# Marine Fisheries Overview

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NCSR curriculum modules are designed as comprehensive instructions for students and supporting materials for faculty. The student instructions are designed to facilitate adaptation in a variety of settings. In addition to the instructional materials for students, the modules contain separate supporting information in the "Notes to Instructors" section, and when appropriate, *PowerPoint* slides. The modules also contain other sections which contain additional supporting information such as assessment strategies and suggested resources.



## Acknowledgements

We thank Bill Hastie of Northwest Aquatic and Marine Educators (NAME), and Richard O'Hara of Chemeketa Community College for their thoughtful reviews. Their comments and suggestions greatly improved the quality of this module. We thank NCSR administrative assistant, Liz Traver, for the review, graphic design and layout of this module.

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# NCSR Marine Fisheries Series

The marine fisheries issue is complex and represents an opportunity to approach the nature and management of a natural resource from several different perspectives in courses in natural resource or environmental science programs. Complete coverage of all fisheries-related topics is probably impractical for most courses unless the course is entirely devoted to fisheries. Instructors may select some topics for coverage and de-emphasize or ignore others. Thus, these curriculum materials are designed to meet a variety of instructional needs and strategies. The *NCSR Marine Fisheries Series* is comprised of the following:

1. *PowerPoint* Presentations

These presentations include *PowerPoint* slides, lecture outlines and detailed instructor notes on various marine fisheries topics.

- *Marine Fisheries Overview*
- *Marine Fisheries – Introduction and Status*
- *Marine Fisheries – Causes for Decline and Impacts*
- *Marine Fisheries – Management and Proposed Solutions*
- *Declining Expectations – The Phenomenon of Shifting Baselines*
- *The Role of Marine Reserves in Ecosystem-based Fishery Management*

2. *The Decline of Atlantic Cod - A Case Study*

This module provides a comprehensive examination of the decline of the Atlantic cod. Instructional materials include student learning objectives, a *PowerPoint* presentation with instructor notes, student handouts, suggested resources and assessment. Brief descriptions of other fisheries for development as case studies are also provided.

3. *Comprehensive Resources for NCSR Marine Fisheries Series*

This module provides detailed summaries for six excellent videos that examine various aspects of the marine fisheries issue:

- *Empty Oceans, Empty Nets* (2002) – an overview of major marine fisheries issues (one-hour) – student handout provided
- *Farming the Seas* (2004) – an examination of issues associated with aquaculture (one-hour) – student handout provided
- *Deep Crisis* (2003) – an examination of current research on salmon and bluefin tuna using modern technology (one-hour)
- *Strange Days on Planet Earth – Episode 3- Predators* (20 minutes)
- *Strange Days on Planet Earth – Episode 5 – Dangerous Catch* (one hour)
- *Journey to Planet Earth – The State of the Planet's Oceans* (one hour)

This module also provides a comprehensive glossary of terms commonly used in marine fisheries.

In addition, complete citations and brief summaries of web, print and video resources are provided that can be used to:

- Enhance existing lecture topics
- Develop lectures on new topics
- Develop geographically relevant case studies
- Update fishery statistics
- Select articles for student reading
- Access video and photos for presentation purposes

4. Activity-based Instructional Modules

- *Shrimp Farming – Environmental and Social Impacts* - an evaluation of the environmental and social impacts of shrimp aquaculture (one hour)
- *Where Does Your Seafood Come From?* – students evaluate the sustainability of locally available seafood and the criteria that are used to make that determination (3-4 hours)

The manner in which instructors use the modules in this series will depend upon:

- The course in which the module will be used

The marine fisheries modules are most appropriate for inclusion in undergraduate courses such as *Environmental Science*, *Introduction to Natural Resources*, *Marine Biology*, *Introduction to Fisheries* and *Fisheries Management*. Parts of the modules may also have application in courses with a broader scope such as *General Ecology* and *General Biology*.

- The background of the students

The marine fisheries modules assume some understanding of basic ecology including populations, communities and ecosystem structure and function. The treatment of ecology in either a college-level or high school-level general biology course should be sufficient. Instructors may need to provide additional background to students who are not familiar with this material.

- The time that will be dedicated to the study of marine fisheries

There is sufficient information and resources in the marine fisheries modules to present anything from a single one-hour lecture to a major portion of a full academic term, lecture-only course. Instructors may select from the various components depending on course objectives and the amount of time allocated for marine fisheries topics.

# Marine Fisheries Overview Module Description

This instructional guide is designed to provide instructors with lecture support on the topic of marine fisheries with an emphasis on those species that are commercially harvested in the United States. A general lecture outline and a more detailed *PowerPoint* presentation with instructor notes are provided. Historical perspectives are addressed as well as assessments of the current status of the resource. Proposed and implemented management activities that are designed to manage fisheries stocks in a sustainable manner are also discussed with an emphasis on those that take an ecosystems approach to fisheries management.

The overview module is designed primarily for use in introductory courses such as *General Biology*, *Introduction to Natural Resources*, *General Zoology, Wildlife Conservation, Conservation Biology* and *Environmental Science*. Some background in basic ecological concepts such as population growth and energy flow (trophic levels and food webs) is assumed. High school-level coverage of these topics should be adequate. Delivery of the *PowerPoint* presentation associated with this module requires approximately two, one-hour lecture sessions. The presentation can also be easily modified by instructors who choose to dedicate just a single lecture session to the marine fisheries topic. Those instructors who choose to dedicate a significant portion of their course (several lectures) to marine fisheries topics should use the following modules from the *NCSR Marine Fisheries Series*, which take a more detailed approach to the same topics covered in this overview module:

- *Marine Fisheries – Introduction and Status*
- *Marine Fisheries - Causes for Decline and Impacts*
- *Marine Fisheries – Management and Proposed Solutions*

Instructors who are looking for videos or additional print and web-based resources on the topics covered in this module should consult the *Comprehensive Resources for NCSR Marine Fisheries Series* where these resources are summarized and cited.

# Objectives

Upon successful completion of this module, students should be able to:

1. Define and characterize the marine fisheries resource
2. Describe the general status of marine fisheries
3. Describe the various causes for fishery declines
4. Describe the community and ecosystem-level effects of fishery declines
5. Describe traditional, market-based and ecosystem-based approaches to fishery management

# General Lecture Outline

I. Characterize the resource
- Define marine fisheries
- Importance as a food source
- What areas are fished?
- Fish as components of food webs

II. Status of the resource
- Historical perspective
- Current status
- Examples of fishery declines

III. Causes for fishery declines
- Overfishing
- Highly efficient technology
- Bycatch
- Overcapacity

IV. Community and ecosystem-level impacts of fishery declines
- Fishing down the food web
- Habitat degradation
- Trophic cascades
- Changes in life history traits

V. Why are fishery declines allowed to occur?
- Government subsidies
- Increasing demand
- Shifting baselines
- Lack of adequate fisheries data

VI. Traditional fisheries management
- Quotas/Total Allowable Catches
- Gear restrictions
- Maximum sustainable yield
- Closures

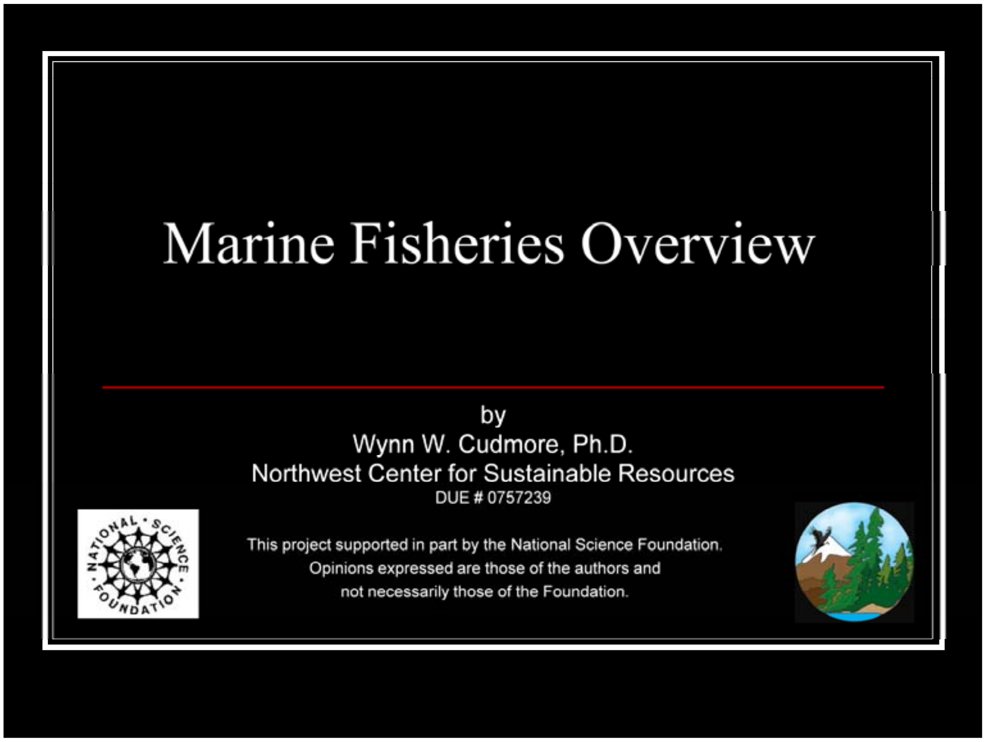
VII. Market-based solutions
- Certification
- Consumer-based solutions
- Reduction in fishing effort by purchase of fishing rights
- Aquaculture
- Increased use and marketing of underutilized species
- Reduce government subsidies

VIII. Ecosystem-based fishery management

- Reduce bycatch
- Marine reserves
- Catch share programs
- Ecologically sustainable yield

IX. The future of marine fisheries

# *PowerPoint* Presentation with Instructor Notes




This presentation is an overview of issues related to marine fisheries resources. Fisheries resources are characterized and their status described. Causes for declines of marine fish stocks are discussed as well as the implications of fishery declines for marine communities and ecosystems. Traditional fishery management practices are described as well as relatively new market-based and ecosystem-based approaches to fisheries management.


A fishery is composed of three elements – the resource (e.g., swordfish, squid, halibut) = "**fishery stocks,**" the habitat and the people who are involved in the capture, processing and sale of the resource. Modern fisheries management focuses on:

1. regulation and conservation of the harvested resource
2. protection of the habitat associated with the resource


Although some other groups of wild species are still hunted commercially for food (e.g., turtles, some large mammals), none attain the level of fisheries. They contribute significantly to the human food chain. Marine fish provide humans with more animal protein than any other source (including beef, chicken and pork). Despite declining stocks, demand continues to increase due to both human population growth and increased per capita consumption.

More than 2.6 billion people get at least 20% of their animal protein from fish and shellfish. This number increases to 30-90% for some coastal and island regions.

Japan, for example, is among the world's largest consumers of seafood. The Tsukiji Fish Market in Tokyo is the largest seafood market in the world. Over 2000 metric tons of seafood change hands there every day. Photographs here show the end of the fresh tuna auction and frozen tuna being prepared on a band saw.

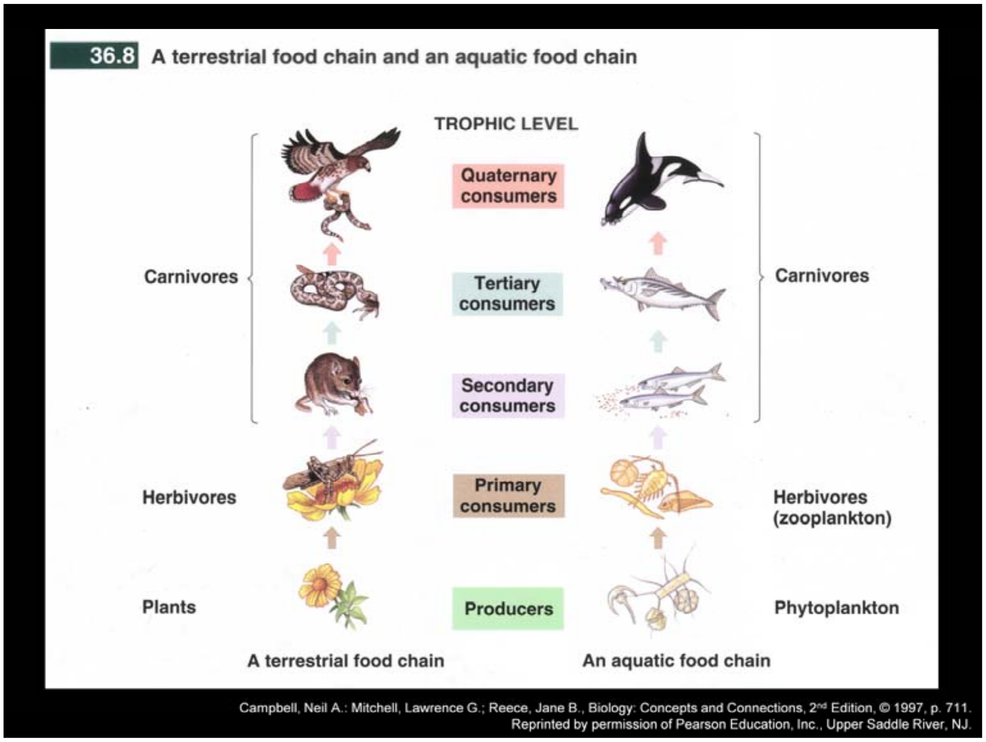

Although oceans cover about 70% of the Earth's surface, they are not uniformly populated with fish. The most productive areas are closely associated with continental land masses where about 90% of commercial harvest occurs. This is due to both the accessibility of these areas to boats from land and their high productivity. Water in these areas is sufficiently shallow to allow light penetration and support large populations of phytoplankton – the base of marine food webs. Specific areas include:

**Upwellings** – rising currents in water column carrying nutrient-rich water to surface (e.g., off Vancouver Island, Canada, note resulting phytoplankton bloom). Also, off the western coast of South America where the Humboldt Current creates an upwelling.

**Continental shelves** – relatively shallow (200 m and less), highly productive ocean regions (e.g., historical fishing grounds off New England such as Georges Bank, Nantucket Shoals and Brown's Bank).

**Estuaries** – areas of salt and fresh water mixing where streams empty into oceans; important nursery areas for many commercially important fish species and the most productive areas for marine invertebrates such as shrimp, clams and oysters.

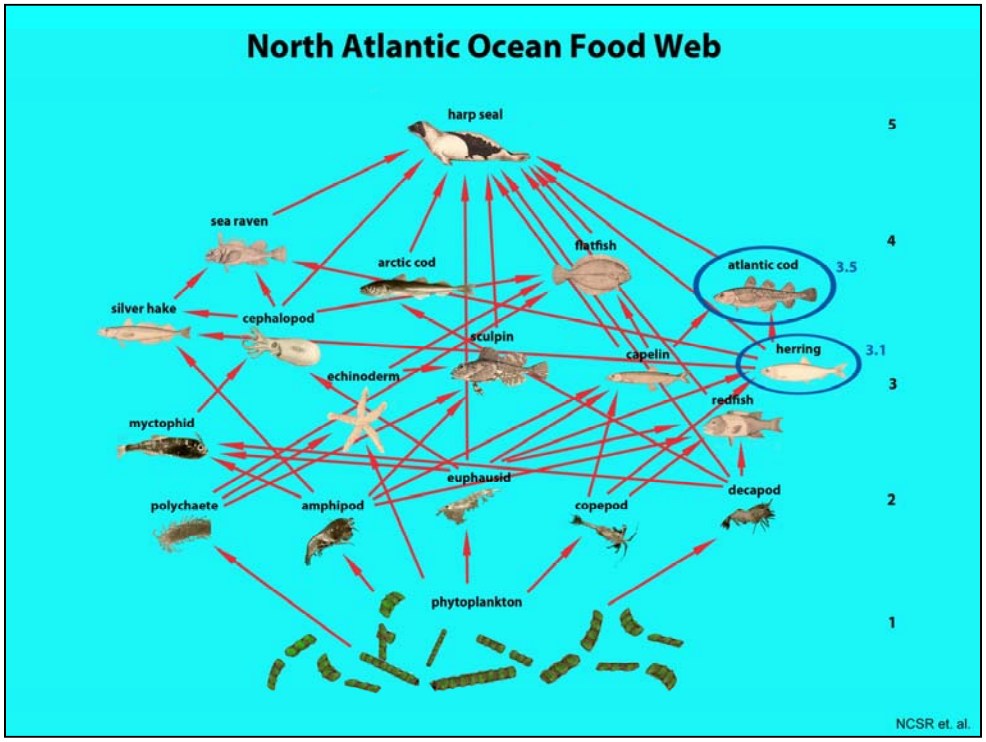
**Open ocean** areas are generally less productive; however, fisheries that target large migratory species such as tunas and swordfish often fish these areas. These species are highly adapted for swimming long distances in pursuit of schools of small fish.




Most fish that are harvested occur in mid- and upper trophic levels (secondary and tertiary consumers) in food webs; therefore, their production is dependent upon the amount of biomass that exists at lower trophic levels (producer and primary consumer). This illustrates the importance of phytoplankton ("producers") and zooplankton ("primary consumers") to marine ecosystems and, in particular, to the production of harvestable fish.

Secondary consumers in marine ecosystems are represented by small fish such as sardines, herring and anchovies.

Tertiary consumers include typical table fish such as halibut, tuna, cod and snapper.



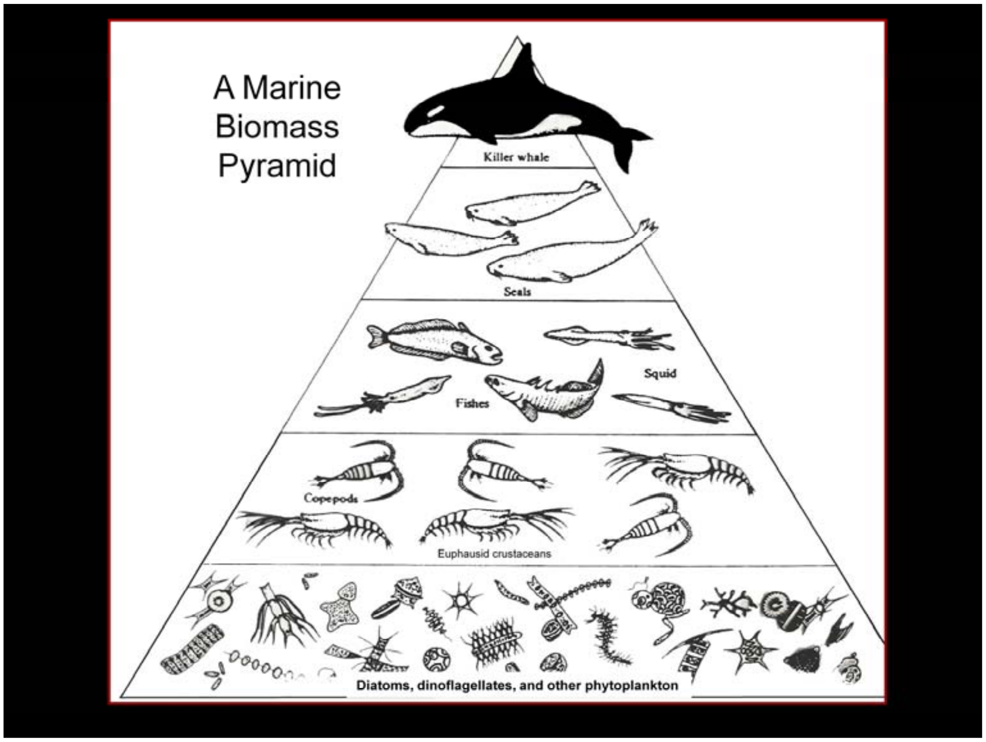

Due to taste preferences, humans typically harvest at trophic levels 3 and 4. Marine food webs are complex and many fish species feed at more than one trophic level. Thus, most individual fish species have trophic designations that are not whole numbers - e.g., snapper (4.6), cod (3.5), herring (3.1), sardine (2.5). An understanding of trophic levels in marine ecosystems is required to understand the change in trophic levels that may occur in response to fishing effort (discussed later).

Image created by NCSR.

Graphics from:

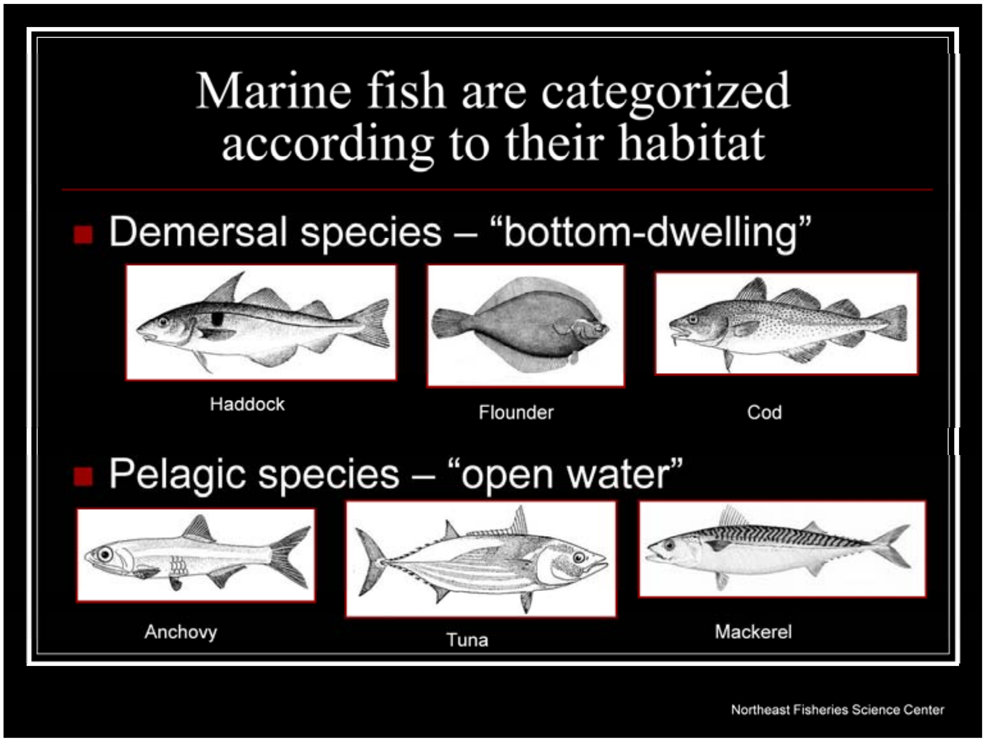
NOAA (all images not listed are from NOAA): B. Sheiko (Arctic cod), Russ Hopcroft (Amphipod, Copepod), Alaska Fisheries Science Center (Euphausid), Jerry McLelland (Polychaete), NOAA Ocean Explorer (Decapod, Myctophid)

NASA (Phytoplankton, adapted)




A biomass pyramid illustrates the relative amount of living material at each trophic level. Due to the inherent energetic inefficiencies of living systems, progressively less biomass is available at each trophic level. In most ecosystems, only about 10% of the biomass at any one trophic level is converted into biomass at the next highest trophic level. Decisions about which trophic level we choose to harvest has an important impact on the ability of a fishery to provide a reliable food supply in a sustainable manner.

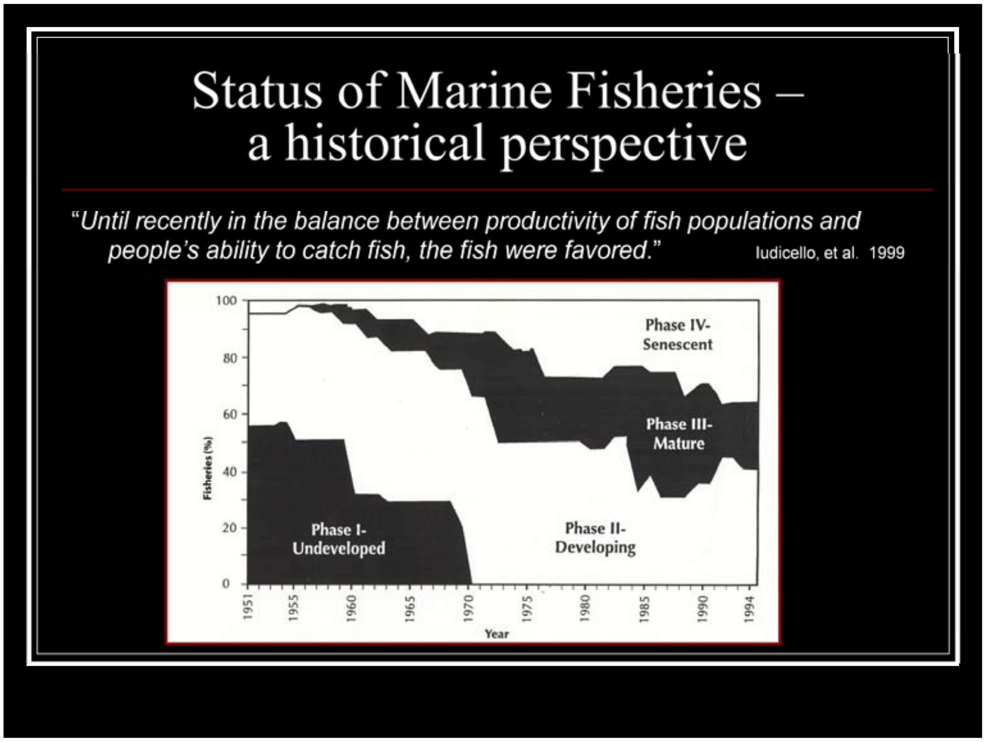
To illustrate – approximately 3 million tons of the three major tropical tuna species are harvested each year. These tuna consume approximately 60 million tons of fish (e.g., sardines, anchovies) at the next lowest trophic level. Despite a general human preference for tuna over anchovies and sardines, clearly more biomass is available for harvest at these lower trophic levels.



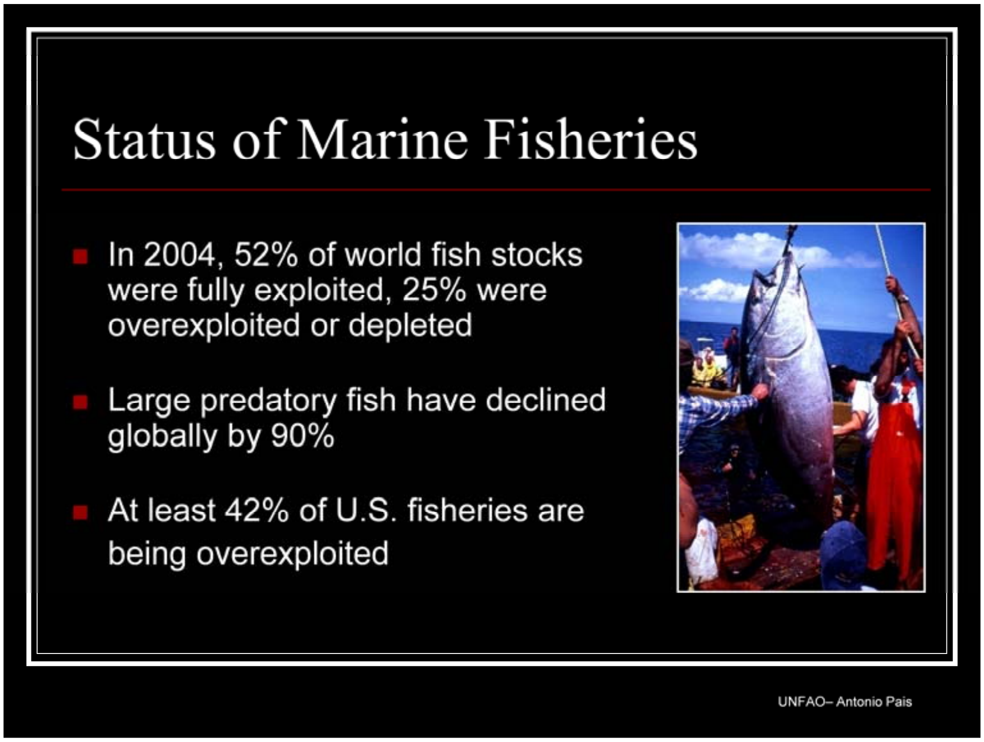

Demersal species are closely associated with the ocean bottom (sometimes referred to as "groundfish") – most are high value species. Examples shown here are haddock, yellowtail flounder and Atlantic cod.

Pelagic species are open water species that swim and feed close to the surface. Sometimes further categorized as large pelagic (e.g., tuna, swordfish), which are high value and small pelagic (e.g., anchovy, herring) which are usually low value species and are primarily caught for the oil and fish meal markets. Examples shown here are striped anchovy, skipjack tuna and Atlantic mackerel.

About 60% of global landings are used for direct human consumption. The remaining 40% are used to produce fish meal and fish oils which are often added as a supplement to animal feed.




Percentage of fisheries in various stages of development illustrates significant changes that have occurred since 1950. In 1950, the fisheries were dominated by those that were "undeveloped" (low and relatively constant level of catches) or "developing" (rapidly increasing catches). Since 1950 there has been a rapid transformation to those that are "mature" (high and static catch rates) and "senescent" (catches declining from higher levels).




See notes slide 10

Notes Slide 10

In recent years fisheries biologists and fisheries managers have expressed concern that many stocks of marine fish are overexploited and in decline. Large predatory fish, in particular, such as bluefin tuna (shown here), swordfish and sharks have declined 90% from un-fished levels. For species fished in U.S. waters, at least 42% are being fished at a level that exceeds <u>maximum sustainable yield</u> (i.e., the largest average catch that can be continuously taken from a stock without compromising the ability of the population to regenerate itself). Species that have experienced precipitous declines due to overfishing include the Atlantic halibut, orange roughy, bluefin tuna, Atlantic cod, herring, Atlantic salmon and American shad. In 2002, the Secretary of Commerce declared a West Coast groundfish fishery "disaster" driven by the rapid decline of four rockfish species – bocaccio, canary rockfish, blotched rockfish and yelloweye rockfish.

By 2003 29% of fish species had collapsed and some authors have predicted that if current trends continue, all seafood species will suffer the same fate in less than 50 years. The authors defined "collapse" as when the catch level drops below 10% of the maximum catch level (i.e., 90% below the historical maximum). This collapse is based on an extrapolation of catch data.

See Kavanagh, E. 2007. Biodiversity loss in the ocean: How bad is it? Science 36:1281-1285 for a critique of this study and the response from its authors.

The most recent evaluation by the United Nations Food and Agriculture Organization found that over half of world fish stocks were fully exploited (fished at or near maximum sustainable yield), while 25% were overexploited or depleted.

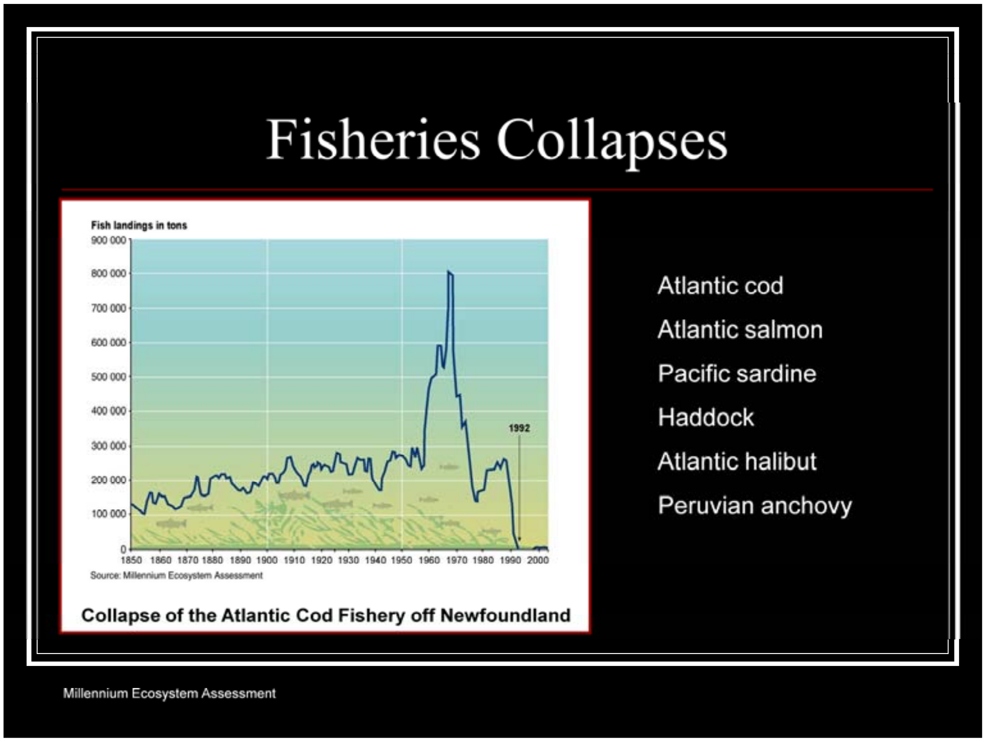
Large marine predators include 1m+ fish such as cod, halibut, tuna, swordfish and sharks. By any measure, current population levels are but a fraction of historical levels – multiple sources of information support this conclusion. Some species (e.g., white marlin and both Pacific and bluefin tuna) have shown both a reduction in abundance and species distribution – a dangerous combination for large migratory species (see *Comprehensive Resources for NCSR Marine Fisheries Series* for sources). Using logbooks kept by longliners as a source of information, Baum, et al. (2003) found that of the 17 species of sharks studied, all but two had experienced declines of over 50% in less than 20 years. Hammerhead sharks showed the most serious decline with an 89% decrease in population since 1986. Until recently, populations of large predatory fish have been seen as "extinction proof" due the perceived inexhaustible supply of marine life, the remoteness of many marine habitats and the high fecundity of marine fish populations. Each of these arguments has been shown to be false.

At least 50 million tons of tuna and other top-level predators have been removed from the Pacific Ocean pelagic ecosystem since 1950. An analysis of Pacific tuna fishery data for 1950-2004 (Sibert, et al 2006) suggests that:

1. Current biomass ranges from 36-91% of the biomass predicted in the absence of fishing (depending on the species examined)

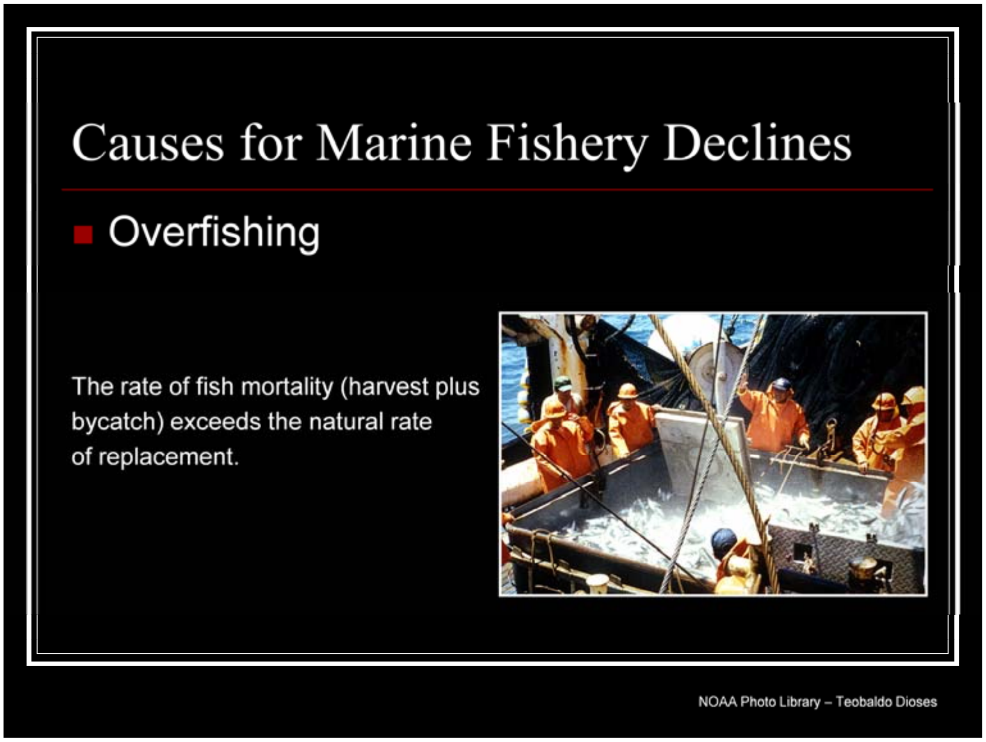
2. Fish larger than 175 cm (approx. 5.7 feet) have decreased from 5% to approximately 1% of the population

Studies such as those described above provide the "missing baselines" by which current levels of these species can be compared.




The history of fisheries is characterized by the development, exploitation and collapse of several fisheries. Examples include the Atlantic cod (data for population off the coast of Newfoundland are shown here), Pacific salmon, Pacific sardine, anchovy, menhaden, haddock and Atlantic halibut.

Some species collapses have resulted in “commercial extinction” – species declines below a level where it is economically feasible to target as a fishery and have shown no sign of recovery even though they are no longer targeted (Atlantic halibut and Pacific abalone are examples).




**Overfishing** – occurs when the rate of fish mortality (harvest plus bycatch) exceeds the natural rate of replacement resulting in a decline of the fish stock

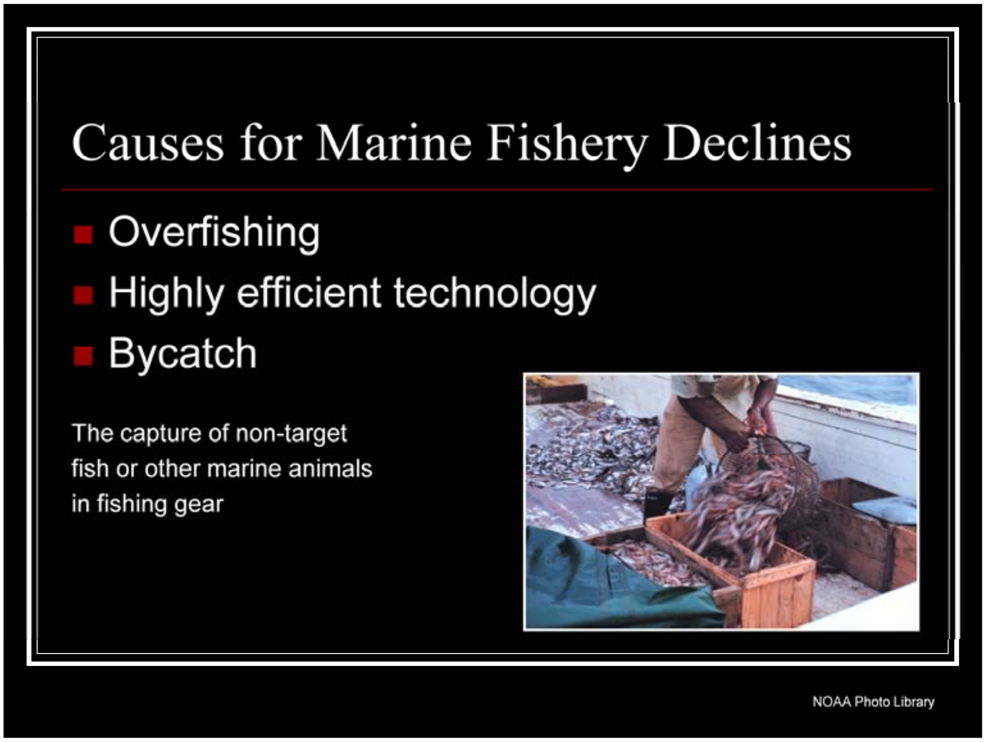
While many in the general public are under the impression that pollution is responsible for the decline of marine species, it has become clear in recent years that overfishing is the number one human activity that threatens marine ecosystems. Most fisheries are "open access," acting as a common resource to all and thus are susceptible to the "tragedy of the commons" as originally described by Garrett Hardin.


**Highly efficient technology** – the availability of highly sophisticated tools to locate, harvest and process fish

Many modern fishing vessels are large, floating fish processing factories that can deploy large amounts of highly efficient gear – miles of submerged longlines, huge trawl nets and, until their recent prohibition, 40-mile long drift nets – and process their catch at sea. Photo shows a Chilean purse seiner about to land several tons of chub mackerel - a small pelagic species.

An explosion of new technologies in the 1950s and 1960s including the adaptation of military technologies greatly increased capacity to catch fish. Radar allowed navigation under weather conditions that would have prevented fishing previously. Sonar made it possible to detect large schools of fish and to create detailed maps of the ocean floor. The maps allow seeking out terrain favorable to fish populations. Electronic navigation (LORAN – Long-Range Navigation) and, more recently, GPS (Global Positioning Systems) and GIS (Geographic Information Systems) allow fishing vessels to pinpoint the most productive fishing grounds.

Aircraft are frequently used to locate pelagic fish such as swordfish and tuna and some are equipped with infrared sensors that detect subtle changes in ocean surface temperature. This technology can be used to find fish since some high value species have highly specific temperature preferences. Even the oils given off by fish collect on the ocean surface and can be detected using ultraviolet sensors. Airborne electronic image intensifiers can be used to detect light given off at night by some marine algae when they are disturbed by passing schools of fish.

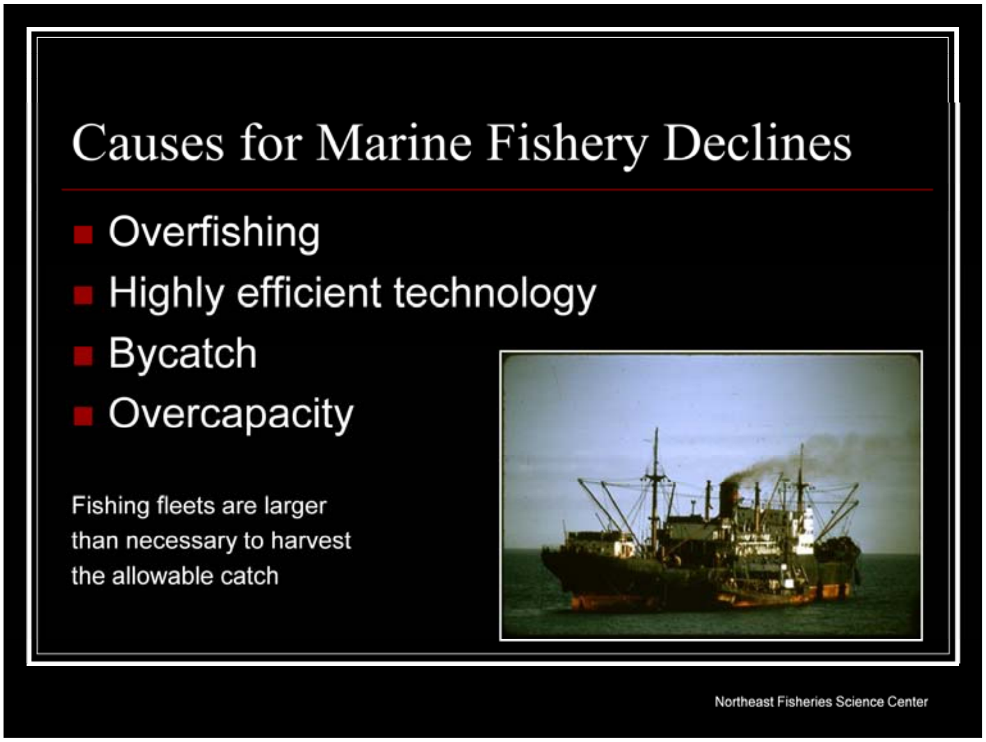



**Bycatch** – the capture of non-target fish or other marine animals in fishing gear

This “collateral damage” was once thought to occur at minimal levels and considered an unavoidable consequence to the use of non-selective fishing gear. Bycatch is now recognized as a serious problem that has had far-reaching impacts on marine ecosystems. Bycatch of non-target fish is estimated at approximately 25% of global fish landings and is not incorporated into landings figures. About 30 million tons per year are discarded as bycatch.

Longline fisheries for tuna and swordfish have been particularly damaging to non-target species. Large sharks, blue marlin, white marlin and sea turtles are frequently caught. Over 90% of white marlin mortality can be attributed to this “unintentional harvest.”

In some fisheries bycatch exceeds the targeted catch. The Gulf of Mexico shrimp fishery for example (shown in this photo) discards about 5 pounds of bycatch (mostly under-sized fish) for every pound of shrimp caught. Most of this bycatch (shown on deck behind fisherman) is dumped overboard.



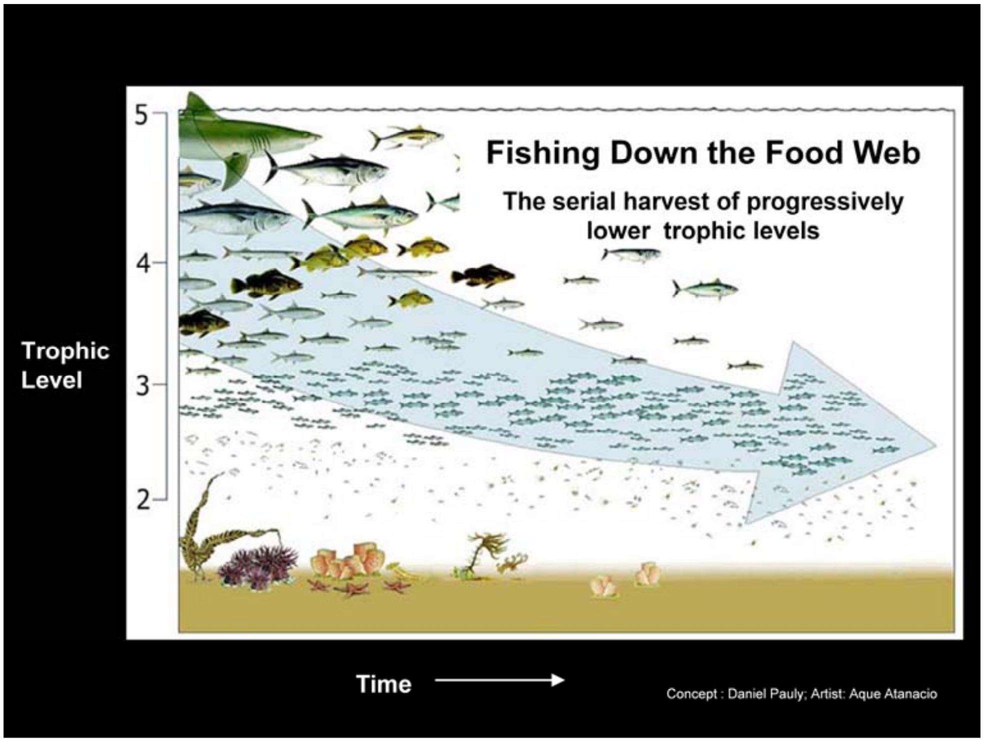

In many fisheries around the world, fishing fleets are larger than is necessary to catch the amount of fish that fish populations can produce over the long run. This is called **overcapacity**. By the early 1980s the world's fishing fleets were 30% larger than needed to catch the maximum sustainable yield of the world's fish. Thus, with overcapacity it is almost inevitable that the capacity to catch fish will exceed the ability of fish populations to keep up with harvest.

The Bering Sea crab fleet, for example, now numbering about 250 vessels, has as much as five times the capacity to catch the available crabs. The capacity of the Atlantic cod fleet in Canada and the U.S. still exceeds the reproductive capability of the cod population.


It is important to recognize that species we harvest are part of complex ecosystems. When we impact one part of the system, there are impacts in other parts of the ecosystem due to the interconnectedness that exists between ecosystem elements. Fishing pressure obviously has an impact on the targeted species. However, in recent years it has become clear that there are community and ecosystem effects as well.

These include:

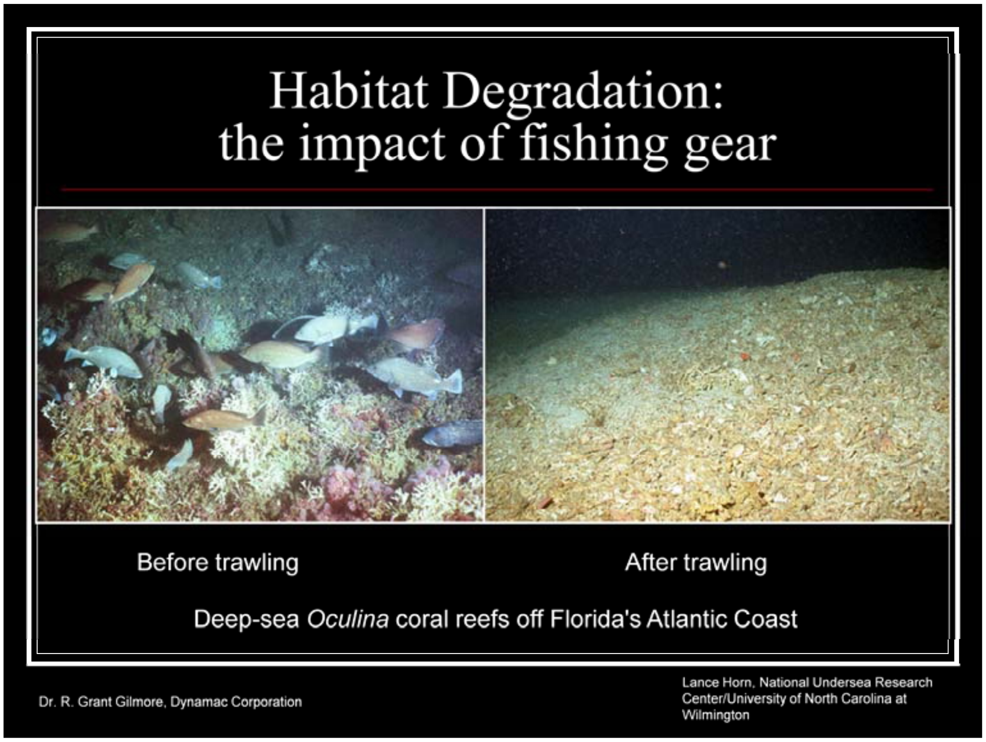
1. Fishing down the food web
2. Habitat degradation
3. Trophic cascades
4. Changes in life history traits




In this illustration of “fishing down the food web” the arrow indicates the trajectory of time. The pre-fished condition (on the far left) is characterized by abundant predators and complex ocean floor habitats. Conditions at present are depicted in the middle of the diagram. Predator populations are much depleted and complex bottom habitats have been simplified due to the impacts of fishing gear.

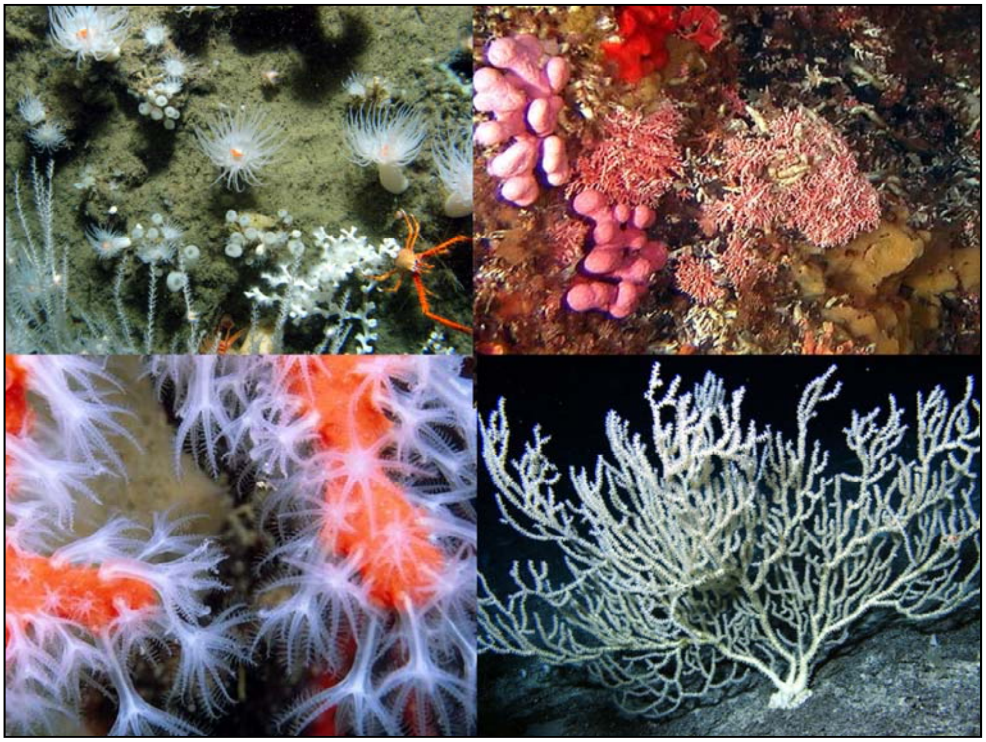
Daniel Pauly contends that the health and sustainability of fisheries can be assessed by monitoring the trends in average trophic levels of fish that are landed (see Pauly, et al. 1998 for details). When these values drop, it indicates that fishers are relying on progressively smaller fish and that populations of larger predatory fish at higher trophic levels are beginning to collapse. By 1998 this phenomenon had already occurred in the North Atlantic, off the southern coast of South America, the Arabian Sea and around parts of Africa and Australia. These regions experienced trophic level declines of 1.0 or greater between 1950 and 2000. Off Newfoundland the average trophic level change was from 3.65 in 1957 to 2.6 in 2000. During that time the average size of fish landed decreased by one meter.

Pauly contends that if current conditions persist we may end up with even more simplified systems that favor only a few small fish species and invertebrates such as jellyfish.




Certain types of fishing gear can damage the physical structure of marine habitats as they pass over the ocean floor. Bottom trawls used to capture demersal fish species and dredges used to capture scallops have been shown to be particularly damaging to sensitive habitats. These methods also capture significant amounts of both vertebrate and invertebrate bycatch, disturb benthic sediments and crush or bury benthic organisms. Community composition may be altered as a result.

PHOTOS - Groupers (seen in photo at left) were abundant on deep-sea *Oculina* coral reefs off Florida's Atlantic Coast before trawling began; legal and illegal trawling has nearly eliminated the corals and large fishes in this ecosystem.



Some benthic habitats such as the deep sea coral reefs off the coast of Alaska are particularly vulnerable to bottom-fishing gear.  The cold-water corals from waters off the Aleutian Islands shown here are an example.  Invertebrates such as these form an important structural component of these marine ecosystems. Other habitats such as muddy or sandy bottoms that do not have marine invertebrates as an important structural component may not be as vulnerable to bottom fishing gear.

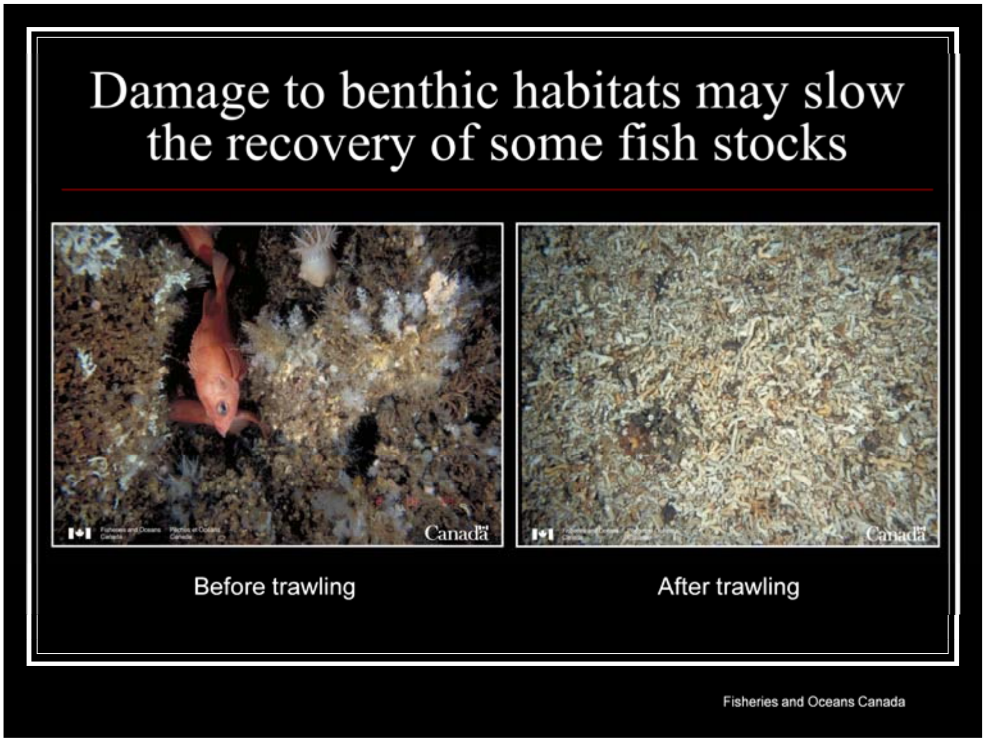
Photo Credits:

Top left – NOAA / S. Brooke

Top right - Robert Stone, NOAA Fisheries/Marine Photobank

Bottom left - G. Marola, 2007/Marine Photobank

Bottom right - Brooke et. al., NOAA OE 2005/Marine Photobank




Repeated damage caused by bottom trawling slows (or prevents) the recovery of these degraded habitats and probably contributes to the slow recovery rates of some fish stocks, even when fishing effort is reduced. NOAA Fisheries estimates that some areas on George's Bank off the New England coast are trawled three to four times each year. The extent of damage to benthic communities by fishing gear is largely unknown and is currently an active area of research.

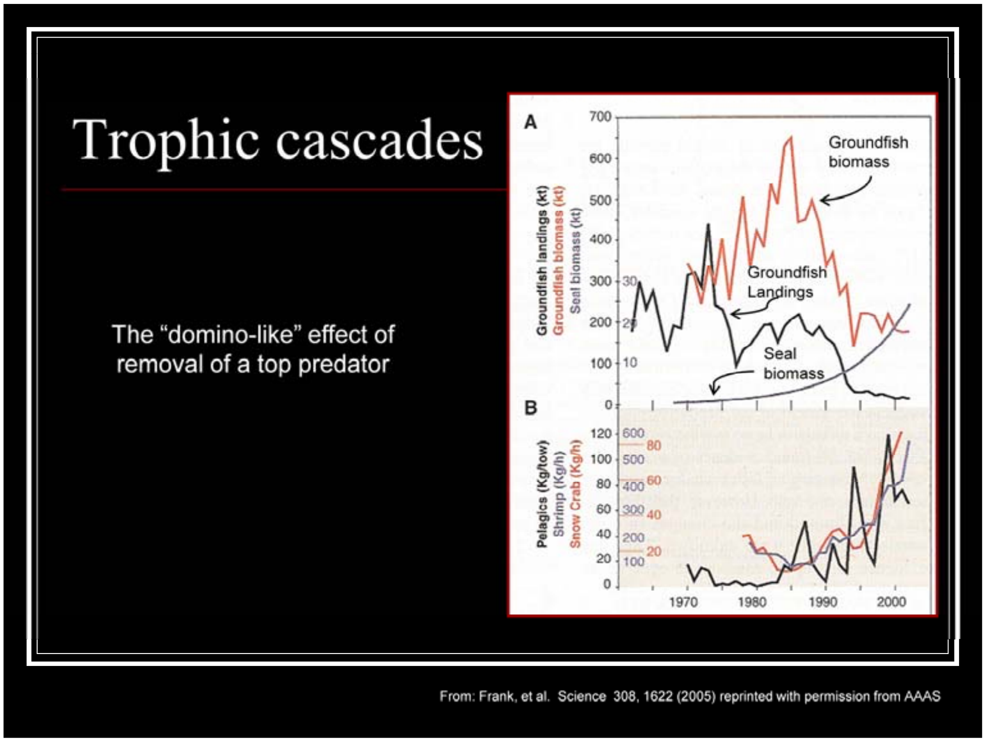
Photo at left shows an intact *Lophelia pertusa* reef or mound with a redfish (*Sebastes* sp.) peering out
Photo at right shows *Lophelia pertusa* reef reduced to rubble from the impact of trawling

For more detail on the impacts of fishing gear on benthic habitats, see:

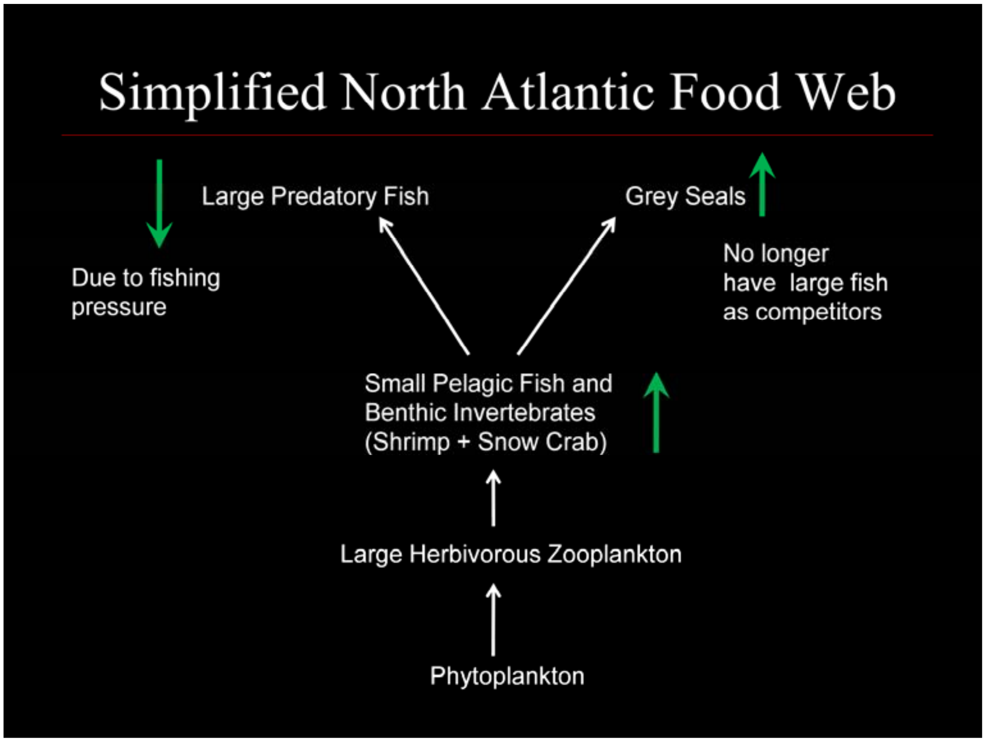
1. Morgan, L.E. and R. Chuenpagdee. 2003. Shifting gears: Addressing the collateral impacts of fishing methods in U.S. waters. Island Press, Washington, D.C. 42 pp. www.mcbi.org
2. Fuller, et al. 2008. How we fish matters: Addressing the ecological impacts of Canadian fishing gear. Ecology Action Centre (Halifax, Nova Scotia), Living Ocean Society (Sointula, B.C., MCBI (Bellvue, WA). 25 pp. www.mcbi.org

A few short videos of the ocean bottom habitat before and after trawling as well as trawling in action are available on this website:

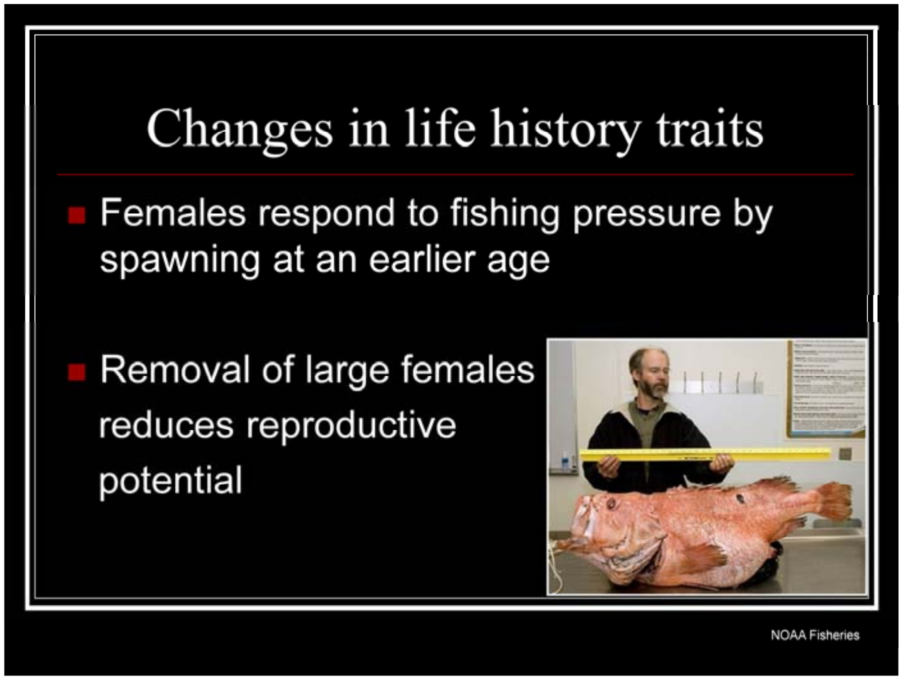
http://www.mcbi.org/cgi-bin/photo_library.pl?ID=8




The decline of one species (particularly a top predator) can have impacts that reverberate throughout the ecosystem in a domino-like fashion (i.e., a “trophic cascade”). These graphs illustrate evidence for just such an event that involves Atlantic cod, seals, crabs, small pelagic fish and zooplankton. The first graph (A) illustrates declines in groundfish (mostly cod) biomass with a corresponding increase in seal populations. With declining cod populations, species that are preyed upon by cod (pelagic fish, shrimp and crabs) all show increases over the same time period (see graph B). In addition, it has recently been demonstrated that grey seals are significant predators of cod, accounting for 21% of cod mortality since 1993. This may be contributing to the slow recovery of cod despite decreased fishing pressure. Studies such as these enhance our understanding of the interconnections between marine ecosystem components and point out the potential hazard of species-level only management.




Above is a simplified food web for the North Atlantic. The white arrows indicate flow of energy while the green arrows indicate changes in population as a result of increased fishing pressure on large predatory fish, thus demonstrating a "trophic cascade" as described on the previous slide. Interestingly, as a result of the changes shown here, shrimp and snow crabs have become the targets of an important new fishery.




See notes slide 23.

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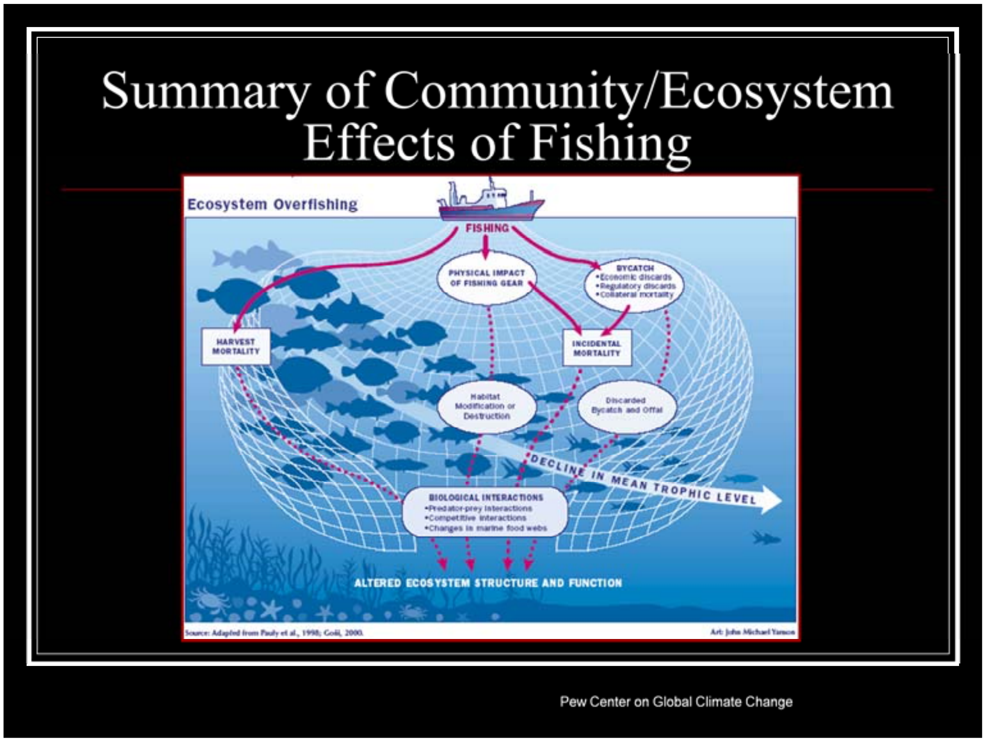
Female cod responded to intensive fishing pressure  by spawning at an earlier age.  On Georges Bank, average spawning age declined from 5-6 years to less than 3 years.  In the Barents Sea north of Scandinavia, cod matured at age 9 or 10 years 70 years ago, but now mature at 6-7 years.  This response is thought to be an adaptation to small population sizes.  However, younger spawners produce smaller and fewer eggs and, therefore, smaller fry.  This makes the new generation more prone to predation and may be contributing to the slow recovery of cod stocks.

In long-lived species (like this 100-year old shortraker rockfish from Alaska), the removal of larger, older individuals from the population diminishes the capacity for the population to rebound from declines caused either by overfishing or changing ocean conditions.  These large fish are often among the first to be harvested due to their high market value.

These demographic changes can be particularly troublesome when fishing creates selection pressures that favor smaller and slower-growing fish.  A 50-year study of larval fish populations in the California Current (Anderson, et al. 2008) suggests that demographic changes such as earlier age at maturation or population growth rate may be <u>permanent</u> as a result of decades of this type of selection.  Once this evolutionary change has occurred, genetic change may be irreversible or at least only slowly reversible contributing to slow or non-existent recovery of depleted fish stocks.

Steven Berkeley at the University of California, Santa Cruz reported on the effects of changes in life history traits in the black rockfish, a long-lived (50 years) species off the Oregon Coast.  Gravid females ranging from 5-17 years old were housed in lab aquaria and allowed to spawn.  Their offspring were then tracked for growth and survivability.  The offspring from the <u>oldest</u> females were twice as likely to survive short periods of starvation and grew three times as fast as offspring from <u>younger</u> females.  It seems that “big old fat females” contribute disproportionately to the future population.




These community and ecosystem effects when taken together can contribute to further degradation of marine ecosystems and decline of fisheries. Recovery of depleted stocks may be hampered by these effects even when corrective actions such as closures or other regulations are implemented.

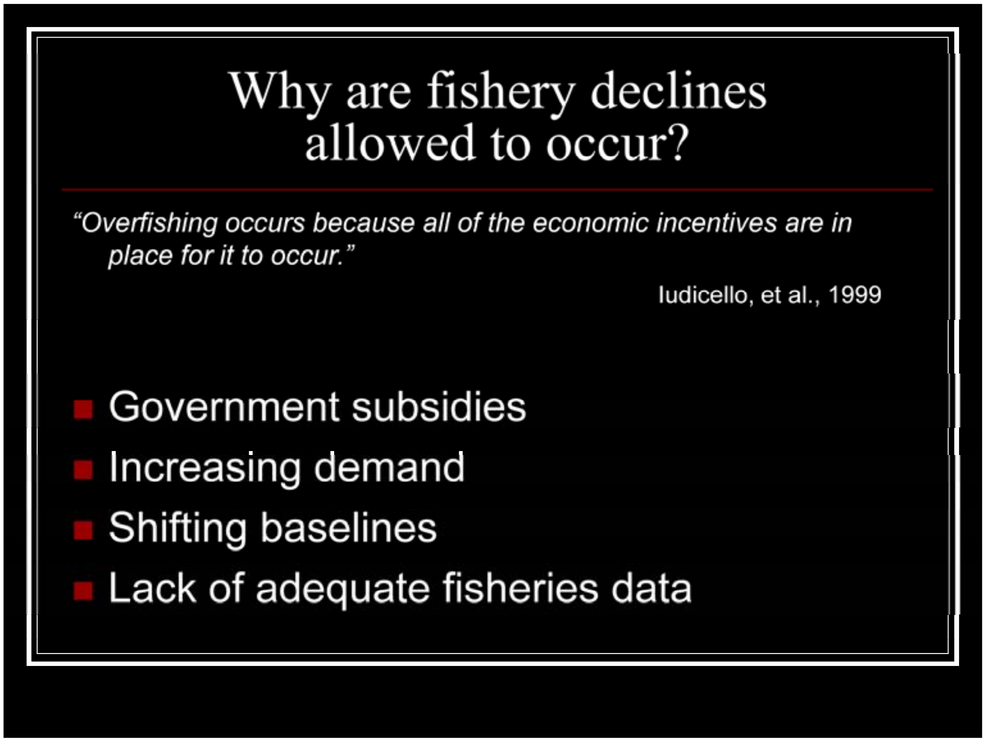
The decline of one fish stock often triggers the development of fisheries for new species in the same area. Large, predaceous fish such as tuna, saithe, swordfish, salmon and sharks are often the primary focus of developed fisheries. As the populations of these species are depleted, fishers shift their efforts to middle and then lower trophic level species to meet increased demand for fish protein. These substitutes come from progressively lower trophic levels because greater biomass is present at lower trophic levels due to the pyramid shape of biomass pyramids and the "10% efficiency rule." The shift from large predators to lower trophic levels is known as "fishing down the food web." The result may be the disruption of marine ecosystems as intricate connections between species in the food web are unraveled. Consequently, fishing down the food web may impact entire communities and ecosystems, not just the target species.

Note: The 10% efficiency rule states that in any ecosystem, only 10% of the available biomass at any one trophic level can be converted into biomass at the next highest trophic level.

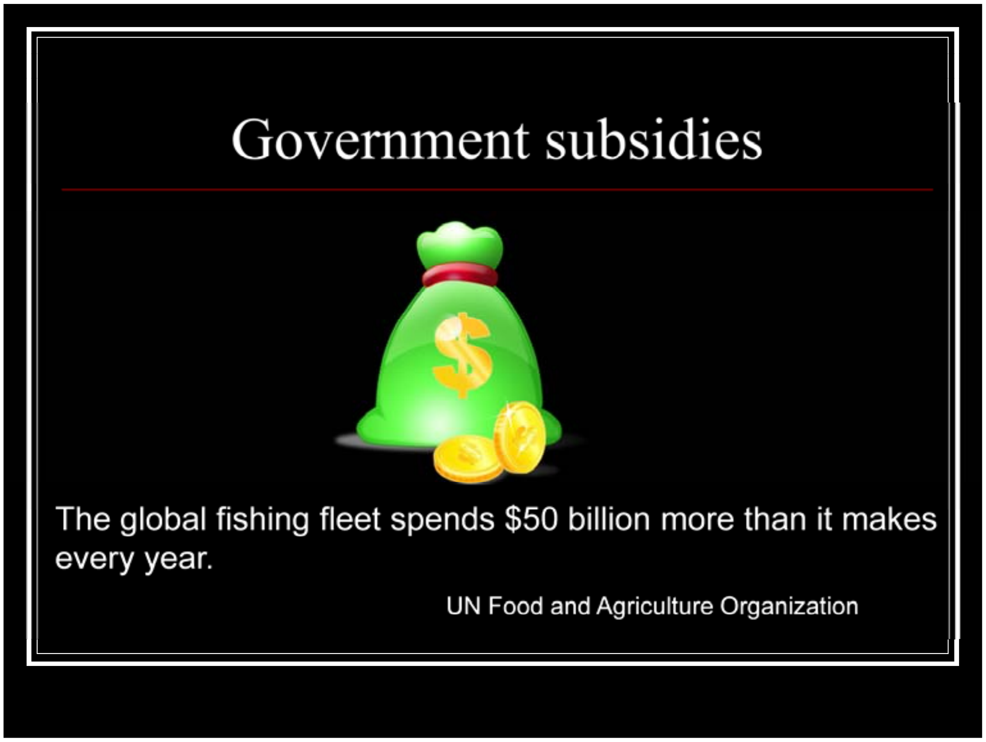
Also, see:

http://mitworld.mit.edu/video/501/

This is a 50-minute Daniel Pauly lecture at MIT. It does a good job of explaining "fishing down the food web" and the role of subsidies in fisheries decline.

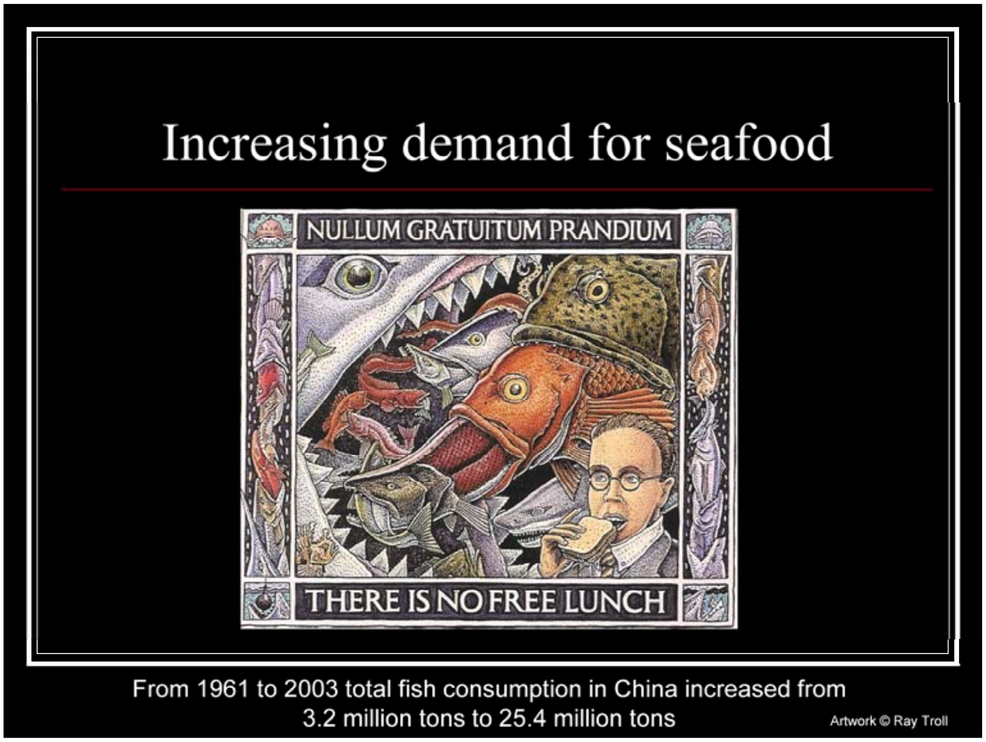



Once students understand the evidence for fishery declines and their causes, they may wonder <u>why</u> these declines have been allowed to occur. At least four societal/psychological phenomena contribute to declines. Each is discussed separately.




Government subsidies are provided to the fishing industry in several forms – extended unemployment benefits, direct payment, tax exemptions on fuel, fishing gear or vessels, low interest loans or grants to encourage investment into the industry.  Overcapitalized fisheries can continue to operate after the resource is depleted by relying on these subsidies.  Thus, individuals remain in the industry longer than the supply would ordinarily dictate.

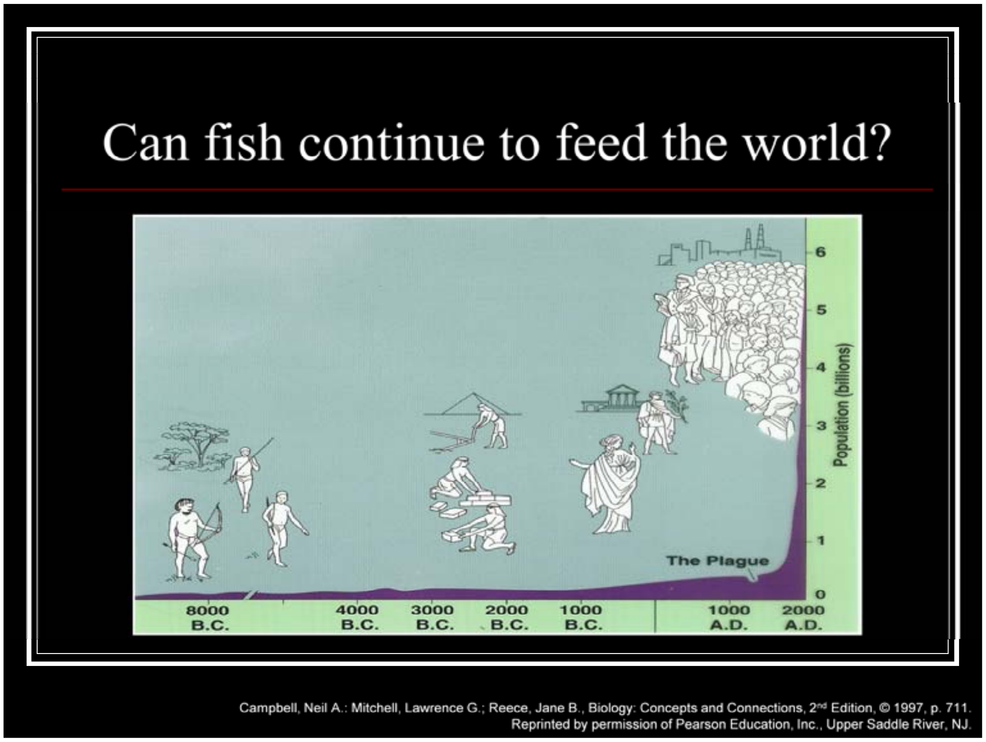
The Food and Agriculture Organization of the United Nations estimates that the global fishing fleet spends $50 billion more than it makes every year.




It is important to recognize that species we harvest are part of complex ecosystems. When we impact one part of the system, there are impacts in other parts of the ecosystem due to the interconnectedness that exists between ecosystem elements. As a result, there is no "free lunch" and real limits on the amount of seafood that we can harvest from the sea do exist.

Despite fishery declines, demand has increased and will probably continue to increase. China, for example, has increased its total consumption of fish from 3.2 million tons in 1961 to 25.4 million tons in 2003. This increase is due only in part to population increases. Per capita fish consumption has increased over five-fold during the same time period.

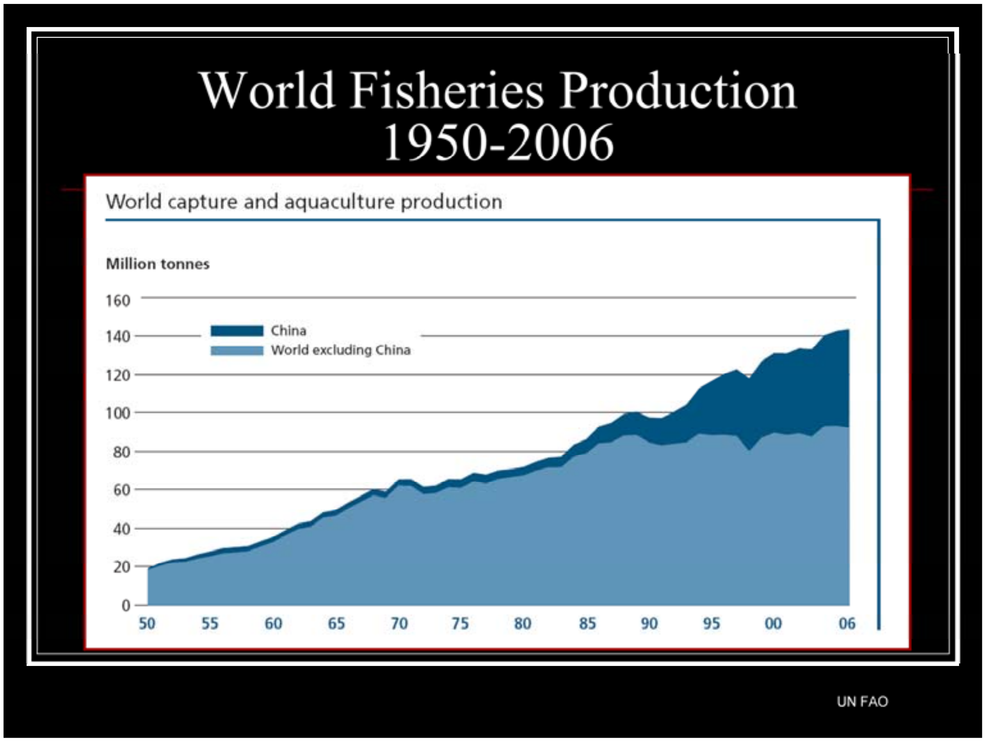
Fish consumption has also increased in the United States over the same time period as total consumption in 2003 was 2.5 times greater than 1961 levels. Per capita consumption increased 1.6 times, presumably due in part to the recognition of the health benefits of fish consumption.




Until recently, the quantity of fish harvested from the world's oceans has kept pace with a rapidly growing human population. It now appears, however, that we have reached (or some would say surpassed) the maximum sustainable yield of the oceans. Precipitous declines in some species such as bluefin tuna, cod and haddock, have served as warnings that for some of our most valued food species we have exceeded their ability to replenish themselves. Additionally, some fishery practices have degraded marine habitats, potentially hampering the ability of some species to recover. The threats of global climate change and further increases in human populations and per capita fish consumption rates apply additional pressure to the resource.

The maximum capacity for the oceans to produce food is unknown and is not constant. It is also, not infinite. Estimates of 100 million metric tons per year are often cited – about 20% above what is now taken. Even if this estimate is valid, it is clear that supplies will fall far short of the needs for a human population that is expected to level off at 9 billion in the next century.

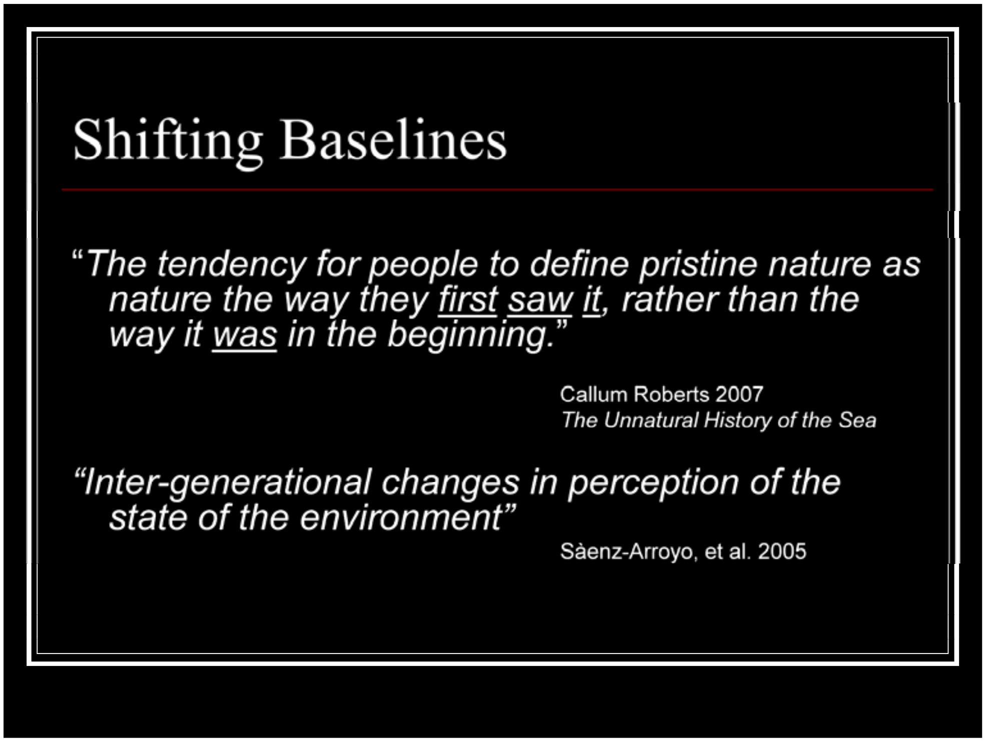
Whether or not oceans will provide an adequate supply of food for future generations will depend in part on how well societies are able to limit consumption while at the same time manage the resource in a sustainable manner.




World fisheries production (including both capture fisheries and aquaculture) has increased steadily since the 1950s and reached over 140 million metric tons in 2006.

China is the largest producer at 51.5 million tons in 2006 (of 140 million tons total), 2/3 of which is produced by aquaculture (rather than wild capture). Increases in global production since the mid-1980s have been almost entirely due to increases in aquaculture production. Aquaculture contributed 47% to total global production in 2006.

Note: All capture and landing values are reported in “metric tons.” A metric ton is larger than an “English ton” and is approximately equal to 2200 pounds.




See notes slide 30.

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The shifting baselines phenomenon is “the tendency for people to define pristine nature as nature the way they first saw it, rather than the way it was in the beginning.” Roberts (2007) provides information from archival records that allow us to evaluate many fisheries (as well as sealing and whaling) from a longer perspective stretching back 100s of years.

Shifting baselines results in an incremental “lowering of standards” as each new generation redefines what is considered “natural” or “normal” based on their own personal experiences. Each new generation lacks an understanding of how the environment “used to be.” This lower standard is now the new baseline for the next generation.

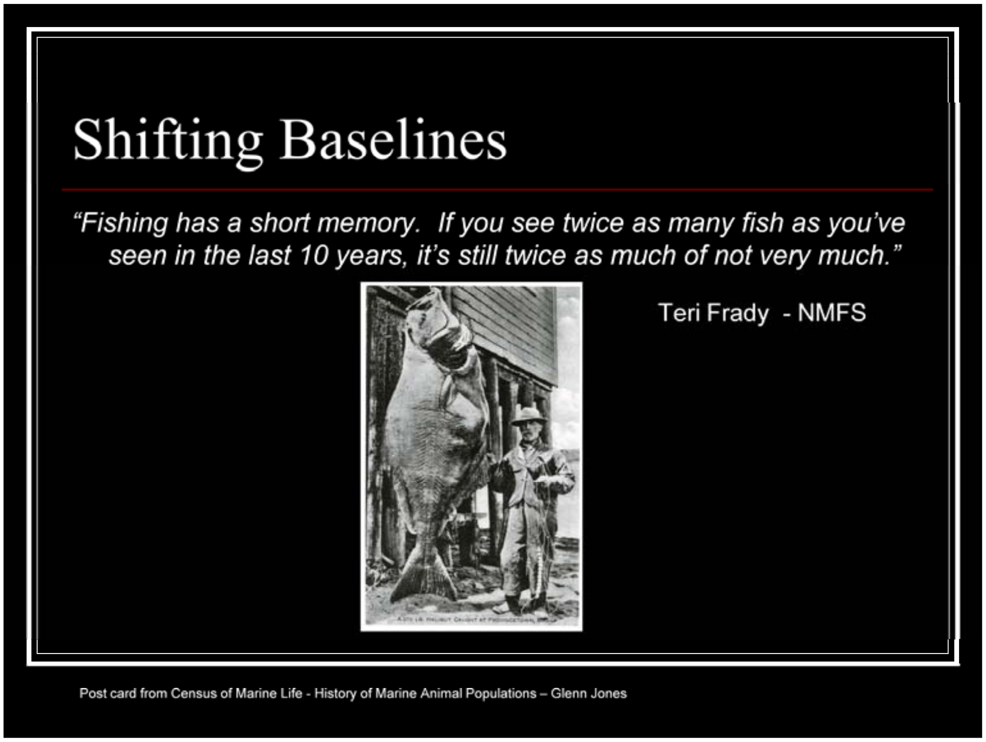
“Modern oceans have been so vastly altered by overexploitation of fishes as to be barely recognizable semblances of their pre-exploitation states.” Historical accounts by early explorers are used to establish a baseline for population levels in the historic past. Fisheries have now penetrated the deepest and most remote parts of the ocean thus driving stocks below any level of sustainability.

Quoted from: Roberts, C. 2007. The unnatural history of the sea. Island Press, Washington, D.C. 435 pp.

Therefore, a fundamental shift is needed in the approach to fisheries management and ocean conservation. Roberts’ proposed solution is to manage fisheries in a global network of marine reserves and protected areas. This is a radical departure from traditional fisheries management.

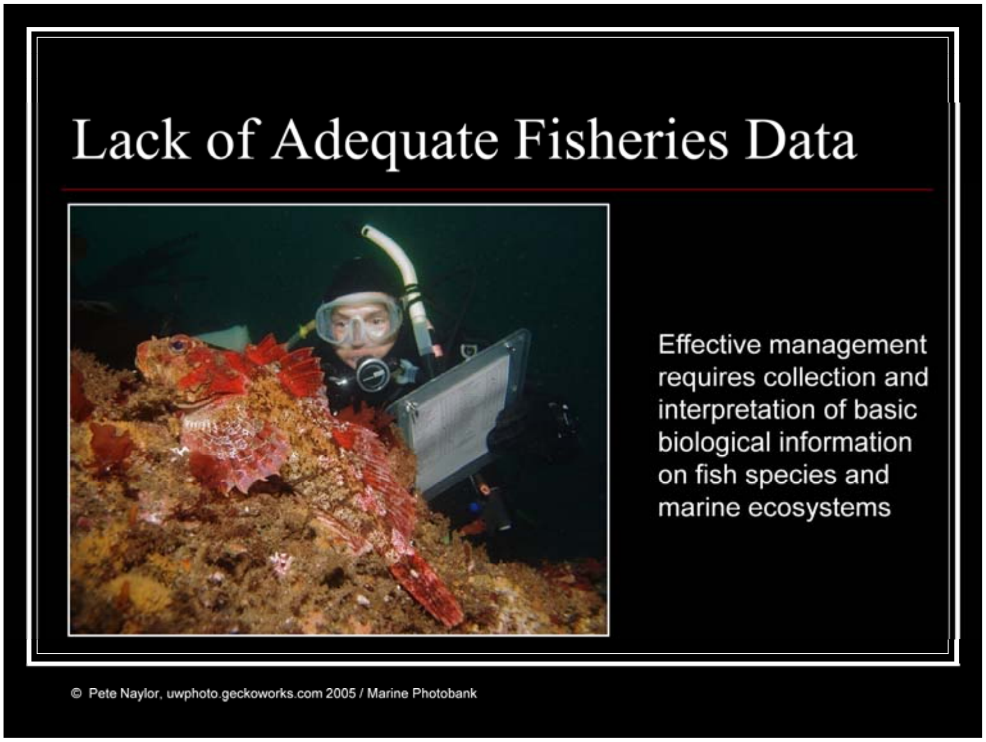
“Shifting baselines are inter-generational changes in perception of the state of the environment. As one generation replaces another, people’s perceptions of what is natural, change even to the extent that they no longer believe historical anecdotes of past abundance or size of species.”

Quoted from: Sàenz-Arroyo, A., et al. 2005




The concept of "shifting baselines" was originally developed in 1995 by a fisheries biologist, to explain the decline of commercial fish stocks. The concept is based on the contention that fishers, scientists and the general public are most familiar with those conditions that exist during their lifetime. Historical conditions that existed prior to this time frame are often not recognized. Those who are not aware of earlier stock levels accept the recent levels as normal. Historical accounts of large fish and huge catches tend to be dismissed as unreliable anecdotes. As reference points of "how things used to be" are allowed to shift, we lose track of our standard and accept a more degraded state as being "normal" or "natural."

Atlantic halibut (270 lb.) caught off Provincetown, Massachusetts circa 1910. Halibut have virtually disappeared from the North Atlantic due to overfishing. The few that are caught now are much smaller than the one seen on this post card.




We lack even the most basic of biological data for many fish species. Essential information such as lifespan, stock trends, limiting factors, food preferences, reproductive biology, and migration patterns are lacking for many species that are already being exploited. Consequently, we often lack adequate data for effective management. Fisheries often develop before this information is known and incorporated into management plans. Without this information fisheries managers are "operating in the dark" and are far more likely to make errors in judgment that could lead to fisheries collapses and the social and economic impacts that they bring.

Traditionally, landings data have been our primary source of information on population trends with the underlying assumption that landings are proportional to population size. However, as various types of management become implemented (e.g., closures, gear restrictions), landings data become less reliable as an indicator of population trends. Consequently, greater emphasis must be placed on the collection of relevant fisheries data to assure more science-based management.

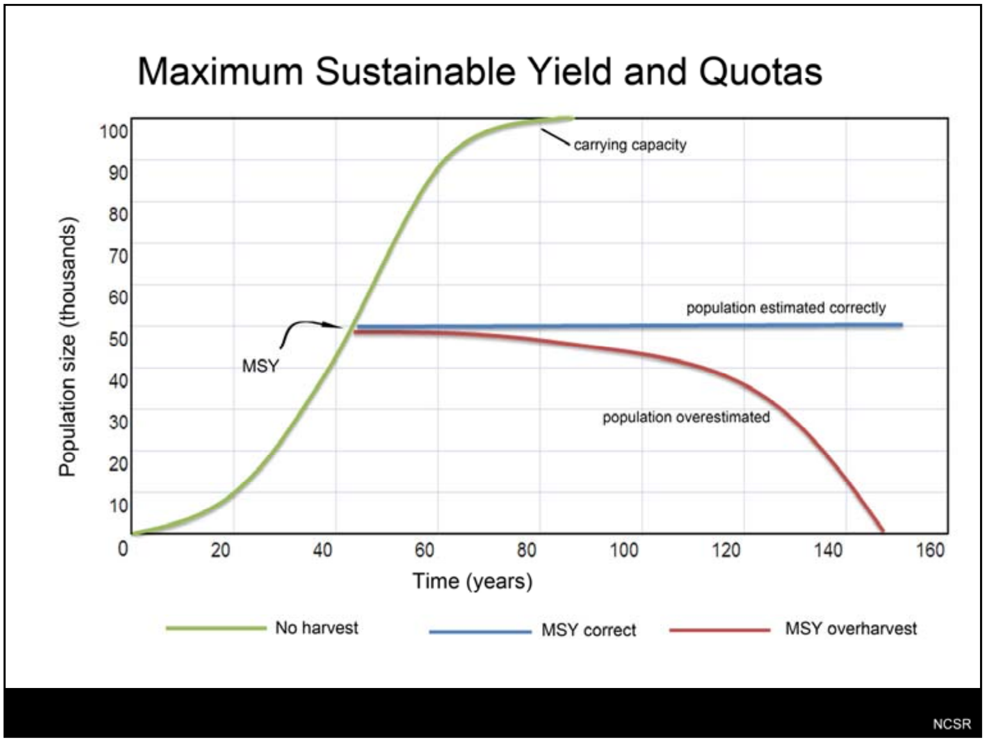

Until recently, most global fisheries were considered “open access” – the concept that fish stocks are not owned by anyone and can be captured on a “first come, first served” basis. Widespread application of this idea has led to over-exploitation, declining fish stocks and struggling fishery-based economies. In response, traditional fisheries management has attempted to allocate the resource in ways that sustain the resource in a “politically acceptable” manner.

Traditional fisheries management has historically focused on single species management with an emphasis on production.

Four general approaches (listed here and described on the following slides) have been used to manage fisheries:

1. **Quotas** or total allowable catches establish a limit on the total weight of fish that can be harvested in one year. Once that limit is reached, the fishery is closed.


2. **Gear restrictions** – for example, mesh size regulations on trawl nets that allow non-target (especially smaller) fish to escape.




See notes slide 35.

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3. **Maximum Sustainable Yield**

The concept of maximum sustainable yield (MSY) has been a guiding principle of fisheries management since the 1950s. It is based on the relationship between fish population dynamics and fish harvest. It relies on the inherent nature of fish populations to replenish themselves based on their "surplus production" – the natural ability for a population to compensate for increased mortality (i.e., as more fish are captured, the population compensates by increasing its reproductive rate or survival of fish recruiting into the population is enhanced).

The logic of MSY goes like this:

1. Population size is determined in part by population growth rate

2. Growth rates are lowest when the population is small (the lag phase of logistic population growth) and large (population is near the carrying capacity and population growth is limited by density dependent factors like food availability)

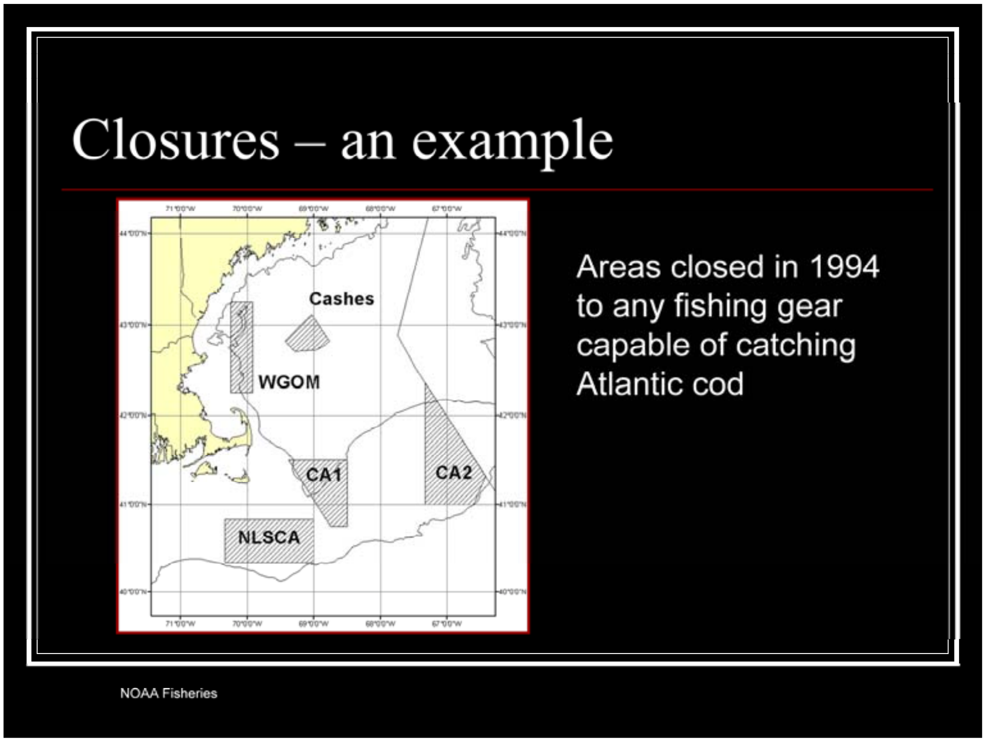
3. Intermediate-sized populations have the greatest growth capacity and the ability to produce the greatest number of fish that can be harvested each year.

4. Therefore, fisheries can maximize production by keeping the population at an intermediate level (1/2 of carrying capacity).

Application of MSY, assumes that we can estimate the <u>size</u> of fish stocks, which for most species is very difficult and includes a significant amount of uncertainty.

Attempts to implement MSY have resulted in the collapse of several fisheries due to:

1. The difficulty of estimating population size (populations are frequently over-estimated and year to year natural fluctuations in populations must be accounted for)
2. The model assumes exponential growth (which may be an invalid assumption)
3. The model is a single-species approach and does not take into account ecosystem effects
4. Societal pressure to overestimate stock size and underestimate fishing effort is significant




An example of closures: In response to the collapse of the cod fishery in the early 1990s, year-round restrictions were put in place in key groundfish areas (cross-hatched) on Georges Bank and in the Gulf of Maine. These areas were closed to any bottom –fishing gear. Seasonal restrictions were also implemented in most of the areas represented on this map from Cape Cod to the Gulf of Maine. Closures are an extreme method of reducing fishing mortality and implemented most often on a temporary basis to allow a fish stock to recover. The responses of sea scallops will be used to illustrate the effect of closures.

The terminology on the map is irrelevant in this discussion, however they do represent "area names."

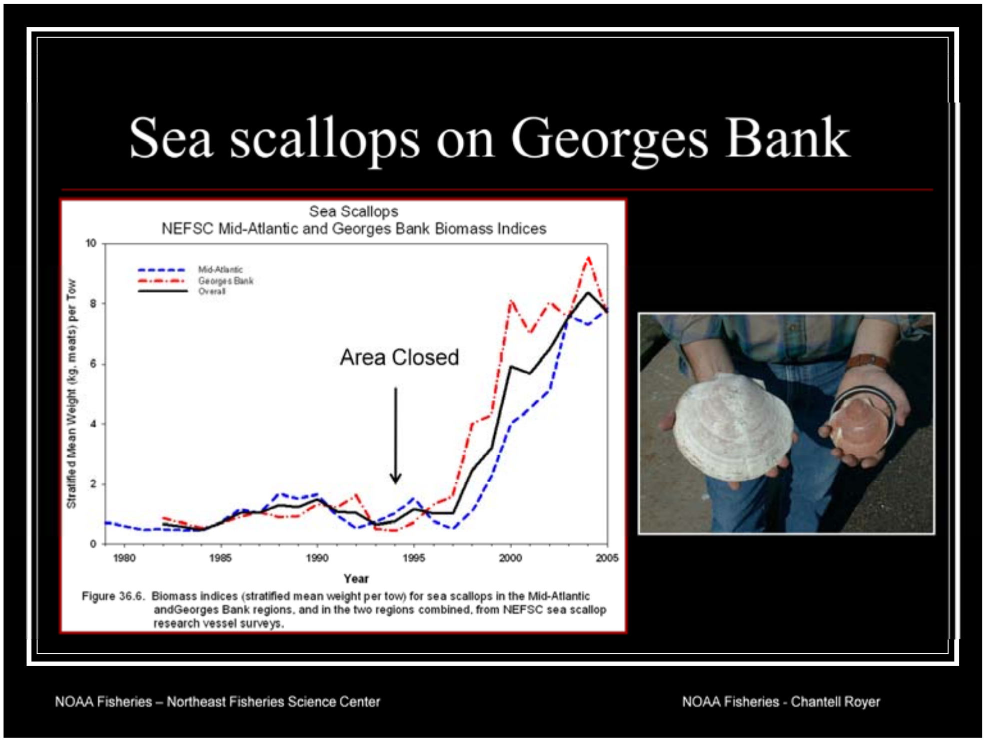
WGOM = Western Gulf of Maine

Cashes= Cashes Ledge

CA1= Conservation Area 1

CA2= Conservation Area 2

NLSCA= Nantucket Lightship Conservation Area




Sea scallops increased dramatically inside the closed areas just a few years after the emergency cod closure. Between 1994 and 2002 sea scallop biomass on Georges bank increased more than 20 fold. In 2003, scallop biomass inside the closures was 25 times the biomass before the closures. Compared to areas outside the closures that were being fished, scallop biomass was 4-5 times greater inside the closed areas. This change took place over just 10 years and was presumably due to not harvesting scallops during the closure.

This suggests that for some species, recovery can be quite rapid once fishing pressure is removed. Some long-lived, slow-growing species and complex benthic habitats probably recover only on longer time frames.

Atlantic cod, for example, has not experienced the same type of recovery as sea scallops.

Sea scallops shown in photo at right – a large shell on left and small shell on right with a metal ring used to determine minimum size allowed to be harvested. Only the adductor muscle of the scallop is marketed.


In addition to traditional fishery management tools such as those just discussed, a number of market-based approaches have been implemented or proposed to address declining marine fisheries. Unlike previous approaches, these methods use the power of the market in various ways to promote sustainable fisheries. Each will be discussed separately.


Green certification by independent organizations has been adopted in organic agriculture and forestry as a mechanism by which consumers can identify "sustainably produced" products and make corresponding choices in the marketplace. Seafood purchasers can now make similar choices in their selection of seafood. Fishing interests have an incentive to adopt less harmful practices to meet the criteria for certification. A fundamental assumption in this process is that the consumers (or at least some of them) are willing to pay extra for sustainably harvested fish. The Marine Stewardship Council (MSC) based in London, England is the largest of these certifiers. As of August 2009 this organization has certified 52 fisheries (some representative fisheries shown on map) including North Sea herring, Australian mackerel, Oregon Pink Shrimp and Baja California red rock lobster. MSC logo (shown at right) is used to identify MSC-certified products.

Wal-Mart, the world's largest retailer, recently (2007) committed to purchasing all of its seafood from sustainably certified sources.

MSC certification is based on three main criteria:

•Status of the target fish stock

•Impact of the fishery on the ecosystem

•Performance and effectiveness of the fishery management system


See notes slide 40.

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Since 1998, a number of groups have produced simple reference guides designed to assist consumers who wish to make informed decisions about seafood purchases. The Blue Ocean Institute, Monterey Bay Aquarium and the National Audubon Society all produce these guides. Fish are placed in different categories based on their abundance and the degree to which they are harvested using sustainable methods.

The seafood guide produced by the Monterey Bay Aquarium, for example, assigns farmed shellfish and Alaska salmon to its "best choices" category, while Chilean sea bass and Atlantic cod are assigned to the "avoid" category. In general, consumers make more sustainable choices when they choose seafood that is at a lower trophic level (e.g., clams and squid rather than tuna and swordfish). While these guides may have only a small impact on purchases, they may provide seafood companies and fishers with the incentive to adjust their habits towards more sustainable practices as they realize that the "consumer is watching."

Seafood choices made by restaurants and chefs also may play a role in which fish are served and ultimately harvested. Restaurants may boycott certain items based on unsustainable practices (e.g., Chilean sea bass). In 1998, 27 chefs from prominent East Coast restaurants announced the removal of swordfish from their menus until a recovery plan was in place. One year later, 500 chefs nationwide had done the same. In August of 2000, NOAA Fisheries announced a plan to protect swordfish nursery areas and the "Give Swordfish a Break" campaign was formally ended.

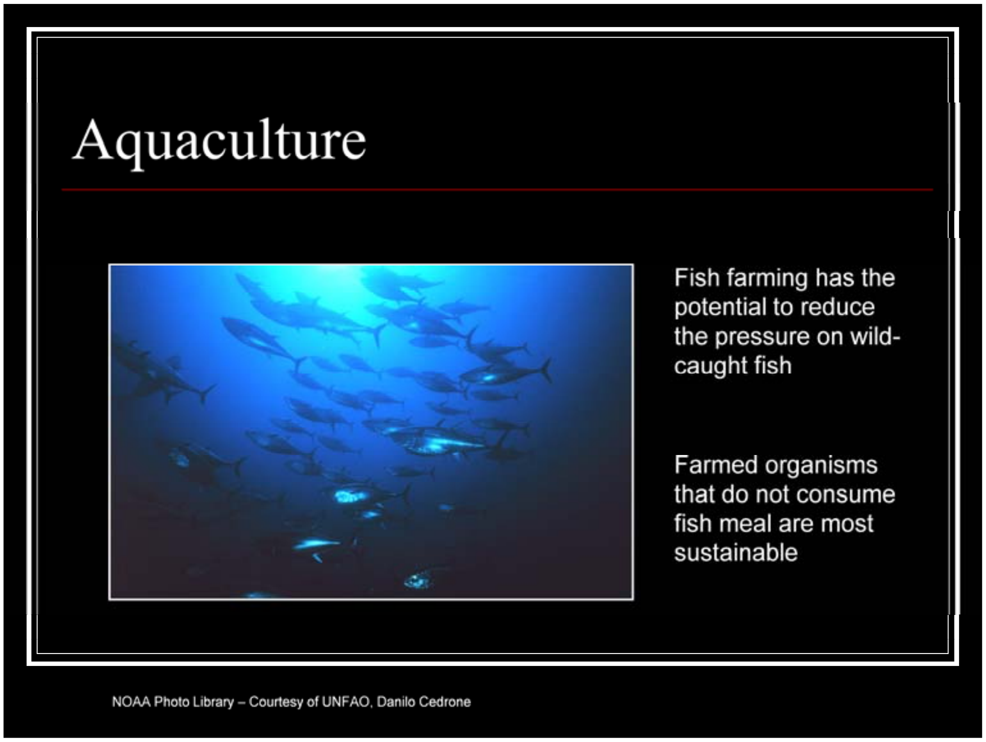
Some seafood companies commit to identifying and marketing seafood that originates from sustainable practices. *CleanFish* markets high quality seafood that is "safe, sustainable and delicious" by purchasing from fishers who use the most selective methods of harvest.

A text message service has been developed and implemented by the Blue Ocean Institute to rank seafood sustainability using cell phone technology and text messaging while standing at the fish counter. See web site:

[www.blueocean.org/fishphone.index.html](www.blueocean.org/fishphone.index.html)


A decrease of 30-50% in fishing effort may be required to attain sustainable harvests. This reduction in fishing effort could be obtained by reducing the number of permits available and thus, the number of fishing vessels allowed to fish. NOAA Fisheries issues fishing permits but, in an effort to reduce the amount of pressure on fish stocks, does not issue any <u>new</u> permits. Further reduction in fishing effort could be obtained by having governments “buy out” willing fishermen who want to get out of the fishery by purchasing permits or fishing vessels. In 2002, for example, Congress approved $46 million to buy fishing vessels from willing sellers in an effort to protect declining West Coast rockfish (*Sebastes* sp.) populations. By 2003, the program had reduced the size of the fishing fleet by half from 300 to 147 vessels.

Fishermen usually obtain permits by purchasing them from other fishermen. In July of 2006, the first private buyout of commercial fishing permits occurred when the Nature Conservancy purchased six federal trawling permits from fishermen in Morro Bay on the California Coast.




See notes slide 42.

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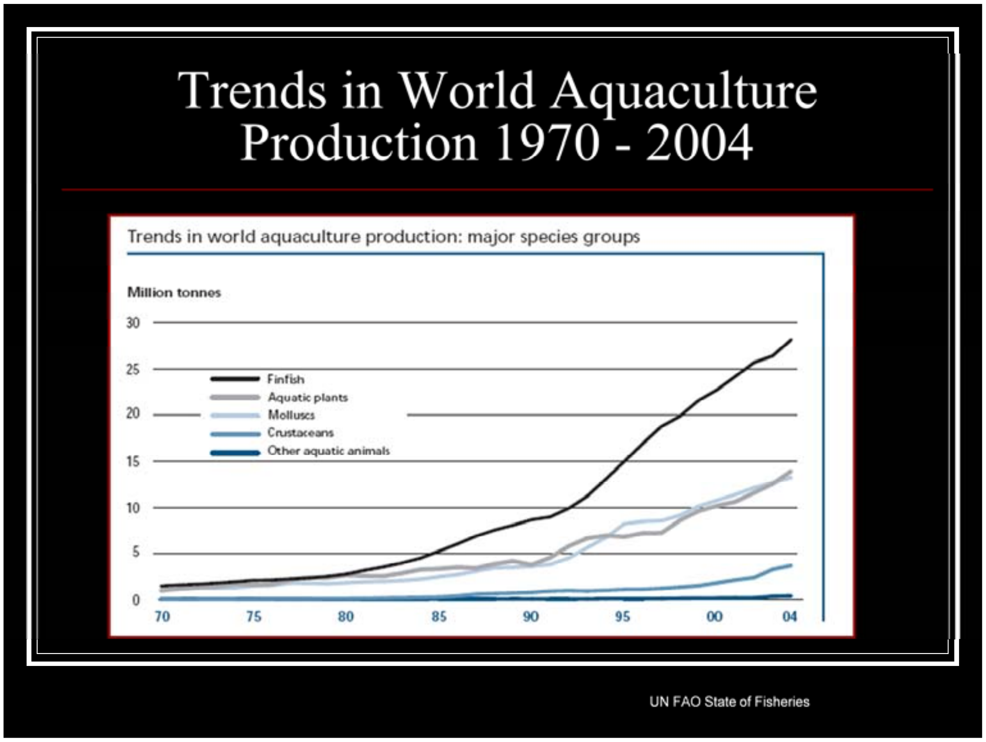
China and India are the world leaders in aquaculture production. Over 200 fish and shellfish species are grown in aquaculture. While freshwater fish such as carp and their relatives dominate global production, the most common marine species include shrimp, salmon, oysters, clams and mussels. In the U.S., 5 of the top 10 species (shrimp, salmon, catfish, tilapia and clams) consumed in 2004 were at least partially produced in aquaculture operations.

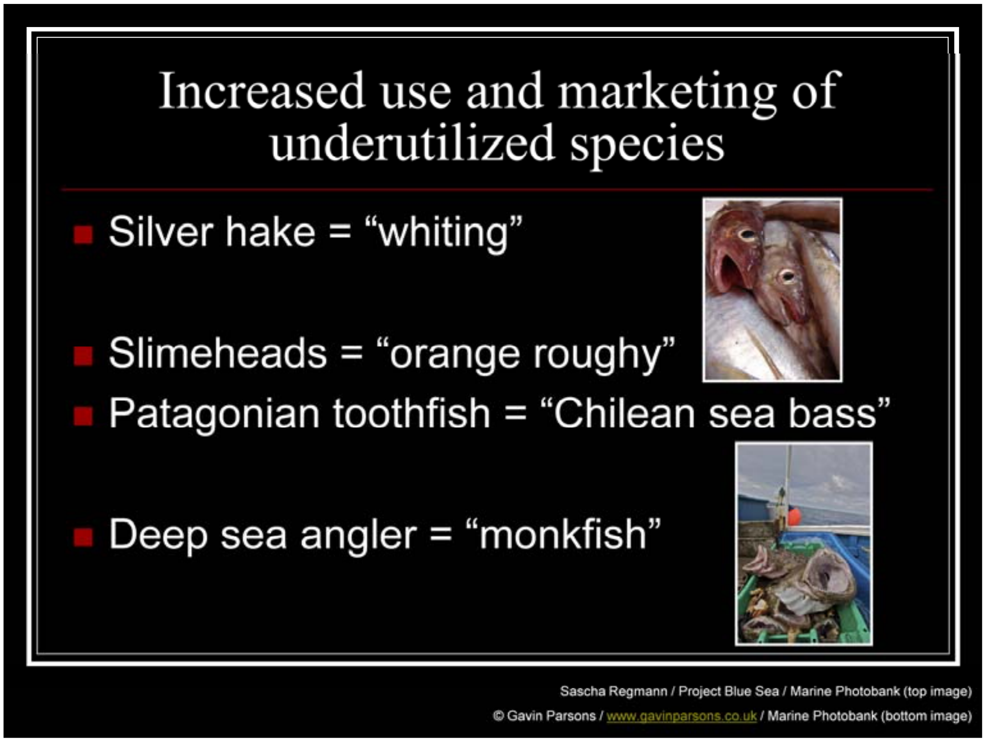
While aquaculture has the potential to reduce pressure on wild-caught fish, this has not yet been realized. Ironically, it may do just the opposite, particularly when fish at higher trophic levels are raised such as bluefin tuna (shown here) or salmon. These fish require a diet that contains animal protein. When farmed fish are fed fish meal, fishing effort is often required to get enough food to feed these captive fish. To feed fish and shrimp, growers typically rely on wild-caught ocean fish. For example, about 3 metric tons of wild-caught fish are required to produce 1 metric ton of farmed shrimp or salmon.

Additionally, large-scale aquaculture operations often replace coastal ecosystems such as estuaries, tidal flats and mangrove swamps. These coastal ecosystems often play a key role in the life cycle of other marine fish species. Aquaculture operations also may release a large amount of nutrient rich effluent into natural waterways and promote disease and parasites in native fish populations. Native salmon that migrate past salmon pens, for example, have been shown to carry a higher parasite load of sea lice.

Despite these shortcomings, aquaculture is likely to play an increasingly important role in meeting the ever-increasing global demand for seafood. Farmed organisms that do not consume fish meal hold the most promise for a sustainable fishery – e.g., mussels, clams, tilapia (an herbivorous fish).



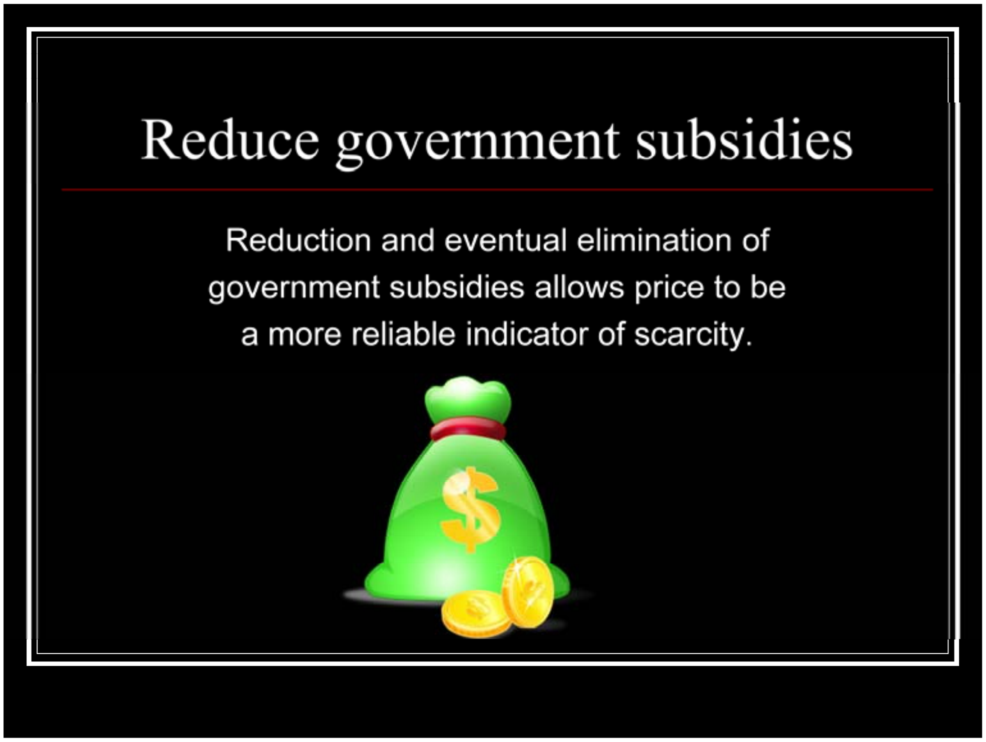

Increases in total fish production for the past decade have been largely due to increases in aquaculture ("fish farming") production rather than increases in the harvest of wild-caught fish.  Since 1970, global aquaculture production has increased at an annual rate of nearly 9%. Aquaculture contributed 43% to total fish production in 2004.




In an effort to reduce bycatch and pressure on those fish we currently target, it has been suggested that markets could be developed for underutilized (and often discarded) species. One strategy, implemented since the 1970s has been to encourage use of underutilized species by assigning them market names that might be more attractive to the consumer. Here are some examples of species that have been given more appealing market names.

In some cases, fish that was once regarded as "trash fish" can now command over $10/pound. The deep sea angler is now marketed as "monkfish“ and, given the massive head and gaping mouth only the tails are sold in the marketplace! Once discarded as bycatch, this species is now being overfished.

SEE WINTER 2009 NEWSLETTER ARTICLE “FISH BY ANY OTHER NAME” FOR MORE INFO ON THIS TOPIC
http://www.ncsr.org/documents/Winter2009.pdf




Reduction and eventual elimination of government subsidies allows price to be a more reliable indicator of scarcity.  As described earlier, subsidies distort the marketplace and cause individuals and businesses to remain in the industry even when the market dictates otherwise.  The result, is continued and even increased pressure on already depleted fishery stocks.  Elimination of subsidies should reduce fishing effort as more individuals make the decision to exit the fishery.

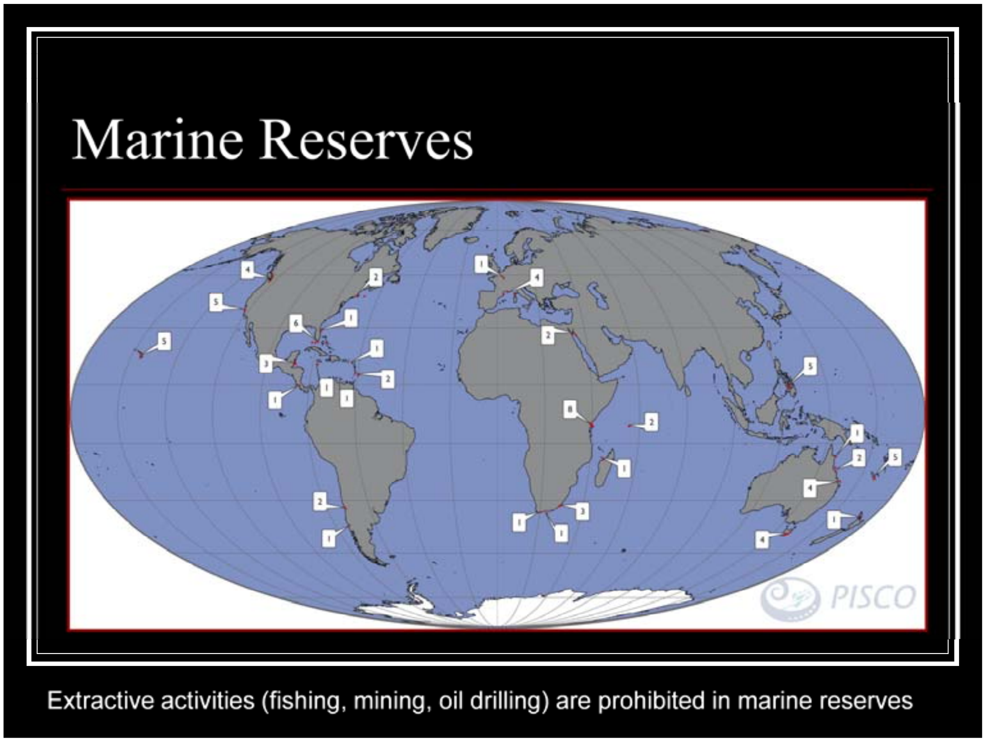

Recent reports by the National Research Council (2006), the U.S. Commission on Ocean Policy (2004) and the Pew Oceans Commission (2003) have documented the need for a new, ecosystem-based approach to the management of marine fisheries (EBFM). The overall objective of EBFM is to sustain healthy marine ecosystems and the fisheries they support.

An approach that attempts to apply ecosystem management to fisheries management includes these elements. Each will be discussed separately.

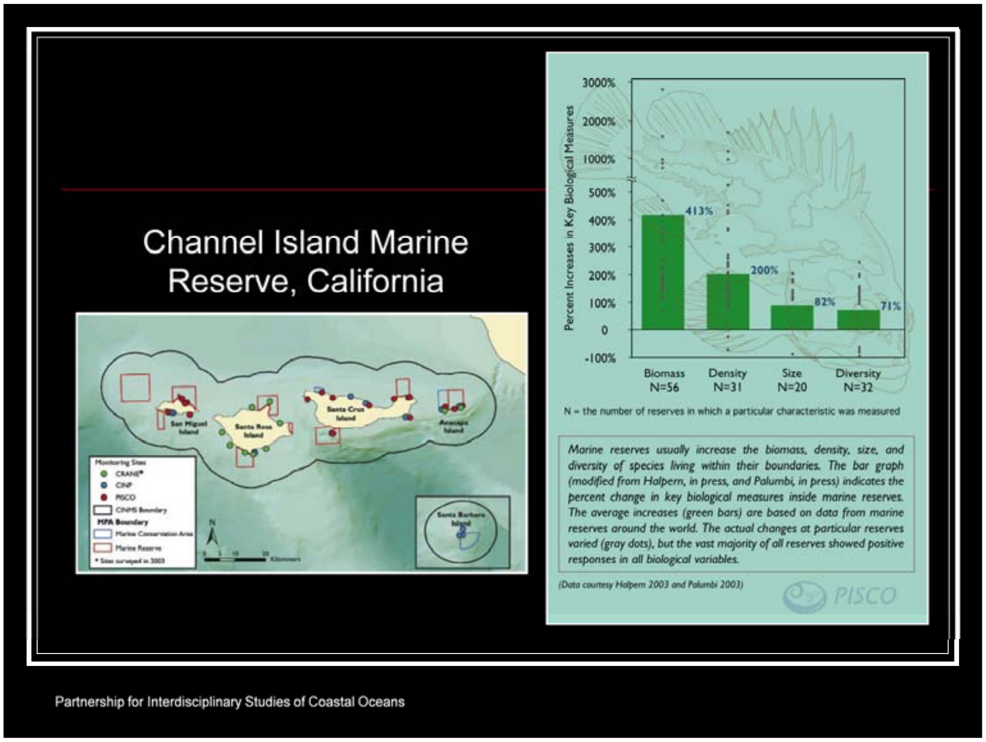

Changes in fishing practices (gear alterations, closures of fishing areas, changes in timing of fishing effort, etc.) that reduce bycatch are an essential part of achieving sustainable fisheries. There have been some successes in the reduction of bycatch.

Turtle excluder devices (TEDs) on shrimp trawls, for example, have reduced the number of sea turtles killed each year. A TED is a grid of bars (seen in photo at right) and an opening in either the bottom or top of a trawl net. Small fish and shrimp pass through the bars and are caught in the bag of the net. Larger animals such as marine turtles and sharks are deflected by the bars and directed towards the opening.

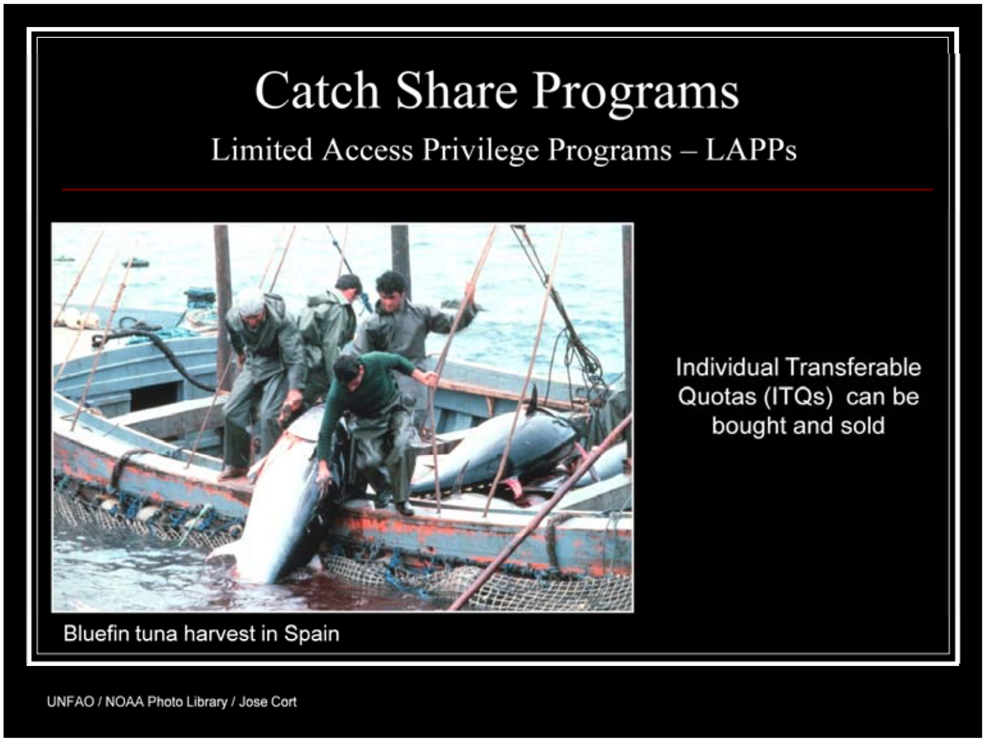

Loggerhead turtle escaping from a net equipped with a TED.




Marine reserves are ocean areas in which extractive activities such as fishing, mining and oil drilling are prohibited. They represent the most restrictive type of "marine protected areas," which may afford a wide variation in degree of protection. Map shows locations of some existing reserves. Currently, less than 1% of territorial waters in the United States are in marine reserves including reserves off the coasts of Washington, California and Florida.

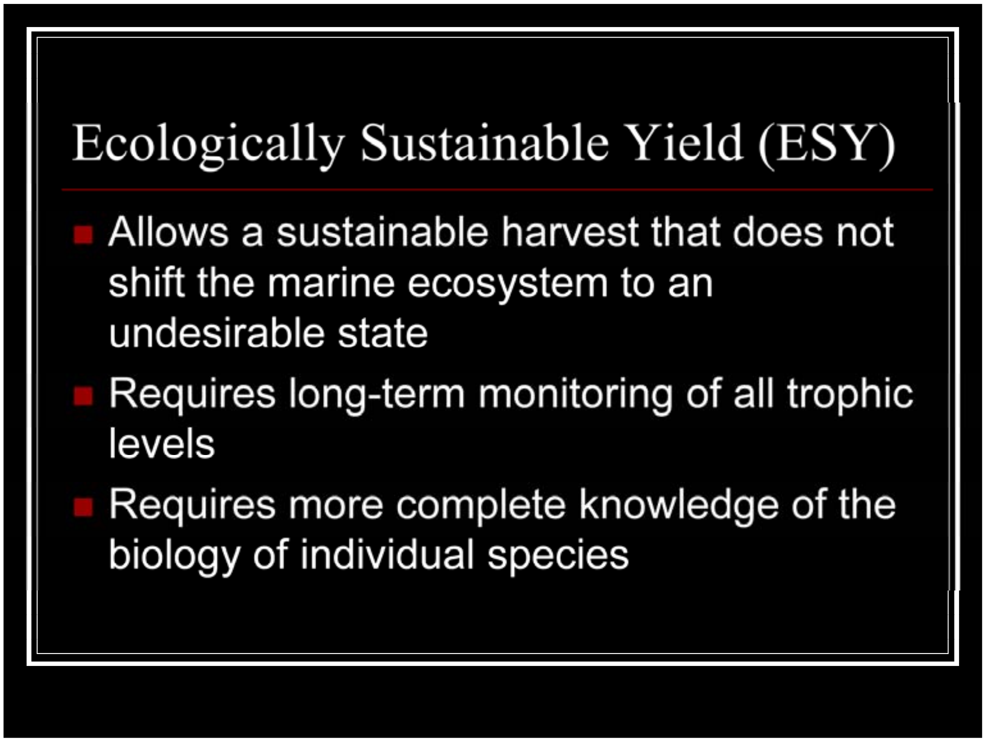



Channel Island Marine Reserve off the California coast is an example of a marine reserve. Marine reserves have been shown to increase the biomass, density, size and biodiversity when compared to non-reserve areas. For more detail on marine reserves, see NCSR's *The Role of Marine Reserves in Ecosystem Based Fishery Management* module.




Some fisheries managers have suggested allocating portions of total allowable catches (TACs) with catch share programs (sometimes known as, Limited Access Privilege Programs – LAPPs). This type of system gives fishers a guaranteed portion of the catch and it is up to each individual to determine how and when that amount is harvested. Under some catch share programs (e.g., Individual Transferable Quotas or ITQs), allocations can be bought and sold. The assumption is that with fewer time constraints on the harvest, more selective methods would be used resulting in less overall impact. Also, fishers have an economic incentive to protect the resource to obtain the same quota in future years. Transferable ITQs can be bought and sold like private property. One concern with this system is that if individual quotas can be bought and sold, the largest and wealthiest operators within the fishery may accumulate the lion's share of the quotas, eliminating smaller operators.

ITQs were implemented in the Alaska halibut fishery in the 1990s. A pound limit is now established for each licensed boat. In part, as a result of this management change, Pacific halibut is now assigned as a "best choice for consumers" by those organizations promoting sustainable fisheries.



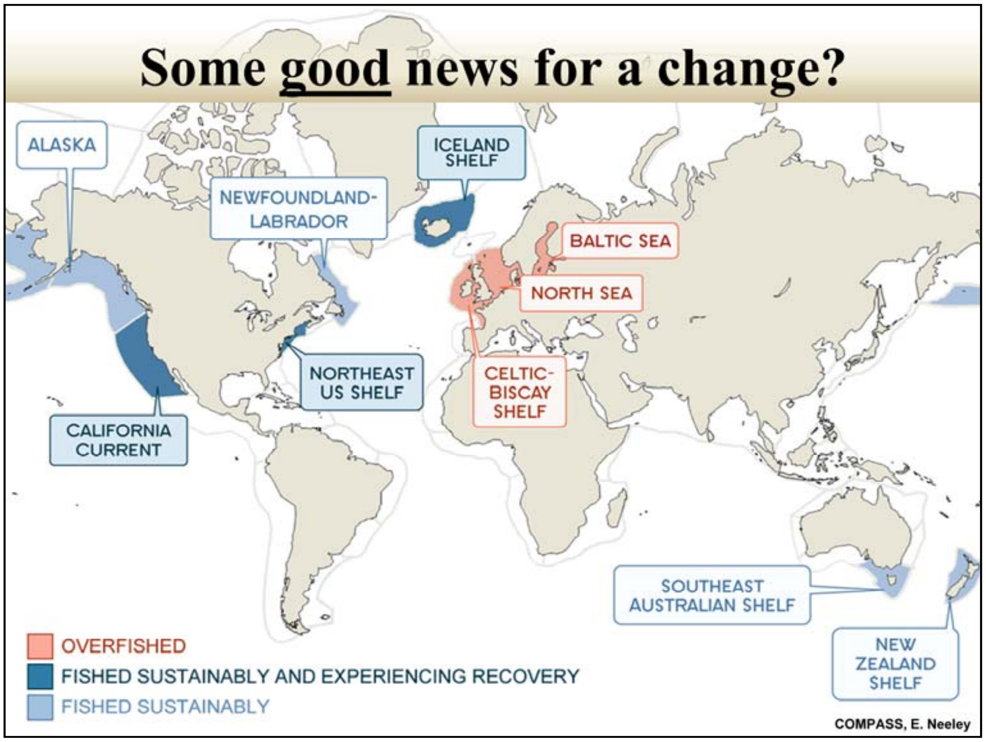

As part of an ecosystem-based approach to fisheries management, some fisheries scientists suggest replacing the traditional standard of “maximum sustainable yield” with “ecologically sustainable yield” (ESY) as a management goal. Rather than emphasizing the maximum yield of a single species, the goal of ESY is to allow a harvest that an ecosystem can sustain without shifting to an undesirable state. ESY requires a long term commitment to monitoring marine ecosystems at all trophic levels, not just the target species.

Also, since many more factors must be considered to implement ESY, a more complete knowledge of marine ecosystems and the biology of individual species is required to guide policy and to translate policy into practice. Much of the information on these essential elements is currently lacking. In most cases, ESY will reduce the allowable harvest to less than the amount allowed by MSY. However, sustainable fishing based on ESY will still lower fish populations below that of un-fished populations. Thus, ESY is not the same as the conservation goal of maintaining natural marine communities.


Past efforts to regulate fisheries have frequently resulted in tensions and sometimes dramatic conflicts among various interests. Tensions between commercial fishermen and government regulators, between U.S and foreign fleets, between commercial and recreational fishermen, between environmentalists and the fishing industry have created a climate of antagonism among what are seen as competing interests.

Past fishery management practices have provided us with "boom and bust" cycles in the harvest of marine fish – development of a fishery, followed by over-exploitation and population declines. The future of fisheries and the ecosystems that support those fisheries will probably depend on our willingness to recognize that harvested fish do not exist in a vacuum, but rather in the context of a larger ecosystem. And, if we want to harvest fish, we have to manage in such a manner that does not degrade the ecosystem that supports them.

Note that the future envisioned by Pikitch, et al. in the quote above, would require a precautionary approach. This would be akin to the approach we take in health and safety matters. When a new drug is developed, extensive testing is required by the FDA to assure efficacy and safety. Similarly, new sitings for nuclear power plants go through an extensive permitting process to reduce risk. See Dayton (1998) for further discussion.




See notes slide 54.

Notes Slide 54

The most recent analysis of the status of global fisheries provides some reason for optimism (Worm, et al. 2009):

Several prominent fisheries biologists recently collaborated on a thorough evaluation of the worldwide status of marine fisheries. Their conclusions suggest some reason for optimism as there appear to be some recent trends that show declines in average exploitation rates.

In 5 of 10 well-studied ecosystems, average exploitation rate has recently declined (see map above). However, there is still plenty of work to do as 63% of assessed global fish stocks still require rebuilding. The authors of the study claim that fisheries and conservation objectives can be met by using a variety of management actions, such as catch restrictions, gear modification and closures.

The good news:

Five of the 10 ecosystems studied are now being fished sustainably (blue areas in figure). ALL (except Alaska) had been fished unsustainably previously. For example, the haddock fishery off New England is probably as healthy as it has been in the last several decades. Fisheries around Iceland and the California Current are also experiencing recovery.

The bad news:

Atlantic bluefin tuna is being fished at about 10 times what would be considered sustainable. Approximately 80% of Europe's fisheries are overfished. The western Pacific Ocean near China is being overfished, although data for that part of the world are not as complete as they are for most regions.


Summary of major points.

More detailed coverage on marine fisheries topics discussed in this presentation may be found in the following NCSR Marine Fisheries modules:

- *Marine Fisheries – Introduction and Status*
- *Marine Fisheries – Causes for Decline and Impacts*
- *Marine Fisheries – Management and Proposed Solutions*
- *Declining Expectations – The Phenomenon of Shifting Baselines*
- *The Role of Marine Reserves in Ecosystem Based Fishery Management*
- *The Decline of Atlantic Cod – A Case Study*

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