Marine Fisheries – Introduction and Status

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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 David Lonsdale of Chemeketa Community College and Jan Hodder of the Oregon Institute of Marine Biology (University of Oregon) 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*
- *Strange Days on Planet Earth – Episode 5 – Dangerous Catch*
- *Journey to Planet Earth – The State of the Planet's Oceans*

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 – Introduction and Status

An Instructional Guide

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. Marine fisheries are first defined and characterized and then the various marine habitats that are exploited are described. The historical condition of fisheries is discussed, as well as assessments of the current status of the resource.

A general lecture outline and a more detailed *PowerPoint* presentation with instructor notes are provided. Print, video and web-based resources that cover the topic are summarized and cited. Instructors who wish to obtain greater detail on any of the topics discussed in this module are encouraged to seek out these additional resources or those cited in the *Comprehensive Resources for NCSR Marine Fisheries Series*.

Objectives

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

1. Define and characterize the marine fisheries resource
2. Describe those habitats that support the most productive fisheries
3. Describe the importance of fish as a food source for humans
4. Contrast the historical status of marine fisheries with current status
5. Evaluate evidence of declines of large predatory species

General Lecture Outline

Topics I, II and III in the general lecture outline below are covered in this module. Topics IV through X are covered in detail in other NCSR Marine Fisheries modules.

I. Introduction – Why study marine fisheries?
II. Characterize the resource
- Define marine fisheries
- What areas are fished?
- Importance as a food source
- Importance to societies

III. Status of the resource
- Historical perspective
- Current status
- Case studies of fishery declines
- Endangered species

IV. Causes for fishery declines
- Overfishing
- Highly efficient technology
- Bycatch
- Overcapacity
- Climate change and ocean acidification
- Recreational fishing

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

VI. Why are fishery declines allowed to occur?
- Economics of overfishing/Government subsidies
- Growing human populations and increasing demand
- Shifting baselines
- Lack of adequate fisheries data

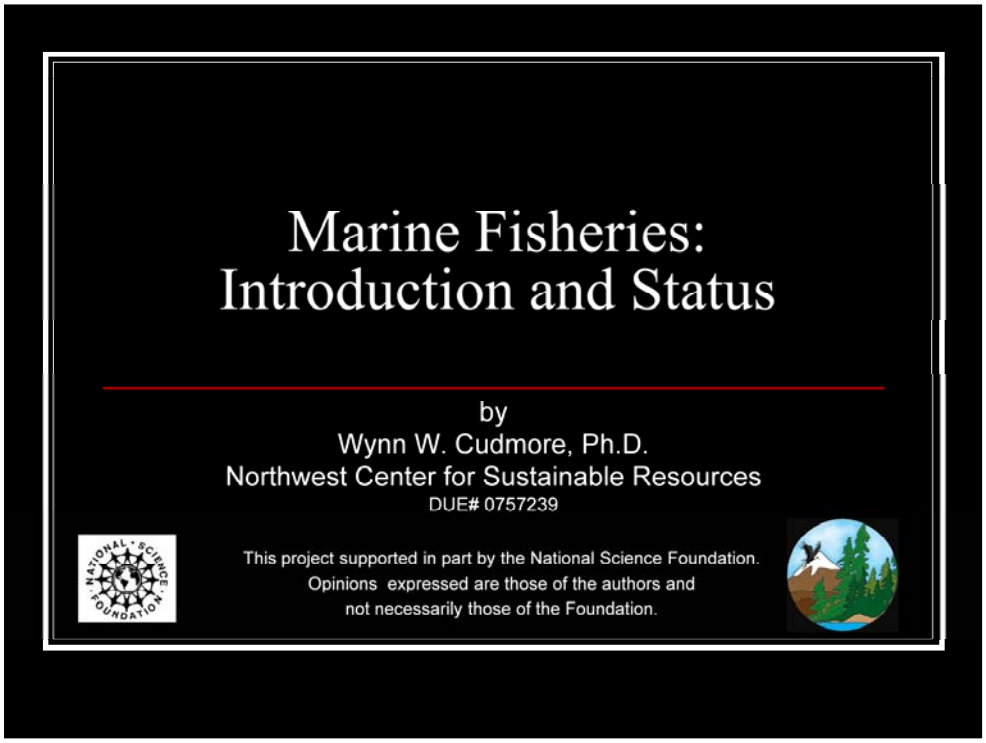
VII. Traditional fisheries management
- The challenge of management
- Maximum sustainable yield
- Quotas (Total Allowable Catches)
- Relevant legislation
- Closures

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

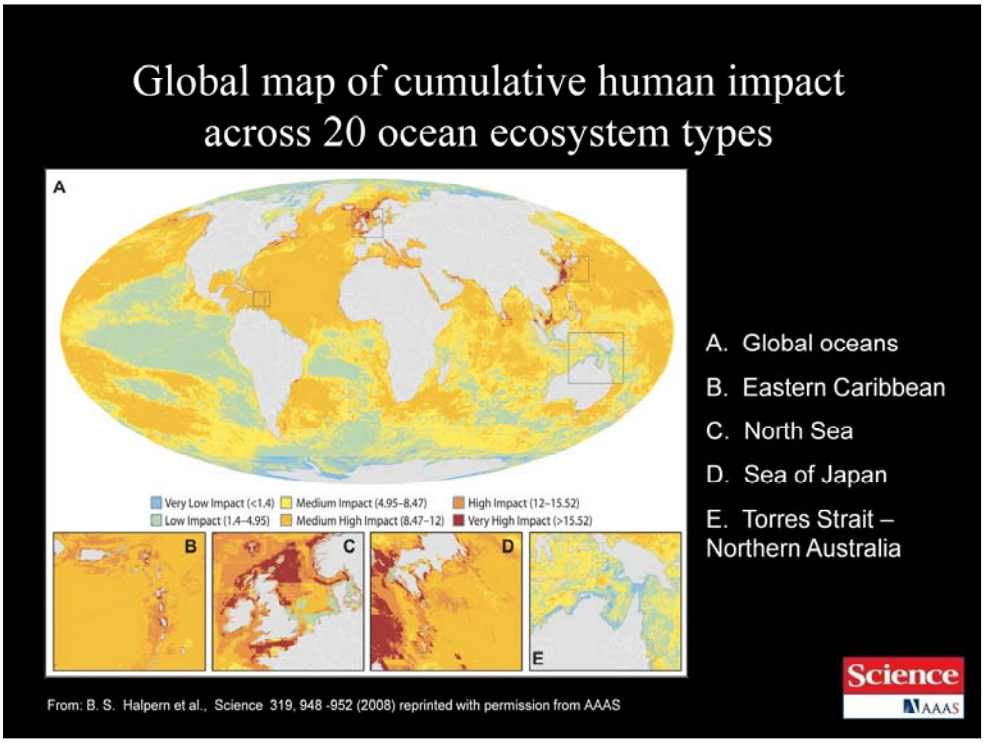
IX. Ecosystem-based fishery management
- Reduce bycatch
- Gear restrictions
- Marine reserves/marine protected areas
- Monitoring of population characteristics
- Implementing catch share programs
- Ecologically sustainable yield

X. The future of marine fisheries

PowerPoint Presentation with Instructor Notes



This presentation provides a detailed examination of the nature of marine fisheries and their status as natural resources. Other marine fisheries topics such as causes for declines, the implications of fishery declines for marine ecosystems and fishery management practices are described in detail in other NCSR marine fisheries modules.



Humans depend on the world's oceans for valuable goods and services. However, human activities over the course of time have also altered oceans as represented in "A" above. The map is a synthesis of 17 global data sets that measure the effect of human activities over 20 marine ecosystems.

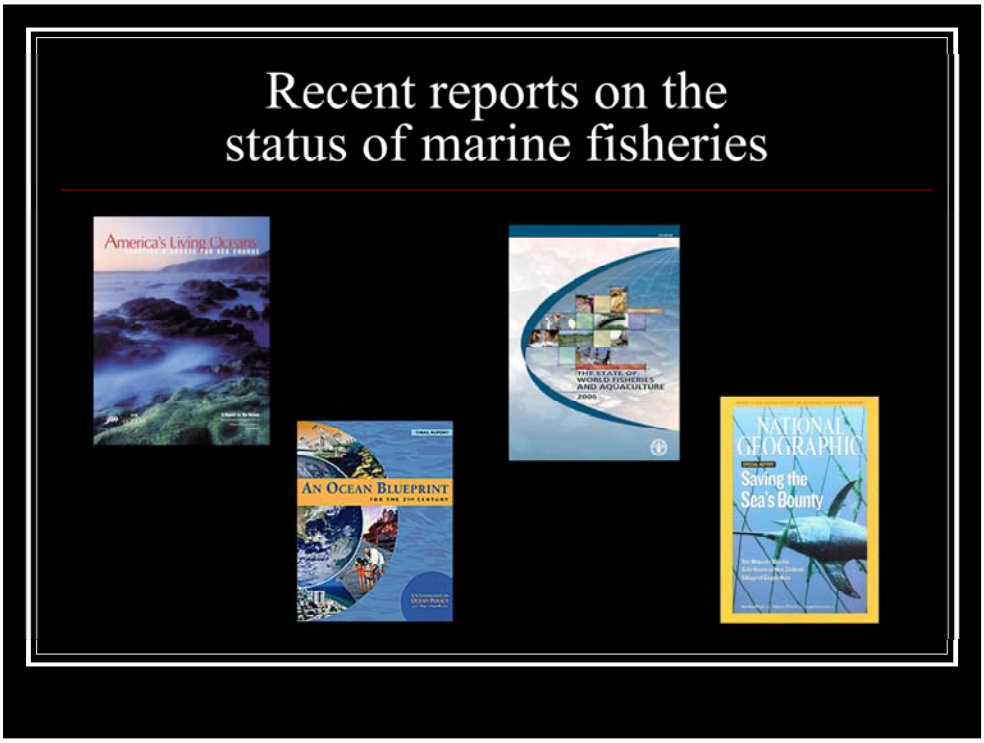
This analysis indicates that no ocean areas are unaffected and that nearly half (41%) are affected by multiple factors. Highly impacted regions, for example, include the Eastern Caribbean, the North Sea and the waters around Japan (see insets B, C, and D on map). Much of the coastal area of Europe, North America, the Caribbean, China and Southeast Asia are heavily impacted. The least affected areas tend to be close to the poles. Northern Australia (inset E) was also found to be among the least impacted.

Impacts include (among others):

1. Runoff of pollutants into coastal waters
2. Ocean acidification (as a result of an increase in carbon dioxide input into the atmosphere)
3. Global climate change and increasing ocean temperatures
4. Fishing impacts

The effects of fishing are thought by some to be the one human activity that has the greatest impact on marine ecosystems.

From: Halpern, B.S. et al., 2008. A global map of human impact on marine ecosystems. Science 319:948-952 (2008) reprinted with permission from AAAS.

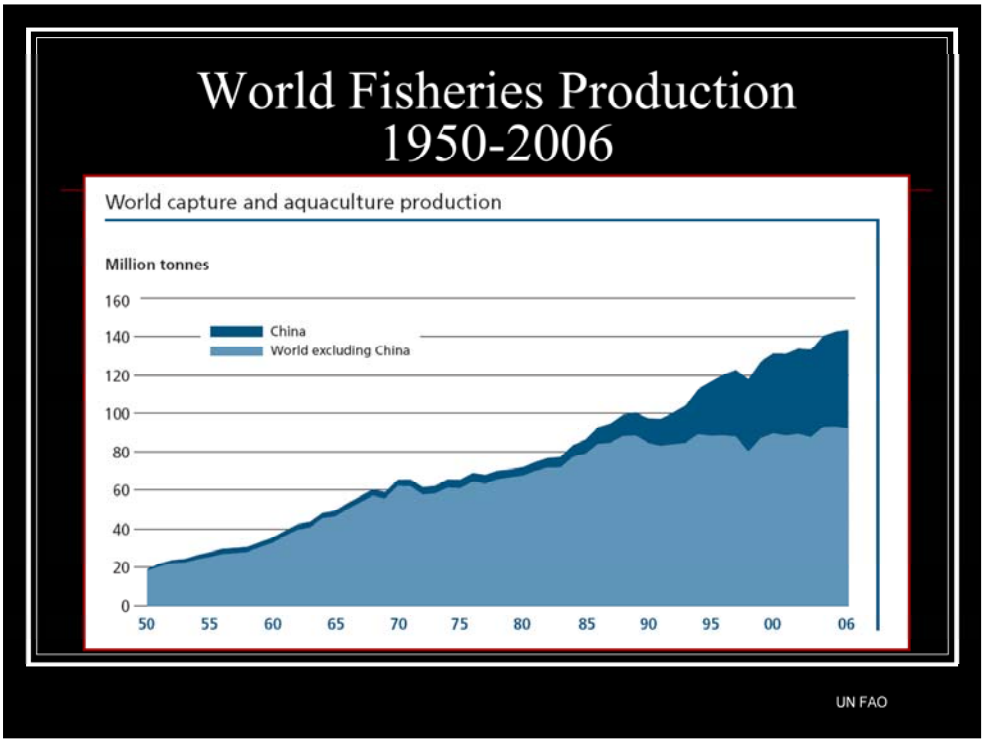


The status of marine fish as well as the ecosystems that support them has been of great interest in recent years. A number of publications in the scientific and popular literature have raised concerns over marine conservation. All have recommended a shift in marine conservation strategy to one that takes an ecosystem-based approach.

From left to right – *America's Living Oceans* by Pew Ocean's Commission, *An Ocean Blueprint for the 21st Century* by the U.S. Commission on Ocean Policy, *The State of World Fisheries and Aquaculture* by the U.N. Food and Agriculture Organization (FAO) and *Saving the Sea's Bounty* – National Geographic.

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

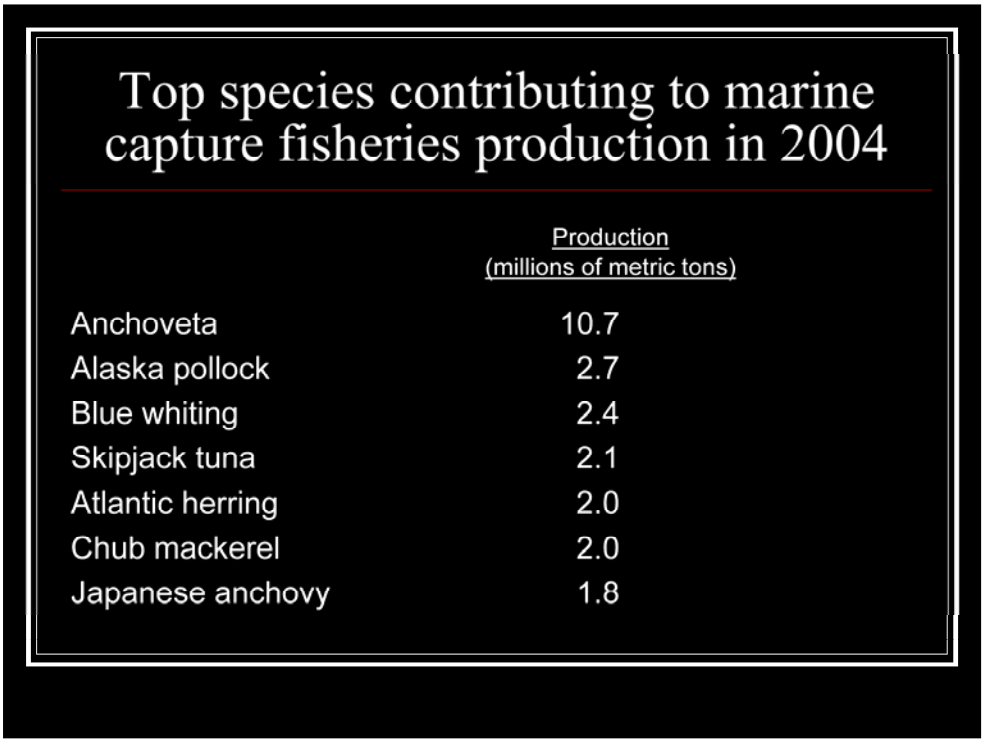
1. regulation and conservation of the harvested resource
2. protection of the habitat associated with the resource



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

Increases in global production since the mid-1980s have been almost entirely due to increases in aquaculture production. Aquaculture contributed 47% to total production 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).

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.



These data include a number of species unfamiliar to most students, emphasizing the fact that the majority of fish landed by weight are small pelagic species (like most of these) that are reduced for fish meal, fish oils and animal feed (including those used in aquaculture operations) as opposed to the more familiar species that are mostly eaten directly (e.g., salmon, halibut, haddock, sole). Alaska pollock is an exception and is important as a direct human food source. It is most commonly used in making surimi (marketed as “fake krab”) and fish sticks.

Updated marine capture fisheries production values available at:

U.N. Food and Agriculture Organization – The State of World Fisheries and Aquaculture (www.fao.org/sof/sofia/index_en.htm).

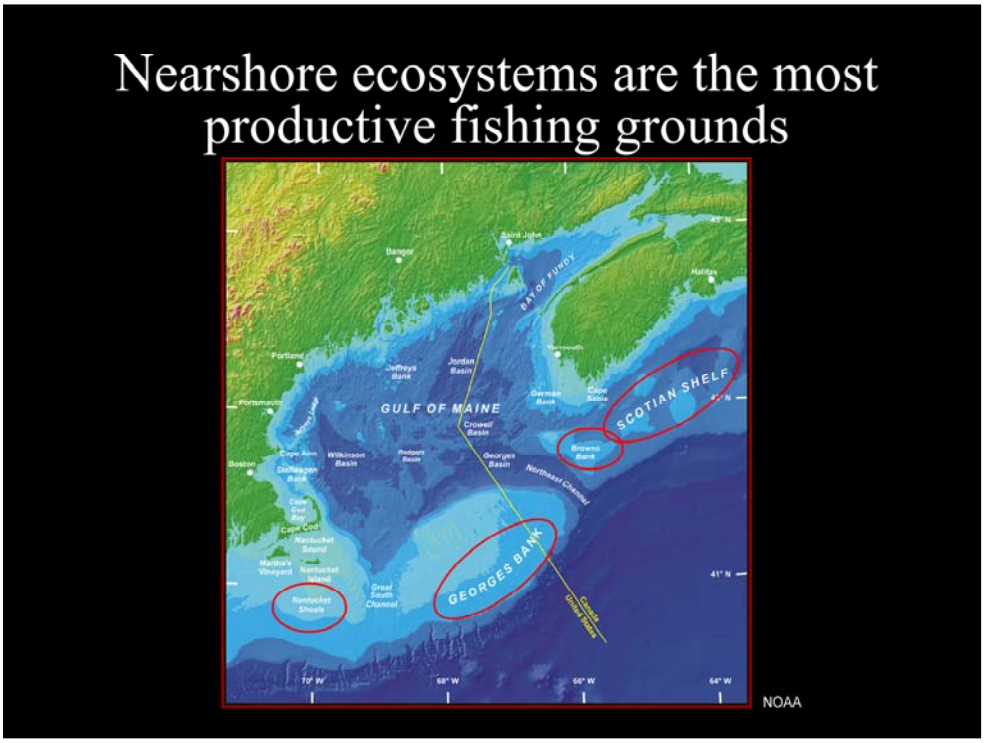
Although oceans cover about 70% of the Earth's surface, they are not uniformly populated with fish. The most productive areas are closely associated with continental land masses where about 90% of commercial harvest occurs. This is due to both the accessibility of these areas to boats from land and their 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., continental shelf along the eastern United States.)

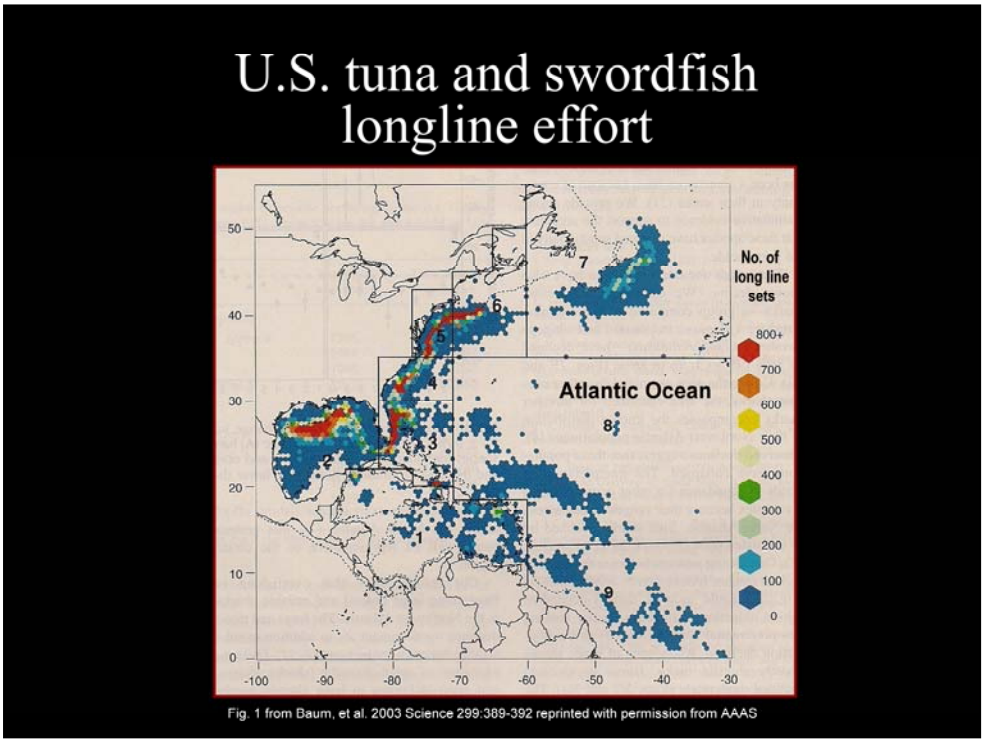
Estuaries – areas of salt and fresh water mixing where streams empty into oceans; important nursery areas for many commercially important fish species and the most productive areas for marine invertebrates such as shrimp, clams and oysters.

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.



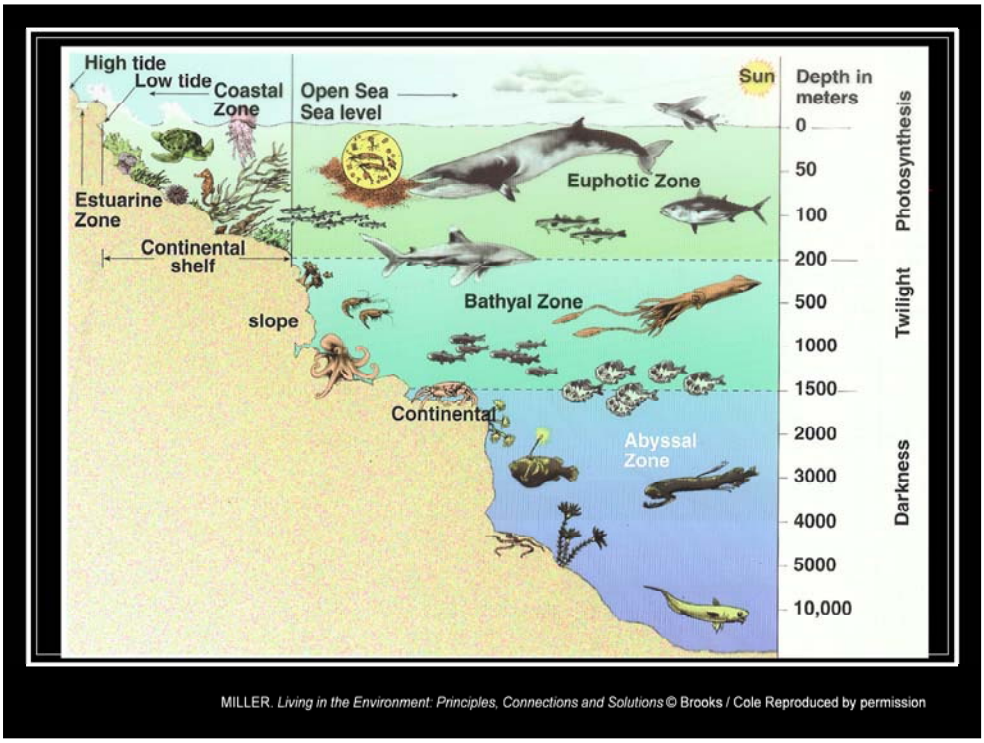
Most historical fishing grounds, such as Georges Bank and Nantucket Shoals (off the Massachusetts coast) and Brown's Bank and the Scotian Shelf (off Nova Scotia) are nearshore ecosystems associated with continental shelves. These banks are known for their phytoplankton blooms that are fueled by nutrients stirred up by cross currents. Zooplankton feed on the phytoplankton and shrimp and small fish feed on zooplankton, providing an important food source for larger, commercially-harvested fish.

Interestingly, the whaling industry of the 1800s was also centered in this area for the same reasons cited above. Only after whales were harvested to commercial extinction did whalers expand to other parts of the world's oceans.



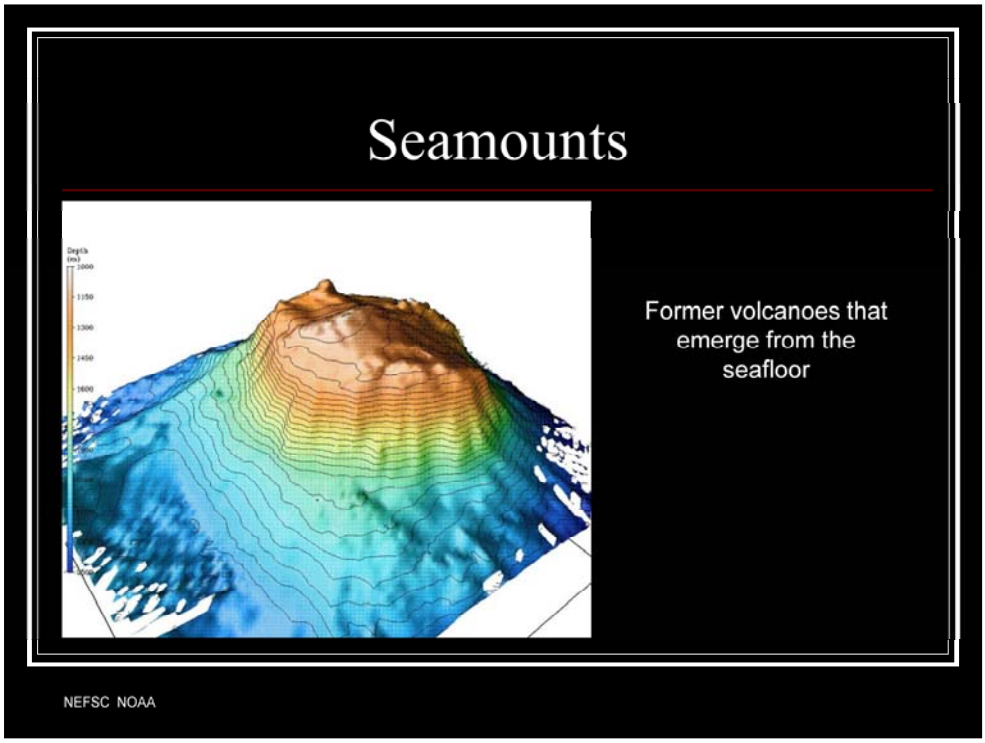
This is a map of the Northwest Atlantic illustrating the effort of the U.S. longline fishery between 1986 and 2000. The fishery targets tuna and swordfish. Colors indicate relative fishing effort (number of longline sets) with red, orange and yellow indicating high fishing intensity and various shades of blue indicating lower fishing intensity. White areas indicate no fishing effort. Dotted line represents the 1000 m depth along the coast. Note that fishing effort concentrates on the continental shelf.

Fig. 1 from Baum, et al. 2003. Collapse and conservation of shark populations in the Northwest Atlantic. Science 299:389-392. Reprinted with permission from AAAS.

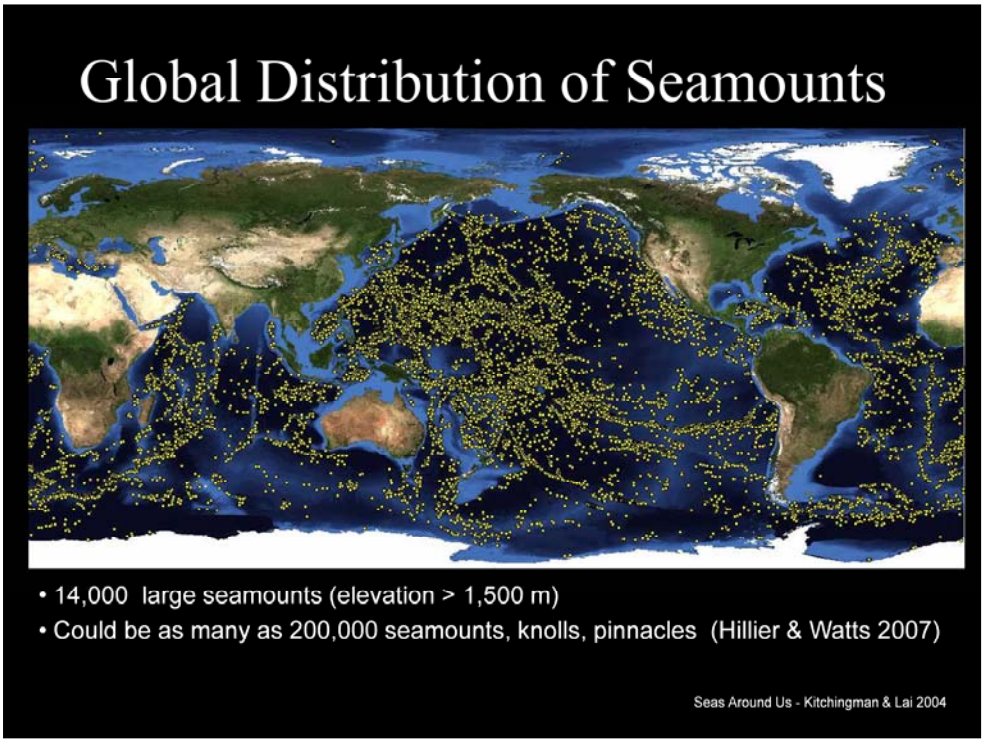


Nearshore ecosystems are the most productive fishing areas. However, as a result of improved fishing technology and depleted nearshore stocks, fishers have recently begun to exploit fish populations that inhabit the “deep sea” (1300 to 10,000 feet) – the bathyal and abyssal zones seen in the figure. This change has raised new concerns about the sustainability of fisheries in these less productive regions of the ocean. In habitats below 3300 feet, in particular, fish tend to be long-lived, less numerous and slow-growing. Most are scavengers waiting for morsels from above to float down to their level. These fish tend to congregate around topographical features on the ocean floor (raised banks, ridges and seamounts).

Image: From MILLER. *Living in the Environment: Principles, Connections, and Solutions (with CD-ROM and Info Trac),* 14E. © 2005 Brooks/Cole, a part of Cengage Learning, Inc. Reproduced by permission. www.cengage.com/permissions

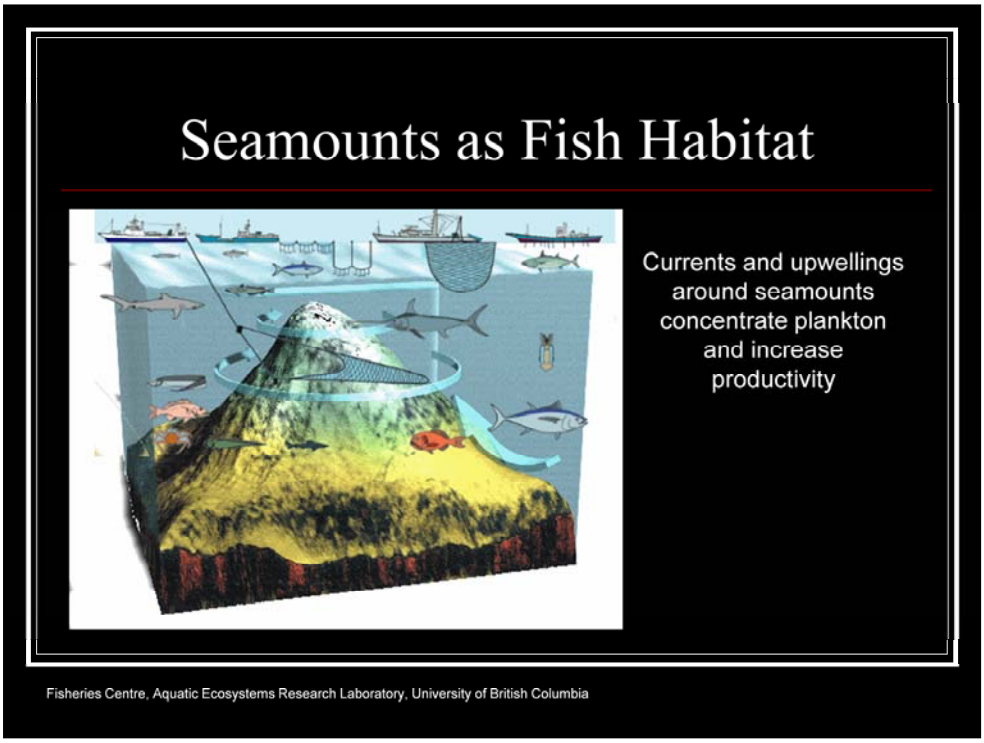


Seamounts are former volcanoes that emerge from the seafloor. They are particularly abundant in the Pacific Ocean (est. 30,000) vs. only about 6000 in the Atlantic. Seamounts are among the most unique of deep sea marine habitats and we are only now beginning to understand their ecology.



Global distribution of seamounts. Over 14,000 large seamounts have been identified and mapped. Hiller and Watts (2007) suggest that there may be as many as 200,000 seamount-like structures on the ocean floor.

Image from: Kitchingman, A.; Lai, S. (2004). Inferences on potential seamount locations from mid-resolution bathymetric data. In: Seamounts: Biodiversity and Fisheries (eds T. Morato, D. Pauly) UBC Fisheries Centre, 78, pp. 261, Vancouver, B. C.



The localized currents and upwellings created by these seamounts (shown in this diagram) concentrate plankton and thus, provide the base for a food web that supports fish. In recent years, a number of deep sea fisheries have developed around fish populations that congregate around these features.

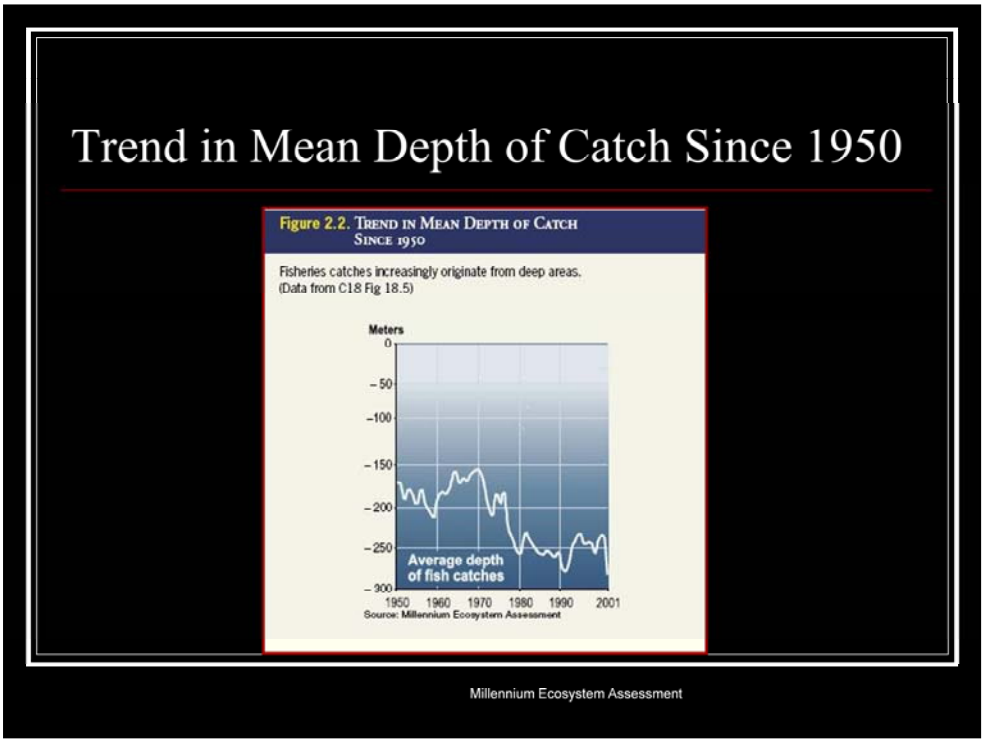
Orange Roughy and other deep water species

Stephen McGowan, Australian Maritime College, 2006 / Marine Photobank

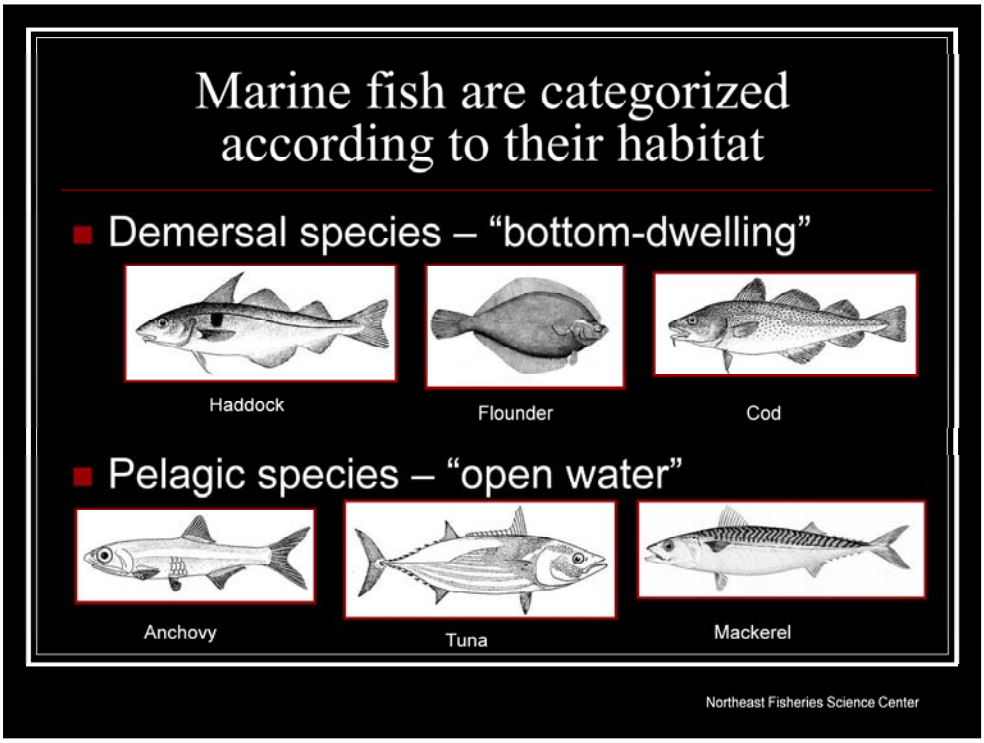
Orange roughy are among the best known of these species that gather in great numbers at seamounts to spawn. Orange roughy are extremely long-lived fish with an estimated maximum of 150 years based on growth rings on otoliths ("ear bones"). Sexual maturity is reached at about 30 years. Fecundity is low relative to most shallower water species (several thousand eggs per female vs. several million for Atlantic cod). Long life and low fecundity is common for deep sea species. The effects of fishing as well as the basic biology of these deep water species is mostly unknown.

The Orange roughy fishery began in the early 1990s. As a relatively bland but firm white fillet, the orange roughy gained favor in Europe and the U.S. In France its name was changed to *empereur* (not coincidentally similar to the Spanish name for swordfish, *emperador*). Thus, fishing effort and demand increased rapidly and by 1994 the catch rate in the North Atlantic was only 25% of what it was initially. Given the low fecundity, slow growth and long generation time, sustainable fisheries developed for these deep water species are quite different from shallower water species. Many scientists believe that it is not possible to have a sustainable fishery built around these deep water species.

New Zealand probably has the longest history of fishing for Orange roughy (since the 1970s) and claims to have some success in managing the resource on a sustainable basis. Monitoring population levels and recovery after overexploitation however, is very difficult and many fisheries scientists are skeptical.



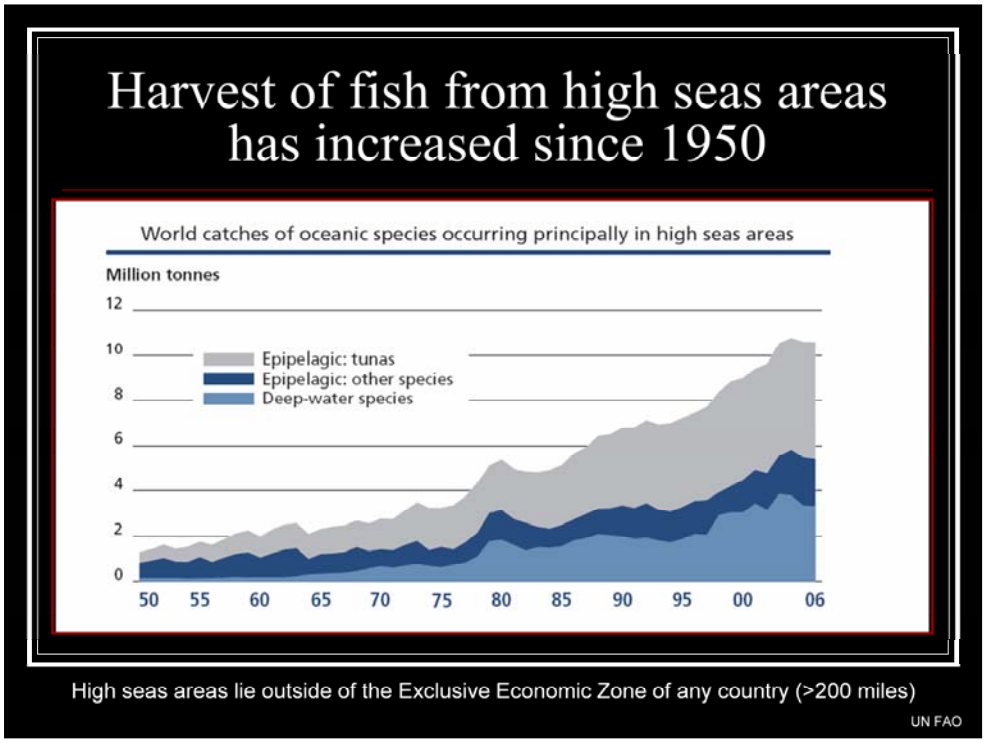
As evidence that fishing effort has moved to offshore fishing grounds over the past several decades, fisheries catches have come from progressively deeper waters. The trend has been especially pronounced since the 1970s.



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.

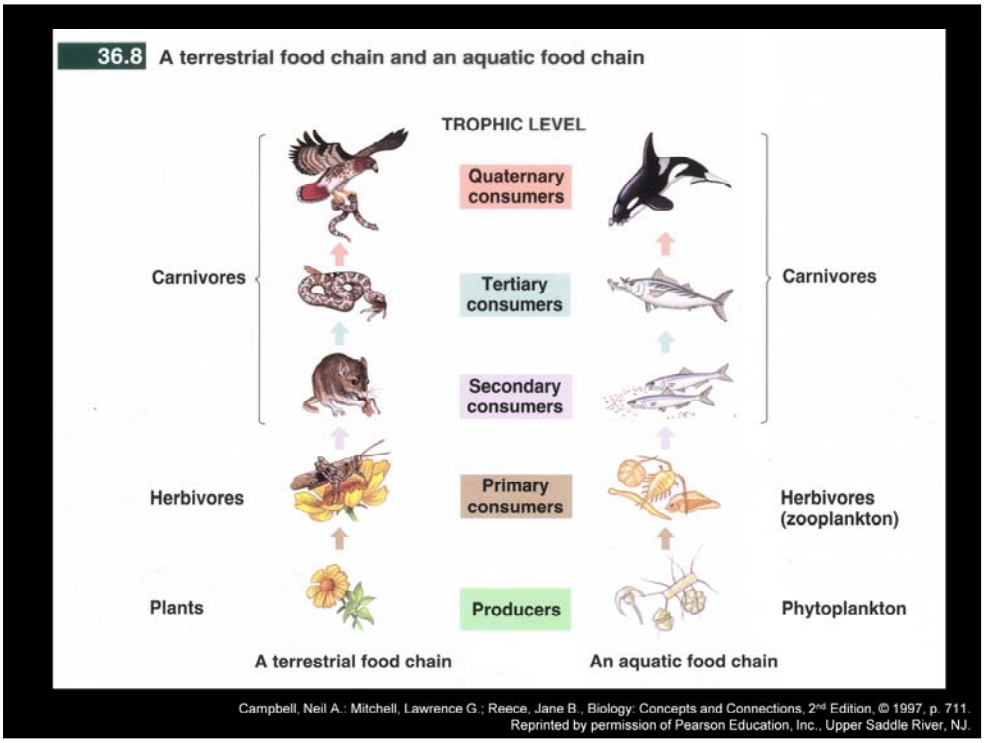
Pelagic species are open water species that swim and feed close to the surface. Sometimes further categorized as large pelagic (e.g., tuna, swordfish), which are high value and small pelagic (e.g., anchovy, herring), which are usually low value species and are primarily caught for the oil and fish meal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



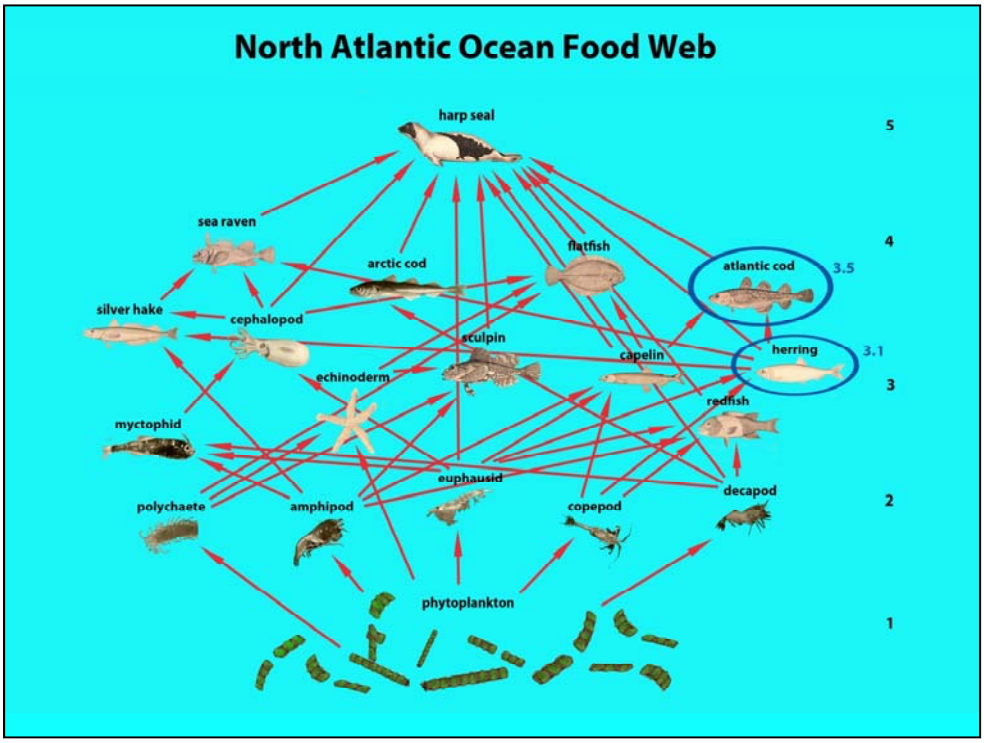
Although most fish are harvested in continental shelf areas, in recent years "high seas" areas have become increasingly important. High seas areas are those areas that lie outside of the Exclusive Economic Zone (EEZ) of a country. The EEZ generally includes those ocean areas within 200 miles of a country's shoreline.

Note that catches are grouped by biological characteristics of the fish that are being harvested. Epipelagic catches (in gray and dark blue) are dominated by various tuna species (gray). Over 150 deep-water species (light blue in figure) are harvested from high seas areas including orange roughy and blue whiting.



Most fish that are harvested occur 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 and zooplankton 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.



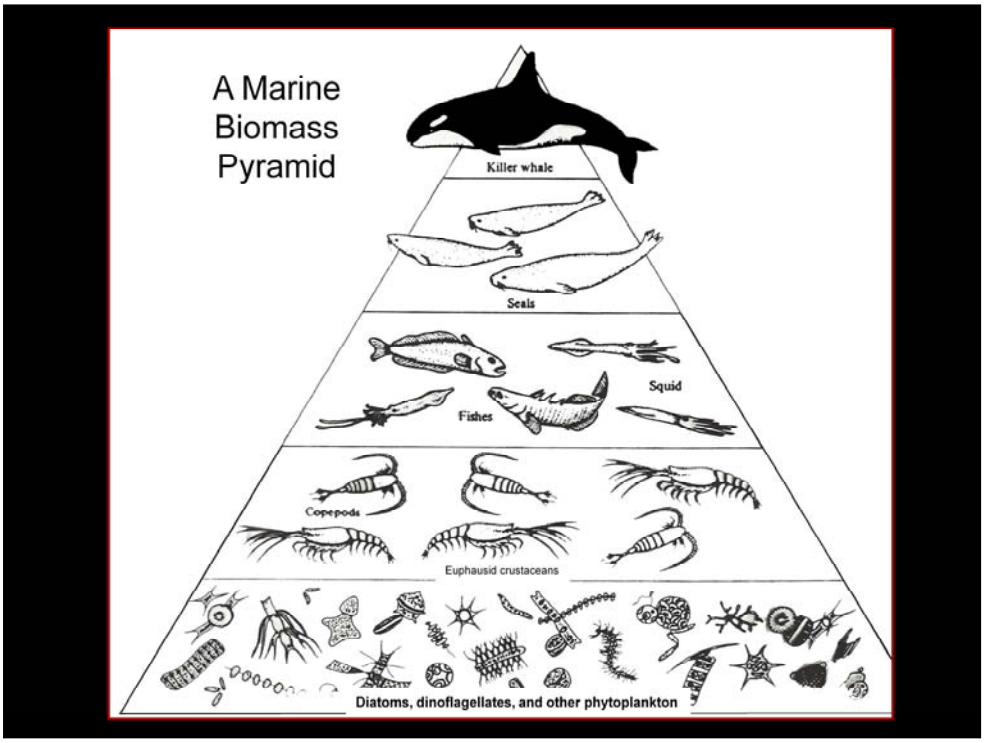
Due to taste preferences, humans typically harvest at trophic levels 3 and 4. Marine food webs are complex and many fish species feed at more than one trophic level. Thus, most individual fish species have trophic designations that are not whole numbers - e.g., snapper (4.6), cod (3.5), herring (3.1), 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:

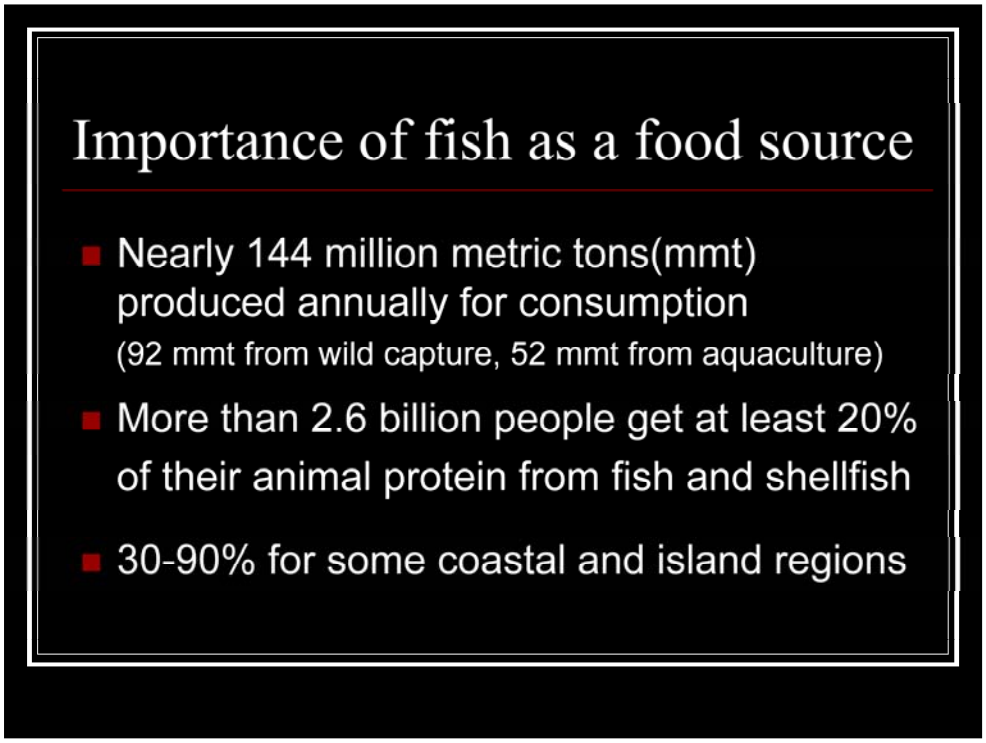
NOAA (all images not listed are from NOAA): B. Sheiko (Arctic cod), Russ Hopcroft (Amphipod, Copepod), Alaska Fisheries Science Center (Euphausid), Jerry McLelland (Polychaete), NOAA Ocean Explorer (Decapod, Myctophid)

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.



Fish represent the only group of wild species that we still hunt commercially and contribute significantly to the human food chain worldwide. 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.

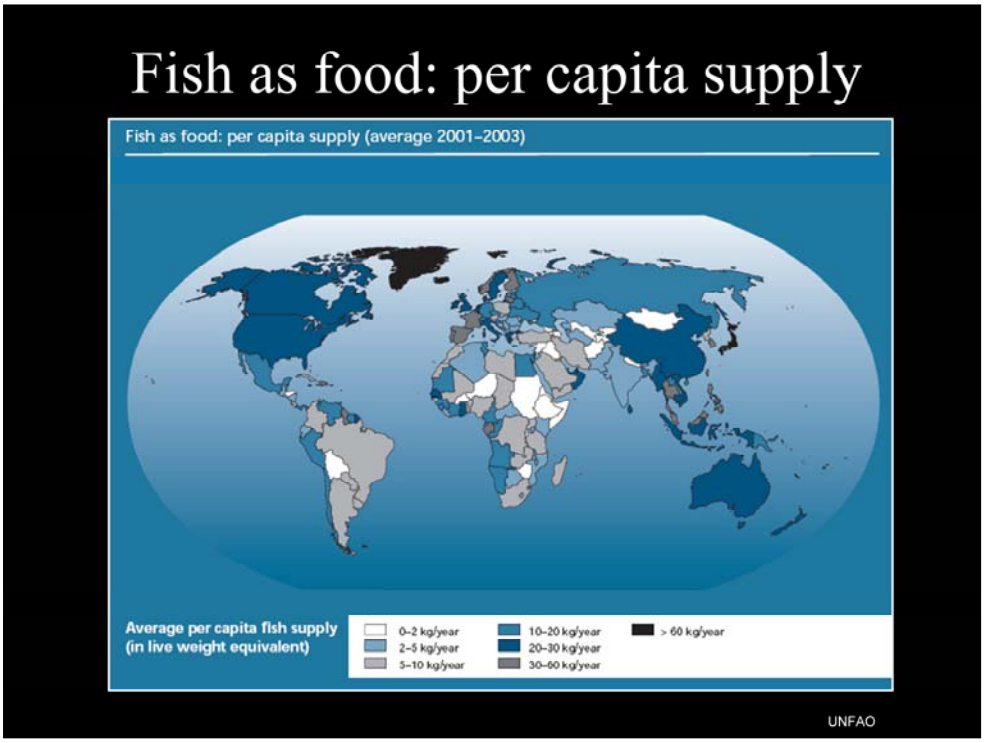
Nearly 144 million metric tons were produced for consumption in 2006. Approximately 92 million metric tons of this total were from capture fisheries. The remaining 52 million metric tons were produced by aquaculture.

More than 2.6 billion people (over 38% of the world population) get at least 20% of their animal protein from fish and shellfish. This number increases to 30-90% for some coastal and island regions.

Commercial fishing is also an important economic force – worldwide, 38 million people are directly employed by the industry. An additional 162 million people are indirectly involved with the industry. In 2001, seafood industry contributed $28.6 B to U.S. economy.

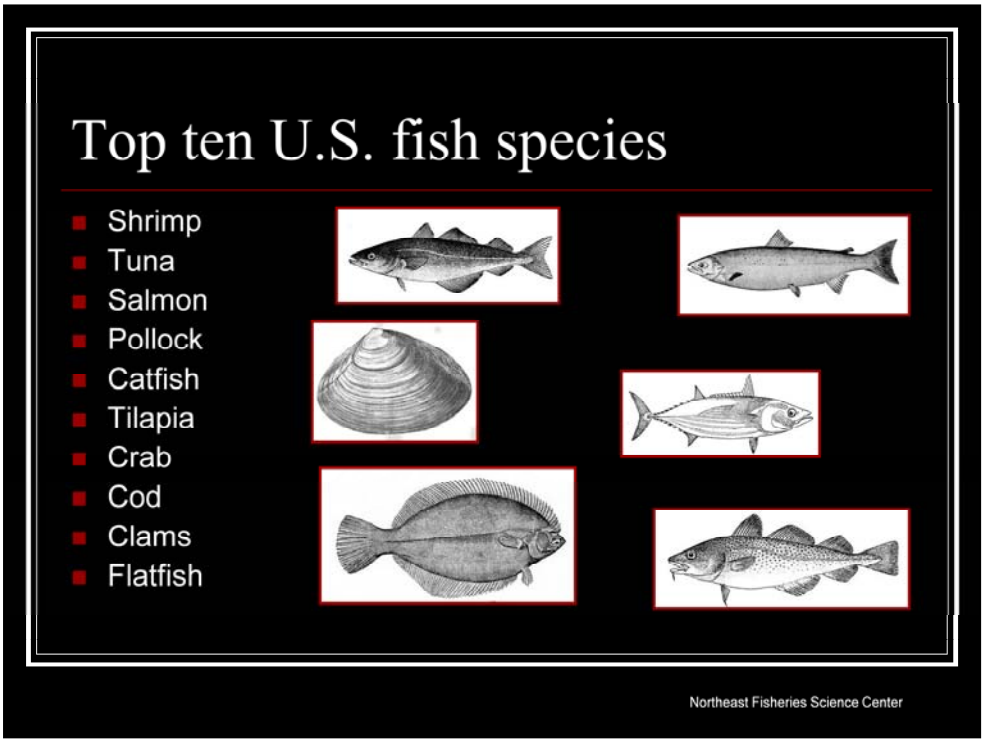
Japan, for example, is among the world's largest consumers of seafood. The Tsukiji Fish Market in Tokyo is the largest seafood market in the world. Over 2000 metric tons of seafood change hands there every day.

Photographs here show the end of the fresh tuna auction and frozen tuna being prepared on a band saw.

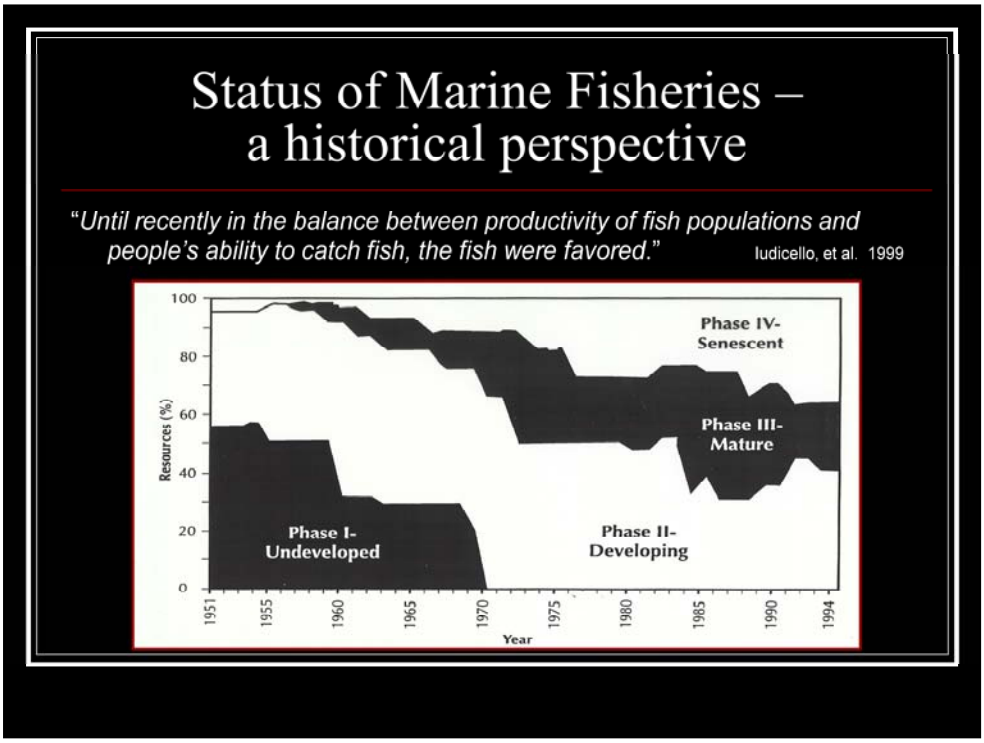


Fish consumption is unevenly distributed across the globe; per capita consumption varies from less than 1 kg per capita to over 100 kg. Two-thirds of the 2003 global total of 140 million metric tons (includes both wild caught and fish produced in aquaculture operations) were consumed in China.

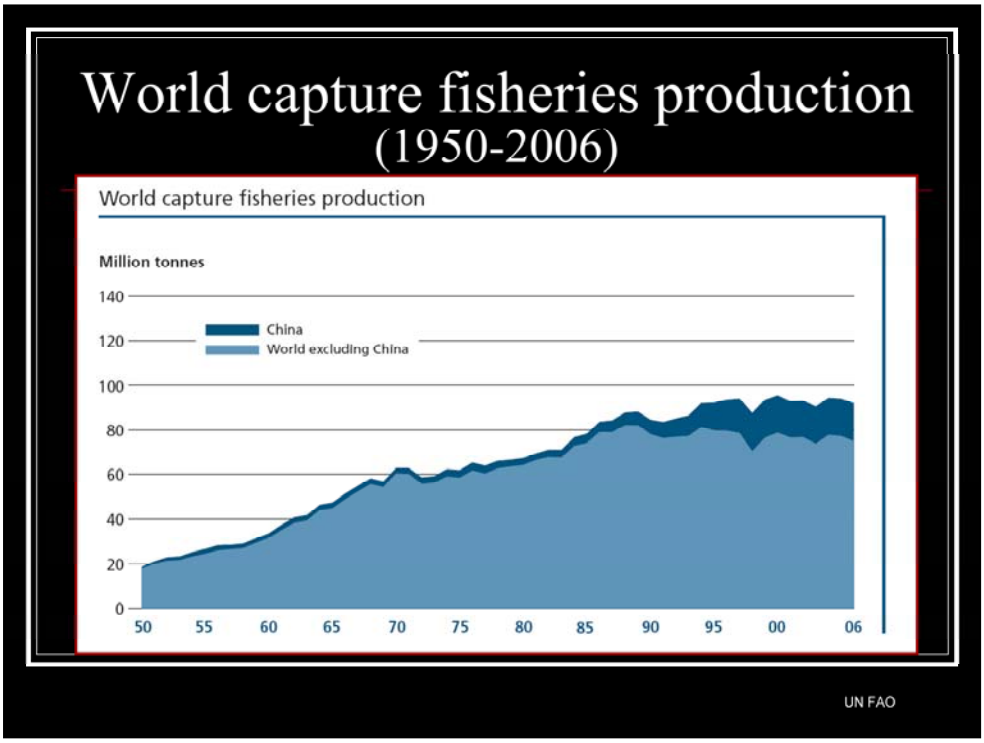
Japan, Iceland and several European countries are among the most enthusiastic consumers of seafood on a per capita basis. The U.S. and Canada consume seafood at a more moderate rate.



These species represent the top 10 U.S. fish species (in descending order) based on per capita consumption in 2004 (NMFS data). Several of these species (shrimp, salmon, catfish and tilapia) are provided primarily (or at least, in part) by aquaculture rather than by wild capture fisheries.



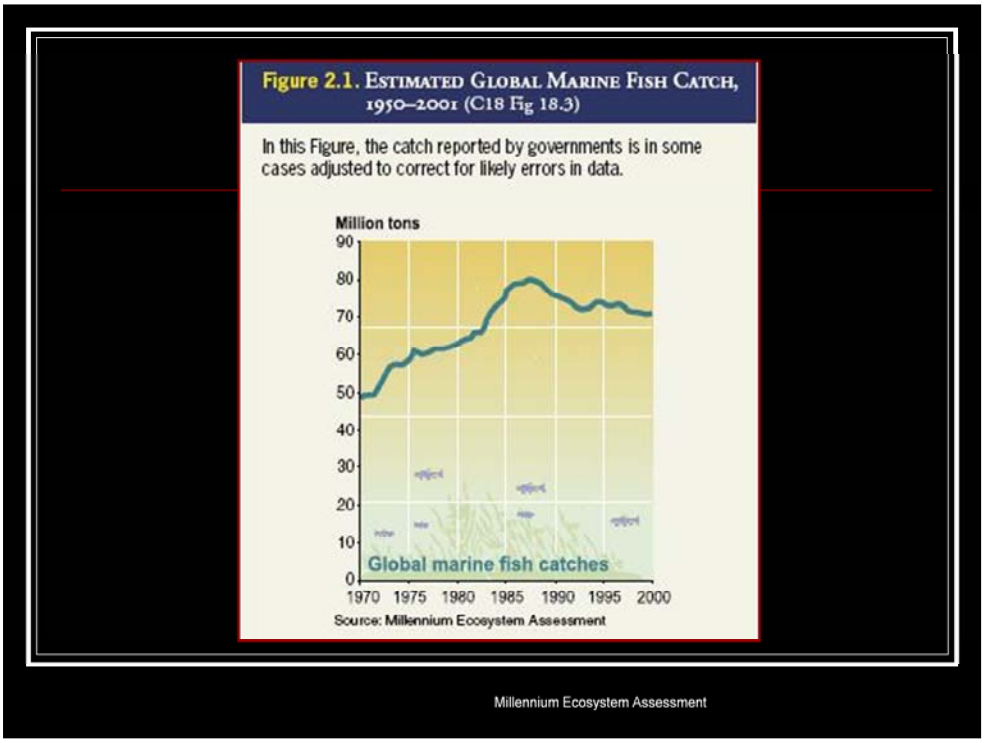
Percentage of fisheries in various stages of development illustrates significant changes in the status of marine fisheries that have occurred since 1950. In 1950, fisheries were dominated by those that were "undeveloped" (low and relatively constant level of catches) or "developing" (rapidly increasing 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).



Global capture fisheries production was 92 million tons in 2006 with an estimated value of $91.2 billion. China, Peru and the U.S. were the top producers. Total marine capture accounted for 82 million tons of the total, while inland waters contributed 10 million tons.

Recent analysis by Daniel Pauly has shown that previous estimates of global fisheries landings were over-estimated (primarily due to over-reporting by China to maintain higher quotas) and that landings are now declining by about 500,000 metric tons per year. Based on this analysis, fisheries capture production peaked in the late 1980s at 80-85 million tons per year and has been declining since then.

Over-reporting of fisheries production by China is apparently due to an assessment and promotion system for fisheries officials that is based on production output from their jurisdiction. This provides tremendous incentive for statistical over-reporting. For a detailed discussion, see Watson and Pauly, 2001.



Estimated global marine catch from 1970 to 2000 with these adjustments for inaccurate reporting by some countries (primarily China) is reflected here. Note that global catch has declined since the late 1980s.

Status of Marine Fisheries

- In 2004, 52% of world fish stocks were fully exploited, 25% were overexploited or depleted
- Large predatory fish have declined globally by 90%
- At least 42% of U.S. fisheries are being overexploited

UNFAO– Antonio Pais

See notes slide 28

Notes slide 28

In recent years fisheries biologists and fisheries managers have expressed concern that many stocks of marine fish are overexploited and in decline. 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 (UN FAO 2006).

Large predatory fish, in particular, such as bluefin tuna (shown here), swordfish and sharks have declined 90% from un-fished levels (Myers and Worm, 2003). Large marine predators include 1m+ fish such as cod, halibut, tuna, swordfish and sharks. By any measure, current 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 Atlantic 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). A 2003 study published in *Science* (Baum, et al. 2003) using logbooks kept by longliners as a source of information, 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.

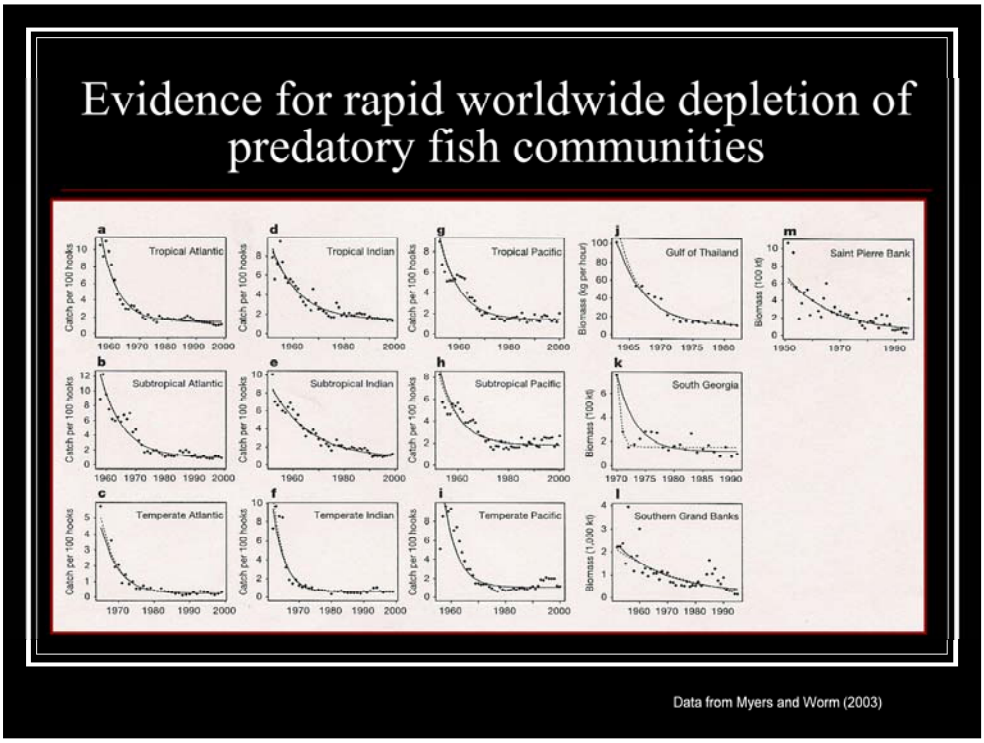
At least 50 million tons of tuna and other top-level predators have been removed from the Pacific Ocean pelagic ecosystem since 1950. An analysis of Pacific tuna fishery data for 1950-2004 (Sibert, et al 2006) suggests that:

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 these provide the "missing baselines" by which current levels of these species can be compared.

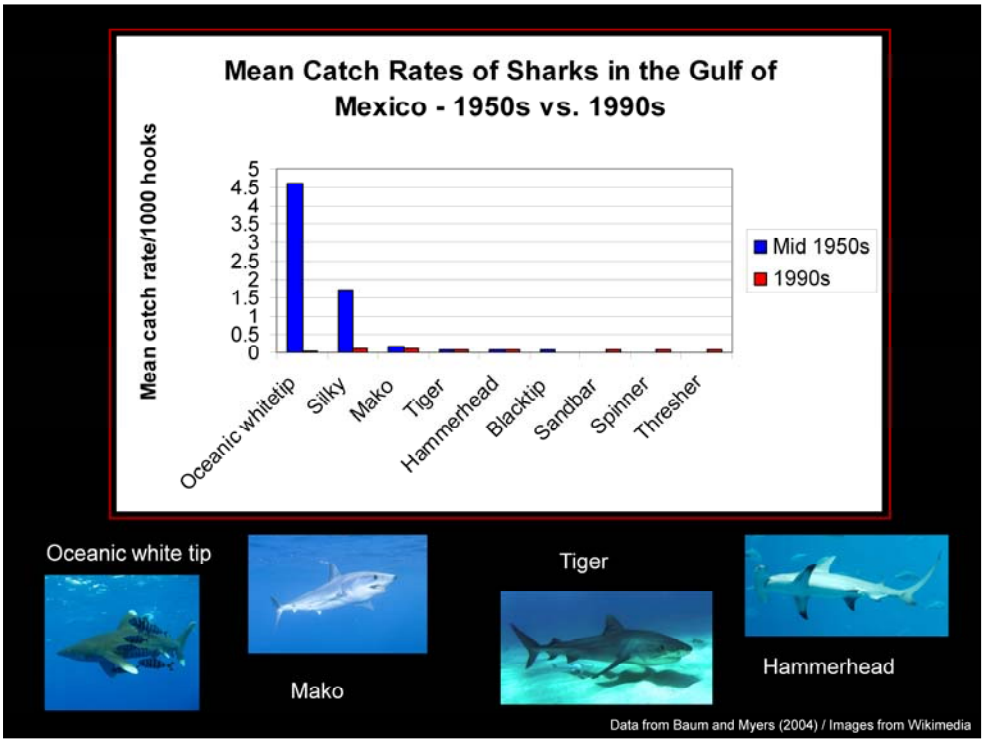
For species fished in U.S. waters, at least 42% are being fished at a level that exceeds maximum sustainable yield (=overexploitation) (NMFS 2004). Species that have experienced precipitous declines due to overfishing include the Atlantic halibut, orange roughy, bluefin tuna, Atlantic cod, herring, Atlantic 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 (Worm, et al. 2006). 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.



Trends in community biomass for 9 oceanic (a-i) and 4 continental shelf (j-m) ecosystems. Graphs for continental shelf ecosystems were based on trawl surveys designed to estimate the biomass of large demersal species (e.g., cod, flounder, skates). Japanese longlining data were used to evaluate oceanic ecosystems and represent trends in large predatory fish such as tuna, marlin, sailfish and swordfish. Beginning in 1953 the Japanese longline fishery expanded out from waters around Japan to include the Atlantic, Pacific and Indian Oceans. The left portion of each plot represents “un-fished” conditions before industrial exploitation.

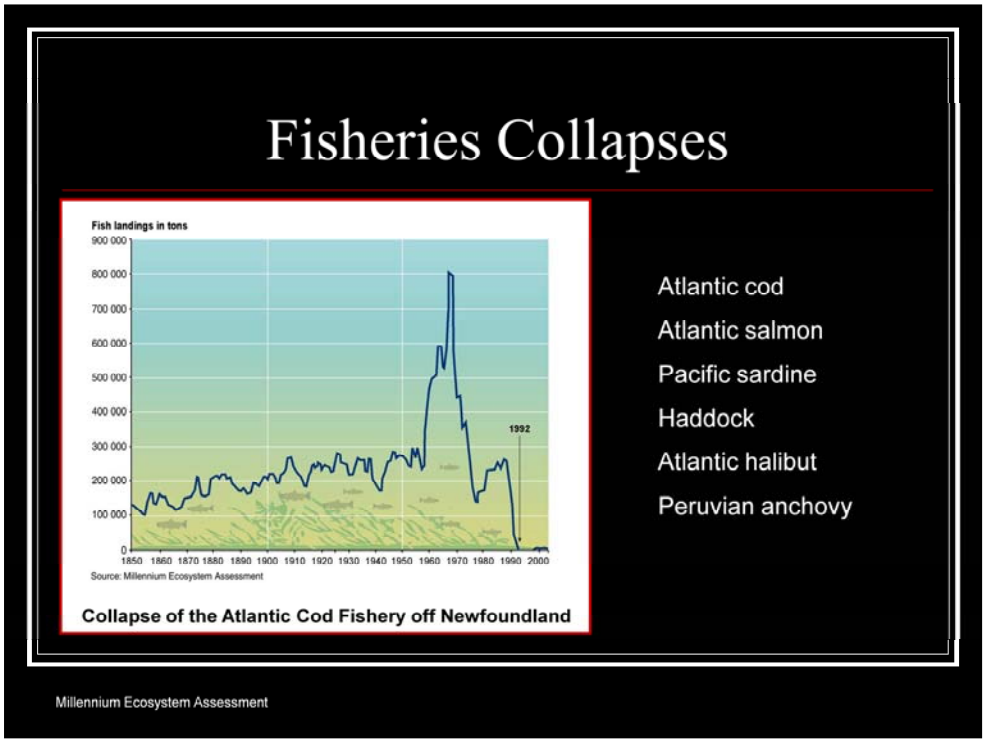
For those species studied, industrial fishing typically reduced community biomass by 80% within 15 years of exploitation. The authors estimate that large predatory fish biomass is only about 10% of pre-fished levels. This study, along with several others, suggests that human impact on global ecosystems has been vastly underestimated.



Baum, J. and R. Myers. 2004. Shifting baselines and the decline of pelagic sharks in the Gulf of Mexico. Ecology Letters 7(2):135-145

Sharks are among those top predators that have experienced precipitous declines over the past 50 years. This graph illustrates declines in pelagic sharks in the Gulf of Mexico based on longliner data. Overall catch rates of sharks declined from an average of 7.30 (+/-7.94 SD) to 0.92 (+/- 2.51 SD) per 1000 hooks. Ocean whitetip and silky sharks accounted for about 15% of the total longline catch in the 1950s, but only 0.3% in the 1990s. Over approximately a 50-year period oceanic whitetip sharks declined 99%, silky sharks 91% and dusky sharks 79%. Tiger and hammerhead sharks were caught at low rates (<0.06/1000 hooks) in both the 1950s and 1990s survey. Blacktip sharks were also caught at low rates in the 1950s, but were not caught in the 1990s. Three species (sandbar, spinner and thresher sharks) were caught at low rates (<0.07) only during the 1990s.

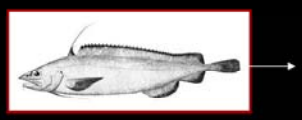
The decline of large sharks is not limited to the Gulf of Mexico. Using a variety of data sources including commercial and recreational fishery landings, scientific surveys and sighting records Feretti, et al (2008) found that five species of sharks (Hammerhead, blue, mackerel (2 species) and thresher sharks) in the Mediterranean Sea had declined from 96-99.9% relative to their former abundance. This level of decline would be sufficient under World Conservation Union (IUCN) criteria to list these species as “critically endangered.”



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).

Are any marine fish “endangered”?



Blue hake

Roundnose grenadier

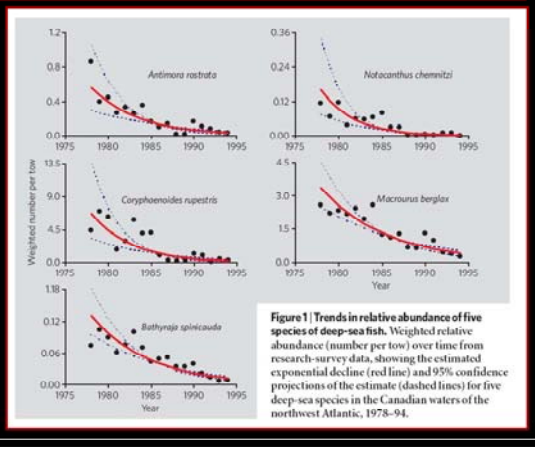


Figure 1 | Trends in relative abundance of five species of deep-sea fish. Weighted relative abundance (number per tow) over time from research-survey data, showing the estimated exponential decline (red line) and 95% confidence projections of the estimate (dashed lines) for five deep-sea species in the Canadian waters of the northwest Atlantic, 1978–94.

NOAA - Northeast Fisheries Science Center

See notes slide 32

Notes slide 32

Severe declines can occur in any species long before they reach the threshold of being designated as "threatened," "endangered" or "extinct." A species may decline to the point where it no longer occurs in sufficient number to perform its ecological function or numbers may be so low that harvesting the species is no longer economically viable ("commercial extinction"). Nevertheless, Devine, J.A., et al. (2006), using research survey data, demonstrated that 5 deep-sea fish from the northwest Atlantic have declined to a level that warrants their listing as being "critically endangered." Criteria established by the World Conservation Union were used to reach this conclusion. The graphs illustrate declines that range from 87-98% in these species over 17 years from the late 1970s to 1995. These 5 species are:

1. Roundnose grenadier – *C. rupestris*
2. Onion-eye grenadier – *M. berglax*
3. Blue hake – *A. rostrata*
4. Spiny eel – *N. chemnitzi*
5. Spinytail skate – *B. spinicauda*

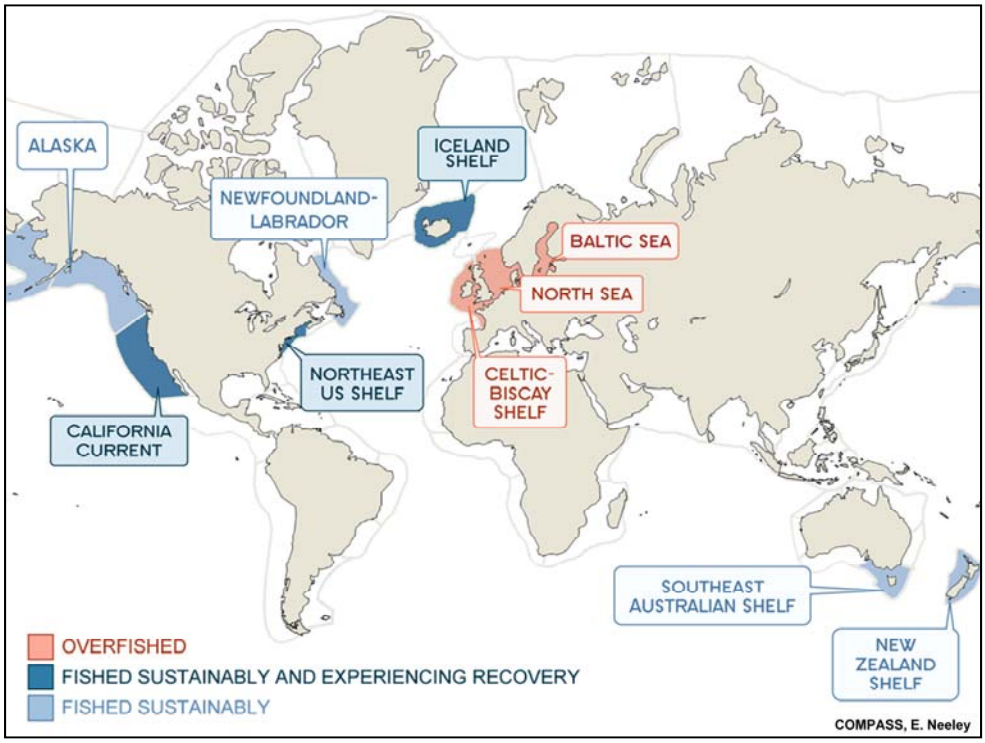
All are taken as bycatch in fisheries that target Greenland halibut and redfish. Both grenadier species have been commercially fished as well.

Lack of adequate survey data, particularly in less studied oceans, may be masking other dramatic declines. The barndoor skate (*Dipturus laevis*) caught as bycatch in the Atlantic fishery, for example, was driven to extinction nearly unnoticed over the same time period.

Fisheries managers often contend that commercial extinction will prevent biological extinctions because fishers will switch target species when they become too expensive to catch. However, this protective mechanism may not work for highly valuable species or for fish caught as bycatch. Bluefin tuna, for example, frequently sell at a very high price (one specimen sold in Tokyo, Japan for $173,600 in 2001).

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 figure on following slide). 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.

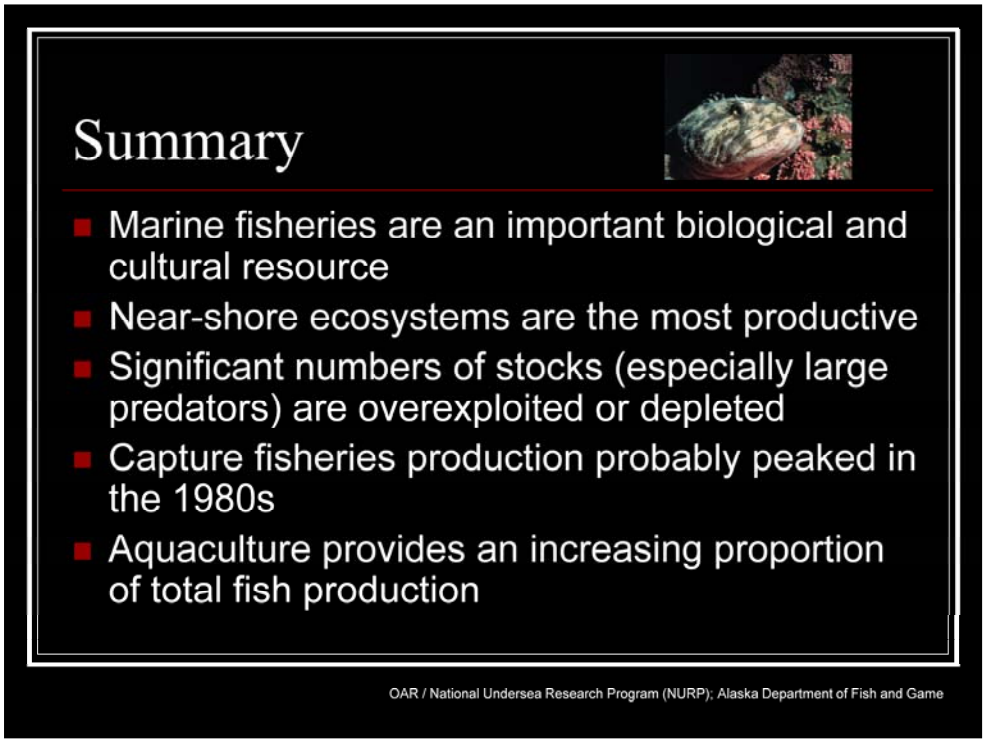


The good news:

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 main points.

Additional coverage on marine fisheries topics may be found in the following NCSR Marine Fisheries modules:

- *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*

Photo Credits

- Baum and Myers (2004)
- Communication Partnership for Science and the Sea (COMPASS), E. Neeley
- Fisheries Centre, Aquatic Ecosystems Research Laboratory, University of British Columbia
- Food and Agriculture Organization of the United Nations (UNFAO)
- Marine Photobank- ARC Centre for Excellence for Coral Reef Studies, Stephen McGowan, Antonio Pais
- Millenium Ecosystem Assessment
- MILLER, *Living in the Environment: Principles, Connections and Solutions*
- Myers and Worm (2003)
- NASA - MODIS Rapid Response Team
- *Nature* one figure reprinted with permission
- NOAA- Alaska Fisheries Science Center, Northeast Fisheries Science Center, NOAA Ocean Explorer, Kip Evans, Russ Hopcroft, Jerry McLelland, B. Sheiko
- *Science* multiple figures reprinted with permission from AAAS
- Seas Around Us - Kitchingman & Lai 2004
- Wikipedia, Wikimedia

Detailed Lecture Notes

The detailed lecture notes below are provided as background for instructors who use this module. They may be used to enhance the lecture material provided in the *PowerPoint* presentation associated with this module.

I. Introduction – Why study marine fisheries?

For centuries, fish in the world's oceans were assumed to be a limitless resource, available to all for the taking. However, beginning in the mid-1990s, prominent fisheries scientists such as Carl Safina, Ransom Myers and Daniel Pauly called attention to the poor state of the world's fisheries. The growing human population, economic pressures, improved fishing technology and growing demand had combined to deplete fish stocks around the world. The National Academy of Science identified fishing as the number one threat to marine ecosystems and the United Nation's Food and Agriculture Organization (FAO) stated that marine fisheries were "globally non-sustainable and major ecological and economic damage was already visible."

Although fishery declines had probably occurred decades before, public recognition of the issue was relatively slow. Several analyses have shown that many fisheries are in danger of collapsing; however, most of the consuming public still sees the ocean as a limitless resource, one that we have only begun to tap. This is probably due to a number of factors including the vastness of our oceans and the fact that much of the ocean is out of view. Also, consumers still see a wide variety of fish products available for sale including many at "reasonable prices."

In addition to environmental impacts, the declining state of marine fisheries has had a profound effect on the social and economic fabric of fishing communities. The implementation of regulatory measures such as area closures and catch quotas by fishery managers often lead to unemployed fishermen, vacant fish processing plants and all of the social ills that come with a declining economy.

Despite declines, most large marine organisms still persist in numbers that could recover with proper management. This is in contrast to terrestrial ecosystems where many large animals have either gone extinct or have been extirpated from significant portions of their range. Thus, ecosystem recovery is still a real possibility for most marine ecosystems. Most fishery scientists now recognize that a transition from traditional single-species management to the implementation of ecosystem-based fishery management will be needed to meet this goal.

II. Characterize the Resource

- **Define marine fisheries**

Marine fisheries may be simply defined as the interaction between marine aquatic organisms and humans. A fishery is composed of three elements – the resource, the habitat that supports the resource and the people who harvest, process or sell the resource. Although the term "fishery" has traditionally been restricted to aquatic resources that are directly consumed by humans, in recent years the definition has been expanded to include interactions other than harvest. Modern fisheries management focuses on harvested resources, as well as the quality of aquatic habitats themselves.

Coastal and marine ecosystems are among the most productive ecosystems in the world and provide a wide range of ecological, social and economic benefits to humankind. Among these services is food production provided through the endeavors of commercial fishing and aquaculture (fish farming). With many fish stocks being overexploited, the state of commercial fisheries is of concern, in particular to those who depend on this resource for both food and employment. Unsustainable use of fisheries resources may result in threatened food security due to overexploited fish stocks.

About 1000 of the world's 30,000 species are harvested routinely for human consumption. Most are taken in relatively small amounts by traditional fishing methods. Only 40 species are harvested in large amounts commercially. Of these, 22 species are taken in amounts exceeding 100,000 metric tons annually comprising the majority of the total catch. One metric ton is approximately 2200 pounds.

In 2003 the top world fish harvest (both wild capture and aquaculture are included) and the approximate weight of the catch was as follows:

Herrings, sardines, anchovies	19 million tons
Carps and relatives	18 million tons (majority aquaculture)
Cods, hakes and haddock	9 million tons
Tunas, bonitos and billfish	6 million tons
Shrimp and prawns	5 million tons (majority aquaculture)

The top ten species contributing to marine capture fisheries production in 2004 were:

Anchoveta	10.7 million tons
Alaska pollock	2.7 million tons
Blue whiting	2.4 million tons
Skipjack tuna	2.1 million tons
Atlantic herring	2.0 million tons
Chub mackerel	2.0 million tons
Japanese anchovy	1.8 million tons
Chilean jack mackerel	1.8 million tons
Largehead hairtail	1.6 million tons
Yellowfin tuna	1.4 million tons

Fish are often categorized in various ways according to their habitat, behaviors or physical characteristics (categories are not necessarily mutually exclusive):

Demersal species - bottom-dwelling and bottom-feeding species (e.g., cod, haddock, pollock, hake, halibut, flounder); the term "groundfish" is loosely equivalent; mostly "high value" species

Pelagic species - open-water species that feed in surface waters; they are typically fast swimmers and include species such as tuna, swordfish, herring, anchovy, sardines, mackerel and salmon; mixed "high value" and "low value" species; pelagic species have dominated the world catch by weight since 1950 (60% of total catch in 1994)

Anadromous species – species that live out one portion of their life cycle in freshwater and another in salt water; these species typically spend most of their lives in the ocean and then return to freshwater streams to spawn, hatch and rear (e.g., salmon, smelt, shad)

Finfish – fish with fins (as opposed to shellfish)
Shellfish – mollusks (clams, oysters, cockles)
Crustaceans – shrimp, prawns, lobsters
Flatfish – flounders, halibut, soles

Fish are a potentially renewable resource if sustainable yield is maintained. However, probably since the mid-1970s, harvest levels for many species have exceeded the capacity of populations to replace them.

The trophic levels at which we choose to harvest has an important impact on the sustainability of fisheries. In contrast to foods derived from terrestrial ecosystems, most of the fish we harvest occur 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, zooplankton and herbivorous fish to marine ecosystems and, in particular, to the production of harvestable fish.

Due to taste preferences, humans typically harvest at trophic levels 3 and 4. However, due to varied food habits and the fact that any species likely feeds at more than one trophic level, 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).

- **What areas are fished?**

The fishery resource is unevenly distributed across marine ecosystems. Over 90% of fish come from within 200 miles of the coast. These include nutrient-rich areas of upwellings, relatively shallow continental shelves, and estuaries. Ironically, these zones are also the most vulnerable to pollution and other human-caused disruptions due to their proximity to human population centers. Consider, for example, the impact on fisheries stocks by the Exxon Valdez oil spill or agricultural runoff into the Gulf of Mexico.

Upwellings

- ✓ typically occur on the west coast of continents where winds and the earth's rotation cause surface waters to move away from the coast
- ✓ this results in cool, nutrient rich water from the ocean bottom being brought up to the photic zone where it fuels the food web

Continental shelves

- ✓ relatively shallow, highly productive ocean regions associated with continental land masses
- ✓ nutrients from these land masses are washed into coastal waters where they are mixed throughout the water column
- ✓ includes productive fishing grounds off the Canadian maritime provinces and the New England coast such as Browns Bank, Nantucket Shoals and Georges Bank

Estuaries

- ✓ areas of fresh and salt-water mixing where rivers empty into the ocean; under tidal influence and tend to be highly productive ecosystems
- ✓ important nursery areas for large numbers of commercial fish species and also areas important for shellfish harvest (crabs, clams, oysters, shrimp, etc.)

- **Importance as a food source**

Worldwide, more than 2.6 billion people (over 38% of the world population) get at least 20% of their animal protein from fish and shellfish. This percentage increases greatly (30-90%) in some Asian coastal regions and island nations. For more than one billion people, fish supplies over 30% of their total protein intake. Marine fish provide humanity with more animal protein than any other source including beef and pork.

More than 90 million metric tons are captured annually for consumption and an additional 30 million tons are discarded as bycatch.

Fish represent the only group of wild species that we still hunt commercially. Once considered "poor man's protein," declining stocks have resulted in escalating costs. 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 primarily as a result of increased aquaculture production. This increase is due only in part to population increases. Per capita fish consumption in China 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 such as its high concentration of omega 3 fatty acids and trace minerals, its importance in the proper development of the nervous system and the reduced risk of cardiovascular disease and some cancers.

In 2004, the top 10 U.S. fish species based on per capita consumption were (National Marine Fisheries Service data):

	Species	Per-capita consumption (lbs)
*	Shrimp	4.0
	Tuna	3.4
*	Salmon	2.2
	Pollock	1.3
*	Catfish	1.1
*	Tilapia	0.7
	Crab	0.6
	Cod	0.6
	Flatfish	0.3

* These species are produced primarily (or at least in part) by aquaculture operations rather than by wild capture.

- **Importance to societies**

Commercial fishing is an important economic force. The fishing and fish products industry directly employ approximately 38 million people worldwide, 10 million of which are associated with aquaculture. An additional 162 million people are indirectly involved in the industry. Since fishing does not require land ownership and is generally open to all, it is often the "occupation of last resort" in the developing world.

Fishing effort is dominated by 7 countries (listed in order of total weight of harvest in 2003) – China, Peru, India, Indonesia, U.S., Japan and Chile. These countries accounted for about two-thirds of the global catch of 132.5 million tons in 2003. In 2004, 30 million tons of fish products were exported, valued at over $70 billion. Japan is among the highest per capita consumers of marine fish (10 million tons of marine products per year). Japan once was able to meet this demand with its own fishing fleet. However, it now imports about half of its fish and is now the world's largest importer of marine products.

In the United States, the domestic seafood industry contributed $28.6 billion to the U.S. economy in 2001. Fishing is the number one employer in Alaska, which usually accounts for about half of the total U.S. catch. In 2002, the most valuable U.S. species were shrimp ($461 million), crabs ($398 million), lobsters ($319 million), Alaska pollock ($210 million), and scallops ($204 million).

The economic aspect of fisheries is an important consideration since tremendous social, economic and political pressure is generated to maintain the status quo.

III. Status of the Resource

"Until recently in the balance between productivity of fish populations and people's ability to catch fish, the fish were favored." (Iudicello, et al. 1999)

Changes in fisheries stocks must be examined from a long-term, historical perspective. Where available, current population estimates must be viewed in light of what we know about past population sizes, distributions and age distributions.

- **Historical perspective**

The perception of the seas as an "inexhaustible resource" has been around for a very long time. The following quote from a British political commentator was used to expand commercial fishing in Great Britian in the early 1800s. It probably represents the prevailing view of the time:

"…the seas which surround us afford an inexhaustible mine of wealth. Every acre of those seas is far more productive…than the same quantity of the richest land…"

Henry Schulles 1813 (quoted from Roberts 2007, p. 163)

Although a number of factors (e.g., pollution, habitat degradation and loss, global climate change) have been proposed as contributing to the decline of fish populations, excessive fishing is generally recognized as the primary cause. Overfishing results in the depletion of stocks due to the removal of excessive numbers of breeding stock – more fish are harvested than can be replaced by natural reproduction. This may lead to **commercial extinction,** the point at which the species no longer occurs in sufficient numbers to support an economic enterprise. For some stocks 80-90% of individuals are removed every year, resulting in precipitous declines. Prior to new restrictions put in place in 1992, it was estimated that 66% of cod and flounder were being caught every year on Georges Bank off the New England coast.

The past 100 years have been marked by repeated development, over-exploitation and collapse of numerous fisheries including the anchovy, Atlantic herring, norwegian cod, North Sea herring, haddock, menhaden, Pacific sardines and Atlantic halibut. 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.

In 1950, 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). Of the 200 major fish stocks that are fished throughout the world commercially, 25% are overfished and 38% are fully exploited.

- **Current status**

Worldwide, the harvest of wild fish (i.e., not including aquaculture) has remained stable at approximately 90 million tons since 1997. Increases in total fish harvest since 1990 have been primarily due to production from aquaculture ("fish farming"). In 2004, aquaculture accounted for over 43% of total fish harvest and by 2020, fish farming may produce the majority of fish harvested. In China, over two-thirds of fish harvested now comes from aquaculture operations.

Recent analysis (Watson and Pauly 2001; Pauly 2003) has shown that previous estimates of global fisheries landings were over-estimated and that landings are now declining by about 500,000 metric tons per year. This overestimation has been shown to be due to over-reporting of fisheries landings particularly by China. China's assessment and promotion system for fisheries officials is based on production output from their jurisdiction, providing tremendous incentive for statistical over-reporting. Also China declared a "zero growth" policy in 1998 and catch reports for 1999, 2000, and 2001 were exactly the same as those reported for 1998. Watson and Pauly provide evidence that fishery statistics are reported to fit stated policy rather than actual landings data. Based on this analysis, fisheries landings reached a peak in the late 1980s at 80-85 million tons per year.

SUMMARY OF STATUS ACCOUNTS

The manner in which estimates of the status of fishery resources are reported varies with geographic region and author. A representative sample of status summaries for U.S. and global fishery stocks follows. Complete citations for sources are given in the resources section of this module.

ESTIMATES FOR THE UNITED STATES

Year	Source	Status account
1995	NMFS	40% of U.S. fish stocks are overexploited
2002	NMFS	93 of 304 (31%) of U.S. fish populations are overfished or being fished at unsustainable rates
2004	NMFS	At least 42% of the species in American fisheries are being overexploited… some stocks are at their lowest levels since we've been keeping records.

GLOBAL ESTIMATES

Year	Source	Status account
1992	UN FAO	There are 16 major fish species whose global catch has declined by more than 50% over 3 decades
1995	UN FAO	Of the world's 17 major fisheries, 9 are in serious decline, and 4 others are depleted (swordfish and tuna are in particularly poor shape)
1997	Vitousek, P.	Of 200 major fish stocks fished commercially throughout the world, 25% are overfished and 38% are fully exploited
1998	UN FAO	70% of global fish stocks are overexploited, fully exploited, depleted or recovering from overexploitation
1999	MEA	Global marine fish stocks: recovering 1%, depleted 9%, overexploited 18%, fully exploited 47%, moderately exploited 21%, underexploited 4% (i.e., 27% depleted or overexploited)
2003	Helvarg, D.	Approximately 70% of global seafood species are overfished
2003	Myers and Worm	Predatory fish have declined by 90% in the past 50 years including tuna, marlin, swordfish, sharks, cod, halibut and flounder
2006	Worm, et al.	As of 2003, 29% of fish and seafood species had collapsed (declined by 90%). If current trends continue, all seafood species are projected to collapse by 2048.
2006	UN FAO	23% underexploited or moderately exploited; 52 % fully exploited (at or close to maximum sustainable limits); 25% overexploited (17%), depleted (7%), or recovering from depletion (1%)

With more than 75% of the world fish stocks reported as already fully exploited or overexploited (or depleted or recovering from depletion), most fisheries scientists now recognize that the maximum wild capture fisheries potential for the world's oceans has been reached or exceeded.

- **Status of large marine predators**

Global estimates of large marine predators (fish over one meter such as cod, halibut, tuna, swordfish and sharks) suggest that this group has been particularly depleted by overfishing. By any measure, current levels are but a fraction of historical levels – multiple sources of information support this conclusion. Current populations are approximately 10% of unfished levels.

Some species (e.g., white marlin and both Pacific and Atlantic bluefin tuna) have shown both a reduction in abundance and species distribution – a dangerous combination for large migratory species (see Myers and Worm, 2003; Myers and Worm, 2005). A 2003 study published in *Science* (Baum, et al. 2003) and using logbooks kept by longliners as a source of information, 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. Tagging data confirms that bluefin tuna and white marlin have also undergone range contraction. In contrast, swordfish have not yet shown any range contraction.

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

The dramatic decline of large sharks has been documented for the Gulf of Mexico (Baum and Myers, 2004) and the Mediterranean Sea (Feretti, et al. 2008). Based on longliner data from the Gulf, oceanic whitetip sharks declined 99%, silky sharks 91% and dusky sharks 79% when compared to unfished levels. Using a variety of data sources including commercial and recreational fishery landings, scientific surveys and sighting records, Feretti, et al. (2008) found that five species of sharks - hammerhead, blue, mackerel (2 species) and thresher sharks - in the Mediterranean Sea had declined by 96-99.9% relative to their former abundance. This level of decline would be sufficient under World Conservation Union (IUCN) criteria to list these species as “critically endangered.”

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.

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

- **Case studies of fishery declines**

Specific fisheries declines are best illustrated through case studies. The NCSR Marine Fisheries module entitled *Marine Fisheries Declines – Atlantic Cod* provides a detailed description of a case study of that species. Brief descriptions of additional species are also provided along with resources for additional information and suggested visuals to illustrate each situation. Instructors may choose those cases that are specific to their geographic region or those that best illustrate the concepts they wish to convey. The decline of the Atlantic cod is probably one of the best documented and additional information is provided for this species.

- **Endangered species**

Have any marine fish reached "endangered" status? Until recently, it had been assumed that the extinction of marine fish was improbable due to the vastness of the oceans and the remoteness of fish habitats. However, there is now evidence that this may not be the case (Devine, et al. 2006). With the collapse of continental shelf fisheries in the 1960s and 1970s in the Canadian waters of the Northwest Atlantic, harvesting shifted to deeper water species on the continental slope. Fish that had not been taken in significant numbers either in a targeted fishery or as bycatch prior to the 1970s, were now being fished. Most of these species are long-lived, slow growing species that reach sexual maturity at between 10 and 20 years of age. An examination of research trawl surveys from 1978-1994 found that five species for which adequate data were available (roundnose grenadier, onion-eye grenadier, blue hake, spiny eel and spinytail skate) had declined by 87-98%. Additional survey data from 1995-2003 for the two grenadier species indicated declines over the entire 26-year period of 99.6% and 93.3%, respectively. Both of these species are commercially fished; the others are taken as bycatch in other fisheries. When criteria established by the World Conservation Union are applied to these five species, each qualifies as "critically endangered" in the Northwest Atlantic.

Fisheries managers often contend that commercial extinction will prevent biological extinctions because fishers will switch target species when they become too expensive to catch. However, this protective mechanism may not work for highly valuable species. Bluefin tuna, for example, have declined dramatically in recent years and frequently sell at a very high price (one specimen sold in Tokyo, Japan for $173,600 in 2001). With values at this level, the incentive to continue fishing for this species is great.

RESOURCES

The literature on marine fisheries declines is voluminous and scattered. I have tried to organize resources such that they will serve a variety of instructor needs. There has been a concerted effort to emphasize those print and web resources that provide the most recent and easily accessible information. Selections from journal articles are primarily from readily available journals (e.g., *Science*, *Nature*) and from the "secondary literature" (e.g., *Scientific American*, *Bioscience*) rather than the less accessible and more detailed "primary literature" found in fisheries journals.

I. Comprehensive Resources

Most of these are comprehensive print and web resources that provide a broad view of marine fisheries issues. Those marked with an asterisk (*) are relatively short, general resources on marine fisheries that would be appropriate to be assigned as student reading.

Chiras, D.D. and J.P. Reganold, 2005. Natural resource conservation: Management for a sustainable future. 9th ed. Pearson/Prentice-Hall. Upper Saddle River, NJ.

Clover, C. 2006. The end of the line – How overfishing is changing the world and what we eat. Univ. of California Press, Berkeley, CA. 386 pp.

Communication Partnership for Science and the Sea (COMPASS)
http://compassonline.org/

COMPASS is a collaborative effort that advances marine conservation science and communicates scientific knowledge to policymakers, the public, and the media. Concise statements and access to peer-reviewed literature on a variety of marine fisheries issues are provided, including the state of oceans, marine ecosystem services, ecosystem-based management, marine reserves and sustainable aquaculture.

Ellis, R. 2004. The empty ocean. Shearwater Books. Washington, D.C. 384 pp.

In addition to a general description of fishery declines, case study accounts for several species are provided, including menhaden, tuna, swordfish, cod, Patagonian toothfish and Atlantic salmon.

Fisheries Management and Ecology

This journal is published bi-monthly and is promoted as the only fully peer-reviewed fisheries management and ecology journal available. Its scope is international and all aspects of the management, ecology and conservation of inland, estuarine and coastal fisheries are given treatment. Sample papers can be viewed on-line at www.blackwellpublishing.com/fme.

Halweil, B. 2006. Catch of the day: Choosing seafood for healthier oceans. World Watch Paper #172. World Watch Institute, Washington, D.C. 75 pp.

Helfman, G.S. 2007. Fish conservation: A guide to understanding and restoring global aquatic biodiversity and fishery resources. Washington D.C. Island Press.

Iudicello, S., M. Weber and R. Wieland. 1999. Fish, markets and fishermen: The economics of overfishing. Island Press, Washington, D.C. 192 pp.

This text provides excellent insight into the question of why overfishing occurs. Detailed explanations of subsidies, overcapacity, individual fishing quotas and other economic aspects of marine fisheries issues are provided.

National Oceanic and Atmospheric Administration (NOAA) Fisheries Service
www.nmfs.noaa.gov

This is a large, comprehensive government web site that includes the U.S. government perspective on sustainable fisheries, fisheries management, etc. NOAA Fisheries Service (formerly the National Marine Fisheries Service) is "dedicated to the stewardship of living marine resources through science-based conservation and management, and the protection of healthy ecosystems….. (NOAA Fisheries) conserves, protects and manages living resources in a way that ensures their continuation as functioning components of marine ecosystems, affords economic opportunities and enhances the quality of life for the American public."

National Oceanic and Atmospheric Administration (NOAA) Fisheries Service
www.st.nmfs.noaa.gov/st4/documents/FishGlossary.pdf

This document is a complete glossary of fishery-related terms provided by NOAA Fisheries.

National Oceanic and Atmospheric Administration (NOAA) Fisheries – FishWatch
www.nmfs.noaa.gov/fishwatch/

This site is designed to help consumers make informed choices about the seafood they eat. It includes lots of useful information on most commercially-important U.S. species such as sustainability status, management, ecology, biomass and landings.

National Oceanic and Atmospheric Administration (NOAA) Fisheries – Office of Sustainable Fisheries
www.nmfs.noaa.gov/sfa

Among the more useful web pages to educators on the massive NOAA Fisheries site are those that are dedicated to the Sustainable Fisheries Act (SFA). These pages provide links to reports that describe how the SFA is being implemented and those changes that have occurred as a result of its implementation. This site provides the most recent information on the status of U.S. fish stocks.

NRC. 1999. Sustaining marine fisheries. National Academy Press, Washington, D.C. 164 pp. http://books.nap.edu/catalog.php?record_id=6032

This comprehensive report by the Committee on Ecosystem Management for Sustainable Fisheries of the National Research Council documents the status of marine fisheries and discusses the challenges of achieving sustainability. The shortcomings of current fisheries management and regulation are described. Like many similar publications, this document recommends a broader ecosystem perspective to fisheries management that takes into account all relevant environmental and human influences. Specific recommendations are made to build workable fisheries while changing current practices that encourage overexploitation of fisheries resources.

*Pauly, D. and R. Watson. 2003. Counting the last fish. Scientific American (July 2003): 43-47.

Pauly, D. and J. Maclean. 2003. In a perfect ocean. Island Press, Washington, D.C. 175 pp.

This book from the Sea Around Us Project provides a comprehensive examination of the status and history of the fisheries of the North Atlantic Ocean.

Pew Oceans Commission. 2003. America's living oceans: Charting a course for sea change – a report to the nation. May 2003. Pew Oceans Commission, Arlington, VA. www.pewtrusts.com/pdf/env_pew_oceans_final_report.pdf

This Pew Oceans Commission report is an evaluation of America's ocean resources. Chapters 3 and 11 ("Restoring America's Fisheries") are excellent reviews of U.S. marine fisheries issues. Additional fisheries-related publications may be obtained at:
www.pewoceans.org
www.pewtrusts.org

*Raloff, J. 2005. Empty nets: fisheries may be crippling themselves by targeting the big ones. Science News 167:360-362.

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

This text evaluates many fisheries (as well as sealing and whaling) from a perspective that stretches back hundreds of years. Roberts claims that, "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. The author claims that a fundamental shift is needed in the approach to fisheries management and ocean conservation. His proposed solution is to manage fisheries in a global network of marine reserves and protected areas, a radical departure from traditional fisheries management.

Ross, M.R. 1997. Fisheries conservation and management. Prentice Hall, Inc., Upper Saddle River, NJ. 374 pp.

This is a general text that would be appropriate for an undergraduate course in fisheries. Most fisheries texts are designed for upper-level undergraduate and graduate-level courses and, as a result, provide much detail and are often heavily based in mathematics. This text is specifically designed for sophomore-level students and provides a broad-based introduction to fisheries management and conservation. Consequently, it may be more appropriate for students in community college programs than other texts.

* Rothschild, B.J. 1996. How bountiful are ocean fisheries?
www.gcrio.org/CONSEQUENCES/winter96/oceanfish.html

The U.S. Global Change Research Information Office is a clearinghouse for reports generated or supported by U.S. governmental agencies. In addition to dealing with the major issues related to marine fisheries, this article addresses the predicted impacts of global climate change.

Safina, C. 1998. Song for the blue ocean: Encounters along the world's coast and beneath the seas. Henry Holt and Co., NY. 445 pp.
This resource examines fisheries resources in the Northeast, Pacific Northwest and the western Pacific Ocean.

*Safina, C. 1995. The world's imperiled fish. Scientific American Nov. 1995:46-53.

Although now a bit outdated, this brief article provides an excellent summary of the status of marine fisheries and the primary causes for decline.

SeaWeb
www.seaweb.org

The SeaWeb Project is designed to increase public awareness of the world's oceans and the biodiversity they support. Their web site provides access to a great deal of fisheries-related information that is useful to instructors including publications, links to other sites and a "marine photo bank." The images in the photo bank are free for non-commercial use and would be useful to develop in-class presentations. All aspects of fisheries are portrayed in these images including fishing methods, aquaculture, marine species of concern, bycatch and marine protected areas.

I would encourage all instructors to sign up for SeaWeb's Marine Science Review*, a free periodic summary of recent fisheries research. Abstracts of recent publications and often links to the original articles are provided via e-mail.*

The Sea Around Us Project
www.seaaroundus.org

The Sea Around Us Project is dedicated to the scientific study of the impact of fisheries on the world's marine ecosystems. The project is housed at the University of British Columbia (Vancouver) and is supported by the Pew Charitable Trusts. Their web site provides a wealth of information on all aspects of global fisheries. Species-specific information such as geographical distribution, status, catch rates, gear type, etc. are provided in easily accessible graphs. Links to other sites such as FishBase (www.fishbase.org) *provide additional information including biological data and photographs. Interactive maps allow the user to determine location and catch rates for any species throughout the world. The site also includes a global map of marine protected areas (MPA's) and the ability to search for information on specific MPA's. A graphical simulation ("North Atlantic Trends") illustrates the change in biomass distribution for high trophic level fish in the North Atlantic from 1900-2000.*

Turning the Tide: The State of Seafood. 2009. Monterey Bay Aquarium
http://www.montereybayaquarium.org/cr/cr_seafoodwatch/content/media/MBA_SeafoodWatch_StateofSeafoodReport.pdf

The Monterey Bay Aquarium has a long history of providing information on fisheries-related issues to the general public. This most recent effort is a comprehensive examination of the current status of fisheries and aquaculture as well as trends in both the seafood industry and marine ecosystems. New solutions are offered to address the decline of marine resources. The document is science-based and professionally produced with colorful photographs, graphs and other images adapted from scientific publications on this topic.

United Nations Food and Agricultural Organization (FAO). 2004. The State of World Fisheries and Aquaculture.
www.fao.org/sof/sofia/index_en.htm

This United Nations web site is the premier resource for global fishery trends, statistics and policy issues. If you need graphs that illustrate changes in any aspect of fisheries (fish stocks, landings, economic value, etc.), this is the first place to look. All materials may be reproduced for educational use without written copyright permission.

The report is published every two years and copies of past reports are available on the web site. Beyond fishery statistics, the site also provides excellent treatment of global fishery issues. The 2004 report, for example, examines capture-based aquaculture, endangered species, depleted stock recovery, the management of deep-water fisheries and the impacts of trawling on benthic ecosystems.

A hardcopy version of the FAO report is also available:

UN FAO. 2005. Review of the state of world marine fishery resources. U.N. Food and Agriculture Organization. FAO Fisheries Technical Paper No. 457. 242 pp.

United States Commission on Ocean Policy. 2004. An ocean blueprint for the 21st century.
www.oceancommission.gov

United Nations Environmental Program (UNEP). 2006. Marine and coastal ecosystems and human well-being: A synthesis based on the findings of the Millennium Ecosystem Assessment. UNEP. 76 pp.
www.millenniumassessment.org/en/synthesis.aspx
www.maweb.org

The Millennium Ecosystem Assessment (MA) is an international collaborative established in 2001 by the United Nations. The MA takes a scientific approach to assess ecosystems, the service they provide and how changes in these services will impact human well-being. This synthesis reports the MA findings concerning marine and coastal ecosystems including fisheries.

Like the FAO web site, this resource provides excellent coverage of global fishery trends and issues in a user-friendly format. Instructors will find the tables, graphs, illustrations and their descriptions particularly useful. All materials are available for educational use without seeking copyright permission as long as their source is acknowledged.

II. Single-issue Resources (Introduction and Status)

These sources are more narrowly focused than the previous list, emphasizing one or few aspects of the marine fisheries issue. They are listed according to the primary issues that are addressed in this module.

The Importance of Marine Fisheries to Society

National Oceanic and Atmospheric Administration (NOAA) Fisheries – Office of Science and Technology. 2005. Fisheries of the United States – 2004. Silver Springs, Maryland. www.st.nmfs.gov/st1/fus/fus04/index.html

This publication summarizes the most recent landings data for commercial and recreational fisheries in the United States.

Pew Oceans Commission. 2003. Socioeconomic perspectives on marine fisheries in the United States. Pew Oceans Commission, Arlington, VA. www.pewoceans.org or www.pewtrusts.org

This document describes the economic and social impacts of fishery declines and the potential for benefits to society if fishery stocks are restored.

The Status of Marine Fisheries

Baum, J., et al. 2003. Collapse and conservation of shark populations in the northwest Atlantic. Science 299:389-392.

Baum, J.K. and R.A. Myers. 2004. Shifting baselines and the decline of pelagic sharks in the Gulf of Mexico. Ecology Letters 7(2):135-145.

Block, B.A., et al. 2005. Electronic tagging and population structure of Atlantic bluefin tuna. Nature 434:1121-1127. http://www.nature.com/nature/journal/v434/n7037/full/nature03463.html

Devine, J.A., K.D. Baker and R.L. Haedrich. 2006. Deep-sea fishes qualify as endangered. Nature 439:29.

Ferretti, F., et al. 2008. Loss of large predatory sharks from the Mediterranean Sea. Conservation Biology 22:952-964.

Hutchings, J.A. and J.D. Reynolds. 2004. Marine fish population collapses: Consequences for recovery and extinction risk. BioScience 54(4): 297-309.

Iudicello, S., M. Weber and R. Wieland. 1999. Fish, markets and fishermen: The economics of overfishing. Island Press, Washington, D.C. 192 pp.

Myers, R.A. and B. Worm. 2003. Rapid worldwide depletion of predatory fish communities. Nature 423:280-283.
http://www.mindfully.org/Water/2003/Predatory-Fish-Depletion15may03.htm
http://www.oceanlegacy.org/pdfs/nature01610_r_Canada_Report.pdf

Myers, R.A. and B. Worm. 2005. Extinction, survival, or recovery of large predatory fishes. Philosophical Transactions of the Royal Society B 360:13-20.
http://myweb.dal.ca/bworm/Myers_Worm_2005.pdf

NMFS. 2001. National Marine Fisheries Service. Report to Congress: Status of fisheries of the United States. Silver Springs, Maryland.
www.nmfs.noaa.gov/sfa/status%20of%20fisheries2000.htm

National Oceanic and Atmospheric Administration (NOAA) Fisheries Service
www.nmfs.noaa.gov

National Oceanic and Atmospheric Administration (NOAA) Fisheries Service Sustainable Fisheries Act
www.nmfs.noaa.gov/sfa

Pauly, D. and R. Watson. 2003. Counting the last fish. Scientific American (July 2003): 43-47.

Rothschild, B.J. 1996. How bountiful are ocean fisheries?
www.gcrio.org/CONSEQUENCES/winter96/oceanfish.html

Safina, C. 1995. The world's imperiled fish. Scientific American 273:46-53.

Siebert, J. et al. 2006. Biomass, size and trophic status of top predators in the Pacific Ocean. Science 314:1773-1776.
http://www.sciencemag.org/cgi/content/abstract/314/5806/1773
http://www.spc.int/oceanfish/docs/research/sibert2006_tuna_biomass.pdf

Authors analyzed all available data from the Pacific tuna fisheries for 1950-2004 and conclude that at least 50 million tons of tuna and other top-level predators have been removed from the Pacific Ocean pelagic ecosystem since 1950. The current biomass for several species ranges from 36% to 91% of pre-fishing levels. Large fish (>175 cm in length) have decreased from approximately 5% to approximately 1% of the total population.

United Nations Food and Agricultural Organization (UN FAO)
www.fao.org/

Every two years the Fisheries Department of the FAO publishes a report entitled, "The State of World Fisheries and Aquaculture." The report is the definitive source for global statistics on capture fisheries, aquaculture and fisheries policy issues.

Vitousek, P.M. et al. 1997. Human domination of Earth's ecosystems. Science 277:494-499.

Watson, R. and D. Pauly. 2001. Systematic distortions in world fisheries catch trends. Nature 414: 543-536.

Worm B, Sandow M, Oschlies A, Lotze HK, Myers RA. 2005. Global patterns of predator diversity in the open oceans. Science 309:1365-1369.
http://myweb.dal.ca/bworm/Worm_etal_2005.pdf

Worm, B., et al. 2006. Impacts of biodiversity loss on ocean ecosystem services. Science 314:787-790.

Worm B., et al. 2007. Biodiversity loss in the ocean: How bad is it? Response. Science 316:1282-1284.
http://myweb.dal.ca/bworm/Worm_etal_2007a.pdf

III. Resources For Digital Images

There are a number of web-based sources for fisheries-related digital photos that instructors can use to augment NCSR fisheries modules. Most of those listed below allow educational use of their images without seeking copyright permission as long as proper acknowledgement is presented along with the photo. However, instructors should check the documentation on each web site and follow the required procedure for use.

ARKive – Images of Life on Earth
www.arkive.org
This web site provides useful biological and conservation information (description, status, range, habitat, threats and conservation) on a wide variety of species as well as images and short video clips.

FishBase – A Global Information System on Fishes
www.fishbase.org
FishBase *is a huge relational database that emphasizes the biological characteristics of nearly all fish known to science. Photos and other media are available for download.*

MarineBio
www.marinebio.org
A comprehensive conservation-based site that includes links to multimedia (video and images) for a number of commercially important fish species.

Marine Photobank
www.marinephotobank.org
This SeaWeb-*sponsored web site provides access to a great deal of fisheries-related information that is useful to instructors including publications, links to other sites and a "marine photo bank." The images in the photo bank are free for non-commercial use and would be useful to develop in-class presentations. All aspects of fisheries are portrayed in these images including fishing methods, aquaculture, marine species of concern, bycatch and marine protected areas.*

Northeast Fisheries Science Center
www.nefsc.noaa.gov
This regional center of the National Marine Fisheries Service provides all of the original line drawings from the "Bible of New England Fisheries," Fishes of the Gulf of Maine.

NOAA Ocean Explorer
http://oceanexplorer.noaa.gov/gallery/gallery.html

This site includes visual and audio material from NOAA Ocean Explorer expeditions. There are videos, podcasts, slideshows and audio files available. Files are organized into several categories including: maps, living ocean, sound in the sea, cultural heritage, history, technology, explorers and a YouTube video playlist.

NOAA Photo Library
www.photolib.noaa.gov/collections.html
This site, maintained by the National Oceanic and Atmospheric Administration, is a government site with several image collections relevant to fisheries. Instructors will find the following collections particularly useful:

The National Undersea Research Program
National Marine Sanctuaries
Fisheries
National Marine Fisheries Historical Image Collection

IV. Video Resources

America's Underwater Treasures. 2006. Jean-Michel Cousteau Ocean Adventures. DVD 120 min.
PBS Home Video
1-800-PLAY PBS
www.pbs.org

This two-part, two-hour production examines all 13 of the U.S. National Marine Sanctuaries. Their role in the conservation of marine biodiversity is emphasized including their role in the recovery of marine fish stocks.

PBS also maintains a web site (www.pbs/kqed/oceanadventures/episodes/treasures/) *that provides links to the National Marine Sanctuary web site, live underwater video feeds and additional information on the marine sanctuary system.*

Common Ground I: Oregon's Oceans. 2005. Green Fire Productions. DVD 28 min.

Common Ground II: Oregon's Ocean Legacy. 2007. Green Fire Productions. DVD 15 min.

Common Ground III: Oregon's Network of Marine Reserves and Marine Protected Areas. 2009. Green Fire Productions. DVD 18 min.

This series of three short films describes the rationale behind the establishment of a network of marine reserves off the Oregon Coast. The viewpoints of several stakeholders are presented including marine biologists, recreational fishermen, commercial fishermen, small business owners and conservationists. The latest scientific information on the effectiveness of marine reserves is also included. The DVDs can be ordered for $15 each (or $20 for the entire set) from www.oceansonline.org. *Brief excerpts are also available on-line for preview.*

Deep Crisis. 2003. Scientific American Frontiers. VHS 57 min.
PBS Home Video
1-800-PLAY PBS
www.pbs.org

This one-hour Scientific American Frontiers *production, narrated by Alan Alda, is conveniently divided into three equal segments of approximately 20 minutes each. The first addresses salmon in the Pacific Northwest with an emphasis on new technologies being used at hydroelectric dams on the Columbia River to monitor salmon populations and reduce impact. The second examines recovery efforts for Atlantic salmon in Maine including captive breeding of wild stocks and their re-introduction into Maine rivers. The third segment describes current research on Atlantic bluefin tuna using tagging technology and aerial surveys to monitor tuna population sizes and migration patterns.*
DETAILED NOTES ON THIS VIDEO ARE AVAILABLE IN THE *COMPREHENSIVE RESOURCES FOR NCSR MARINE FISHERIES SERIES.*

Empty Oceans: Global Competition for Scarce Resources. 2004. DVD 30 min.
Films for the Humanities and Sciences
1-800-257-5126
www.films.com

This video illustrates the social and economic consequences of marine fishery declines. An emphasis is placed on the international aspect of the issue with examples from West Africa, Japan, Spain and Canada. A short video clip of the film can be seen on the distributor's web site.

Empty Oceans, Empty Nets. 2002. Habitat Media. VHS/DVD 57 min.
734 A Street
San Rafael, CA 94901
415-458-1696
www.habitatmedia.org

This one-hour video explores most aspects of commercial fisheries from several perspectives including commercial fishers, fishery scientists and concerned citizens. It is probably the most comprehensive, high quality video production on this topic. Case studies of the Atlantic cod, salmon, bluefin tuna and swordfish are provided. The ecological impact of commercial fishing is emphasized but there is also good coverage of proposed solutions and success stories. Current efforts to restore fisheries, protect essential fish habitat and implement market-based solutions are included.

A low-cost ($12) edited version of this production is now available for educators. An activity guide that describes six student exercises linked to this video production is also available on the Habitat Media web site. Although designed primarily for high school students, several of these exercises could be adapted for college-level courses. (Available at www.habitatmedia.org/educators.html)

The *Marine Fisheries Series Activity Guide* can be accessed at:
www.pbs.org/emptyoceans/educators/activities.html
DETAILED NOTES ON THIS VIDEO ARE AVAILABLE IN THE *COMPREHENSIVE RESOURCES FOR NCSR MARINE FISHERIES SERIES*.

End of the Line – Imagine a World Without Fish. 2009. New release 80 min.
http://endoftheline.com/film/
http://www.babelgum.com/endoftheline

This feature-length documentary film is adapted from Charles Clover's book of the same title. It examines the impacts of overfishing on marine ecosystems and the human food supply. It premiered at the Sundance Film Festival in 2009 and is being distributed. It features several of the examples cited in NCSR Fisheries modules including discussions of bluefin tuna and Atlantic cod. See web sites above for film trailer and individual episodes.

Fate of the Ocean – Our Threatened Fisheries. 2005. VHS/DVD Two 30 min. programs
Films for the Humanities and Sciences
1-800-257-5126
www.films.com

This two-part series takes a global view of the issue of declining fisheries. A wide range of examples are examined from around the world. The first program, Plundering the Oceans, *explains the general nature of fishery declines using examples from India, the Mediterranean and the North Atlantic (cod and tuna). The second program,* Protecting the Oceans, *describes examples of sustainable fishing practices, some of which may be used as models for large-scale reform of fishing policy. Examples from the Canary Islands, Oman and Great Britain, including marine reserves, ecotourism and aquaculture are used to illustrate. A sample video clip and a detailed outline of the videos are available at the distributor's web site.*

Farming the Seas. 2004. Habitat Media. VHS 56 min.
734 A Street
San Rafael, CA 94901
415-458-1696
www.habitatmedia.org

This 1-hour video production addresses the many issues surrounding aquaculture - the cultivation of fish and other marine organisms. General issues are discussed and specific case studies are provided from the United States (bluefin tuna), Canada (salmon), China (carp) and Thailand (shrimp). The notes that follow provide a summary of the content of the Farming the Seas *video production. Approximate elapsed time is given at the beginning of each section to facilitate the selection of excerpts or other planning.*
DETAILED NOTES ON THIS VIDEO ARE AVAILABLE IN THE *COMPREHENSIVE RESOURCES FOR NCSR MARINE FISHERIES SERIES.*

Fisheries – Beyond the Crisis. 1998. The Nature of Things. VHS 46 min.
Bullfrog Films
P.O. Box 149
Oley, PA 19547
610-779-8226
www.bullfrogfilms.com

This production, hosted by David Suzuki, examines community responses to the decline of marine fisheries in the Bay of Fundy, Canada and in southern India. Both communities opposed a quota system of management and demanded a locally controlled, ecosystems-based approach to achieve long-term sustainability of the fisheries and the communities they support.

Fish for today, fish for tomorrow. 2008. Marine Stewardship Council. On-line 8 min.
www.youtube.com

This short "You tube" *video describes the rationale and process for Marine Stewardship Council certification of seafood.*

A Fish Story. 2007. Public Broadcasting Service - Independent Lens. DVD 54 min.
www.pbs.org/independentlens/fishstory
www.pbs.org/independentlens/fishstory/updates2.html

This video production is most appropriate for those instructors who would like to present the social impacts of fishery declines. The plights of two Massachusetts fishing families are followed, one from Gloucester and the other from Chatham, during a time of increased regulation and declining fish stocks.

An update is provided by the Northeast Seafood Coalition, a non-profit organization that represents commercial fishermen, fishing-related business owners and fishing community members. A representative of the coalition describes how fishing regulations implemented after the collapse of the groundfish fishery are affecting the fishing industry.

Gutted: The Demise of Scotland's Fishing Industry. 2005. Wide Angle. DVD 57 min.
Films for the Humanities and Sciences
1-800-257-5126
www.films.com

This one hour documentary depicts the social impacts of fishery declines on a community in Scotland. Much like the situation in New England, overfishing of cod and other species in the North Sea, followed by government restrictions on fishing, decimated local economies. A short video clip of the film can be seen on the distributor's web site.

Has the Sea Given Up Its Bounty? 2003. New York Times. 10 min.
www.nytimes.com/packages/khtml/2003/07/29/science/20030729_OCEANS_FEATURE.html

This is an interactive video feature developed by Andrew Levin of the New York Times on the effects of bottom trawling and overfishing on the world's oceans. Brief video segments, animations and diagrams are used to illustrate. There is also an associated NY Times article.

Journey to Planet Earth – The State of the Ocean's Animals. 2007. PBS. DVD 60 min.
www.pbs.org/journeytoplanetearth/about/purchase.html
PBS Home Video
1-800-PLAY PBS

This PBS production addresses global marine conservation issues including several that are related to marine fisheries. Short segments that highlight the Atlantic cod fishery off the New England coast, the impacts of industrial fishing on traditional fisheries in Senegal, Africa, the decline of shark populations and the salmon fishery in the Klamath Basin, Oregon are included. Other segments describe conservation issues concerning sea turtles, dolphins and sea otters.

Journey to Planet Earth – The State of the Planet's Oceans. 2009. PBS. DVD 60 min.
www.pbs.org/journeytoplanetearth/about/purchase.html
PBS Home Video
1-800-PLAY PBS

The Journey to Planet Earth *series (hosted by Matt Damon) is designed for a general audience and addresses a number of current environmental issues. This episode examines marine issues with an emphasis on global climate change and overfishing.*
DETAILED NOTES ON THIS VIDEO ARE AVAILABLE IN THE *COMPREHENSIVE RESOURCES FOR NCSR MARINE FISHERIES SERIES*.

The Long View: A Plan to Save Our Ocean Fish. 2006. Marine Fish Conservation Network
Web-based. 12 min.
www.conservefish.org/site/catch06/index.html

This conservation-based site includes a downloadable 12-minute video that provides a good overview of the U.S. fisheries management situation from the perspective of an environmental organization dedicated to marine conservation.

New Whiting Fishery in Newport. 2000. Oregon Field Guide. VHS/DVD 15 min.
Oregon Public Broadcasting Productions
7140 SW Macadam Ave.
Portland, Oregon 97219-3099
1-800-241-8123
www.opb.org

This short Oregon Field Guide *segment describes the development of a new trawl fishery off the Oregon Coast for Pacific whiting.*

Net Loss – The Storm Over Salmon Farming. 2003. Moving Images Video. DVD 52 min.
Bullfrog Films
P.O. Box 149
Oley, PA 19547
610-779-8226
www.bullfrogfilms.com

This video production examines the risks and benefits of "net pen" salmon farming, a type of aquaculture used in Washington and British Columbia in which salmon are raised in giant underwater cages. While decades of past management failures have caused the decline of many wild salmon populations, salmon farming is seen as a sustainable method for providing fish for markets. This video production examines the controversy surrounding salmon farms and the threat they pose to wild salmon. The perspectives of salmon farmers, conservationists, traditional fishermen and government officials are portrayed.

Oceans and Marine Life – Marine Video and Animation
National Environmental Trust
www.net.org/marine/video.vtml

This environmental organization posts on-line video clips (or links to clips on other sites) concerning fisheries issues. Short (2-3 minute) videos include:

- *"Take a Pass on Chilean Sea Bass" – a humorous depiction of seafood choices made by consumers in a restaurant*
- *"Overfishing Animation" – an illustration of the global decline of large, predatory fish over the past 50 years (based on data from Myers and Worm, 2003)*
- *"Small Fish, Big Problem" – a humorous depiction of shifting baselines*

Over-exploiting the Oceans – The Dangers of Overfishing. 2007. VHS/DVD 47 min.
Films for the Humanities and Sciences
1-800-257-5126
www.films.com

This video production examines the environmental and socioeconomic impacts of overfishing from a global perspective. Ancient artisanal fishing practices are contrasted with large-scale modern fishing techniques used in the oceans off the African coast. International economic and political factors are also examined. A sample video clip and a detailed outline of the video are available at the web site above.

Resources Assessment and Conservation Engineering – Field Videos
Alaska Fisheries Science Center
NOAA Fisheries
www.afsc.noaa.gov/race/media/videos/vid_habitat.htm

Underwater video has been used in an attempt to evaluate benthic habitats and the impacts of bottom trawls on those habitats. The Alaska Fisheries Science Center of NOAA Fisheries has posted a number of on-line video clips that illustrate the impacts of various types of fishing gear.

Strange Days on Planet Earth. 2004. Episode #3 – Predators. National Geographic Television and Film. Vulcan Productions, Inc. DVD 20 min.
www.nationalgeographic.com
www.pbs.org
1-800-PLAY-PBS
This video is divided into three segments of roughly equal length. Each segment describes the intricate relationships between fish populations and other environmental phenomena. In the first segment, historical archives are used to describe how the decline of large African mammals is related to the availability of fish in Ghana. As fish populations decline, hunting for "bush meat" increases to compensate for the loss of protein in the diet. Conversely, when fish numbers increase, hunting declines and wildlife populations rebound. The second segment establishes a connection between fish kills on the coast of Namibia and the release of large amounts of hydrogen sulfide from marine sediments. The hydrogen sulfide deposits appear to have resulted from the decomposition of phytoplankton, which flourished after sardine populations were depleted by foreign fishing fleets in the 1970s. The final segment examines various proposals for achieving sustainable fisheries management. Marine reserves and aquaculture (integrated aquaculture and open access "Aquapods") are emphasized.
DETAILED NOTES ON THIS VIDEO ARE AVAILABLE IN THE *COMPREHENSIVE RESOURCES FOR NCSR MARINE FISHERIES SERIES*.

Strange Days on Planet Earth. 2008. Episode #5. National Geographic Television and Film. Vulcan Productions, Inc. DVD 60 min.
www.nationalgeographic.com
www.pbs.org
1-800-PLAY-PBS
DETAILED NOTES ON THIS VIDEO ARE AVAILABLE IN THE *COMPREHENSIVE RESOURCES FOR NCSR MARINE FISHERIES SERIES*.

Weather the Storm: The Fight to Stay Local in the Global Fishery. 2008. DVD 37 min.
Bullfrog Films
P.O. Box 149
Oley, PA 19547
610-779-8226
www.bullfrogfilms.com

This production by the Ethnographic Film Unit at the University of British Columbia presents the case for supporting small-scale, artisanal fisheries as part of a global sustainable fisheries strategy. In contrast to industrial floating fish factories that deplete fish stocks and then move to other areas, artisanal fisheries serve local communities and can readily adapt their fishing methods to changing local conditions. Small-scale fisheries from around the world are described, but the emphasis is on the ground fishery (cod, haddock and halibut) off the west coast of France. Although the film is narrated in English, much of the conversation among fishermen, community members and others involved in the industry is in French with English subtitles.

Where's the Catch? 2005. VHS/DVD 26 min.
Films for the Humanities and Sciences
1-800-257-5126
www.films.com

This video examines fisheries in the Pacific Islands (Fiji, Kiribati and the Marshall Islands) emphasizing the impacts of fishery declines on subsistence and commercial fisheries. The roles of modern indiscriminate fishing techniques, illegal fishing, and government corruption and their impact on Pacific Island culture are illustrated. A sample video clip and a detailed outline of the video are available at the web site above