Covering The Seas

An Issue Guide written by Paul Greenberg

WITH SUPPORT FROM THE DAVID AND LUCILE PACKARD FOUNDATION'S MARINE FISHERIES PROGRAM

Internews

EARTH JOURNALISM NETWORK

COVERING THE SEAS

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Why Report on the Ocean?

Is it really over? Are these last gatherers of food from the wild to be phased out? Is this the last wild food? Is our last physical tie to untamed nature to become an obscure delicacy?

- Mark Kurlansky, Cod

Atlantic salmon in a fish farm, Ryfylke, Norway Photo by Erling Svensen / WWF-Canon

The ocean is one of the most dynamic and at the same time most under-reported food systems on the planet. About a billion people rely on fish as their primary source of protein and, collectively, the nations of the world catch around 90 million metric tons of wild fish and shellfish from the oceans annually. This is equivalent to the weight of the human population of China removed from the sea each and every year. The United Nations Food and Agriculture Organization (FAO) produces a highly useful report every two years called The State of World Fisheries and Aquaculture (abbreviated as SOFIA) that identifies trends in the seafood industry. These and other sources note that in the last 60 years the global wild catch has risen approximately 400 percent.

But the harvest of wild fish is only half the story. In addition to the growth of fishing, the farming of freshwater and ocean organisms, or "aquaculture" as it is commonly called, has risen from producing only a few million metric tons per year in the 1960s to more than 60 million metric tons annually. Currently, aquaculture is increasing at an annual rate of 6.9 percent per year. This qualifies aquaculture as the fastest growing form of animal husbandry in the world. The growth of aquaculture is likely to continue. We are reaching the limit of the amount of arable land that can be used for terrestrial agriculture. Climate change, soil degradation, and shortages of fresh water are also placing serious limitations on land-based food systems. It is therefore very likely that the ocean will play an ever larger role in meeting the nutritional needs of future generations.

Meanwhile, as we increase our reliance on the oceans for food, we are threatening the ocean's resiliency. Human-caused climate change is placing stress on marine environments. The ongoing and significant rise of sea temperatures will have profound impacts. Not only are fish migration patterns changing, but the melting of the polar ice caps, particularly in the northern hemisphere, is also opening up vast new areas of previously unfishable waters. In the next century the competition for these newly accessible food resources will escalate as the world's major powers jockey for position to secure those resources for their populations.

The ocean is also chemically changing in dramatic ways in response to human influences on the environment. Sea water is becoming progressively more acidic due to the influence of industrially generated carbon in the atmosphere. The ocean today is also subject to severe influxes of nitrogen- and phosphorous-based nutrients that industrial agriculture and wastewater treatment facilities are introducing into the marine environment. The resulting oxygen-depleting algal blooms that come about because of all these added nutrients (a phenomenon called "eutrophication") has resulted in more than 400 large "dead zones" around the world – areas where water is so oxygen-poor that fisheries are threatened. In all, some 245,000 square kilometers of ocean are affected with some of the largest hypoxic areas being in the East China Sea offshore from the Yangtze River, on the US side of the Gulf of Mexico at the mouth of the Mississippi River, and in the Baltic Sea off Scandinavia and Russia.

All of this is happening as seafood is increasingly seen as a healthier alternative to land-based proteins. Notwithstanding worries about pollutants in seafood, recent health studies have identified the regular consumption of seafood to be critical to prenatal development, heart health, and neural resiliency. Most notably, the prestigious Journal of the American Medical Association in a meta-analysis of scientific studies to date on seafood concluded that the overall benefits to eating seafood far outweigh the risks.

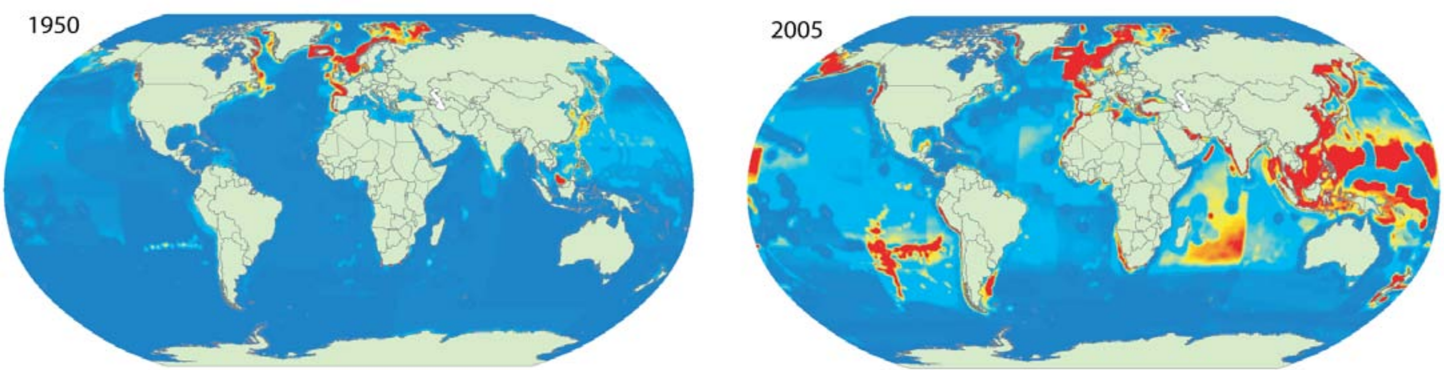
While all of the above might be unsettling news for our oceans and our future, it is actually good news for the journalist who seeks to cover the ocean. The best reporting always occurs at the nexus of conflicting points of interests and opposing visions for the future. In this respect, the ocean is an environment where conflicts of interests abound; an environment where issues of climate change, population growth, wildlife management, energy development, state of the art animal husbandry and a host of other disciplines overlap. By knowledgably positioning oneself at the intersection of these different disciplines and conflicts, the enterprising journalist can make a career, or at least a beat, covering ocean issues and contributing to a better societal understanding of how best to share ocean resources in the future. The journalist in China is particularly well situated to make a global contributions to the dialogue on ocean issues. China is today not only the largest harvester of wild fish and shellfish but also by far the largest grower of farmed seafood.

But before jumping in, so to speak, it's first necessary to orient oneself among some fundamentals and identify a manageable selection of data and analyses so that pursuit of one's story is on sound scientific footing and presented in a way that will draw readership and future interest. With that in mind, let's begin.

Seafood: Wildlife or Food?

"Imagine what people would say if a band of hunters strung a mile of net between two immense all-terrain vehicles and dragged it at speed across the plains of Africa. This fantastical assemblage, like something from a Mad Max movie, would scoop up everything in its way: predators such as lions and cheetahs, lumbering endangered herbivores such as rhinos and elephants, herds of impala and wildebeest, family groups of warthogs and wild dogs. Pregnant females would be swept up and carried along, with only the smallest juveniles able to wriggle through the mesh.... left behind is a strangely bedraggled landscape resembling a harrowed field... this efficient but highly unselective way of killing animals is known as trawling . . . it is practiced the world over every day, from the Barents Sea in the Arctic to the shores of Antarctica and from the tropical waters of the Indian Ocean and the central Pacific to the temperate waters off Cape Cod."
- Charles Clover, The End of the Line

The Expansion of Global Fishing



Primary Production Required (PPR) to sustain global marine fisheries landings, expressed as percentage of local primary production
Sea Around Us, UBC

Seafood is the last wild food. Indeed we are at a place with the exploitation of wild seafood similar to where we were with terrestrial animals 10,000 years ago. It is as if we are just emerging from our Neolithic caves, trying to figure out how to eat from herds of wild animals while maintaining their long-term viability.

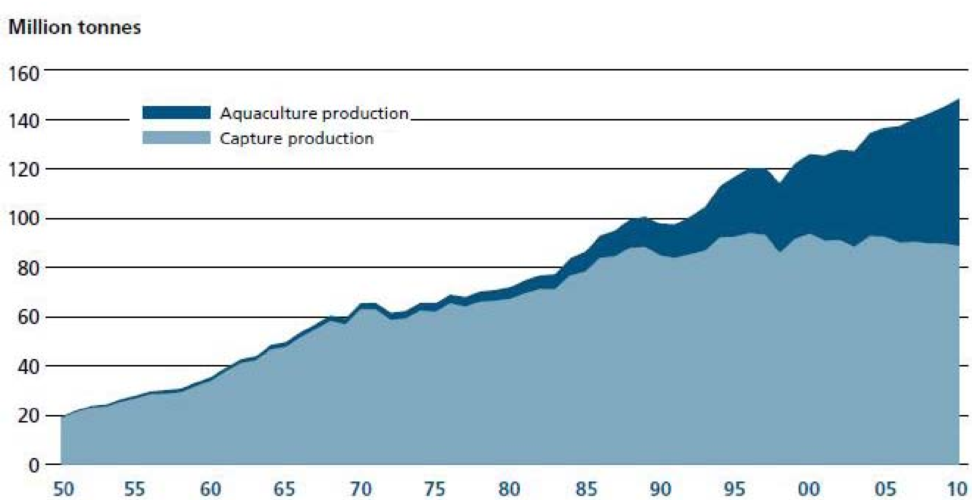
Up until the mid-1970s, attempts to rationally exploit wild fish had not fared much better than our ancestor's Neolithic management techniques of wild land game. This mismanagement stemmed from the fact that humans had a poor and incomplete knowledge of the dynamics that underlie wild fish populations. This is understandable. For most of human history, our ability to catch fish was often compensated for by nature's ability to replace them. Fish and shellfish are remarkably fecund. Most fish produce hundreds of thousands, if not millions, of eggs. As a result, when "removals" occur, fish have the potential to rebuild their populations relatively quickly. And while there have in the past been notable exceptions of locally specific overfishing in pre-industrial societies, a general global trend of over-exploitation of fisheries was not recognized until the mid-20th century.

Perhaps the greatest change in the dynamic between fish and humans came as a result of innovations stemming from World War II. Wartime research and development produced significant innovations in maritime technology. Sonar was perfected, enabling vessels to locate fish populations and fish-rich habitat remotely with greater and greater precision. Petroleum-based polymers were advanced considerably, allowing for the production of lighter-weight fishing line and nets. Diesel engines aboard fishing vessels were lightened and strengthened, increasing the range and the number of days at sea a vessel could spend fishing. Finally, mobile freezing technology was advanced, giving fishing vessels the ability to range the open ocean, freeze their catches at sea and continue fishing until their holds were full. There was also an economic and political driver behind all of this growth: nations reeling from food crises after World War II saw the subsidization of fishing as a way to alleviate hunger. Governments also saw expanding fishing fleets as a way to assert national sovereignty beyond their shores into the High Seas.

FISHING EFFORT

The combined total potential of fishing present within a given fishery. Fishing Effort is often expressed as "E" in fisheries management equations

All of this greatly increased what is called "**FISHING EFFORT,**" or as the FAO defines it "the amount of fishing gear of a specific type used on fishing grounds over a given unit of time." From the end of World War II to the present era the global fishing fleet has increased by 75 percent to 4 million vessels. With that increase came a dramatic increase in harvest. A rise from 20 million metric tons in 1920 to over 90 million metric tons in the late 1980s. At present it is widely recognized that there are simply too many boats, nets, and hooks in the water. According to the World Bank's "Sunken Billions" report, the world's fishing fleet is more than twice as large as it needs to be to catch the amount of fish that is available to be sustainably harvested.



World capture fisheries and aquaculture production, 1950 to 2010

Source: UN Food and Agriculture Organization, 2012

OVERFISHING

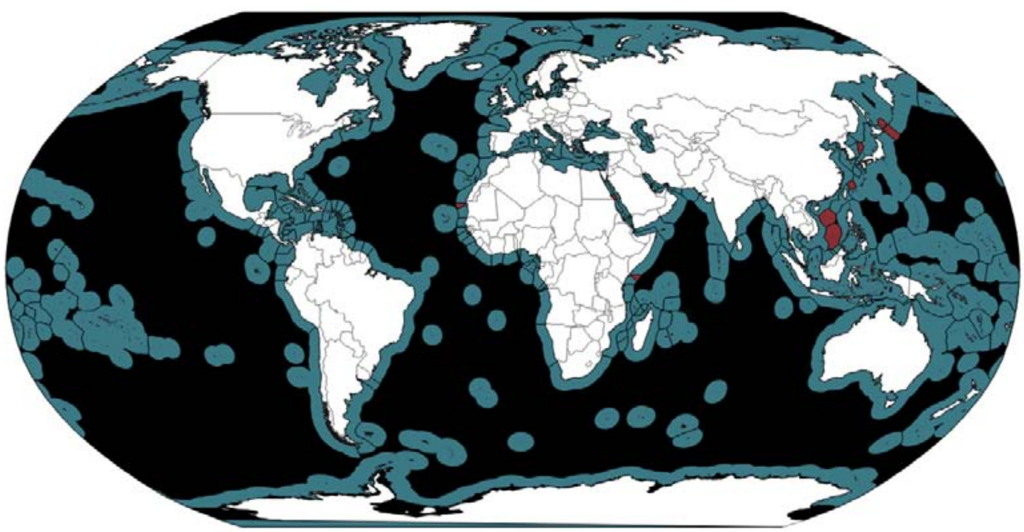
Overfishing is defined to occur when fishing mortality is higher than the level at which fishing produces the maximum sustainable yield (MSY). A stock is overfished when stock biomass has fallen to a level below that which can produce MSY

The result is a phenomenon called **"OVERFISHING"**, a condition in which a given population of fish or shellfish, sometimes called a "stock," is exploited beyond a productive equilibrium point. Overfishing is now estimated to cost the world $50 billion per year. The same World Bank report cited above notes that 75 percent of the world's wild fish stocks are "underperforming" – in other words, fished too heavily to produce a maximum, consistent yield. And while the total global catch has remained fairly constant at around 90 million tons for the last two decades, some scientists believe this consistency is an illusion. A recent study in the journal PLoS ONE noted that over the last half century fishing increasingly reached into larger and larger portions of the ocean. That territorial expansion continued even as the world catch leveled off. In other words, larger and larger portions of the ocean must now be fished in order to simply match the levels of the historical world catch.

The Beginnings of Reform

Fisheries management occurs at the intersection of science and policy. Because many fish species are highly migratory and do not recognize national borders, it is necessary for nations to reach international agreements in order to come to a rational plan for fisheries exploitation. But for most of human history, such accords were impossible because nations had no coherent agreement on who owned the ocean in the first place. To some extent, the normalization of ocean ownership can be considered the first step in fisheries management and only in the last quarter century has some degree of rationalization of this vital component being realized. Prior to the 1970s, nations had little or no jurisdiction over the open ocean. In 1609 a Dutch political philosopher named Hugo Grotius wrote the treatise "Mare Liberum," or "The Freedom of the Seas." In this work Grotius asserted that oceans, beyond the near shore of a given nation, should be free for all to use. For 350 years, this treatise was the de facto law governing fisheries exploitation.

EXCLUSIVE ECONOMIC ZONE (EEZ)
The ocean territory extending from three nautical miles from a country's shoreline out to 200 nautical miles.



Exclusive Economic Zones of the World

Areas in black are high seas waters while red areas red are disputed regions.

Source: MarineRegions.org, 2013

This began to change in the 1950s as individual nations, finding their fisheries resources considerably depleted, began declaring **EXCLUSIVE ECONOMIC ZONES (EEZS)**. Chile and Peru, which are home to the world's largest fishery (Peruvian anchoveta), were the first nations to declare territorially exclusivity from the shoreline out to 200 nautical miles (roughly 370 kilometers). Other nations followed suit, notably the United States, which unilaterally declared a 200-mile EEZ in 1976 as part of a sweeping fisheries reform law called the Magnuson-Stevens Act. Eventually the United Nations codified the concept of EEZs into international law, in what became known as the **UNITED NATIONS CONVENTION ON THE LAW OF THE SEA (UNCLOS III)**. The treaty was drafted in 1982 and came into effect in 1994. 164 nations have signed the treaty including the People's Republic of China. To date, the United States has not signed.

UNITED NATIONS CONVENTION ON THE LAW OF THE SEA (UNCLOS)
The treaty that established, among other things, territorial limits in the ocean for up to 200 nautical miles from shore. UNCLOS has been ratified by 164 nations but not by the United States

Management in the Modern Era

With territorial ownership clarified, many nations began the process of taking inventory of their marine resources and planning for rational, sustainable harvests of seafood. But it is important to note that even the most advanced nations and well-trained scientists must rely on random sampling and abstract mathematical modeling to judge the size of a wild population of fish and the amount that can be harvested. Nobody is yet capable of physically counting every fish in the sea. At times, the models used to judge the size of fish populations have proven to be flawed, leading to overestimates of the number of fish that could sustainably harvested over time.

In tandem with this historical overestimation was the application by fisheries manager of a concept introduced some 80 years ago called **"MAXIMUM SUSTAINABLE YIELD,"** or MSY. As defined by the US's National Marine Fisheries Service, MSY is "the largest long-term average catch or yield that can be taken from a stock or stock complex under prevailing ecological and environmental conditions." The basic premise behind MSY is that a given population of fish or shellfish can and should be fished up to a maximum value that is calculated according to an estimate of the existing biomass of a fish's population, that population's fecundity (or rate of replacement), and the extraction rate (or "fishing effort") present in the fishery.

MAXIMUM SUSTAINABLE YIELD (MSY)

The highest theoretical equilibrium yield that can be continuously taken (on average) from a stock under existing (average) environmental conditions without affecting significantly the reproduction process. Also referred to sometimes as Potential yield .

The Norwegian fishing vessel Roaldnes

CREDIT: M Tovik, MarrineTraffic.com

The primary criticism of an MSY approach to management is that this model of exploitation does not adequately address other variables within a marine ecosystem, including natural (non-fishing) environmental causes for population fluctuations as well as the inter-related dynamics of multiple organisms that may be disrupted in the presence of significant fishing effort. In addition, critics argue that "limited information regarding catch levels, the impact of management measures, and the condition of the fish population at the time of exploitation adds to the uncertainty." It is for this reason that in 1995 The U.N. Fish Stocks Agreement (UNFSA) was established to require that "precautionary standards" be set that take into account some of these uncertainties. In addition biologists are increasingly advocating for "ecosystem-based management" schemes that, theoretically, would seek to establish multiple species parameters to ensure long-lasting stability of an entire range of species within a given environment.

The application of UNFSA has been inconsistent across nations. But as computing power has increased and sampling methodology has improved, it appears that scientists are building better fisheries models. Among fishing nations, Iceland, Norway, the United States, Australia and New Zealand have all in the last 20 years implemented fishing policies that have caused a stabilization and rebuilding of many stocks of fish. The US, through management plans instituted in 1996, has focused on 44 fish stocks for improvement. According to a report by the US NGO Natural Resources Defense Council, "Of these [fish stocks] 64 percent can currently be considered rebuilding successes: 21 have been designated rebuilt (and have not been determined to again be approaching an overfished condition) or have exceeded their rebuilding targets, and 7 have made significant rebuilding progress, defined as achieving at least 50 percent of the rebuilding target and at least a 25 percent increase in abundance since implementation of the rebuilding plan."

Perhaps the most important tool for fisheries rebuilding has been the institution of rights-based quota systems. Sometimes referred to as **INDIVIDUAL TRANSFERABLE QUOTAS (ITQS)** or **"CATCH SHARES,"** the various forms of rights-based fishing system assign a certain tonnage of a catch to a limited number of fishing entities. The goal in doing this is to limit the total number of fishermen that can enter a given fishery, and to prescribe the amount of fish that each fisherman can catch. Rights-based fishing systems started as early as the 1950s but began accelerating in earnest around the mid-1970s. Prior to the institution of rights-based fishing schemes, fishing was often regulated through a seasonal approach. Managers would open a fishery on a given date and close it months, or sometimes only days, afterwards. This practice resulted in what has come to be known as the "race for fish"– too many vessels trying to extract as much fish as they could before the season closed.

With rights-based fishing systems, managers predetermine a science-based harvest tonnage and pre-allocate that tonnage to the different participating parties. With a limited number of permits being issued to a limited number of vessels for a prescribed amount of fish, managers can theoretically arrive at a more precise tonnage of fish that are withdrawn from the system. Rights-based approaches to fisheries management seem to have positive ecological benefits. In a 2008 paper in the journal ***Science***, researchers found that fisheries that used rights-based systems were half as likely to suffer collapse as those without rights-based management systems in place. Some examples of successful rights-based fishing programs can be found here.

But rights-based fishing schemes can come at societal cost – something the journalist would be well advised to track. The assignment of quota has a tendency to consolidate the ownership of fisheries into the hands of fewer and fewer more powerful entities. The "transferable" aspect of ITQs mean that large companies may purchase quota from smaller parties. In Chile, for example, one of the world's largest fishing nations, consolidation in the fisheries sector has

INDIVIDUAL TRANSFERABLE QUOTAS (ITQS)

A rights-based fishing system whereby certain tonnages of a catch are assigned to a limited number of fishing entities. Similar to, sometimes synonymous with, catch shares (see above), ITQs can typically be bought, sold and traded which can theoretically help promote efficiency but has been accused of leading to consolidation of fishing effort.

CATCH SHARE

A form of rights-based fishing where shares of a given catch quota are pre-allocated to one or more parties. Catch shares theoretically limit overfishing by pre-determining catch amounts before fishing even begins.

resulted in only seven companies controlling 90% of that nation's fishing quota. This, critics argue, undermines coastal communities and overly "corporatizes" fishing.

One solution to this phenomenon is a recently emerging concept called **COMMUNITY-BASED MANAGEMENT (CBM)** systems. CBM systems may also employ a quota approach. But whereas most quota systems divide harvest among fishing interests regardless of their local affiliation, community-based management proponents often seek to acquire quota for the community at large and then divide quota among parties in the community that would, theoretically best serve the interests of those who live and work on the coast. The goals of community-based management as defined by the American NGO Ecotrust are to achieve a system "in which fishermen and their communities exercise primary responsibility for stewardship and management, including taking part in decision making on all aspects of management, such as harvesting, access, compliance, research and marketing."

COMMUNITY-BASED MANAGEMENT

Another form of rights-based fishing where catch allocation is granted to a community of fishermen. Community based management schemes may also include other elements of management including habitat conservation and water quality control

Purse seine fishermen fish for squid and cuttlefish on the central coast of Vietnam. Photo by David Mills, WorldFish, 2009.

Certification and Fleet Revision

While controversial, rights-based management systems have led to the emergence of global sustainability certification schemes for fisheries that are increasingly popular on the international marketplace. The most widely known of these is the Marine Stewardship Council (MSC). Created in 1997 through a partnership between World Wildlife Fund (WWF) and the international supermarket consortium Unilever, the MSC seeks to set standards for fisheries around the world. These standards are based on a number of metrics that include sustainability of catch over time, environmental impact of the fishery on the marine environment, and **"BYCATCH"** -- the unintentional killing of non-targeted species (a very common problem in nearly all wild fisheries that results in 16-17 million metric tons of wasted seafood every year). To date, MSC has certified approximately 200 fisheries worldwide. While significant, this number still represents less than 10 percent of the world's fisheries.

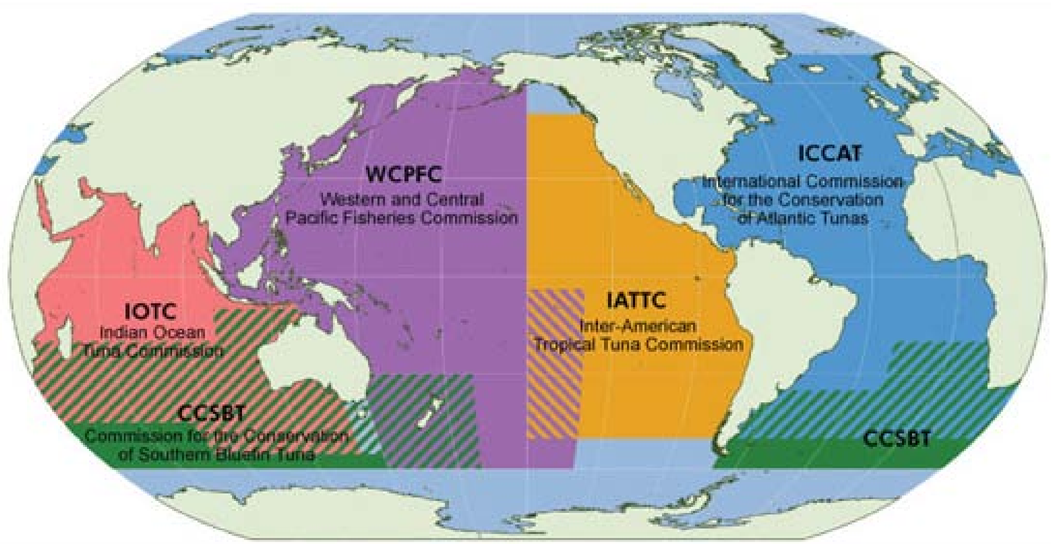
BYCATCH

Fish and wildlife accidentally caught in pursuit of a target species. Shrimp fishing for example can result in bycatches as high as 6 kilograms of bycatch for every pound of shrimp landed

Coupled with calls for better management has come, in some of the world's wealthier countries, the policy goal of decreasing the overall "fishing effort" of nations—i.e. the shrinking of national fishing fleets. In some cases, as in the United States, fisheries authorities have tried to implement a "buy back" program whereby what is deemed excess fishing capacity is purchased by the government and decommissioned. This has been a particular problem in the European Union where it has proved difficult for nations to reach an overall ceiling in the number of vessels fishing.

But as large industrialized nations try to decrease their fishing effort, emerging economies seem to be moving in the opposite direction. As Joseph Powers, who sat on the International Commission for the Conservation of Atlantic Tunas (ICCAT), put it, "When you start talking about negotiating quotas, the first thing that comes up is the historical catches of rich countries. People from developing countries in Africa, where a lot of tuna fishing happens will say, 'You came down and nailed us over the years, and so we're entitled to catch as much now as you had back when tuna fishing started.' And so you get countries like Brazil, Namibia, and the North African countries all wanting their piece of the action." China has been particularly ambitious in the expansion of its fishing fleet in the last quarter century.

The Big Loophole: The High Seas and Highly Migratory Fish



HIGH SEAS
Ocean territory beyond the 200 nautical mile (370 kilometer) limit of nations' exclusive economic zones. High Seas fisheries are difficult to monitor and regulate and the site of most of the world's illegal fishing today

Source:
Pew Environment.org

As individual countries have asserted sovereignty over their exclusive economic zones, some nations have seen their local fisheries improve. But this nationalization of the near shore has in some senses merely shifted the problem of overfishing from near shore to offshore environments. Nations have jurisdiction over their territorial waters out to 200 nautical miles, but beyond that limit is what is known as the **"HIGH SEAS"** – international waters owned by no one but fished by many. As a result, high seas fishing has increased much more quickly than have all other types of fishing, by some estimations by as much as 800 percent.

REGIONAL FISHERIES MANAGEMENT ORGANIZATION (RFMO)
The 17 multinational councils that manage high seas regions outside of nations' Exclusive Economic Zones

The most notable increase has occurred on those 23 species of the taxonomic family *Scombridae* -- known commonly as "tuna" – fish that range the open ocean and which may migrate hundreds if not thousands of kilometers during the course of their lives. Tuna and other highly migratory species are managed through international organizations called **REGIONAL FISHERIES MANAGEMENT ORGANIZATIONS (RFMOs)**. In all, there are 17 RFMOs, each with a mandate to manage a given section of the world. But as the map below reveals, these areas are vast and it is unclear to date whether management has been effective.

Tuna and all high seas fisheries are also deeply affected by what is referred to in governmental circles as **ILLEGAL, UNREGULATED AND UNREPORTED (IUU) FISHING**. Also known as "pirate fishing," IUU fishing takes place outside management regimes and severely disrupts any attempts made to rationalize global fisheries. Up to $23.5 billion in fisheries wealth is lost to IUU fishing every year, and the total illegal catch may be as high as 20 percent of all fish caught globally.

The other fishery where high seas and IUU issues are of great concern are in the waters surrounding Antarctica, often viewed as one of the final frontiers of fishing. Currently Antarctic waters are governed by an RFMO called the Commission for the Conservation of Antarctic Marine Living Resources. In the past IUU fishing for the high value Antarctic and Patagonian toothfish of the genus *Dissotichus*, (more commonly known as Chilean Sea Bass) have been notable. The Antarctic krill fishery (*Euphausia superba*) is also one that concerns ecologist, not only because fishing is difficult to regulate in the Southern Ocean, but also because krill are a keystone prey species for fish and marine mammals. Krill are increasingly being harvested to supply the dietary supplements industry as well as the aquaculture industry.

Marine Protected Areas: A Central Debate of 21st Century Fishing

There are some in the marine conservation community that believe that no matter how much fishing is controlled and how well quotas are managed, large portions of the ocean still need to be set aside as **MARINE PROTECTED AREAS,** or MPA as they have come to be called. Industrial fishing techniques such as bottom **TRAWLING** damage marine habitats and it can take many years for a trawled environment to recover. MPAs and other forms of protection currently encompass less than 2 percent of the ocean. But there is now emerging a substantial global marine protected area movement. This is particularly notable in the Pacific where recently large tracts of the ocean have received new protected status around island nations in the last ten years There is also a growing movement to protect a large area of the Ross Sea in the Antarctic as a marine protected area.

One of the key things that MPAs accomplish is the protection of the largest spawning females. "Big Old Fat Female Fish" or "BOFFF's" as fisheries scientists call the biggest, older breeders, lay exponentially more eggs than smaller individuals and preservation of these larger fish is typically very difficult in environments that are heavily fished.

IUU FISHING
Illegal Unregulated and Unreported Fishing. Fishing that occurs without permits outside of the management regimes of nations. IUU fishing causes not only economic damage for lack of payment for quota but also makes fisheries management difficult because in the presence of IUU fishing managers cannot adequately assess the total removals of fish from a given ecosystem.

MARINE PROTECTED AREA (MPA)
A zone in which fishing is either greatly curtailed or eliminated altogether. Some managers argue that Marine protected areas can serve to recharge a fishery, providing refuge to older individuals which can achieve a "spill over effect" into adjacent non protected areas.

TRAWLING
The dragging of a large net, often along the bottom of the sea. Trawling accounts for the largest amount of wild fish caught and may also result in excessive collateral damage to benthic environments.

While embraced by conservationists around the world, the fishing industry has historically opposed MPAs and some fisheries scientists like the University of Washington's Ray Hilborn assert that there are significant downsides to the implementation of MPAs. This debate is likely to be a key one for journalists to track in the years ahead.

Conclusion and Resources

Wild fisheries management and ocean jurisdiction are evolving. Tracking those changes and making them comprehensible to the lay reader is the great challenge to the journalist in the years ahead. Access to ocean-going vessels is not always possible, especially offshore vessels which may stay at sea for weeks if not months at a time. Government data is often unreliable. According to UBC's Daniel Pauly, China for example overstated its catch dramatically to the FAO from 1995-1999. Nevertheless, wild fisheries are a subject worth covering. They are key to human survival and their rational management is one of the major achievable goals of the current century. To further the reporting and encouragement toward those ends, below are a few resources that may prove useful.

SEAFOOD OR WILDFOOD | *WEBSITES*

FishBase is a searchable database of all the world's fish species with search criteria fields available in Mandarin.

The ***UN Food and Agriculture's fishery page.*** The best resource for global fisheries governmental data. Available in Mandarin.

The ***Sea Around Us Project*** of the University of British Columbia in Canada. Reports and graphics on global fisheries trends.

Seafood Watch, a project of the Monterey Bay Aquarium. This site allows users to search by species and get a sustainability ranking. It also provides longer reports on individual species and sometimes stocks or countries of origin of individual species

The Southeast Asia Fisheries Development Center

A "global ship tracker" that allows users to track the locations of individual ships in the ocean

Home page of the ***Marine Stewardship Council***. Lists of certified fisheries as well as certification criteria.

Sustainable Fisheries Partnership tracks the progress of "fisheries improvement" i.e. fisheries that lack international certification but which are trying to transition to better management practices

A good clearing house for information about tuna. ***ISSF's*** mission is to undertake science-based initiatives for the long-term conservation and sustainable use of tuna stocks

The official website the United States government's ***National Marine Fisheries Service***

The seafood sustainability site of the ***Monterey Bay Aquarium*** with sustainability rankings for individual fish. Also useful here are the lengthy fish-by-fish reports contained at the bottom of every rankings page.

FishSource is a searchable data base on the conservation status of fisheries around the world

The seafood page of the ***World Wildlife Fund***

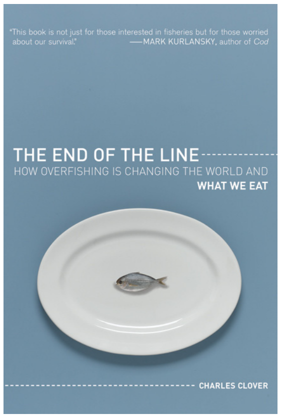
A global directory of marine protected areas

The nonprofit ***Pew Environment Group***'s seafood initiatives

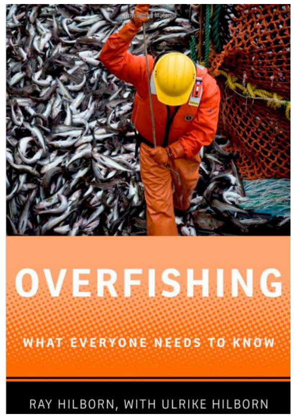
Probably the best seafood industry publication. Requires a paid subscription to view but well worth it if your publication is covering the ocean regularly

Seafood Business Magazine. Also good for regular updates on the seafood business

SEAFOOD OR WILDFOOD | *BOOKS*



The End of the Line,
Charles Clover
A global expose on overfishing



Overfishing,
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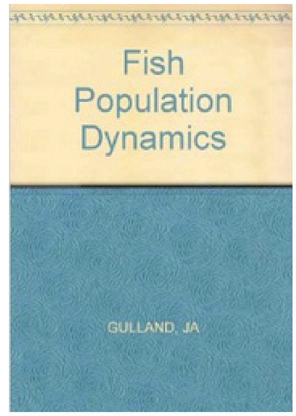
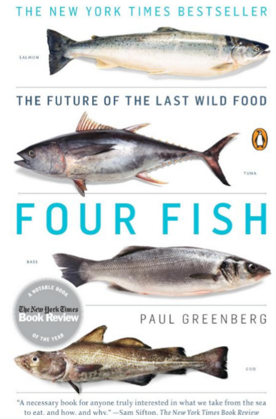
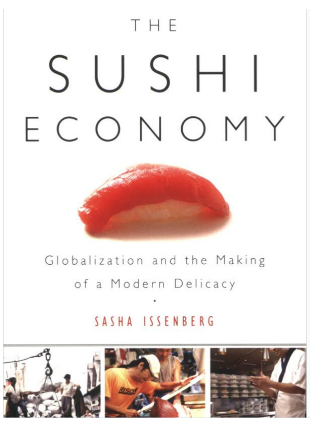


Fish Population Dynamics,
J. L. Gulland.
A fairly technical explanation of the vagaries of patterns of fish populations



Four Fish,
Paul Greenberg.
An examination of salmon, sea bass, cod and tuna in farmed and wild form



The Sushi Economy,
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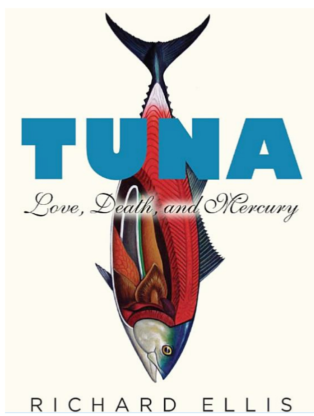
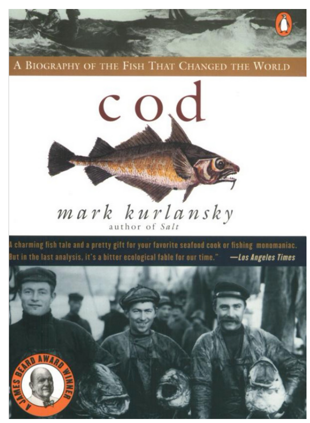
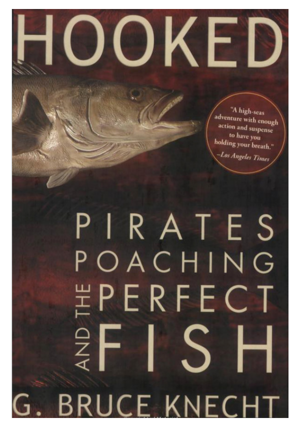


Tuna: a Love Story,
Richard Ellis.
A global story of tuna

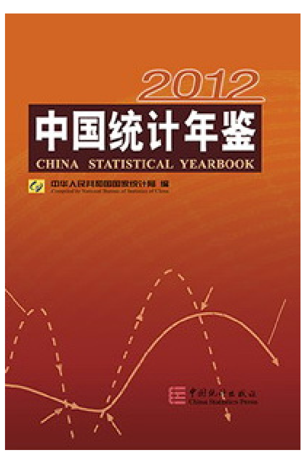


Cod
Mark Kurlansky
. An excellent "biog-raphy" of Atlantic codfish that puts the global fisheries situation in historical perspective.



Hooked: Pirates, Poaching and the Perfect Fish,
Bruce Knecht.
An examination of illegal fishing with particular focus on Chilean sea bass.

MANDARIN SOURCES:



China fisheries yearbook
(The latest version is for 2013)
China seafood and fishing vessels and gears imports and exports.(The latest version is for 2012)

Website of 2012 ***World Ocean Week*** in Xiamin

Aquaculture and Mariculture: A Sea Change

"We must plant the sea and herd its animals . . . using the sea as farmers instead of hunters. That is what civilization is all about — farming replacing hunting."
- Jacques Cousteau

Mariculture off the coast of Chile, EcoTrust 2013

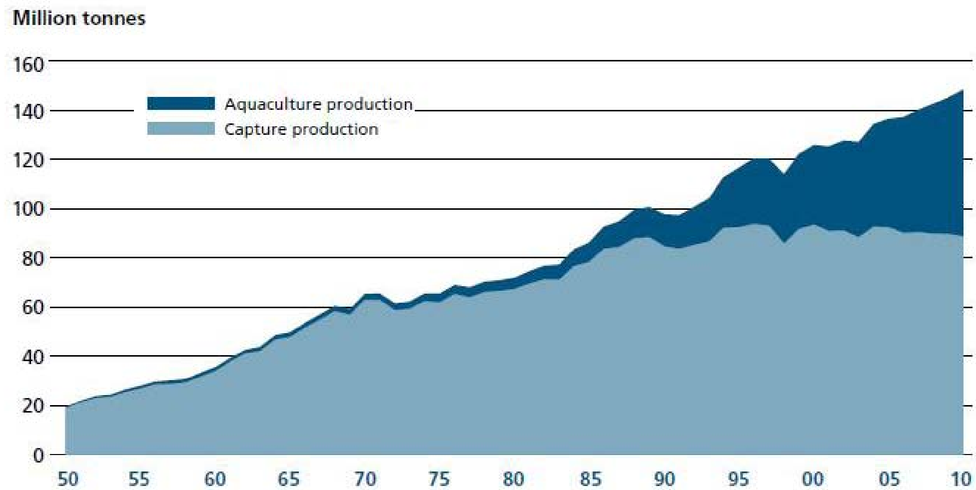
Aquaculture and Mariculture: Scarcity Breeds Abundance

If we return to the central infographic that fisheries analysts use as their benchmark, the rate of seafood exploitation over the last 70 years as produced by the UN's Food and Agriculture Organization, the most notable trend aside from the rise and eventual plateauing of the total wild catch is the rise of **AQUACULTURE** (products grown in a freshwater environment) and **MARICULTURE** (products grown in a saltwater, marine environment). For the purposes of simplicity we will refer to them both as "aquaculture" throughout the remaining text since that term is commonly applied to both environments in popular and scientific literature.

The dark blue portion of the graphic on the next page represents farmed marine product grown on a global basis. It's instructive to note that it first begins to surge just as world capture fisheries begin to level off. This is no coincidence. The world's population continued to grow even as the total wild capture from the ocean's reached its limit. By the time modern aquaculture was born in the late 1970s, there literally was nowhere else for us to turn if we wanted to continue to eat from the sea. But just as with the surge in fishing from 1950 to 2000, the boom in aquaculture often came at considerable environmental cost. Any journalist covering the ocean today needs to understand the dynamics of those costs and to be able to discuss the tradeoffs between fishing and aquaculture in a coherent way.

AQUACULTURE
The culture of fish and shellfish technically in freshwater environments. More recently aquaculture is used to describe farming systems in both fresh water and saltwater

MARICULTURE
Farming of marine organisms (as opposed to aquaculture which is technically the farming of freshwater organisms)



World capture fisheries and aquaculture production, 1950 to 2010

Source: UN Food and Agriculture Organication, 2012

The Beginnings of Aquaculture

The history of aquaculture is a long one, although it is only recently that the practice became one of global significance. Ancient Egyptians may have farmed Nile tilapia (*Oreochromis niloticus*) in ponds adjacent to the mighty river as long ago as 4000 BCE. China, too, was an early adopter and produced the world's first aquaculture manual. The Chinese Fish Culture Classic by the scholar Fan Lai was written around 475 BCE and standardized for the first time the methodology for rearing fish.

周　陶朱公　撰
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A facsimile of "The Chinese Fish Culture Classic by Fan Lai, c. 475 BCE

For most of the next 2000 years of aquaculture, farmers focused on freshwater fish with various species of carp (family *Cyprinidae*) being the primary varieties used for cultivation. Carp made for a natural first choice for fish farming because they possessed a series of traits that make them highly adaptable to the farm. Some of those traits include:

- Fast growth
- Adaptability to a wide range of feeds and water temperatures
- Ability to withstand crowding in contained areas

Early forms of aquaculture with carp at their center were largely environmentally sound and even benign. It is speculated that carp culture began in tandem with Chinese propagation of silk worms and rice. Silk worm casings, discarded after worms metamorphosed into butterflies, proved to be excellent aquaculture feed for carp. Rice could be fertilized by carp feces and grown in carp ponds. In this way, the ancient form of aquaculture was in fact a "polyculture"—a system that produced multiple species with multiple uses, which recycled waste and which provided the independent farmer with food throughout the year.

Another good example of a polyculture system – this one involving saltwater species -- is the *gei wai* system used in China, which entailed capturing young marine life brought in by high tides in ponds along the shoreline, then growing them to adulthood. This method can still be seen in action at the Mai Po Marshes Nature Reserve near Hong Kong.

The Blue Revolution: The Rise of Modern Aquaculture

For most of aquaculture's history, production was of a small-scale, artisan nature. This would begin to change after World War II with the beginning of the domestication of key species or groups of species that have become the fundamentals of the modern global seafood market. Today, 50 percent of all aquaculture production is finfish, 25 percent is aquatic plants, and 25 percent are crustaceans (shrimp, prawns, crabs) and mollusks (clams, oysters, mussels, etc.). Most of the most commonly farmed species are still carp. But in the last 40 years, several new classes of species have been added that now greatly contribute to aquaculture development and trade. Among these new forms of culture are:

SALMON: Fish of the family *Salmonidae* collectively referred to as "salmon" lend themselves to aquaculture because, unlike many fish, they hatch out of a large nutrient rich egg. Salmon juveniles can live off this egg sac for a number of days and then transition directly onto industrially produced feed pellets.
This obviates the need for live larval feeding, something necessary for other finfish species.
Salmon farming was first pioneered in Norway and Scotland in the 1960s and

Salmon "alevin" with egg yolk sac

CREDIT: US Department of Agriculutre, 2011

70s. Selective breeding was introduced shortly thereafter allowing farmers to double growth rates in a little more than a decade. *Salmo salar*, the only one endemic to the Atlantic ocean, is the species that dominates world markets and now there are more farmed *Salmo salar* salmon in the world than the total wild population of all species of salmon combined, Atlantic and Pacific. Not coincidentally, salmon aquaculture arose just as wild populations of Atlantic salmon hit their nadir. Atlantic salmon are now "commercially extinct" in the wild – too rare to support commercial fisheries.

SHRIMP: There are thousands of species within the scientific order *Decapoda* that are called "shrimp" or "prawns," but only a few of them have been domesticated. For centuries, shrimp were farmed using semi-wild methods. Wild fry were collected from estuaries and then grown in ponds to maturity. In the 1940s, the Japanese scientist Motsugu Fujinaga first "closed the lifecycle" on a species of shrimp, meaning that he was able to grow a shrimp from egg to adult and then in turn produce viable offspring entirely under human control. From these early successes, shrimp farming grew to embrace other species in the 1960s, including the black tiger prawn (*Penaeus monodon*) and eventually the world's most dominant shrimp, the whiteleg shrimp (*Litopenaeus vannamei*). Today, the great majority of shrimp grown are white leg shrimp.

TILAPIA: After the six species of farmed carp, tilapia is seventh most commonly farmed in terms of overall tonnage. China alone produces around1.2 million metric tons of the fish, much of which is exported. There are two species of tilapia that are widely farmed — Nile (*Oreochromis niloticus*) and Mozambique (*Oreochromis mossambicus*). Both are originally native to Africa and both were farmed for thousands of years in small artisan systems. The fish started reaching the rest of the world after World War II, spreading throughout Asia. Both Israel and Norway developed high-tech tilapia breeding programs, creating much faster growing lines. Tilapia offer considerable advantages as farmed fish in that they do not require animal protein in their feed in order to grow and thrive. Their neutral flavor has also made them a preferred replacement for depleted ocean populations of fish like cod.

CATFISH: Freshwater catfish of the scientific order *Siluriformes* are fast-growing and omnivorous, making them a natural choice for aquaculture. The United States was among the first to take the lead in their production, growing large amounts of blue and channel catfish in the 1970s. But in the 1980s, Vietnam began to dominate the global catfish industry by propagating species of the family ***Pangasius***. Called "tra," "basa," or "swai" on the international market place, Pangasius are a major export commodity being farmed throughout Southeast Asia. Pangasius also serve the "white fish" market, acting as a functional replacement for species like cod and pollock.

SEA BASS AND SEA BREAM: The farming of marine finfish is quite recent and still very much a work in progress. Two varieties, European sea bass (*Dicentrarchus labrax*) and several species of the family *Sparidae* (often called "sea bream") were the prototypes around which much of today's expanding marine aquaculture is based. Like most marine species, sea bass and sea bream require live feed at birth and the development of microscopic live feed in the form of rotiphers (*phylum Rotifera*) and artemia shrimp (primarily the species *Artemia salina)* were critical in making the sea bass and sea bream industries possible. With the lifecycles of sea bass and sea bream now closed, a whole range of other species are being considered, most notably cobia (*Rachycentron canadum*) and several species known collectively as seriolas. Indeed, in the next decades many more fish are likely to be domesticated, at which point key decisions will have to be made as to which fish should be cultivated and which should exclusively be the product of wild capture.

BIVALVES – OYSTERS, SCALLOPS, CLAMS AND MUSSELS: The culture of bivalves has existed for hundreds of years but as with finfish, scientists have managed to close the life cycle of these animals only recently. Unlike finfish, bivalves require no additional feed in order to grow. They subsist primarily by filtering the water of microscopic photosynthetic phytoplankton. For this reason the culture of bivalves is generally considered to be ecologically neutral if not beneficial.

KELP AND OTHER SEAWEEDS: By weight, seaweeds represent 25 percent of aquacultured product, with the majority being produced in China. Like bivalves, seaweeds require no additional feed and have the potential to remove nutrients like nitrogen from the water column.

Environmental Problems of Aquaculture

In food systems, nothing comes for free. All attempts at increasing human food supplies inevitably produce environmental consequences elsewhere. With aquaculture, those consequences are only now starting to be understood. Reporters looking to cover the aquaculture sector should be well versed in the environmental factors of aquaculture. Some of the key environmental factors are as follows:

FORAGE FISH IMPACTS: Though some aquaculture species are raised on vegetarian feed, many, particularly more recently domesticated species like salmon, require wild fish rendered as fish meal and fish oil for their food. What this means is that most of the time, it takes more than a kilogram of wild fish to create a kilogram of farmed fish. This finding was most famously publicized in a 2000 paper in the journal ***Nature***. In their report, Naylor et al. estimated that the Fish In – Fish Out ratio, or "FiFo" as the feed-to-edible product ratio is called, could be more than 3 kilograms of forage fish to produce 1 kilogram of edible farmed fish. Since their paper was published, the fish farming sector has grown more feed-efficient, but subsequent studies such as "Little Fish Big Impact" by the Lenfest Forage Fish Task Force continue to assert that the exploitation of the world's forage fish is undermining marine food webs. Some 20 percent of the world catch is now forage fish, the vast majority of which is used for aquaculture feed.

FORAGE FISH
Smaller, often filter feeding fish that serve as prey for many popular food fishes. Anchovies, sardines, and even more predatory mackerel can all fall under this category. At present about 20 percent of the global catch is forage fish harvested to feed aquacultured fish, pigs, chickens and pets

POLLUTION: The farming of marine fish, crustaceans and even bivalves produces waste in the form of fecal matter and unused feed. These largely nitrogen-based wastes can cause oxygen depletion in coastal environments and a net loss of marine productivity in certain coastal areas. Additionally, the use of antibiotics, antifoulants, and pesticides are all problems that aquaculture can introduce into the marine environment.

HABITAT DESTRUCTION: Of all aquaculture practices, the farming of shrimp has probably generated the most criticism. Shrimp are farmed in tropical and subtropical ponds and impoundments that are frequently sited within the confines of coastal mangrove forests. Because pollutants can accumulate in ponds over time, in the early days of shrimp culture ponds were often abandoned, only to be replaced by new ponds.

Aerial View of Shrimp Farms

By far the greatest threat to mangrove swamps comes from the rapidly expanding shrimp aquaculture industry, which offers a high economic return.

CREDIT:
American Museaurm of Natural History / CBC, 2009

Diseases such as the bacterially-caused vibriosis and the viral "white spot" disease also led to pond abandonment. This process resulted in the destruction of hundreds of thousands of acres of mangrove forests – ecosystems critical to the production of wild fish and the protection of the coast from storm surges. Though mangrove cutting has abated in recent years in some places—most notably in Thailand where mangrove cutting is now illegal—new challenges continue to arise. In 2009, a new shrimp disease called Early Mortality Syndrome (EMS) arose in China and spread throughout Southeast Asia. In 2013, losses from EMS totaled more than $1 billion.

ESCAPES: Until recently, many aquaculture operations have failed to adequately address the issue of escapes of farmed fish. Farmed fish and shrimp are often genetically different from fish inhabiting the adjacent environment and ecologists have expressed concern that farmed escapes are diluting wild populations' genetics. This is particularly worrisome in salmon aquaculture where millions of fish escape every year from netcages suspended in the open ocean. Tilapia too, which are grown in freshwater ponds have a great proclivity to take over watersheds should they escape.

DISEASE TRANSFER: The farming of species in wild environments can be a vector for disease proliferation in the wild environment. Disease transfer in salmon aquaculture is perhaps the most reported instance of this phenomenon. The disease infectious salmon anemia first appeared in Chile in the 1990s and has since been noted in other environments around the world. Poor biosecurity and global transfer of salmon larvae helped speed the transfer of the disease from country to country and even continent to continent. Sea lice primarily of the genuses *Lepeophtheirus* and *Caligus* are another frequently noted aquaculture side effect. Sea lice attach themselves to the skin of their intended victim and draw nutrients from the body of their host. This is particularly damaging to salmon juveniles. Critics of aquaculture note that large farm operations established near the migration routes of wild salmon can cause sea lice to aggregate and jump from farmed animals to wild.

The Emergence of Global Standards for Aquaculture

In the last 10 years, governments and large supermarket retailers have been more and more concerned about setting environmental and food safety standards for aquaculture. The Aquaculture Stewardship Council (ASC) grew out of a program of the World Wildlife Fund called The Aquaculture Dialogues in which producers were invited to arrive at standards for a selection of criteria that ranged from antibiotic use to feed conversion ratios to worker safety. In total, eight standards covering 12 species, have been formulated. Global G.A.P. covers similar ground with a greater focus on transparency for large retailers. Still another is the Global Aquaculture Alliance.

Although environmental concerns have been key in the development of these standards, another major driver has been consumer concern over seafood safety. The discovery in 2008 of the additive melamin in Chinese fish feed provoked widespread concern about aquaculture products, and since the 1990s the public has raised concerns about the possible overuse of antibiotics, particularly in shrimp production.

Conclusion, Future Topics for Research

Aquaculture is very much a work in progress and is evolving at a time of high sensitivity to the safety and sustainability of food systems. As it is a young industry, it is easy to criticize. But there are many distinct advantages aquaculture offers over land-based food production. The fact that aquaculture species are generally cold-blooded, neutrally buoyant, fecund and fast-growing means that they have the potential to be overall more efficient producers of protein than land-based farm animals.

On the other hand, unlike terrestrial animal husbandry, aquaculturists must often work alongside wild animals that resemble the animals they are farming. A growing minority of seafood producers have attempted to move aquaculture into contained, out-of-ocean facilities that do not expose the wild ocean to the vagaries of the farm. That said many of these out-of-ocean facilities are still too energy-intensive to be cost-effective. Scientists are progressing on alternative fish feeds that may allow the industry to reduce its reliance on wild-caught forage fish. Also on the horizon is the possibility of genetically modified fish, something that exists in the laboratory but not quite yet in the marketplace.

In contrast, a more ecological approach to aquaculture is now gaining attention. Polycultures that hail back to the original idea of re-using resources are being attempted on larger scales through the implementation of integrated multitrophic aquaculture (IMTA) in some locations. All of these subjects are worthy of further research by the enterprising journalist.

AQUACULTURE | *RESOURCES*

The ***Food and Agriculture Organization*** has complied a list of the species used in aquaculture

A report on the history of aquaculture from 1950-present by the ***Sea Around Us Project*** at the University of British Columbia

Little Fish Big Impact
Lenfest Forage Fish Task Force. Discusses issues of forage fish exploitation

The Aquaculture Dialogues
Discusses process of arriving at standards for aquaculture species

The website of the ***Aquaculture Stewardship Council***

The website of the ***United States aquaculture program***

The Great Salmon Run, a report on the effects of farmed salmon on wild salmon markets and production

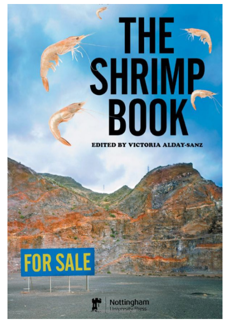
The website of the ***World Aquaculture Society***, a nonprofit trade association for the aquaculture industry

The aquaculture page of the ***Monterey Bay Aquarium***

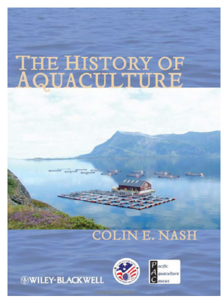
MANDARIN SOURCES

Global Aquaculture Alliance's Mandarin site

BOOKS

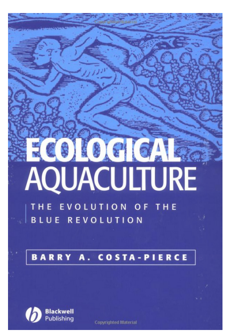


The Shrimp Book
A global look at shrimp culture



The History of Aquaculture
The History of Aquaculture traces the development of fish farming from its ancient roots to the technologically advanced methods of today.

Salmon Fever
A history of the book in salmon farming from the Norwegian perspective



Ecological Aquaculture,
Barry Costa-Pierce
A look at more sustainable options for aquaculture

Non-fishing Environmental Factors

"The world still sings. Yet the warnings are wise. We have lost much and we're risking much more. Some risks, we see coming. But there are also certainties hurtling our way that we fail to notice."
- Carl Safina, The View from Lazy Point

MODIS satellite image of Lake Erie, 10/9/11 showing algae bloom
Credit: NOAA. CoastWatch

It is tempting to look at fisheries and aquaculture in a vacuum, as if simply the rational management of wild fish and the implementation of sound aquaculture standards would be sufficient to keep the ocean healthy. But there are large, human-caused phenomena now affecting the oceans that severely impact the abundance of seafood. As with fisheries and aquaculture management, these issues are complex and worthy of the journalist's attention. It is beyond the scope of this toolkit to produce an in-depth discussion of every major environmental problem affecting the ocean, but below follows a brief outline of topics ripe for future investigation.

Eutrophication/Hypoxia

A regular influx of nitrogen and phosphorous-based nutrients is critical to the productivity of the ocean. Indeed, it is because of the presence of these two nutrients in near shore areas that blooms of phytoplankton are able to take place and form the basis of a marine food web. But it is possible to have too much of a good thing. In the last 100 years, nitrogen and phosphorous loads entering the marine environment have been surging, primarily from synthetic fertilizers, manure lagoons generated by livestock and from municipal and industrial wastewater.

When excessive amounts of nitrogen and phosphorous-based wastes enter a watershed, photosynthetic algae bloom in large amounts – larger than can be consumed by extant filter feeders and other organisms. When those same algae die, bacteria consume them and use up oxygen in the process of respiration. Under certain conditions, so much oxygen is consumed that the water becomes hypoxic, or so low in oxygen that complex life is compromised. In the last de-

EUTROPHICATION

A condition that results from excessive nutrients, particularly Phosphorous and Nitrogen loading a marine environment. When a marine or aquatic system is overly nitrified algae blooms may occur. When this same algae dies, bacteria consume it and in the process of respiration withdraw Oxygen from the water. The resulting water can as a result be too oxygen poor to support complex life

cade journalists have come to term these hypoxic areas "dead zones." Though not completely dead, they are areas where fisheries can be diminished due to lack of oxygen.

There are many ways to combat hypoxia, ranging from better farming techniques to the use of seaweeds and bivalves to process excess nutrient and algae loads. It's instructive to note that after the fall of the Soviet Union and the end of fertilizer subsidies in the Danube Basin, the world's largest "dead zone", in the Black Sea, largely disappeared. But on a global basis, dead zones are growing. There are now 245,000 square kilometers of dead zone in the world affecting ecosystems on every continent except Antarctica. In China, the most notable hypoxic areas occur seasonally in the East China Sea offshore west of the Yangtze River delta, in the Yellow Sea off the Yellow River delta, and close to shore in the vicinity of the Pearl River delta.

Estuary and salt marsh decline

The ocean at first glance appears to be huge. Looking at its broad expanses we are inclined to imagine it all full of fish. But when one examines the actual portions of the ocean that produce significant amounts of life, the ocean becomes a good deal smaller.

The map above shows zones of what is called "primary production" in the ocean – areas where photosynthetic **PHYTOPLANKTON** congregate forming the bases of marine food webs. It is immediately apparent that these zones of productivity occur close to shorelines, where nutrients drain into the sea from land. These are the biological hotspots of the sea. It is in part for this reason why nations were so motivated to stake a claim on their exclusive economic zones out to 200 nautical miles, as these are the richest parts of the oceans.

At the very edges of our continents where rivers meet the sea, ecological environments called **ESTUARIES** are formed. In these areas, 70 percent of our commercial seafood species spend at least part of their lives. The most important biological component of estuaries are the areas in which grasses, worms, shellfish and other organisms collectively form ecosystems called **SALT MARSHES**. These environments serve as safe havens for juvenile marine species. Salt marshes are the most productive ecosystems on earth. The average salt marsh can sequester 10 times as much carbon as a tropical rain forest.

Salt marshes are also areas that are being increasingly impacted by humans. In the last two centuries, coastal wetlands have been systematically drained to make room for housing, agriculture, and industry. In developing nations this process has accelerated greatly over the last half century. In China, where coastal development is only just starting to ramp up, 30 percent of the country's natural wetlands were lost in a single decade, from 1990-2000. This loss is expected to continue as sea levels rise. Rising seas inundate brackish marsh land, cause vegetation loss, and exacerbate the collapse of salt marsh.

Damming/Hydropower

A large portion of the fish of the world relies on rivers for a portion of its lifecycles. **"DIADROMOUS" FISH** like salmon (family *Salmonidae*), sturgeon (family

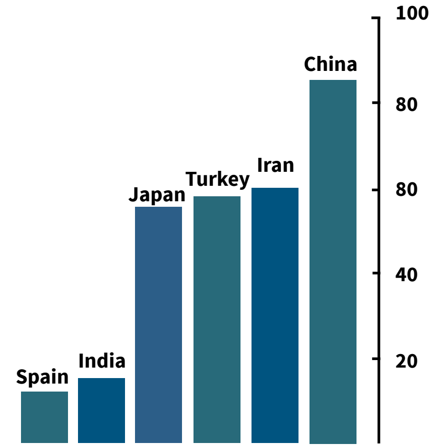
ESTUARY
An ecosystem that occurs at the margin of fresh and saltwater usually at the outflow of a river. Estuaries are among the world's most productive ecosystems, producing more food energy per unit of area than tropical rain forests.

PHYTOPLANKTON
Photosynthetic, microscopic marine organisms that are the base of the entire marine food web. Phytoplankton are consumed by zooplankton which are in turn eaten by fish. In this way energy is transferred from sunlight to complex vertebrates at the apex of the food web

SALT MARSH
An estuary based ecosystem that usually involves the complex collaboration of marsh grasses, shellfish, bacteria, worms and other organisms. Salt marshes are among the most productive ecosystems on the planet

DIADROMOUS FISH
Fish that migrate either from freshwater riverine systems to saltwater ecosystems (salmon, herring, e.g.) or the reverse (eels, e.g.).

Acipenseridae), shad and herring (family *Clupeidae*), and eels (order *Anguilliformes*) all migrate into rivers for a portion of their lives. The last 200 years have seen a serious impediment to the lifecycles of these fish in the form of dams. Humans have constructed dams for a variety of purposes ranging from irrigation to the supplying of mechanical power to adjacent mills to the generation of widely distributed electricity. Whatever their purpose, they now seriously hinder the passage of diadromous fish. There are now 48,000 large dams worldwide ("large" being defined as higher than 15 meters). Sixty percent of the world's major rivers are blocked by dams, and this is just taking into account large dams. Smaller obstructions number in the tens if not hundreds of millions. All of this limits the exchange of biological energy between stream and ocean and decreases overall species diversity. China is currently the world leader in the construction of new dams, but hydropower development is surging throughout the developing world. "Fish passage," or the retrofitting of dams with ladders and other structures designed to aid fishes' ability to swim past dams, is often proposed as a compromise to communities that would seek to expand hydropower. But as recent studies have found, most fish passage technology is ineffective, and dams nearly always result in serous disruptions to diadromous fish populations.



Dams under construction (over 60 meters high) Source: International Journal of Hydropower and Dams, 2005

Ocean Acidification

Perhaps the most worrisome problem the ocean faces is a newly observed phenomenon called [ocean acidification](). Acidification is a direct result of heightened amounts of carbon being introduced into the atmosphere through the burning of fossil fuels. Though this phenomenon is more commonly associated with the changing of the Earth's terrestrial climate, the oceans are being impacted too.

When carbon dioxide (CO2) dissolves in seawater, hydrogen ions combine with carbonate ions to form bicarbonate. Normally **CARBONATE IONS** are seized upon by calciferous organisms and used as the building blocks for shells. But when high levels of CO2 are dissolved in seawater a competing chemical reaction occurs that ties up carbonate ions and renders them as bicarbonate. Carbonate ions are thus removed from circulation and shell making becomes increasingly more difficult.

CARBONATE IONS

Positively charged ions in saltwater that calciferous organisms use to as building blocks for shells. Ocean acidification is contributing to a decline in available carbonate ions and may be affecting the ability of many organisms to form durable shells

OCEAN ACIDIFICATION is most notably visible in the diminishing of coral reefs. Acidification also seems to be affecting the culture of bivalves like oysters and clams. But there is a much larger issue at stake with acidification. At its lowest rungs, energy is transferred in the ocean food chain from photosynthetic phytoplankton (plant-like micro-organisms) to predatory zooplankton (animal-like micro-organisms, which feed on phytoplankton). Predatory zooplankton then consumer smaller forms of zooplankton are themselves, in turn, consumed by fish. The problem with acidification is that most zooplankton have calciferous (calcium-based) shells. A significant drop in the levels of zooplankton will surely mean a decline in the amount of fish in the sea.

OCEAN ACIDIFICATION

The result of a chemical reaction that occurs in sea water when excessive amounts of Carbon Dioxide are introduced into the marine environment. The ocean is naturally alkaline but due to the burning of fossil fuels the ocean is growing progressively more acidic. This can effect the formation of shells in calciferous organisms like zooplankton

Ocean acidification is being observed throughout the world but is most pronounced in the Pacific. Shellfish farmers in United States' Pacific Northwest region have experienced several years where shellfish larvae failed because of an inability to adequately form shells.

Temperature Shifts

Ocean temperatures are rising at a slower rate than terrestrial temperatures, but even a subtle change in temperature in the ocean can cause serious disruptions. The melting of the polar ice caps means that more and more territory will become available to global fishing fleets, and a paucity of agreements over those new fishing grounds means there is a large potential for wide-scale overfishing.

More significantly, water temperature changes seem to be altering the migratory patterns of many species of commercial seafood species. It is still too early to know how those shifts will manifest themselves, but shifts will require a broad rethinking of management strategies, commercial quotas and territorial boundaries. As temperatures change and ice floes melt in the Arctic and Antarctic, releasing large quantities of freshwater into polar ecosystems, salinity shifts may also occur, further changing fish distribution.

Most significant of all, warming seas could disturb the fundamentals of the marine food web. This goes back to the essential phytoplankton/**ZOOPLANKTON** relationship that underpins all marine life. Phytoplankton blooms tend to be driven by daylight. As days lengthen toward the end of winter, these photosynthetic organisms bloom to take advantage of the increased sunlight. Meanwhile, zooplankton blooms tend to be triggered by temperature, not light. With warmer oceans, zooplankton are likely to bloom too early, before phytoplankton is present. This could eventually cause mass die-offs of zooplankton, which in turn would cause similar die-offs among the larval fish that depend on zooplankton for their fodder.

Mercury, PCBs and other Industrial Pollutants

The environmental factor in the ocean that is perhaps of greatest concern to a popular readership is industrial pollutants and the role they play in contaminating seafood supplies. This, like many ocean problems, is one born during the 20th century and stems directly from innovations made in the chemical industry. The two most noted pollutants contaminating the global seafood supply are **METHYLMERCURY** and **POLYCHLORINATED BIPHENYLS** or PCBs.

Methyl mercury differs from elemental mercury in that it is a positively charged ion that readily combines with molecules in the human body. It became internationally infamous after the Chisso Corporation of Japan dumped large quantities acetaldehyde into an enclosed body of water called Minimata Bay from 1908-1955 – a bay where large amounts of shellfish were harvested by the local population. Over 2,000 individuals were diagnosed with what came to be called Minimata Disease – a syndrome of severe birth defects marked by extreme skeletal and organ deformations. The Chisso Corporation finally settled claims with injured parties for a sum in excess of $80 million.

A much more common form of methylmercury contamination today comes from the burning of coal. Mercury is often contained in coal seams and when exposed to high heats during commercial combustion becomes "methylated" and thus absorbable by the human body. China is by far the largest burner of coal in the

ZOOPLANKTON
Microscopic animals that feed primarily on phytoplankton and which in turn feed filter feeding forage fish like herring, anchovies and sardines.

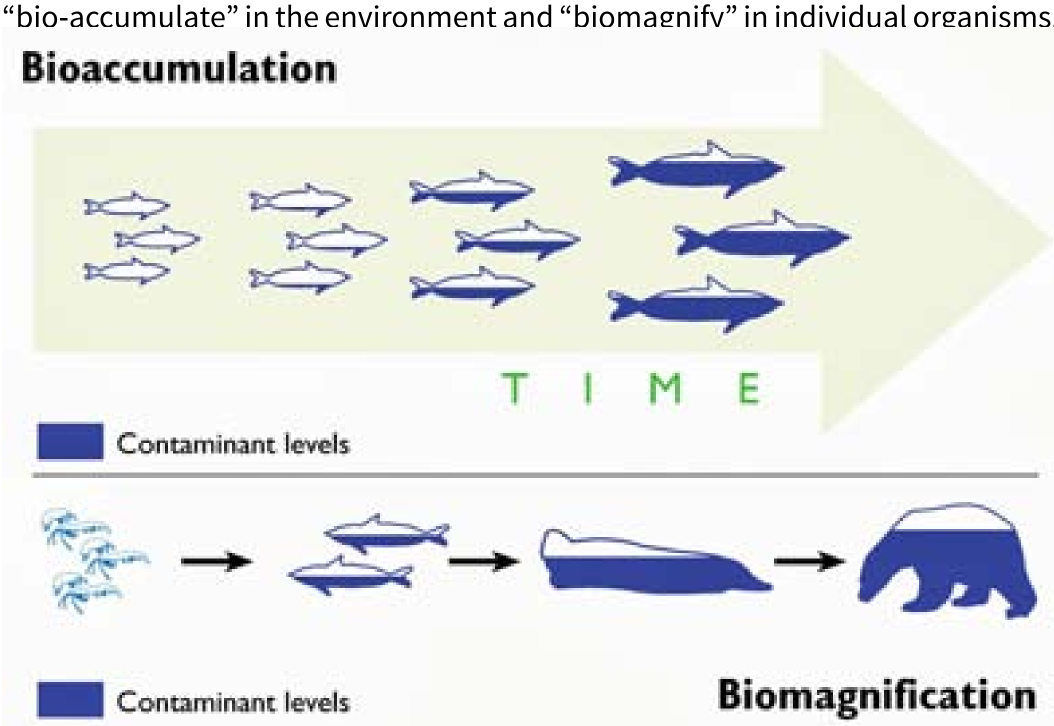
METHYLMERCURY
any of various toxic compounds of mercury containing the complex CH3Hg− that often occur as pollutants formed as industrial by-products or pesticide residues, tend to accumulate in living organisms (as fish) especially in higher levels of a food chain, are rapidly and easily absorbed through the human intestinal wall, and cause neurological dysfunction in humans

POLYCHLORINATED BIPHENYLS OR PCBS
PolyChlorinated Biphenyls, are a group of organic chemicals which were formerly used as hydraulic fluids, plasticizers, adhesives, fire retardants, way extenders, de-dusting agents, pesticide extenders, inks, lubricants, cutting oils, in heat transfer systems, carbonless reproducing paper. They are known carcinogens and can bio-accomulate and amplify in edible fish and shellfish

world.

Polychlorinated biphenyls or PCBs were invented in the late 19th century and used as coolants and inhibitors because of their chemical stability. Large amounts were released into the environment throughout the 20th century, and by the 1960s they became associated with various forms of cancer and heart disease. The production of PCBs was banned in the United States in 1976. But because of the extreme stability of these chemicals they have persisted in the marine environment for many years and will be with us for many years to come.

Both methylmercury and PCBs are problematic because of their tendency to "bio-accumulate" in the environment and "biomagnify" in individual organisms.



Bioaccumulation **and biomagnification in marine organisms**

Because both chemicals are resistant to degradation they are passed up the food chain even after the organism that contained them is consumed. A predatory organism, therefore, receives close to the total pollution load of all the organisms beneath it on the food chain. As a result, apex predators like tuna, sharks and swordfish will tend to have higher pollutant loads than smaller animals because they have in effect absorbed the pollution load of several rungs of the marine food ladder beneath them. Fish with long life spans may also be subject to high mercury and PCB levels because they have had a greater time span to accumulate pollutants.

As countries have become more aware of the dangers of these pollutants they have sought to ban their use in industrial production. Particularly successful has been the United States' Federal Water Pollution Control Act, more commonly known as the Clean Water Act. But new chemicals collectively known as Persistent Organic Pollutants, or POPs, are constantly being invented and the ramifications of those new compounds are often poorly understood even as they are introduced into the marketplace. A reporter who covers the ocean will likely be the first to uncover the environmental consequences of these new compounds.

Environmental Factors | *RESOURCES*

The Website of Restore America's Estuaries (RAE), an NGO devoted to ***estuary research and restoration***

An overview on ***global wetlands loss*** written by the Salmon and Trout Association

"***Altered Oceans***" an award-winning series by the Los Angeles Times on environmental conditions affecting the oceans

Clean Water Act
The Complete Text of the United States Federal Water Pollution Control Act of 1972

A clearing house for links about ***hypoxia/dead zones***

The US government's page on ***ocean acidification***

The website of ***American Rivers***, the US's largest NGO devoted to dam removal and the ecological health of rivers

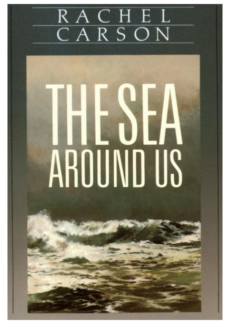
United Nations ***Global Mercury Assessment***

MANDARIN SOURCES

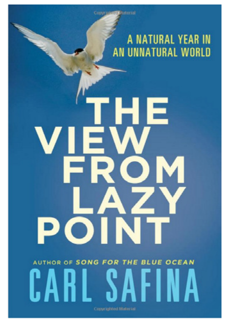
Chinese environmental law resources as compiled by the United States Environmental Protection Agency

An overview on ***Chinese environmental policy***

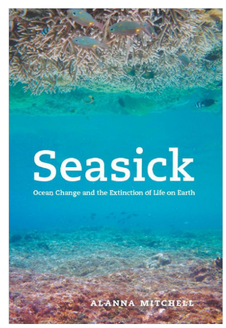
BOOKS



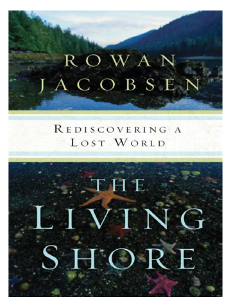
The Sea Around Us,
Rachel Carson
A fundamental book on ocean ecology



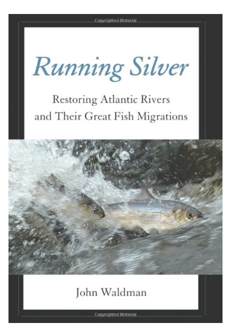
The View from Lazy Point,
Carl Safina
A wide ranging book on how the ocean is changing



Seasick,
Alanna Mitchel
An award-winning book on chemical changes to the ocean



The Living Shore,
Rowan Jacobson
An excellent discussion on the mechanics and importance of estuaries



Running Silver,
John Waldman
A look at river ecology and how dams have impacted diadromous fish

Goals & Solutions for Ocean Problems

Approaches for Journalists

The last century has seen dramatic changes in the exploitation of the ocean. As with terrestrial systems before it, that pattern has been one of poorly regulated expansion of wild harvest followed by similarly unregulated expansion of animal husbandry. By the outset of the 21st century it has become clear that this kind of open-ended, unregulated expansion cannot continue. If we are to achieve the goal of a stable, sustainable supply of seafood for all global citizens we must try to understand and regulate the oceans effectively. There are virtually no more new wild stocks of fish to find and exploit. Many regions have also reached their environmental carrying capacity for aquaculture. Moving forward, therefore, the goal of fishing and aquaculture as well as the goals of journalists covering these industries, is to discover and encourage solutions that work toward the stabilization of the world seafood supply.

Toward this end the reporter should keep in mind five principle goals for reforming the management of fisheries and aquaculture:

1. **THE ACHIEVEMENT OF SCIENCE-BASED, RIGHTS-BASED MANAGEMENT SYSTEMS OF WILD STOCKS**. It is increasingly clear that quota systems that limit the number of parties that can enter a fishery and that pre-allocate catch volume before fish are caught contribute favorably to stabilizing wild fish populations. The great challenge of the next few decades will be to bring all fisheries, even those on the high seas, into these kinds of management regimes. Politics can, unfortunately, often play a role in the setting of catch limits, especially in fish stocks that straddle multiple national jurisdictions. As much as possible, science must trump politics in the establishment of catch limits. Knowledgeable reporting on fisheries reform can help contribute to the establishment of science-based quota systems around the world.

2. **COMMUNITY INVOLVEMENT IN FISHERIES MANAGEMENT**. Coastal communities have an inherent stake in the health and sustainability of their fisheries.

While rights-based management is clearly the path forward toward more stable fish stocks, fishing communities should be carefully included in these schemes and not excluded from the quota allocation process. Here, again, the journalist can help by bringing to light the stories of fishing communities and to point out where their rights have been violated and can be bolstered.

3. **ESTABLISHMENT OF GLOBAL HEALTH AND ENVIRONMENTAL STANDARDS FOR AQUACULTURE**. Aquaculture, as has been stated earlier, is the fastest growing form of animal husbandry on the planet. As such, its growth has often outpaced society's ability to impose meaningful regulation. This has resulted in environmental degradation of coastal habitats, the introduction of impurities into the global seafood supply and unfair labor conditions for aquaculture workers. Several organizations like the newly formed Aquaculture Stewardship Council and the Global Aquaculture Alliance have introduced standards on a global basis but many producers and nations have yet to incorporate those standards into their day-to-day operations. As much as possible, societies need to encourage the adoption of standards throughout the aquaculture industry.

4. **RECOGNITION AND CONSERVATION OF ESSENTIAL FISH HABITAT**. Wild fisheries depend upon an array of ecosystems for their continued endurance. Unfortunately, it is these key ecosystems that are most affected by population growth and development. Any national plan for the stabilization and rebuilding of wild fisheries must include plans for conservation and/or rebuilding of salt marsh and mangrove forests; the establishment of fish passages in rivers of migratory significance; and protection of key environments from bottom trawling as well as other habitats of significance. Reporters covering the ocean are would therefore be well advised to analyze not only patterns of fisheries exploitation but also key environmental factors that affect fish and shellfish abundance.

5. **ENGAGEMENT WITH LARGER ENVIRONMENTAL MOVEMENTS FOR POLLUTION CONTROL AND THE LIMITING OF CARBON EMISSIONS**. Too often fisheries issues are isolated from larger environmental movements. But as we have discussed earlier in this toolkit the very large problems like the introduction of industrial pollutants into the marine environment and the overloading of carbon into the atmosphere have and will continue to have serious impacts on ocean life. As much as possible, journalists covering the oceans should add their science-based observations to those of the larger environmental community to push for greater pollution control and global standards for reducing carbon emissions.

Tips for Journalists

Seafood tanks at a resturant in Sai Kung, Hong Kong, PRC.

Building Bridges with Audiences

Conveying these very ambitious goals and engaging the general readership in ocean issues can be difficult. Most readers' knowledge of the ocean is low. The journalist must therefore continually educate readers about the basic metrics of the sea when reporting. How much seafood comes from wild fisheries? How much from farming? Who owns the oceans? How is it governed? What are the primary ways fish are caught? How do these methods affect the environment? How are fish and shellfish farmed? Which methods are the most sustainable? These basic facts are largely unknown to the general public. And even though the reporter who frequently covers the ocean may find him or herself repeating this information again and again, what we are looking for with ocean issues is a "snowball effect"—i.e. a greater and greater number of general interest readers that will accumulate around a core of readers who already understand some of these foundational elements of ocean science and management.

In addition, many readers also come to ocean issues somewhat distanced from ocean creatures. Whereas terrestrial animals share many common things with us – binocular vision, four limbs, warm bloodedness, fish usually lack these traits and are thus somewhat alien to us. The journalist must therefore figure out how to overcome that distance, to introduce an element of wonder at the great variety and strangeness of the sea, and to bring readers closer to the profundity of that wonder.

The first way is to try to choose subjects that are key to the eating patterns of their readership. Once key species are identified journalists can gather preliminary information through a number of online resources. An excellent starting point is Fishbase.org. Here the journalist can look up species by common or scientific name, and check relative abundance, distribution, and many other factors. This resource is available in several languages including Mandarin Chinese. Some resources like seafoodwatch.org offer more detailed reports on individual species with some country-specific information provided as well.

In looking through all of this data, it's important to remember that each fish or shellfish can be used to tell a story through its evolution and its lifecycle. Salmon tell the story of the interconnection of the distant sea with the rivers that originate into the heartlands of our nations. Tuna tell the story of the open ocean and the crises in negotiating functional multi-national treaties around fishing. Shrimp reveal the issues of coastal degradation, the loss of saltmarsh, and the destruction of mangrove forests. Beyond these familiar species are also the stories told by new arrivals on the seafood marketplace. Whenever a new fish or shellfish appears widely in the marketplace, it nearly always is telling the story of a profound ecological or economic shift. Why, for example, did tilapia appear in China when before it was not native to the country? Why, to give another question, is tuna-based sushi booming in China when before it was considered an exotic cuisine?

Time management & gaining access

If one were to do first-hand reporting of ocean issues aboard fishing vessels every time one wanted to report a fisheries story, one would spend a lot of time at sea and probably not generate that much content. In some countries it is possible to gain access to an ocean going fishing vessel, as the American journalist Rowan Jacobsen did in this excellent article on the crisis in New England cod. But because nowadays fishing vessels often spend weeks if not months at sea, reporting must also be done at arm's length. There are a few ways to produce acceptable fisheries articles without spending excessive amounts of time at sea. A few possibilities:

TRACKING VESSELS AND FISHERIES REMOTELY. Because of innovations in GPS monitoring and the Internet, it can now be possible to remotely track vessels at sea via computer. The website MarineTraffic.com allows researchers to locate vessels throughout the world relatively easily. In other instances reporters working remotely can find fisheries violations literally from space. In 2013 Dalal Al-Abdulrazzak working from her desktop while in residence at the University of British Columbia was able to observe fish traps in the Persian Gulf that were clearly exceeding their quota. This kind of desk-based research has been aided in recent years by the development of Ocean in Google Earth. This function allows journalists to understand a bit more about the geography of the ocean without actually setting foot on a boat.

VISITING LOCAL GOVERNMENT FISHERIES OFFICES and interviewing scientists dedicated to the study of your target species. Most local states or provinces have local administrative organs that set fisheries quotas and interface directly with fishing communities. As such they are responsible for gathering data on annual catches and tracking catches over time. A visit to one of these agencies is often a good place to start a story about fisheries.

INTERVIEWING FISHERMEN BEFORE AND AFTER TRIPS AT SEA. In addition to being good sources of colorful commentary, fishermen offer something scientists often don't: many days at sea. Though scientists will spend their lives studying a given fish or shellfish, their ability to actually work at sea in hampered by available funding for field research. Fishermen, meanwhile, will spend much of the course of their lives in fish's home environment.

VISITING FISH MARKETS. Repeated visits to fish markets often reveal economic and ecological changes over time. The diminishing or price rises of shrimp in local markets in 2009 was probably the first indication of the shrimp disease Early Mortality Syndrome. Similarly, visits to markets over the course of the 1990s would have revealed the rise of Pangasius catfish and tilapia and the decrease in wild "white fish" like cod.

VERIFYING WITH INTERNATIONALLY PUBLISHED REPORTS. Local fisheries agencies and fishermen may either not allow access to fisheries data or may for exhibit local biases in their reporting. Fortunately there are resources available online that give metadata on fisheries and fisheries management that may help the journalist reach more informed conclusions. In this respect, the UN's Food and Agriculture Organization collects data from governments around the world and is a good entry point for finding more detailed reports about a specific fishery or region.

COVERING AQUACULTURE. Since aquaculture now constitutes almost half of world seafood production the reporter on the seafood beat is obligated to spend considerable time on aquaculture. Fortunately this is a good deal easier than covering fisheries. Aquaculture operations are usually accessible from land and permissions can often be obtained on a corporate level rather than on a governmental level. Still, with seafood safety now an issue of concern for many aquaculture companies, the journalist may find resistance to on-site visits of farm sites. In visiting aquaculture sites one must also be aware of the possibility that the aquaculturist in question may have facilities that it commonly shows to reporters which don't necessarily represent the norm of that company's operations.

Common Conflicts in Sources

In assembling final stories on fisheries, certain conflicts of points of view inevitably arise and affect the biases of interviewees you may encounter. It's important to keep these biases in mind. Some of the most common are:

AQUACULTURE VS. FISHING CONFLICTS: Fishermen often feel threatened by the presence of aquaculture. They tend to think aquaculture depresses prices for wild caught fish and threatens their livelihood. The farmers of seafood, meanwhile, tend to regard fishing as an out-of-date, primitive endeavor, an industry that is impossible to be scientifically managed. The truth lies somewhere between these two points of view and the journalists would be well advised to understand these biases before presenting these points of view to the reader.

ARTISAN FISHERIES SECTORS VS. INDUSTRIAL FISHING SECTORS: Most coastal countries have an artisan, small-scale, near-shore fleet with minimal catch effort per vessel but high employment, as well as industrial distant water fleets with larger vessels, a high degree of mechanization, low employment per unit of fish caught but a high overall production in the tonnage of fish. The artisan fishing sector frequently voices opposition to the industrial sector, accusing it of monopolizing quota and depressing market prices. The industrial sector, meanwhile, will frequently point to the difficulty of managing a complex, multiparty artisan fishery. Enforcing quota, the industrial sector frequently asserts, is much easier with fewer, technologically advanced vessels that carefully monitor catch. Many countries have sought to maintain both sectors and to manage conflicts between them. The interstice between these two sectors is fertile ground for the reporter as both sectors have strong, valid opinions.

FISHERIES SCIENTISTS VS. FISHERMEN: Fishermen often believe that because it is they who spend the greatest amount of time on the water, they know best. Fisheries scientists who may only conduct monitoring on a periodic basis, are often seen as biased against fishing or uninformed about the true nature of abundance in a given fishery. Understanding the exact points of disagreement between fishermen and the scientists that are deployed to establish catch limits is key to reporting on a wild fishery.

LOCAL PROBLEMS VS. INTERNATIONAL TRENDS: In fisheries, problems are often expressed in global terms. We are frequently told, for example, that fisheries are at or exceeding their maximum sustainable yield. On a global basis this has proved to be true. But every fishery is different. In some regions good management practices have been put in place and stability in fish stocks have been achieved. Keeping in mind which problems are global in scope and which are local can help clarify the nature of a given problem and lead to region-specific solutions.

Conclusion & Future Topics for Research

There are many dangers confronting the ocean at the dawn of the 21st century. Beyond the problems cited in this toolkit other issues like plastic debris, toxic algal blooms, acoustic pollution, and many others – are all becoming more severe with the passage of time. At the same time, one striking fact must be kept in mind. In spite of all these degradations, in spite of all of the abuse humankind has thrown at the ocean, the ocean is still alive -- alive enough to produce more than 80 million metric tons of seafood each and every year. It is this statistic that the reporter covering the ocean must keep in mind with every interview conducted and with every site visited. We were born into this world with a living, nourishing ocean at our disposal. It is our responsibility going forward that our children have the benefit of such wealth in the future.