculating Systems

allow farmers to raise fish in tanks in which water is treated and recycled through the system. Almost any finfish species such as striped bass, salmon and sturgeon can be raised in recirculating systems. Recirculating systems address many environmental concerns associated with fish farming (*e.g.* fish cannot escape, and wastewater is treated) but they are costly to operate and rely on electricity or other power sources.

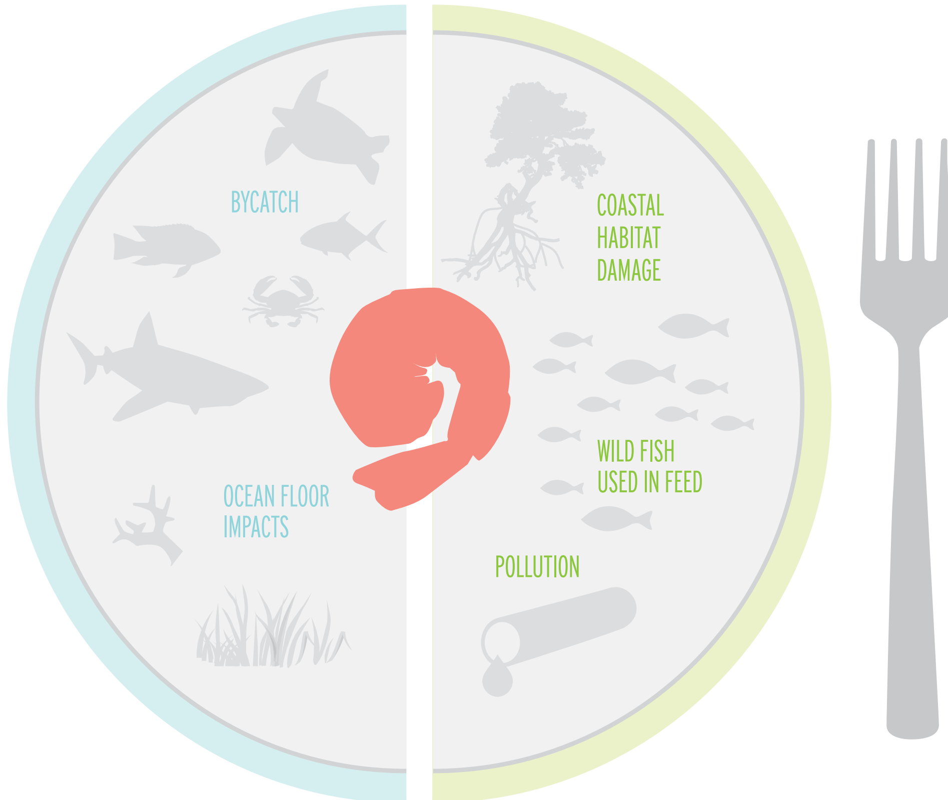


Shellfish Culture

is a method where farmers grow shellfish on beaches or suspend them in water by ropes, plastic trays or mesh bags. The shellfish farmed using these methods (*e.g.* oysters, mussels and clams) are filter-feeders and require only clean water to thrive. Filter-feeders can actually filter excess nutrients out of the water, but farming shellfish in high densities in areas with little current or tidal flow can lead to the accumulation of waste. Historically, some shellfish culture has been responsible for the introduction of exotic species that can sometimes out-compete native species for natural resources.

THE COST OF A SHRIMP DINNER

Shrimp is the most popular seafood item in the U.S., yet few consumers know that both farmed and wild shrimp production come at a cost to marine and terrestrial environments.



Sustainable Alternatives
While a meal of shrimp can come with a plate full of problems, there are better alternatives out there for interested consumers. For example, trap-caught shrimp from British Columbia are a great alternative because they have relatively low bycatch and habitat impacts. Traps are submerged wire or wood cages that attract shrimp and hold them alive until fishermen return to haul in their gear. The traps cause less habitat damage than bottom trawls, and are much better at targeting shrimp. Similarly, some shrimp farms, like those in the U.S., are subject to laws limiting their environmental impacts, such as wetlands loss or untreated pollution, making them a good alternative to most imported farmed shrimp.

WILD-CAUGHT

Bycatch and Discards Shrimp fisheries are the greatest single source of discarded bycatch, accounting for one-third of the world's discarded catch, while producing less than two percent of global seafood (Kelleher, 2005). Bycatch includes fish, crustaceans and occasionally turtles. At its worst, the discard-to-shrimp ratio can be over six-to-one. Proper gear selection can bring that down substantially.

For every pound of U.S. Gulf of Mexico shrimp landed, 4.5 pounds of fish and crabs are caught at the same time, much of which is discarded (Harrington *et al.*, 2006).

Habitat Damage Shrimp trawls drag weighted nets along the ocean floor, which can tear up aquatic plants, sponges and corals, or flatten the seafloor habitat. Fortunately, most shrimp are caught on soft bottoms, which are less vulnerable to trawling.

FARMED

Mangroves Shrimp farms are commonly located in coastal, tropical areas. It is estimated that shrimp farming is responsible for approximately 38 percent of global mangrove loss (Pontidoro *et al.*, 2010).

Impact on Wild Fisheries Farmed shrimp are fed a diet that includes wild-caught fish as an ingredient. For every ton of shrimp that is farmed, 1.4 tons of wild fish are used as a feedstock (Tacon & Metian, 2008).

Pollution When farmed in dense concentrations, shrimp can produce substantial waste. Many industrial shrimp farmers use chemicals like antibiotics or pesticides and, typically, untreated effluent waters flow into the surrounding environment (Miranda *et al.*, 2007; Xuan Le *et al.*, 2005). Additionally, shrimp are known to carry exotic diseases that can threaten both commercial production and wild shrimp populations (Stentiford *et al.*, 2009).

Climate Change and the Oceans

Climate change is a serious issue that will affect global seafood sustainability. Global warming and ocean acidification have profound implications for the health of marine ecosystems and fisheries. The effects of climate change promise to dramatically compound existing environmental pressures on the oceans from industrial-scale fishing and aquaculture. This issue is only now working its way into discussions about marine sustainability, and will become more significant in the future.

Rising atmospheric temperatures are already changing ocean temperature, circulation patterns and the frequency of extreme weather events. The Intergovernmental Panel on Climate Change (IPCC, 2007) has concluded with a high degree of confidence that marine biological systems are already changing, due in part to "rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels and circulation." These changes include shifts in the range and abundance of marine life in high-latitude oceans, and changes in fish migration patterns. It is difficult to predict future impacts, but in a warmer world, marine ecosystem productivity is likely to decline in tropical and subtropical regions, and potentially increase at higher latitudes. Climate change may also disrupt finely-tuned seasonal patterns of reproduction and migration across ecosystems. Fisheries located in the high-latitudes, coastal areas and upwelling and coral reef systems, are expected to be the most affected (FAO, 2008).

There is also growing evidence of climate-related impacts on coral reefs. Climate change may ultimately cause the demise of more than 80 percent of the world's coral reefs. Even the most optimistic scenarios project annual bleaching in 80 to 100 percent of the world's coral reefs by 2080, with the likely result of severe damage and widespread death of corals around the world (Nellemann *et al.*, 2008).

Acidification of the oceans is a related issue of grave concern. When carbon dioxide dissolves in the oceans, it lowers the pH and therefore makes the water more acidic. The average pH of global surface waters has fallen from 8.25 to 8.14 over the past two and a half centuries, and the pace is accelerating (Jacobson, 2005). This change in ocean chemistry weakens animals with structures that can dissolve at higher acidity, including not only corals, but shellfish and smaller organisms at the base of the food web. Even organisms that don't produce shells will be stressed by the need to buffer themselves against the change in pH. The ramifications of ocean acidification are only now beginning to be explored.

How Fishing and Aquaculture Contribute to Greenhouse Gas Emissions

According to the FAO, the seafood industry makes a "minor but significant" contribution to greenhouse gas emissions through the production, processing, transport and storage of seafood (Cochrane *et al*. 2009). Emissions vary substantially, depending on the fishing or farming methods and the form in which seafood goes to market. On the production end, more fuel-efficient ship engines, fleet configurations and fishing gear can lead to fewer emissions. In aquaculture, energy consumption tends to be higher in shrimp and carnivorous fish farms, and lower in omnivorous fish and shellfish farms (FAO, 2008).

Transport of seafood is an additional source of emissions (FAO, 2011). Indeed, though trade of seafood appears to have slowed or stagnated in recent years due to the global recession, more than one-third of all seafood is still traded internationally (FAO, 2011). The highest emissions are associated with seafood that is transported by plane. Air-freight emissions are roughly 3.5 times those of sea freight and more than 90 times those of local transportation (when fish is consumed within 250 miles of where it was caught or farmed) (FAO, 2008). The continued globalization of the seafood trade — upon which many developing nations depend — is likely to further increase the industry's overall contributions to carbon dioxide emissions. Restoring marine fish populations in close proximity to the communities that consume them could both reduce fisheries' impact on the climate and help restore the communities that fish for them.

Life-cycle analyses show that the aquaculture sector performs relatively well compared to terrestrial food-producing systems when it comes to the release of greenhouse gases (Hall *et al.*, 2011). Feed production can account for as much as 90 percent of total energy use in intensive systems. Thus, while some production systems, such as closed containment, are promoted for their ability to reduce some types of impacts, their increased material and energy demands need to be carefully considered (Ayer *et al.*, 2009).

Turning the Tide

Perhaps in response to the many indicators of declining ocean health, several hopeful trends are emerging. Some governments are learning from past mistakes and are making decisions based on an improved scientific understanding of how to better manage their marine resources. At the same time, consumers, business leaders and fishermen are beginning to take bold steps in the right direction. This section offers a road map for making sustainable seafood a reality; it outlines what individuals are doing to make an impact, and describes the steps that forward-thinking companies are taking to bring responsible fishing and aquaculture practices into the mainstream.

Growing Consumer Interest in Sustainable Seafood

The last decade has seen a relative explosion of U.S. and European consumer interest in sustainable seafood. To start, there has been substantially greater media coverage of the issue in recent years. This is true in both mainstream and trade publications. A simple survey of the frequency with which the phrase "sustainable seafood" has appeared in the print media shows a dramatic increase between 2002 and 2008 (see Figure 13). Media coverage has been supplemented by outreach and educational efforts by aquariums and other not-for-profit organizations like the Monterey Bay Aquarium, which have made it a priority to raise public awareness on these issues. For example, nearly 40 million of the Aquarium's Seafood Watch pocket guides, which recommend which seafood to buy or avoid, have been distributed over the past decade.

Due in part to increased consumer awareness, the marketplace appears to be responding. A recent survey by The Ocean Project revealed that Americans believe their seafood purchase decisions impact ocean health, and they are willing to buy and pay more for seafood that is healthy and sustainable (The Ocean Project, 2009). Private studies have quantified willingness-to-pay for sustainable wild salmon over farmed salmon roughly on par with the premium individuals are willing to pay for organic foods (Edge Research, 2006). This consumer interest has been accompanied by substantial growth in the number of private brands and corporate information touting the environmental attributes of seafood products.

The last five years have also seen steady growth in the Marine Stewardship Council (MSC) certification

Continued on next page »

SUCCESS STORY

Atlantic Swordfish
On Track to Recovery

Highly migratory fishes (*e.g.*, tunas, swordfish, sharks, and billfish), which don't limit their range to one country or region's waters, require international cooperation to ensure their conservation. In the 1990s, Atlantic swordfish populations were severely depleted due to overfishing and mismanagement. U.S. conservation groups mobilized consumers and hundreds of influential chefs to "Give Swordfish a Break" and stop eating these fish until better international management practices were in place. Partially due to the efforts, in 1999 the International Commission for the Conservation of Atlantic Tunas (ICCAT), which oversees the fishery, recommended that member countries reduce catches of North and South Atlantic swordfish by 45 percent (ICCAT, 1999). In 2001 and 2002, the U.S. National Marine Fisheries Service (NMFS) also implemented a swordfish protection plan that placed swordfish nursery grounds off-limits to fishing (ICCAT, 2002). With stringent enforcement measures in place, the decline in North Atlantic swordfish stocks was halted. Both North Atlantic and South Atlantic swordfish now appear to have recovered to healthy levels (ICCAT, 2008; ICCAT, 2010). As a result of these actions, U.S. Atlantic swordfish, once on the Monterey Bay Aquarium's "Avoid" list, moved into the "Good Alternatives" list, reflecting the success of these rebuilding efforts.

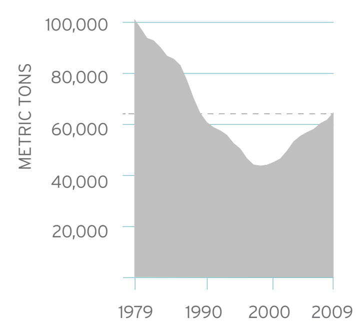


Figure 12. North Atlantic swordfish biomass from 1979 to 2009. North Atlantic swordfish biomass is on the rise and the stock is completely rebuilt (ICCAT, 2010). Dotted line is the biomass management target.

In the 1990s, U.S. conservation groups mobilized consumers and hundreds of influential chefs to "Give Swordfish a Break." Norbert Wu/Minden/National Geographic Stock

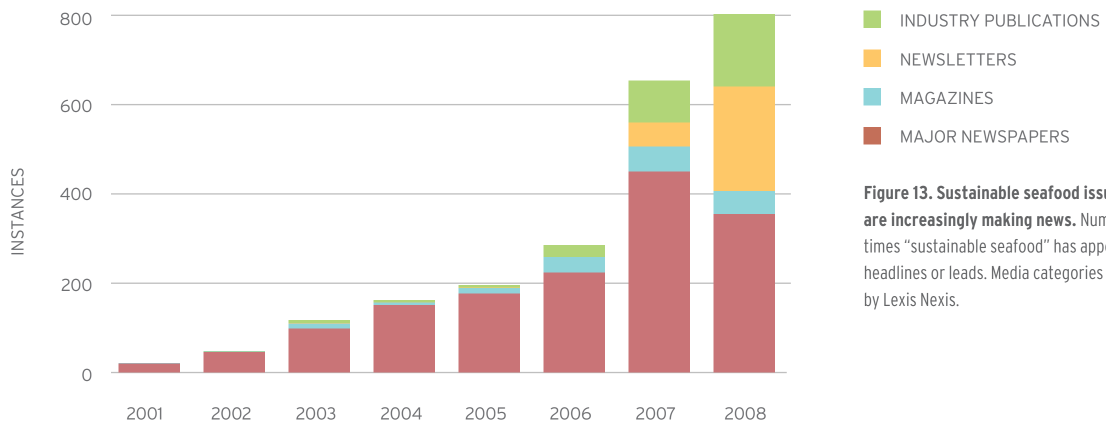


Figure 13. Sustainable seafood issues are increasingly making news. Number of times "sustainable seafood" has appeared in headlines or leads. Media categories as defined by Lexis Nexis.

program. Currently, more than five million tons of seafood – close to six percent of the annual global harvest of wild capture fisheries – is certified through the MSC program (MSC personal communication, 2011; see Figure 14). This represents more than 40 percent of the world's wild salmon and prime whitefish catch, and nearly one-fifth of the world's lobster landings. Globally, nearly 12,000 seafood products from more than 130 certified fisheries bear the blue MSC eco-label. These products have an estimated retail value of more than $1 billion (MSC personal communication, 2011).

Though there is no MSC-equivalent for farmed seafood, an analogous Aquaculture Stewardship Council (ASC) and other aquaculture certification schemes are being developed. These schemes work with independent, third-party entities to certify aquaculture operations that are in compliance with global standards for responsible seafood-farming practices. At the same time, the U.S. Department of Agriculture (USDA) and comparable European bodies are developing organic standards for farmed seafood that could help consumers to identify better products.

Sustainable Seafood in the Mainstream: Corporate Action

Following closely on the heels of consumer interest, progressive companies are making responsible seafood purchasing the norm rather than the exception. A review of activities and commitments over the past decade demonstrates a growing wave of engagement by the business community. Restaurants, retailers and wholesalers anticipate significant growth in the percentage of their seafood coming from sustainable sources within five years (Seafood Choices Alliance, 2007). Increasingly, these segments of the seafood industry are opening themselves to dialogue and are interested in obtaining information that can help them make informed decisions about sustainable seafood. Many companies have removed unsustainable seafood items from their shelves. Others are asking their suppliers where their seafood comes from and how it was fished or farmed. Some of the top grocery retailers have recently developed sustainable seafood sourcing policies or guidelines that dictate from which fisheries and farms they will buy seafood (see Figure 15). Two of the largest food service companies in the U.S., ARAMARK and Compass Group North America, have committed to sourcing seafood that meets Monterey Bay Aquarium's "Best Choice" or "Good Alternative" ranking. For most companies, it is a challenge to define and institute a meaningful sustainable seafood policy.

Because each company has developed its own seafood policy, quantifying the effects of progress to date is a challenge. As an indicator, these case studies below highlight some of the largest commitments thus far and their ramifications for seafood purchases.

Walmart

In 2006, Walmart, the world's largest retailer, pledged that within three to five years it would source all fresh and frozen wild-caught seafood from MSC-certified fisheries. In 2011, Walmart updated the company's sustainability commitment to include all fresh and frozen farmed seafood products. All seafood products will become third-party certified as sustainable using MSC, Best Aquaculture Practices (BAP) or equivalent standards. This expanded commitment will now include shrimp, crab and lobster, among other seafood categories that were not part of the previous commitment. Walmart will require currently uncertified fisheries to develop work plans to achieve certification and report progress biannually. Because Walmart has 1.6 million employees, over 6,000 stores, and roughly 60,000 suppliers worldwide,

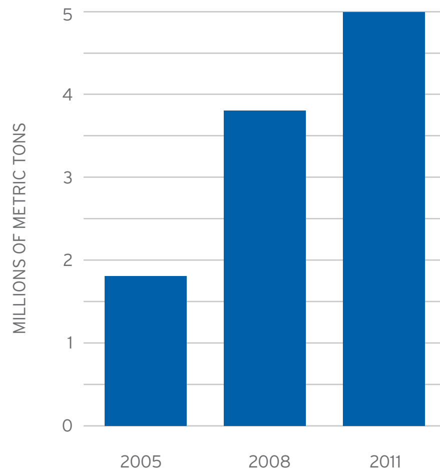


Figure 14. Volume of seafood that is certified by the Marine Stewardship Council (MSC). Fishery certification is on the rise (MSC personal communication, 2011). Look for the MSC logo on packaged seafood products.

its impact on suppliers is enormous. Walmart continues to partner with the MSC, World Wildlife Fund and the Sustainable Fisheries Partnership to help its suppliers and existing source fisheries meet these commitments.

Whole Foods Market

Since 1999, when Whole Foods Market began its partnership with the Marine Stewardship Council, the company has been on the forefront of seafood sustainability. Over the past 12 years, Whole Foods Market has greatly expanded its work to include comprehensive sourcing policies for both farmed and wild-caught seafood. In 2007–2008, Whole Foods Market developed, launched and, together with its supplier partners, implemented its quality standards for farmed seafood, setting high standards for every aspect of sustainability related to finfish and shrimp aquaculture – including traceability and third-party verification of the standards. For wild-caught seafood, Whole Foods Market remains committed to its partnership with MSC, offering an increasingly wide range of seafood from MSC-certified fisheries. The program expanded in 2010 to include partnerships with the Monterey Bay Aquarium and the Blue Ocean Institute. Now, all Whole Foods Market seafood departments provide color-coded sustainability status information on wild-caught seafood that's not certified by the MSC. Phasing out seafood from red-rated fisheries is a major component of the program. The partnerships have helped to bring science-based information and transparency to the company's dedicated customers.

Bon Appétit Management Company

Bon Appétit Management Company has become an international model for what is possible in sustainable food service. Based in Palo Alto, California, Bon Appétit provides café and catering services to over 400 clients nationwide at corporate headquarters, universities, and leading cultural institutions. Since 2002, all of the seafood served by Bon Appétit has been purchased in accordance with the Monterey Bay Aquarium's Seafood Watch guidelines for sustainability. Bon Appétit's CEO, Fedele Bauccio, said, "We truly believe we have the opportunity and responsibility to make this a better world."

Compass Group North America

Bon Appétit went beyond its own operations to convince its parent company, Compass Group North America, to embrace the Seafood Watch guidelines. Since Compass Group and the Monterey Bay Aquarium teamed up, Compass has revamped its menus, replacing nearly 300,000 pounds of Atlantic cod (a Seafood Watch "Avoid" item at the time) with Pacific cod, Alaskan pollock and other more sustainable choices. Additionally, Compass Group has decreased its unsustainable shrimp purchases by 835,000 pounds and farmed salmon by 192,000 pounds since 2006. In total, Compass dropped more than one million pounds of unsustainable products, including Atlantic halibut, bluefin tuna and orange roughy, and increased its more sustainable seafood purchases by 5.5 million pounds by buying more Alaskan pollock, farmed tilapia from Ecuador and wild Alaskan salmon.

ARAMARK

In 2008, leading food service company ARAMARK partnered with the Monterey Bay Aquarium to better promote sustainable seafood. The company, which serves tens of millions of consumers per year at businesses, schools and entertainment facilities, immediately began to shift its U.S. seafood purchases toward sustainable items, and will be completing the transition by 2018. The transition includes purchasing seafood from fisheries listed as "Best Choices" and "Good Alternatives" by the Aquarium's Seafood Watch program, and

A kelp forest in Monterey Bay, California. © David J. Wrobel

discouraging purchases of species on the "Avoid" list. Within the first year, ARAMARK had doubled its "Best Choice" and "Good Alternative" purchases, and to date, has converted 87 percent of its frozen finfish purchases to "Best Choices" and "Good Alternatives." ARAMARK has also taken impressive steps to develop materials to educate both its staff and its guests — helping to increase awareness and prompt consumer action.

Sysco Corporation

Sysco Corporation has pledged to assess its current seafood supply and to develop ways to improve the sustainability of its seafood-buying practices and standards by 2015, as part of a multiple-stage World Wildlife Fund (WWF) commitment.

Specifically, the company will obtain its ten top Sysco-branded wild-caught seafood species from fisheries that are either certified, under assessment by the MSC, or involved in fishery improvement projects with WWF. This represents about 52 percent of the Sysco-branded seafood product line. These wild-caught seafood products include tuna, clams, cod, pollock, shrimp, scallops, salmon, calamari, lobster and crab.

Additionally, Sysco has agreed to encourage its tuna suppliers to participate in the International Seafood Sustainability Foundation in order to move toward long-term procurement from sustainable, MSC-certified tuna sources.

Public Policies to Support Environmentally Responsible Seafood

Consumer and corporate engagement on seafood issues is a positive development, but the reality remains that the health of our oceans has continued to deteriorate over the last decade. In principle, growing consumer demand and business engagement for sustainable seafood products should translate into policies that protect the ocean, but these efforts take time and nothing substitutes for effective public policies. Experience has shown that some fishery management practices are very effective at restoring and rebuilding marine resources (Worm *et al*., 2009). Following are a set of policy objectives that can lead to sustainable seafood production.

Set and Enforce Science-Based Catch Limits

To end the current trend toward overfishing, fishery management must embrace the use of Total Allowable Catch (TAC) limits for fisheries. A TAC puts a limit on the maximum volume of fish that a fishery can catch within a season. TACs should be calculated using a scientific accounting of the natural productivity of a species and the species' role in the ecosystem. Since it can be difficult to determine stock abundance and population dynamics, many fishery experts recommend a precautionary approach to setting TACs — establishing the limits at the low end of the range. The most holistic approach recognizes the importance of the entire ecosystem instead of just single species, and bases catch limits on "ecosystem sustainable yield" (ESY). This new framework reduces population collapses, allows fish populations to rebuild, increases overall food supplies for other marine wildlife, reduces fishing costs and increases profit margins for fishermen over the long term (Grafton *et al.*, 2007; Worm *et al.*, 2009). The conversion of scientific advice into good policies, through a participatory and transparent process, is at the core of robust management (Mora *et al*., 2009).

Implement Ecosystem-Based Management

Most fishery management focuses on a single species or a group of species. In contrast, ecosystem-based management employs a comprehensive approach that considers individual fish populations as part of a larger living system, and addresses the cumulative effects of fishing, coastal development and other activities on marine resources (Ruckelshaus *et al*., 2008; McLeod *et al*., 2005). Integrated management can lead to greater long-term stability of marine resources (Levin & Lubchenco, 2008). Ultimately, management should ensure that the entire ecosystem around a fishery thrives, not just the target fish population.

Establish Marine Protected Areas

Marine Protected Areas (MPAs) are valuable tools for conserving living resources as part of an ecosystem-based approach to management. Like wilderness areas or national parks on land, MPAs can be used to protect biologically rich habitats and help restore overexploited stocks and degraded areas. The IUCN suggests that MPAs should cover at least 20 to 30 percent of key ocean habitats in order to effectively conserve fish stocks and marine biodiversity (IUCN, 2003).

Establish Appropriate Economic Incentives

A key underlying cause of unsustainable fisheries and aquaculture is that fishermen and fish farmers often lack strong incentives to consider the long-term sustainability of fish stocks or collateral impacts to the marine environment. To address this, a growing number of fisheries around the world are managed with catch share programs, which give fishermen a long-term ownership stake in the fishery. Many countries — including Australia, Iceland, New Zealand and the United States — have implemented catch share programs with great success, although such programs have not been as successful in other countries (Chu, 2009). Under the halibut catch share program in Alaska, managers extended the length of the fishing season, which led to higher prices for fishermen, improved crew safety and increased efficiency for the industry as a whole. Implementation of catch shares and associated management measures has been shown to reduce the threat of fishery collapse (Leal *et al*., 2004; Costello *et al*., 2008). The main mechanism for this appears to be ensuring that the catch does not exceed set quotas (Melnychuk *et al.*, 2011), underlining the need for strongly enforced science-based catch limits (see page 46). Other incentives, such as rewards for using less damaging fishing gears, are sure to be important solutions.

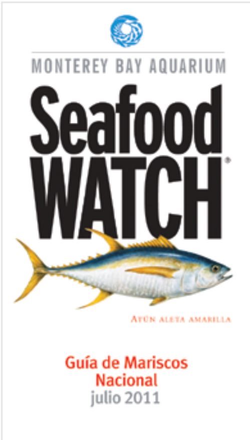
End Perverse Subsidies

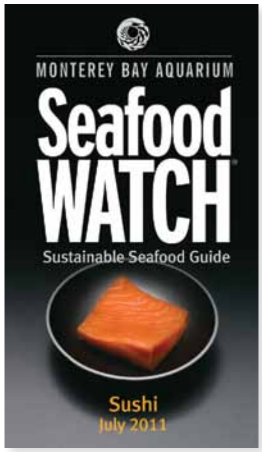
Government subsidies to the commercial fishing sector have been designed to stimulate growth in a nation's capacity to catch fish. The Sea Around Us Project estimates that global fishery subsidies were on the order of $30 to $34 billion per year in 2000 (Sumaila & Pauly, 2006). However, these subsidies often have negative effects, artificially lowering the cost of fishing and putting more boats in the water than there are fish to catch. International trade negotiations and agreements can help to remove subsidies that result in negative environmental impacts and unfair trading advantages.

Support Sustainable Aquaculture Policies

The rapid expansion of aquaculture worldwide makes urgent the need for careful oversight. Government agencies can advance sustainable aquaculture methods and policies by:

- Appropriately siting aquaculture facilities based on an ecosystem approach to protect sensitive habitats (*e.g.*, coastal wetlands) and address cumulative impacts.
- Reducing pollution with improved monitoring and treatment of wastewater from aquaculture operations.
- Reducing dependence on fishmeal and fish oil, specifically by encouraging the farming of species that do not require significant amounts of animal protein or oil in their feed, and by investing in research and development of alternative feeds.
- Creating strong regulations aimed at reducing the introduction of non-native species, the spread of diseases and parasites and the industry's dependence on wild fisheries for feed.
- Promoting ecosystem-based, sustainable management for wild fisheries that are used in aquaculture feeds.
- Improving transparency by monitoring the quantities of chemicals and drugs used in operations, and ensuring that all data collected by regulators is publicly available.
- Developing sustainability performance standards for aquaculture that will reduce the industry's potential impacts.





In addition to the regional Seafood Watch pocket guides, Monterey Bay Aquarium produces a Spanish language version, a sushi pocket guide, which lists Japanese names and is more specific to what consumers are likely to find in a sushi bar, and iPhone and Android smartphone applications.

How Individuals Can Help

The choices that consumers make have an impact on our oceans. Every time we purchase seafood, we have the opportunity to vote with our dollars to support fishermen and fish farmers working to find innovative solutions to problems like overfishing, bycatch, habitat destruction and unsustainable aquaculture. Because it can be difficult for individuals to know which seafood choices are best, organizations including the Monterey Bay Aquarium have developed simple, science-based tools – such as consumer shopping guides that fit in your wallet – to help. Consumers can also find guidance on how to send a compelling message to large businesses that handle vast quantities of seafood. Ultimately, this will create stronger incentives for the sustainable use of ocean resources (see the success story on Atlantic swordfish on page 43).

Make Informed Seafood Choices

Get, Use and Share a Sustainable Seafood Pocket Guide

Every time you purchase seafood, your choices affect the oceans. Carry the Monterey Bay Aquarium Seafood Watch consumer pocket guide that's right for your region – it will help you make educated, ocean-friendly choices in restaurants or grocery stores wherever you live. Always ask where your seafood comes from and whether it was wild-caught or farmed. By asking questions, and knowing what to look for and what to avoid, you can enjoy seafood that is caught or farmed in ways that don't significantly harm the oceans. Since 1999, Monterey Bay Aquarium has distributed nearly 40 million Seafood Watch pocket guides; by simply using and sharing the pocket guide with your friends and family, you can be an active voice for marine conservation.

Buy MSC-Certified Seafood Products

The Marine Stewardship Council (MSC) was established in 1997 to develop standards for sustainably managed, wild-caught seafood. The MSC's standards are applied by independent third-party certifiers, and certified for sustainability and traceability. Seafood products from certified fisheries can elect to bear the MSC's eco-label.

Eat Less and Waste Less

Increased demand for seafood is at the heart of the many threats to the oceans documented in this report. Global fisheries and aquaculture operations supply about 110 million tons of seafood annually – an average of two servings of seafood per person per week. Frequent consumers of seafood should be particularly conscientious about the effects of their purchases on the oceans. By choosing seafood classified by Seafood Watch as a "Best Choice" or "Good Alternative," consumers can be confident that increased demand will not place too much pressure on fisheries.

Eat Local and Seasonal Seafood

Purchase local seafood that is listed on the "Best Choice" or "Good Alternative" lists whenever possible. Buying food from local waters improves the likelihood that you know where the fish comes from, how it was caught and what species it is. It also reduces the carbon footprint of shipping and packaging. A good alternative is eating fish flash-frozen at sea to ensure freshness. Frozen seafood can be easily shipped by boat rather than air freight, reducing the carbon footprint of transport. However, even when local, eating seafood from the Seafood Watch "Avoid" list is not a recommended choice.

Eat Lower on the Food Web

It is not just how much we eat, it is what we eat. By diversifying our diet to include shellfish and smaller fish (*e.g.* anchovies, sardines, squid), we can reduce the ecological footprint of the seafood in our diet.

Support Sustainable Seafood Companies

Look for companies that have made a commitment to source environmentally-responsible seafood according to a set of science-based standards. Seafood retailers and restaurants play a crucial role in the conservation of marine resources. Some seafood companies have taken a leadership role and have made specific commitments to sustainable seafood. With the popularity of sustainability on the rise, it's equally important to watch for companies that tout sustainability but have self-defined standards – or no standards at all – to support their claim.

Be an Advocate for Responsible Ocean Policies

Strong policies that increase the level of environmental protection for the oceans are critical to restoring healthy, thriving marine ecosystems. In most parts of the world, current laws and regulations are weak and insufficient. Policy change may rest in the hands of elected officials, but they are ultimately responsive to public outcry. Communicating the importance of ocean preservation to elected officials may be the single most powerful action that individuals can take.

SUCCESS STORY

The Conservation Alliance for Seafood Solutions

Helping Businesses Move Ahead on Seafood Sustainability

For most companies, it is a challenge to define and institute a meaningful sustainable seafood policy. To assist businesses, a collaboration of 16 leading U.S. and Canadian organizations, called the Conservation Alliance for Seafood Solutions (www.solutionsforseafood.org), developed the Common Vision for Environmentally Sustainable Seafood. The Common Vision outlines six clear steps companies can take to develop a comprehensive corporate policy on sustainable seafood. Steps in the Common Vision include: (1) make a commitment to sustainability; (2) collect data on the sustainability of seafood products; (3) buy environmentally responsible seafood; (4) be transparent; (5) educate customers, suppliers and employees; and (6) engage in and support policy reform that supports the sustainable management of fisheries and aquaculture operations.

Since its launch in 2008, more than 20 companies have pledged their support for the Common Vision, including Walmart, Overwaitea Food Group, Compass Group North America and Giant Eagle.

TOP NORTH AMERICAN SUSTAINABLE SEAFOOD COMPANIES

The companies highlighted in green have public sustainable seafood sourcing policies and are working in partnership with members of the Conservation Alliance for Seafood Solutions.

Figure 15. North American grocery store commitments to sustainable seafood. (Supermarket News).

Grocery Stores	OVERALL SALES
Walmart *Partnership with the Marine Stewardship Council (MSC), World Wildlife Fund (WWF) and the Sustainable Fisheries Partnership (SFP)* Walmart, Sam's Club	$311 billion
Kroger Company *Partnership with WWF and MSC* Baker's, City Market, Dillon's, Food 4 Less, Foods Company, Fred Meyer, Fry's, Gerbes, Hilander, Jay C Food Stores, King Soopers, Kroger, Owen's, Payless Super Markets, Quality Food Centers (Qfc), Ralph's, Scott's, Smith's	$81 billion
Costco Wholesale Corp. *Partnership with WWF and MSC*	$77.9 billion
Target *Partnership with FishWise*	$67 billion
Safeway *Partnership with FishWise and SeaChoice* Safeway Canada, Carr's, Dominick's, Genuardi's, Pavilions, Randall's, Safeway, Tom Thumb, VONS	$41 billion
Supervalu *Partnership with WWF and MSC* Acme, Albertson's, Biggs, Bristol Farms, Country Market, Cub Foods, Farm Fresh, Hornbacher's, Jewel-Osco, Lucky, Save-a-Lot, Shaw's, Star Market, Shop n' Save, Shoppers	$37.9 billion
Loblaws *Partnership with WWF Canada and MSC*	$30.6 billion
Publix Super Markets *Partnership with SFP*	$25.1 billion
Ahold USA *Partnership with New England Aquarium* Stop & Shop, Giant, Martin's Food Market	$23.4 billion
Delhaize America *Partnership with Gulf of Maine Research Institute*	$18.8 billion
Sobeys *Partnership with SFP*	$15.6 billion
Meijer *Partnership with SFP*	$14.2 billion
BJ's Wholesale Club *Partnership with SFP*	$10.6 billion
Whole Foods Market *Partnership with Monterey Bay Aquarium, Blue Ocean Institute and MSC* Harry's Farmers Market, Wild Oats	$9 billion
Giant Eagle *Partnership with SFP*	$8.6 billion

Grocery Stores (continued)	OVERALL SALES
H.E. Butt Grocery Co. H.E.B., Central Market	$16.1 billion
Wakefern Food Corp ShopRite, PriceRite	$11.8 billion
Metro	$11.1 billion
Trader Joe's Market	$8.5 billion
A & P	$8.1 billion
Winn-Dixie Stores	$6.8 billion

Food Service and Broadline Distributors	OVERALL SALES
Sysco Corporation *Partnership with WWF*	$34 billion
US Foods *Partnership with MSC*	$18.9 billion
Compass Group *Partnership with Monterey Bay Aquarium* Bon Appétit Management Company, Eurest, Morrison, Chartwells, Flik International, Restaurant Associates, Wolfgang Puck Catering, Canteen, Levy Restaurants	$9.9 billion
ARAMARK *Partnership with Monterey Bay Aquarium*	$8.6 billion
Sodexo Alliance *Partnership with MSC*	$8 billion
Performance Food Group	$10.3 billion
Gordon Food Service	$7.7 billion
Reinhart Foodservice, Inc.	$4.5 billion
Maines Paper & Food Service	$3 billion
Food Services of America	$2.6 billion
Ben E. Keith Foods	$2.1 billion
Delaware North	$1.9 billion
Shamrock Foods Co.	$1.8 billion
Cheney Brothers	$900 million
Gate Gourmet	$749 million
Centerplate, Inc.	$750 million

Figure 16. Overall sales of U.S. food service companies and broadline distributors that source seafood. (Food Management's 2011 Top 50 Management Companies; ID Report 2011 Top 50 Broadline Distributors).


SILVER WAVE
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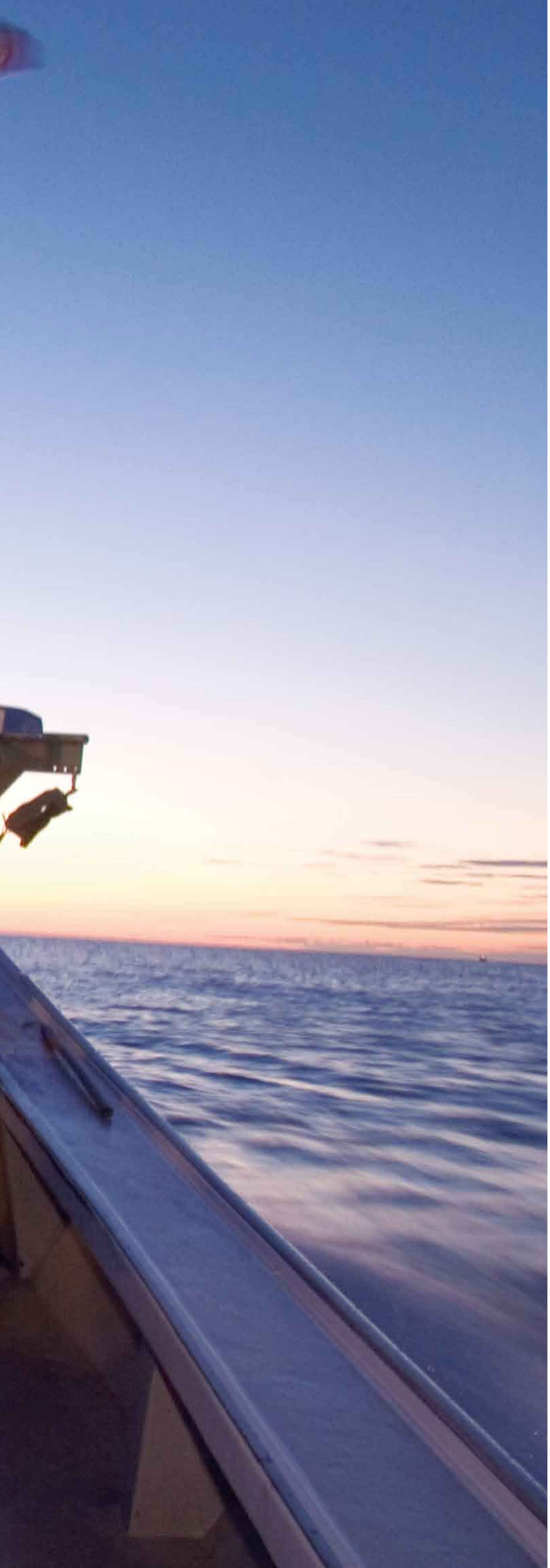

A fishing boat heading out before dawn in Prince Edward Island, Canada. Taylor S. Kennedy/National Geographic Stock

Conclusion

Earth's oceans sustain us. In addition to their value as a source of food, jobs and income, they play a central role in the functioning of the Earth's ecosystems. Without healthy oceans, life would not be possible.

For most of human history, the sea supported an astonishing and diverse array of life. In reviewing the available data, *Turning the Tide: The State of Seafood* demonstrates that much of that majestic wildlife has been depleted; the majority of commercial fisheries have been pushed to their productive limits or collapsed.

What will the coming decades bring? As the global standard of living increases and human population grows, demand for seafood will only grow. Aquaculture will soon provide the majority of our seafood — a development that brings its own compounding set of challenges. To meet future demand while maintaining or restoring natural ecosystems, wild-caught and farmed seafood production must become more sustainable.

There are many reasons to believe that this transition has begun. After decades of depletion, wild fisheries in several regions of the world are improving, thanks to new management approaches that are reducing exploitation rates, preventing overfishing, promoting new technologies and restoring ecosystems. Fishermen are working with governments on developing new, conservation-oriented initiatives. Science-based management of fisheries and aquaculture has succeeded in protecting underwater landscapes in a wide range of settings, and the market for sustainable seafood is growing. Forward-thinking chefs, food suppliers and seafood producers have taken innovative steps to adopt environmentally responsible practices. Consumers are driving the movement by connecting the fish on their plates with the living oceans from which they come, by voting with their wallets. These trends are positive, and offer hope for the future.

This movement has just begun. Individuals, businesses, fishermen, fish farmers and governments all have important roles to play in building the momentum. Together we can turn the tide.

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