# Marine Fisheries –
# Management and Proposed Solutions


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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.

# Table of Contents

# 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 – Management and Proposed Solutions

## 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. Proposed and implemented management activities that are designed to manage fisheries stocks in a sustainable manner are discussed with an emphasis on those that take an ecosystems approach to fisheries management.

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. Describe the challenges of modern fishery management
2. Describe traditional approaches to fishery management
3. Describe ecosystem-based approaches to sustainable fishery management
4. Describe how market-based approaches can be used to supplement ecosystem-based fishery management
5. Evaluate the future of fishery management

# General Lecture Outline

Topics VII, VIII. IX and X in the general lecture outline below are covered in this module. Topics I through VI 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

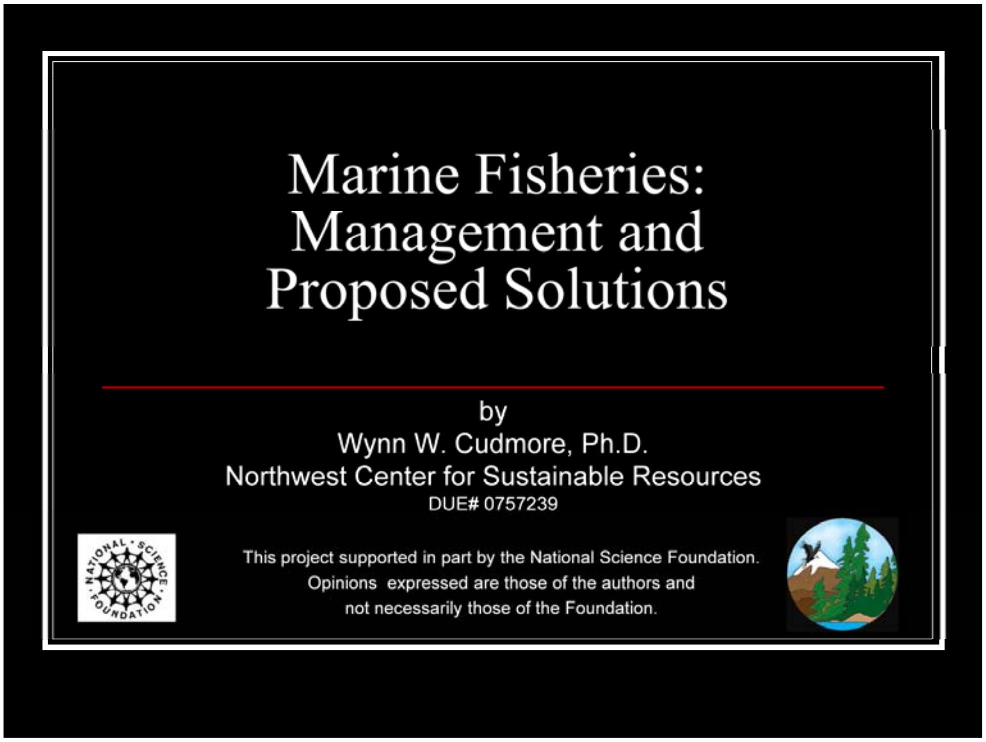
- Certification
- Consumer-based solutions
- Reduction in fishing effort by purchase of fishing rights
- Aquaculture
- Increased use and marketing of underutilized species

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 traditional, market-based and ecosystem-based approaches to marine fisheries management. Other marine fisheries topics such as the status of marine fisheries, causes for fishery declines and the implications of fishery declines for marine ecosystems are described in detail in other NCSR marine fisheries modules.


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

Traditional fisheries management has historically focused on single species management with an emphasis on production, as exemplified by the quote above from a widely used fisheries text from the 1970s.

Five general approaches have been used to manage fisheries:

Maximum sustainable yield

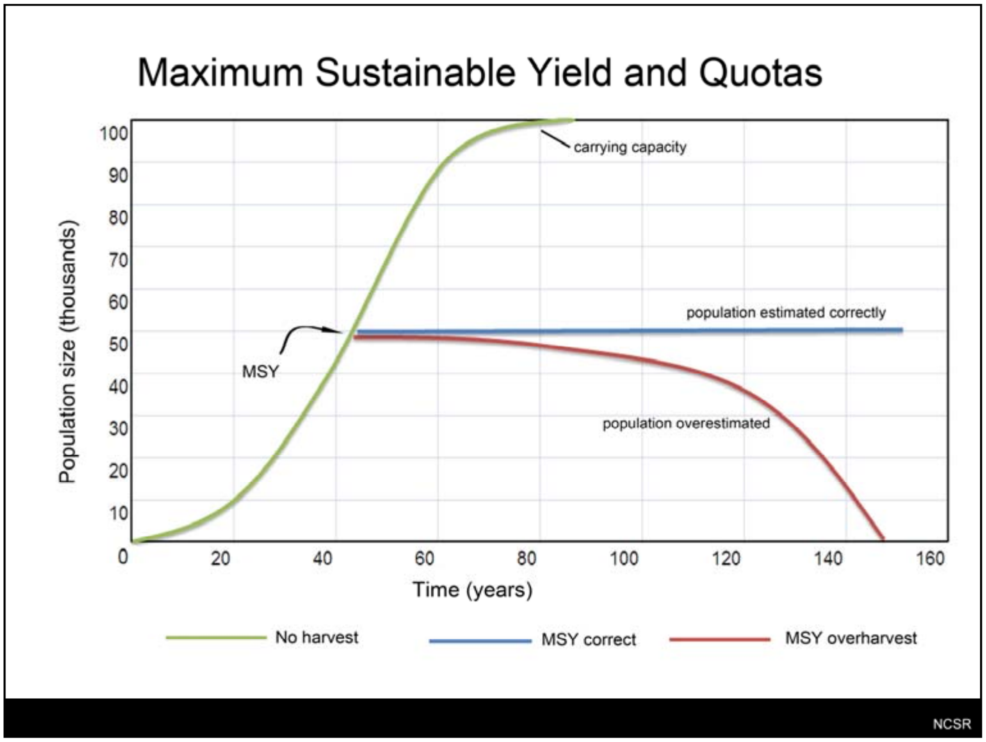
Quotas (Total Allowable Catches)

Legislation

Closures

Gear restrictions

Each will be described separately although they are frequently used in conjunction with one another to manage a fishery.




See notes slide 3

Notes slide 3

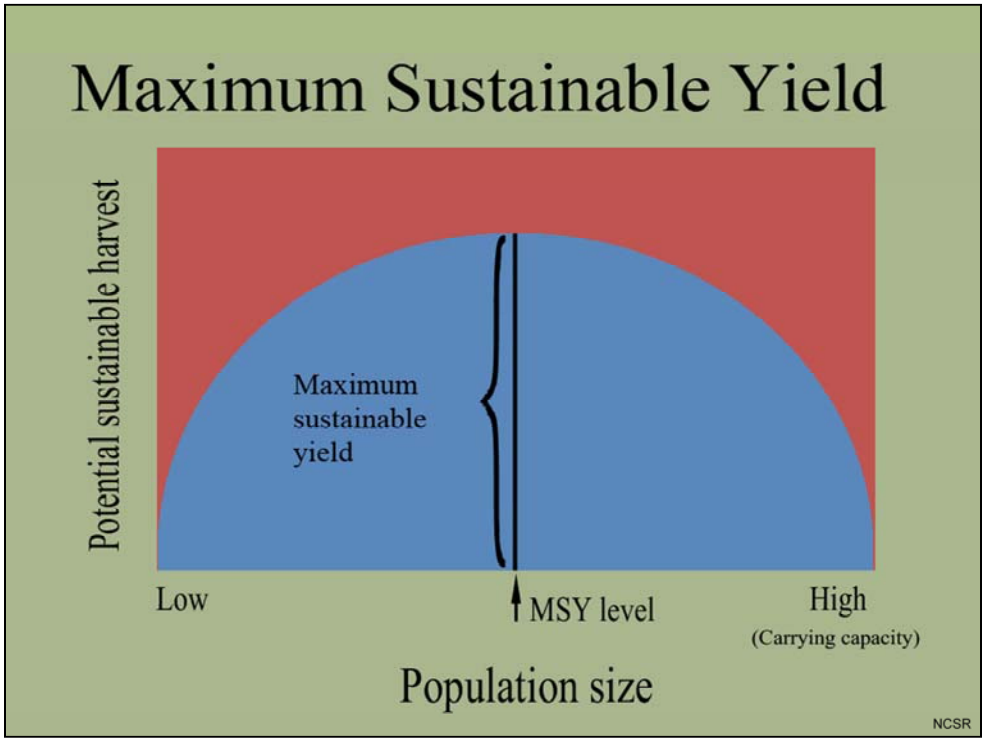
Maximum sustainable yield and quotas will be considered together. A quota (or total allowable catch) is simply the maximum amount of catch that is allowed before a fishery is closed. Traditionally, that quota is established by applying the principles of maximum sustainable yield.

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

The logic of MSY goes like this:

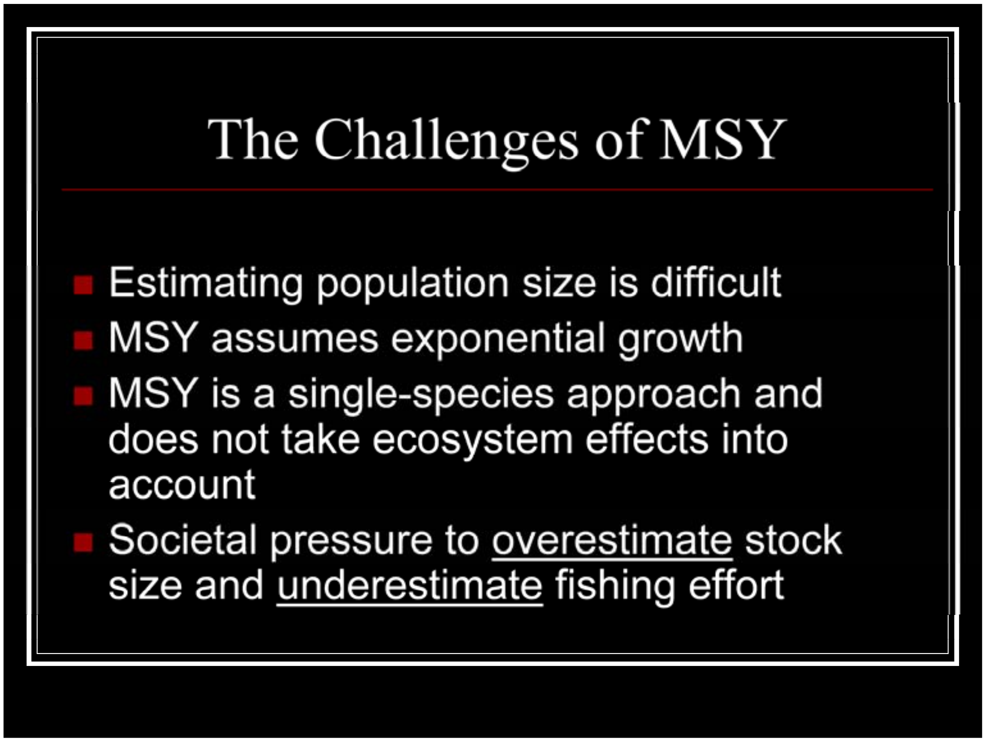
1. Population size is determined in part by population growth rate
2. Growth rates are lowest when the population is small (the lag phase of logistic population growth) and large (population is near the carrying capacity and population growth is limited by density dependent factors like food availability)
3. Intermediate-sized populations have the greatest growth capacity and the ability to produce the greatest number of fish that can be harvested each year.
4. Therefore, fisheries can maximize production by keeping the population at an intermediate level (1/2 of carrying capacity).

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




Due to the shape of the logistic growth curve shown in the previous slide, the maximum yield is obtained at that point that the population is increasing at its highest rate. This relationship is illustrated in the diagram above. The potential sustainable harvest (i.e., the recruitment of new individuals into the population) is low at both low population levels and at high population levels. At low population levels the population is in the lag phase of logistic growth and recruitment is low since there are few individuals that are producing offspring. At high population levels the population is close to carrying capacity and reproductive rates are low (due to density dependent limiting factors). Thus, the recruitment of new individuals into the population (and therefore, the number of surplus individuals available for harvest) is maximized at intermediate population levels approximately half of the carrying capacity (see vertical line on graph).

**Recruitment** – the number of fish that are added to the exploitable stock (available for harvest) each year due to either growth or migration of new fish into the area. This rate is variable and highly dependent on ocean conditions, habitat changes, fishing pressure, etc.




Critics of MSY as a management strategy contend that the model has many shortcomings and that attempts to implement MSY have resulted in the collapse of several fisheries.

1. The difficulty of estimating population size - Time-consuming and expensive stock surveys must be conducted on a regular basis for all species managed under MSY. Marine fish populations are frequently over-estimated and year to year natural fluctuations in populations must be accounted for.
2. The model assumes exponential growth, which may be an invalid assumption
3. The model is a single-species approach and does not take into account community and ecosystem effects
4. Societal pressure to overestimate stock size and underestimate fishing effort is significant


See notes slide 6

Notes slide 6

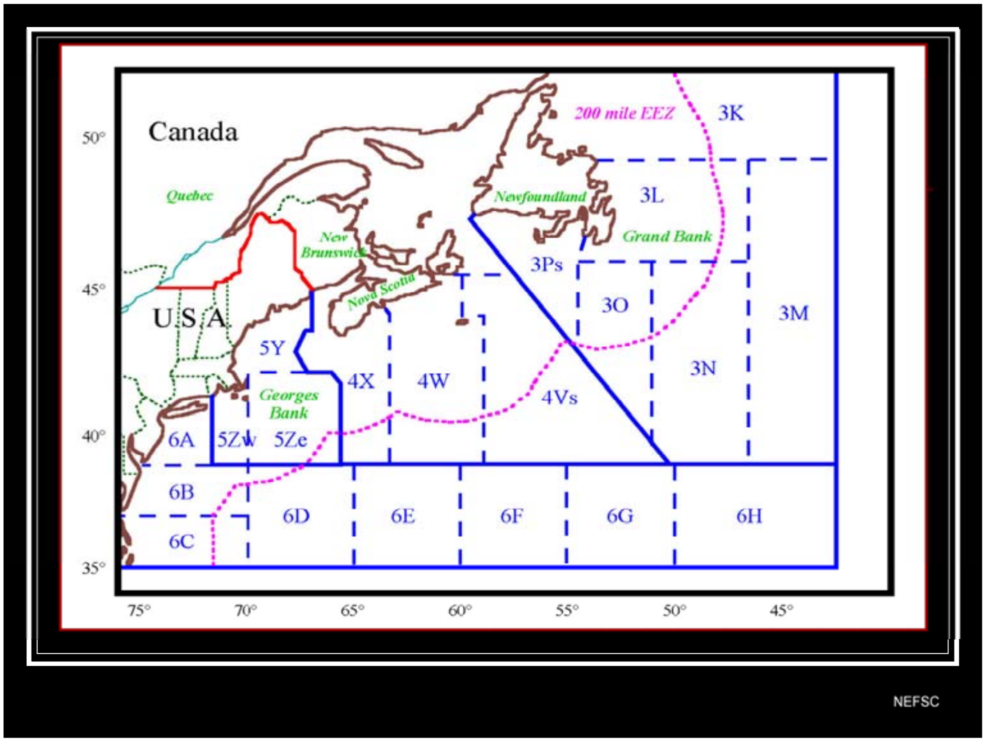
Several pieces of legislation influence fisheries. The most important is the Magnuson-Stevenson Fishery Conservation and Management Act (1976), which guides U.S. fishery management policy in waters from three miles to 200 miles offshore. Waters from the coastline to 3 miles are generally managed by each state. The Act established a 200-mile wide Exclusive Economic Zone (EEZ) along the U.S. coast in which the U.S. has economic jurisdiction. In addition to the "200-mile limit," the Act established eight Regional Fishery Management Councils that monitor fish stocks and establish quotas to prevent overfishing.

In 1996 the Act was reauthorized and substantially modified with the signing of the Sustainable Fisheries Act (SFA). The SFA required the National Marine Fisheries Service to develop a plan for ending overfishing and to begin re-building U.S. fishery stocks by September 1998. The Magnuson-Stevenson Fishery Conservation and Management Act was most recently reauthorized in January of 2007. It strengthened protection against further depletion of dwindling fish stocks by providing market incentives to replenish fish stocks and enforcing existing fishing laws. Implementation of the Act is intended to end overfishing in the United States by 2011. The 2009 Obama Administration budget proposal includes funding for full implementation of the Act.

Other pieces of legislation can impact certain fisheries. The National Environmental Policy Act declares a national policy to promote a harmonious relationship between man and the environment and to support efforts to better understand and prevent damage to ecosystems and natural resources important to the nation. For fisheries, NEPA requires an assessment of both the biological and socioeconomic consequences of fisheries management decisions made by the federal government.

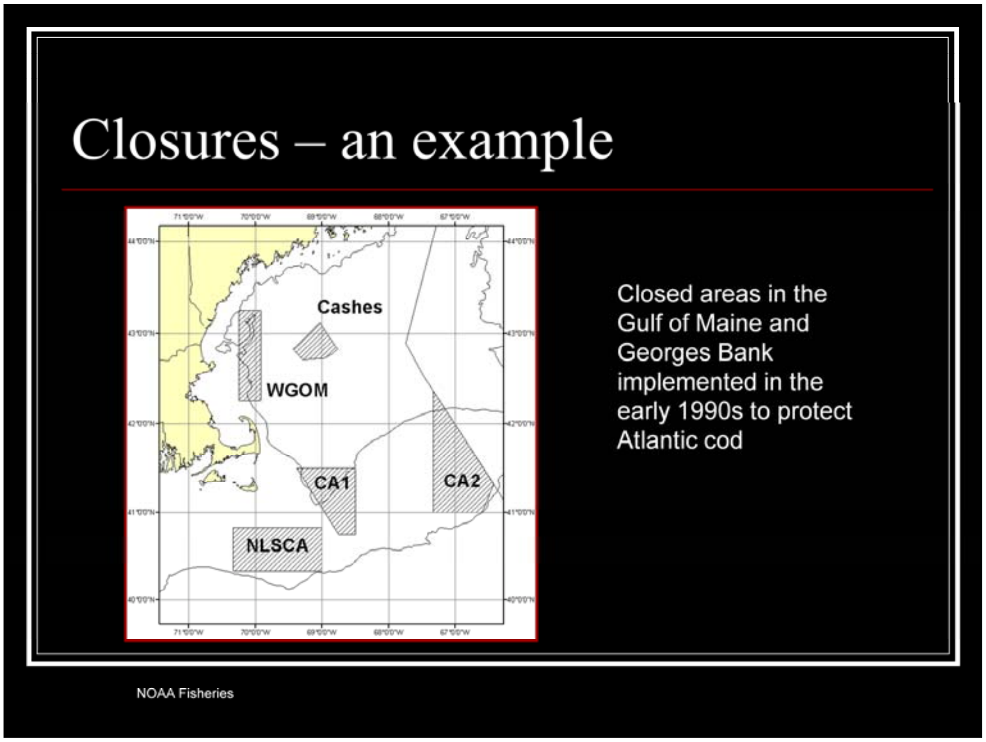
Endangered Species Act (ESA 1973)- provides broad protection for fish and wildlife species that are listed as threatened or endangered. Provisions are made for the formal listing of species, development of recovery plans and the designation of critical habitats. The ESA has had a large impact on the management of salmon fisheries.

The Marine Mammal Protection Act - establishes the conservation of marine mammals (whales, dolphins, seals, sea otter and polar bear) as a federal responsibility. The MMPA is most likely to invoked when marine mammals are unintentionally caught in fishing gear as bycatch or when overfishing depletes their food resources (e.g. Steller sea lion).




This figure illustrates the limits of the Exclusive Economic Zone ("200-mile limit") established by Magnuson Act of 1976 (see pink line on map) for the Northeast Region of the U.S. The establishment of an exclusive economic zone limits entry by foreign fishing vessels. Other zones marked by blue lines delineate various fishery management zones managed by NOAA Fisheries.


The Exclusive Economic Zone (EEZ) of the U.S. is the largest in the world and equal to 1.7X the land mass of the U.S. and its territories.




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

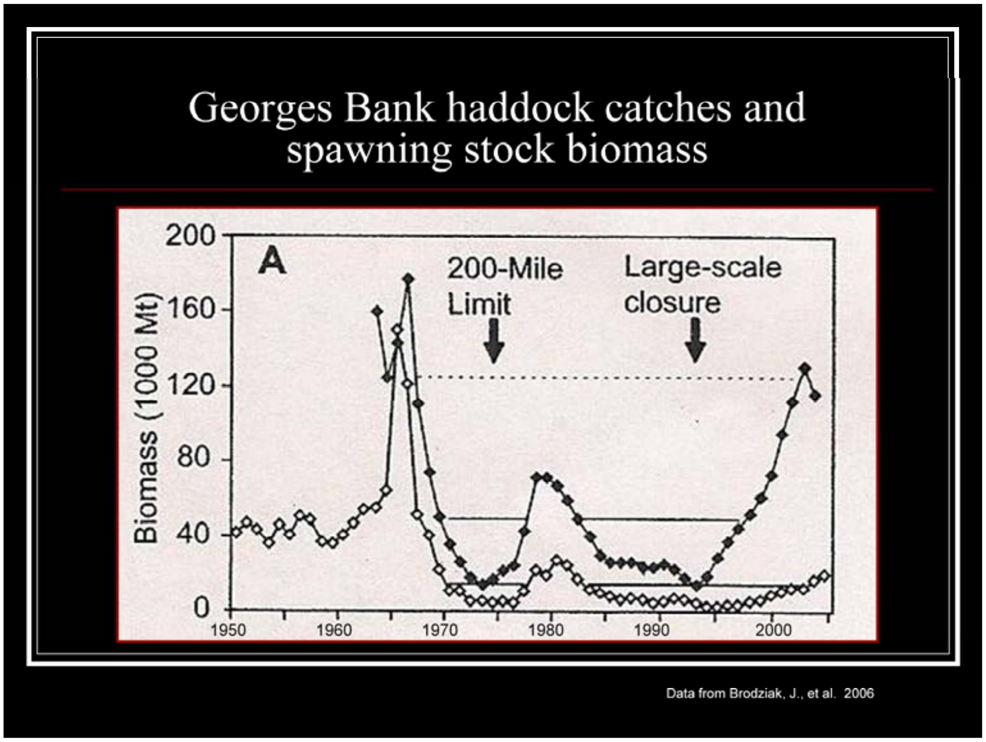
The names assigned to each of the closed areas are not particularly relevant, but just in case someone asks:

WGOM – Western Gulf of Maine

Cashes – refers to “Cashes Ledge,” a traditional cod fishing site

CA1/CA2 – Conservation Areas 1 and 2

NLSCA – Nantucket Lightship Conservation Area

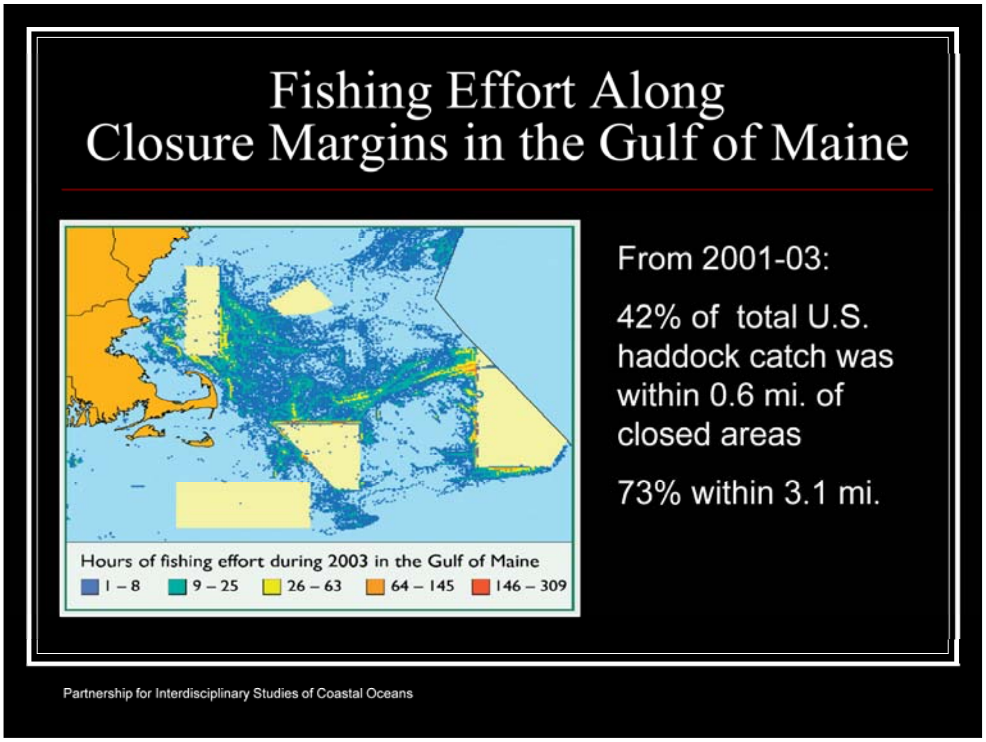



Georges Bank haddock (*Melanogrammus aeglefinus*) catches from 1950 to 2000 are illustrated in graph (white diamonds = catches, black diamonds = spawning stock biomass). The trends seen here suggest that closures <u>can</u> have a major impact on population size and may play an important role in recovery of some stocks. The Georges Bank haddock stock collapsed from 1970-1977 presumably due to overfishing. Implementation of the 200-mile limit in 1977 excluded foreign fishing vessels from Georges Bank and reduced fishing effort on the species, which responded by rebounding in 1978-1982. Increased fishing effort by domestic vessels resulted in a second collapse throughout the 1980s. The large-scale closures described on the previous slide for Atlantic cod has allowed haddock to increase in numbers.

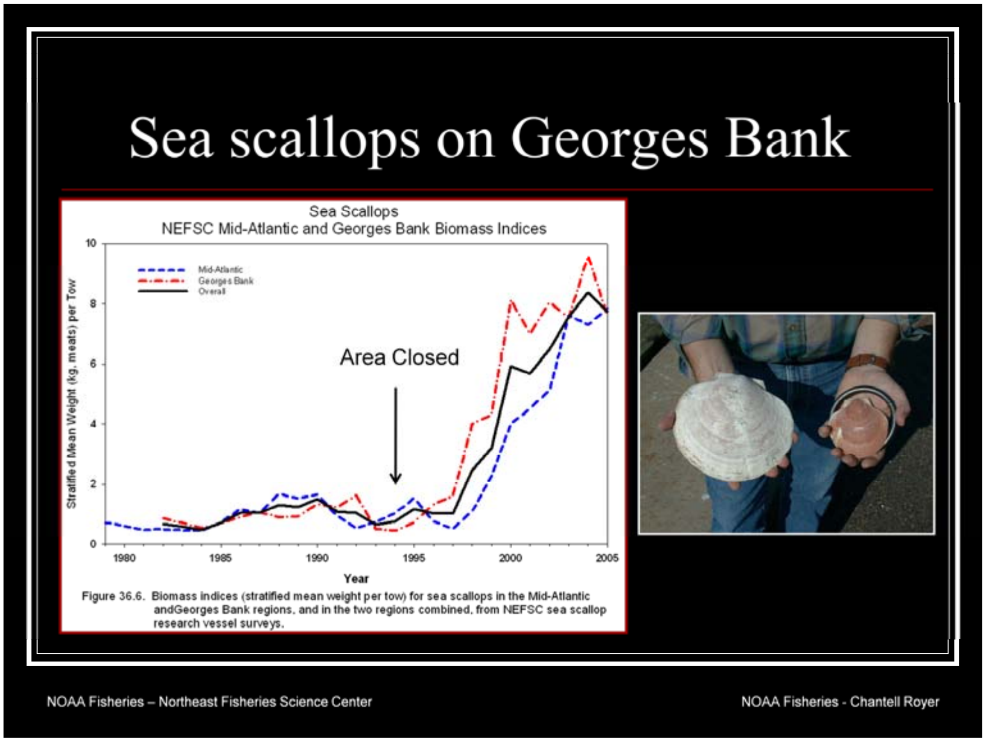
Horizontal lines on the graph represent benchmarks for various levels of decline – the dotted line indicates “overfished” as defined by the National Marine Fisheries Service, the top dark line represents a 90% decline in biomass and the lower line represents a 90% decline in catches.

Stock assessment data from:

Brodziak, J., et al. 2006. Stock assessment of Georges Bank haddock, 1931-2004. Northeast Fisheries Center Reference Document 06-11, NOAA/NMFS Northeast Fisheries Center, Woods Hole, MA.




Note that with these closures in place, fishermen expend a disproportionate amount of fishing effort on the margins of these closed areas. Catch amounts along the closure margins for haddock and yellowtail flounder are higher than other areas. From 2001 to 2003, 42% of total U.S. haddock catch was taken within 0.6 miles of these closed areas and 73% within 3.1 miles. This higher fishing effort along the margins is apparently due to "spillover" from the closed areas.

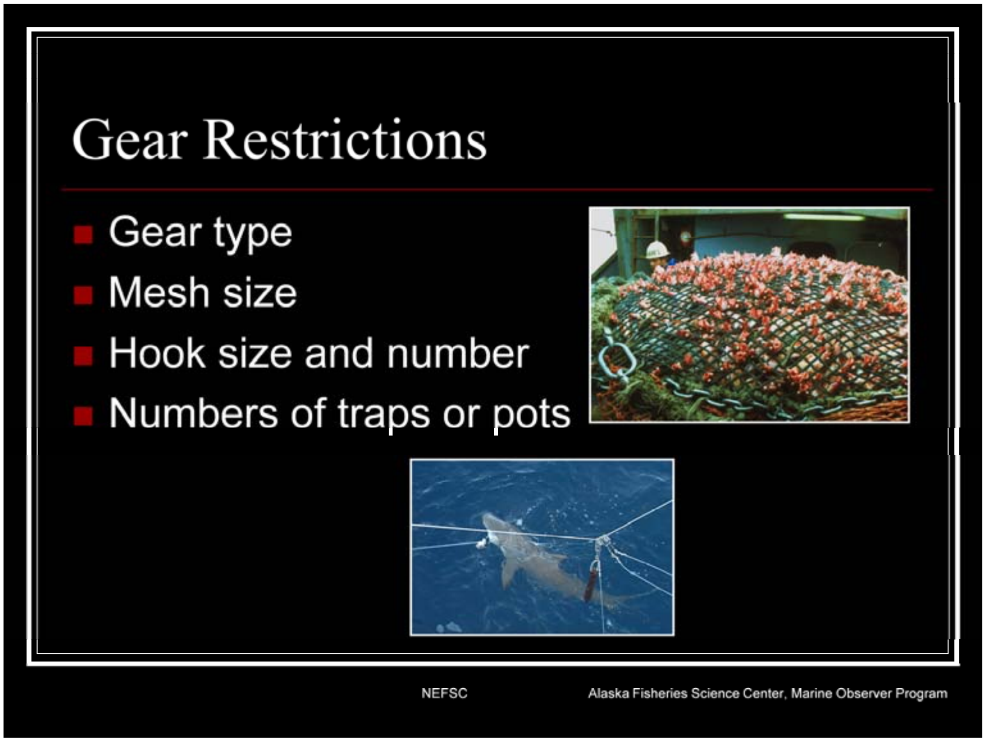



Sea scallops also increased dramatically inside the closed areas just a few years after the emergency cod closure. Between 1994 and 2002 sea scallop biomass on Georges bank increased more than 20 fold. In 2003, scallop biomass inside the closures was 25 times the biomass before the closures. Compared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

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

For reasons discussed later, Atlantic cod has not experienced the same type of recovery as sea scallops and haddock.

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




Fishery managers commonly regulate fisheries by placing restrictions on the type of gear that is allowed to be used for a particular fishery. These restrictions are generally designed to increase escapement (the escape of some portion of the fish population or non-target species).

Some examples:

- Only certain gear types may be allowed in some areas
- There may be a minimum mesh size on gill nets or trawls to allow the escape of smaller fish
- On longline gear there may be limits on the size and number of hooks that are allowed
- Crab and lobster fisheries often limit the number of traps or pots allowed per vessel


Traditional fisheries management – review of main points.


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


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

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

MSC certification is based on three main criteria:

• Status of the target fish stock

• Impact of the fishery on the ecosystem

• Performance and effectiveness of the fishery management system


See notes slide 17

Notes slide 17

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

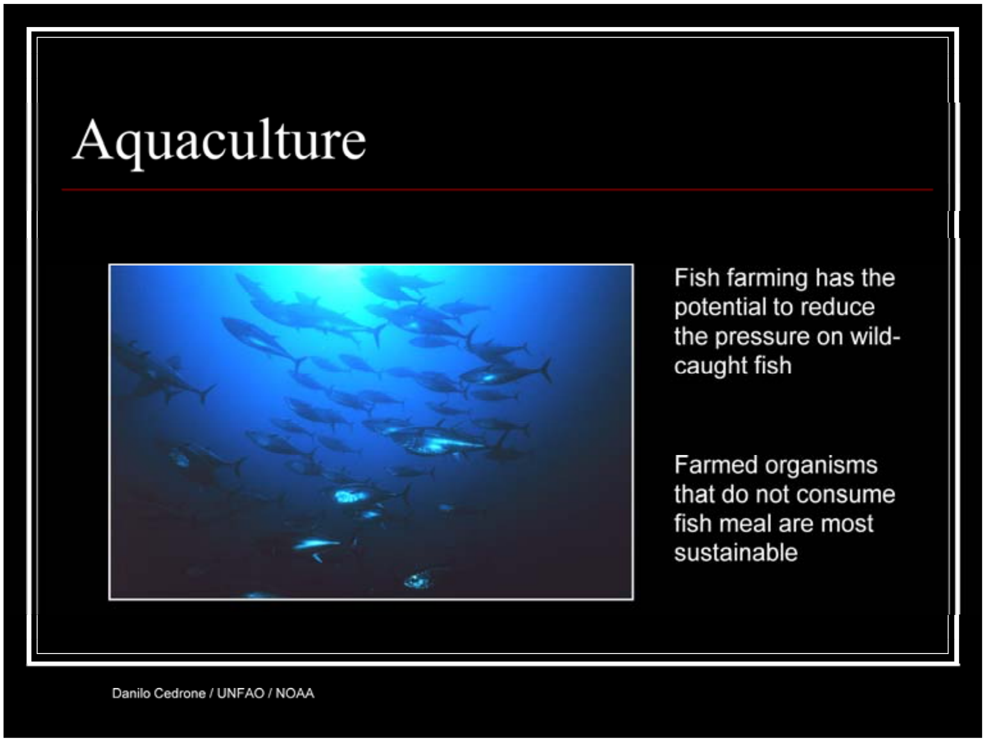
The seafood guide produced by the Monterey Bay Aquarium, for example, assigns farmed shellfish and Alaska salmon to its “best choices” category, while Chilean sea bass and Atlantic cod are assigned to the “avoid” category. In general, consumers make more sustainable choices when they choose seafood that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

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

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

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

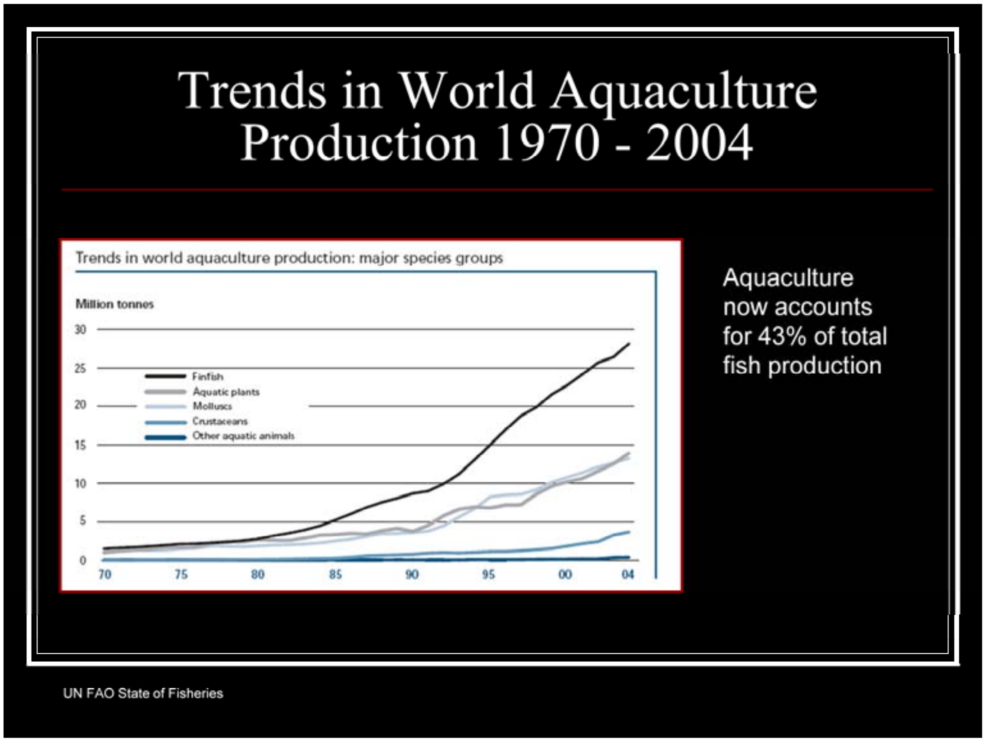

A decrease of 30-50% in fishing effort may be required to attain sustainable harvests. This reduction in fishing effort could be obtained by reducing the number of permits available and thus, the number of fishing vessels allowed to fish. NOAA Fisheries issues fishing permits but, in an effort to reduce the amount of pressure on fish stocks, does not issue any new permits. Further reduction in fishing effort could be obtained by having governments "buy out" willing fishermen who want to get out of the fishery by purchasing permits or fishing vessels. In 2002, for example, Congress approved $46 million to buy fishing vessels from willing sellers in an effort to protect declining West Coast rockfish (*Sebastes* spp.) populations . By 2003, the program had reduced the size of the fishing fleet by half from 300 to 147 vessels. In July of 2006, the first private buyout of commercial fishing permits occurred when the Nature Conservancy (an environmental organization) purchased six federal trawling permits from fishermen in Morro Bay on the California Coast. Fishermen usually obtain permits by purchasing them from other fishermen.




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

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

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



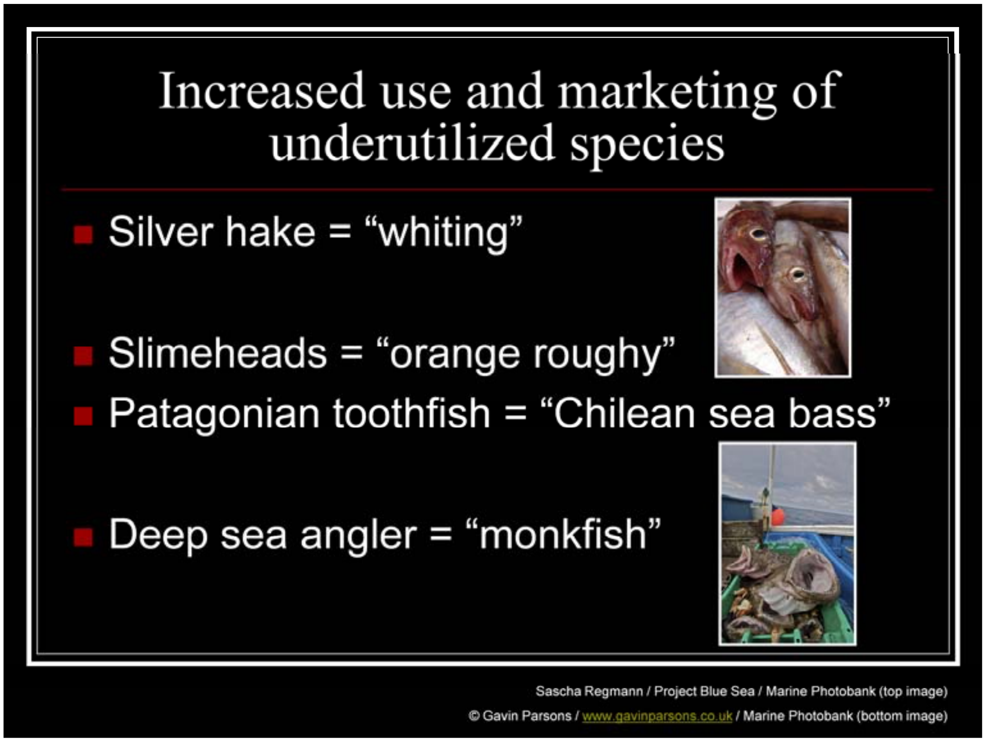

Increases in total fish production for the past decade have been largely due to increases in aquaculture ("fish farming") production rather than increases in the harvest of wild-caught fish. Since 1970, global aquaculture production has increased at an annual rate of nearly 9%. Aquaculture contributed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

## Top ten species groups in global aquaculture production - 2004

| | Production (millions of metric tons) |
|---|---|
| Carp and relatives | 18.3 |
| Oysters | 4.6 |
| Clams, cockles, etc. | 4.1 |
| Misc. freshwater fish | 3.7 |
| Shrimp and prawns | 2.5 |
| Salmon, trout and smelt | 2.0 |
| Mussels | 1.9 |
| Tilapia and relatives | 1.8 |
| Scallops | 1.2 |
| Misc. marine molluscs | 1.1 |

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

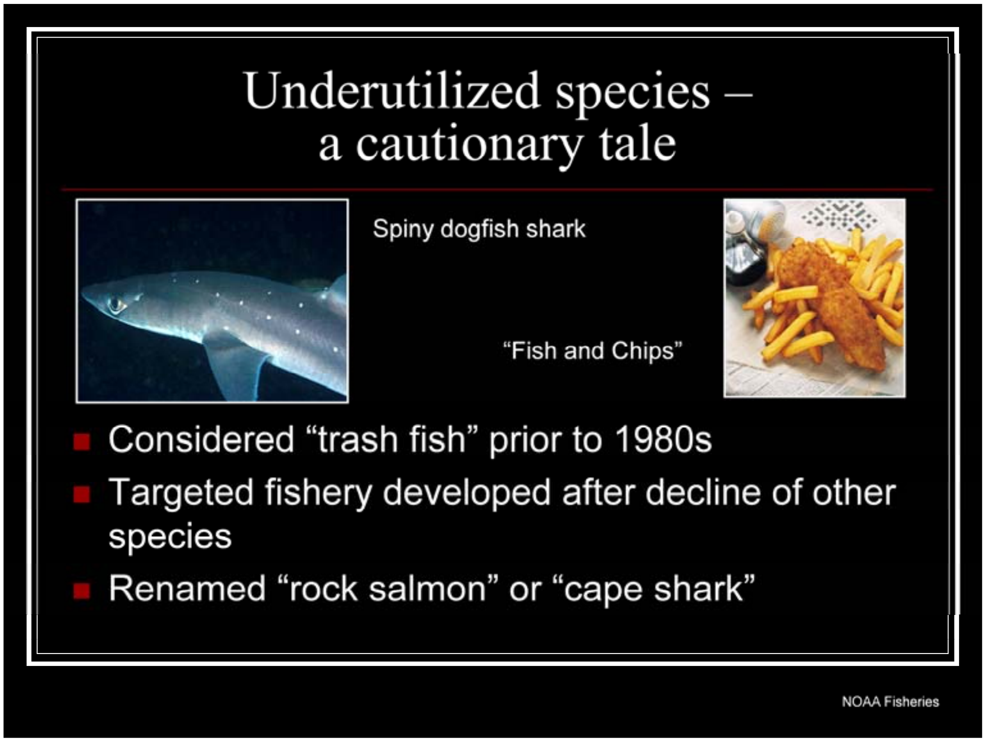
In some cases, aquaculture has been used to provide a new source for fish species that have declined due to overfishing or habitat alteration. All Atlantic Salmon in the U.S. marketplace for example, are now produced in aquaculture facilities and, more recently, farm-raised Atlantic Cod have been produced in Scandanavia and Canada. Modern marine aquaculture (mariculture) is still in its infancy and there is much that still needs to be learned.



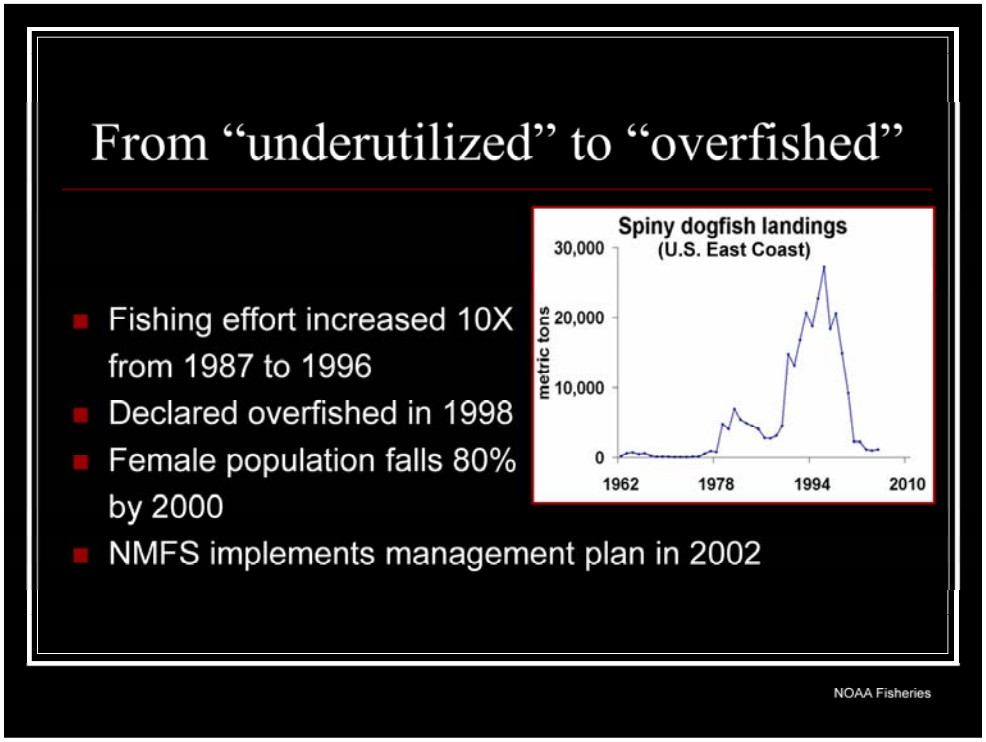

In an effort to reduce bycatch and pressure on those fish we currently target, it has been suggested that markets could be developed for underutilized (and often discarded) species. One strategy, implemented since the 1970s has been to encourage use of underutilized species by assigning them market names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

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

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

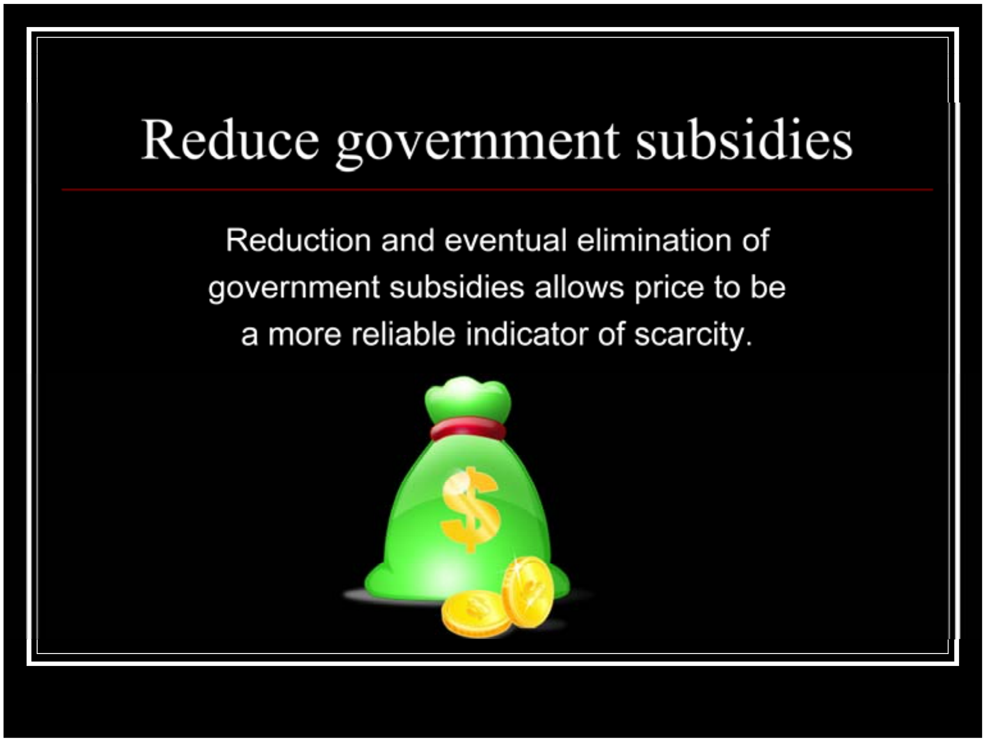



Spiny dogfish, an abundant small shark with little market value, was considered to be a “trash” fish in the North Atlantic. In the 1980s, with declines of cod, haddock and yellowtail flounder, fishermen were encouraged by fisheries managers to direct their fishing efforts to this species. After being renamed “rock salmon” or “cape shark”, most spiny dogfish were exported to Great Britain where they became the preferred species for “fish and chips” because traditional species – cod and haddock – had been overfished and thus were not available.




From 1987 to 1996, commercial fishing for spiny dogfish increased 10 fold and by 2000 the female population had fallen by 80%. The National Marine Fisheries Service finally implemented a fishery management plan for the species in 2002 establishing a reduced fishing quota in an effort to rebuild the overfished stock. The graph illustrates the "rise and fall" of the spiny dogfish fishery based on U.S. East Coast landings.

The case of the spiny dogfish illustrates the need for rapid adoption of management plans for "underutilized fisheries" as they become "emerging fisheries." It also illustrates the importance of considering the life history characteristics of harvested species. Spiny dogfish, like most sharks, exhibit relatively slow growth and reproductive capacity. Females reach sexual maturity at 12 years and their gestation period is about two years with 1-20 "pups" produced per litter.




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


Summary of market-based solutions – a variety of approaches that use the power of the market to achieve sustainable fisheries.


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

An approach that attempts to apply ecosystem management to fisheries management includes these elements.

Reduce bycatch

Marine reserves

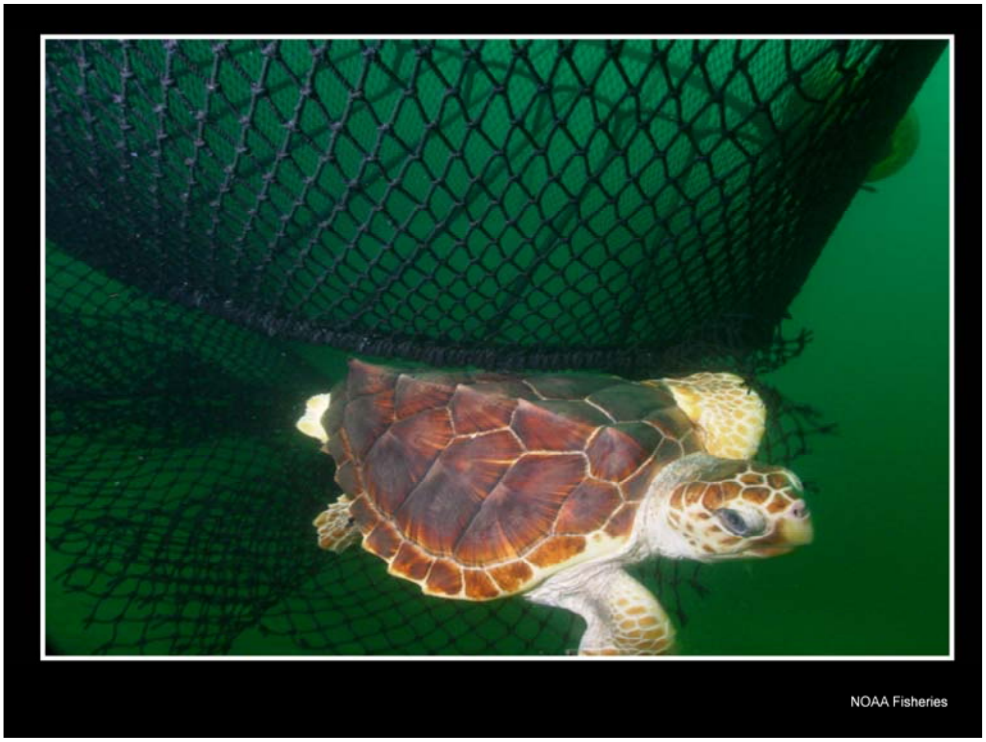
Monitoring of population characteristics

Individual fishing quotas

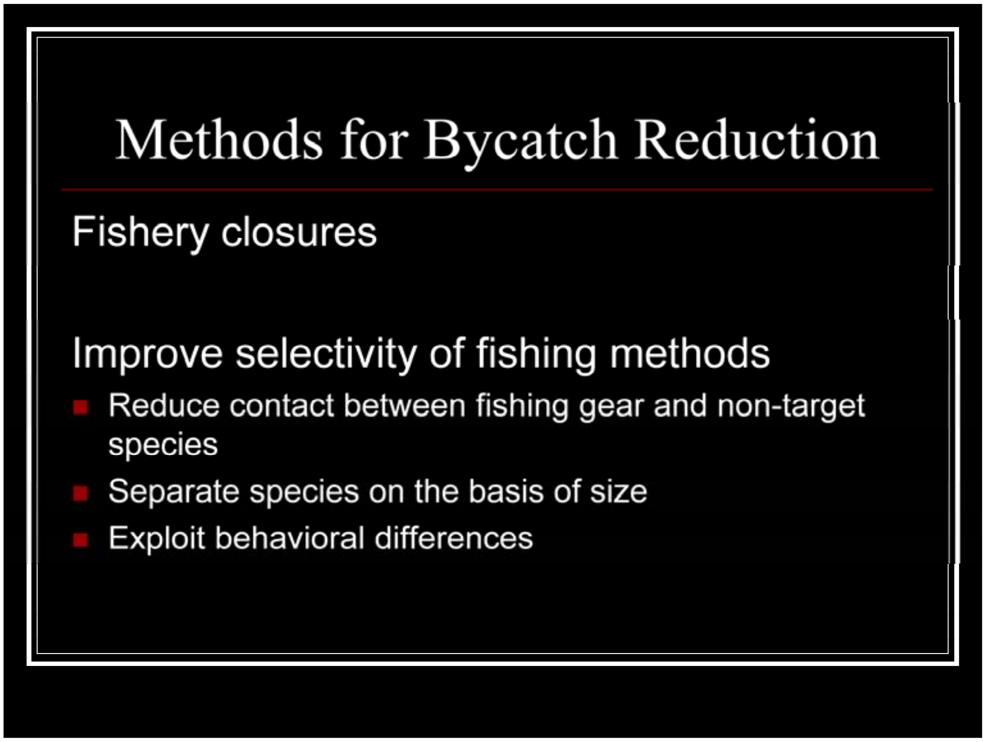
Ecologically sustainable yield


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

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




Loggerhead turtle escaping from a net equipped with a TED.




See notes slide 30

Notes slide 30

Efforts to reduce bycatch are highly fishery-specific. There are two primary approaches:

A. Close a fishery

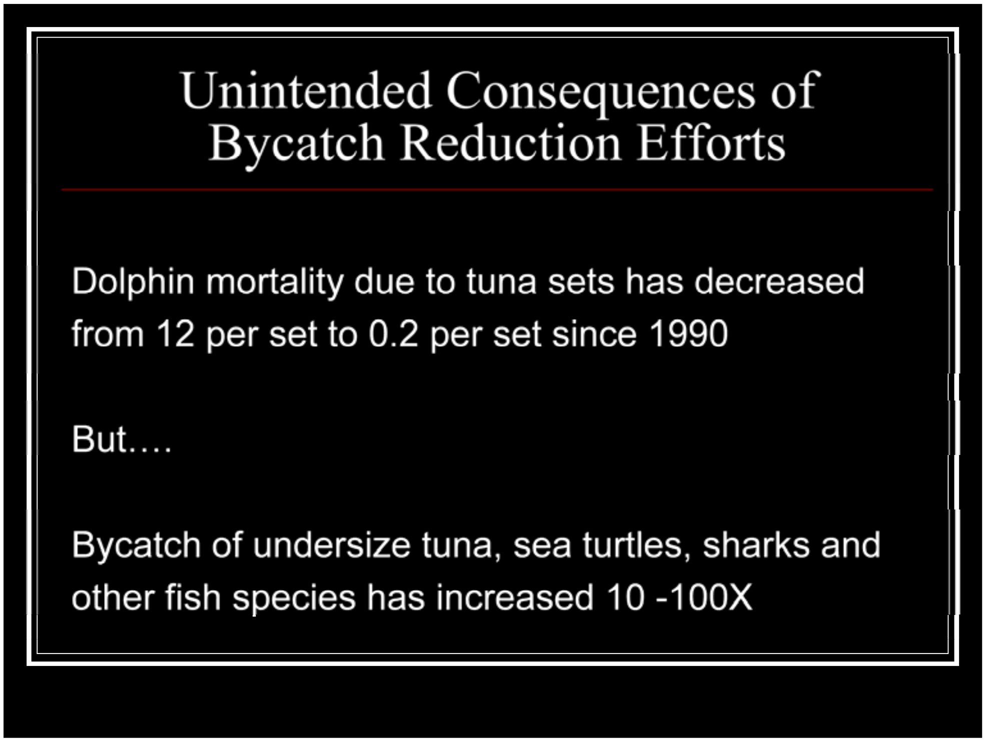
- mandated most often when charismatic species (e.g., sea turtles or dolphins) are collateral damage
- temporary closures may be sufficient to avoid contact with non-target species

B. Improve selectivity of fishing methods

- Reduce contact between fishing gear and non-target species
  Examples:
  - Seabird mortality in longline fisheries - setting hooks at night when birds are not active, using heavier lines so hooks sink faster, using streamers on gear to scare birds away, dying the bait blue to make it less visible in water and using underwater chutes to set lines below water
  - An improved technique of setting nets over dolphins to catch Pacific yellowfin tuna has reduced the number of dolphins caught in tuna nets from 400,000 per year prior to 1990 to 4,000 in 1993.
  - Improvements in net and hook design
  - The use of "pingers" (acoustic alarms) on nets to repel marine mammals
  - Newly designed scallop dredge that uses hemispheric scoops (rather than a horizontal bar of heavy metal teeth) to dislodge scallops from the sea floor. The scoops direct water downward that stimulate scallops to move up from ocean floor but do not harm other species or habitat particularly corals and other invertebrates. See photo Cliff Goudey of MIT in *Conservation Magazine* Vol. 8 (4) 2007. p. 35
- Bycatch may be further reduced by providing economic incentives to develop more selective gear that harvests only the target species.
- Separating species on the basis of size
  Examples:
  - TEDs and mesh size regulations for trawls, traps, gill nets
- Exploiting behavioral differences among species
  Examples:
  - Use of electric stimuli to raise shrimp from seabed and harvest by trawls that are towed just above the ocean floor. Benthic fish are less responsive and remain on the sea floor avoiding capture.
  - Pink snapper co-occurs with silver trevally (the target species) and although both enter fish traps, snapper will turn sideways inside the traps while trevally do not. Capture of snapper can be minimized by orienting the trap mesh horizontally, allowing more snapper to escape.

Adapted from:

Kennelly, S.J., ed. 2007. By-catch Reduction in the World's Fisheries. Dordrecht (Netherlands). Springer.




See notes slide 31

Notes slide 31

Dolphin caught in tuna nets is one of the best known examples of bycatch. Public outcry over dolphin mortality in the tuna fishery in the 1970s brought about significant changes in the industry, including gear improvements, new fishing techniques and the marketing of "dolphin-safe" tuna. Ironically, data collected by on-board observers of the tuna fleet over the past two decades suggests that bycatch in the Eastern Pacific has increased since dolphin-safe protections became law in 1990. Dolphin mortality has decreased from an average of 12 per set to 0.2 per set. However, there has been a shift in bycatch from dolphins to undersize tuna (10-100 times more), sea turtles, sharks and several other species of fish.

Dolphin mortality due to tuna sets has decreased for 3 reasons:

1. U.S. regulations in response to environmentalists concerns about "dolphin sets" (i.e., dolphin-safe labeling)

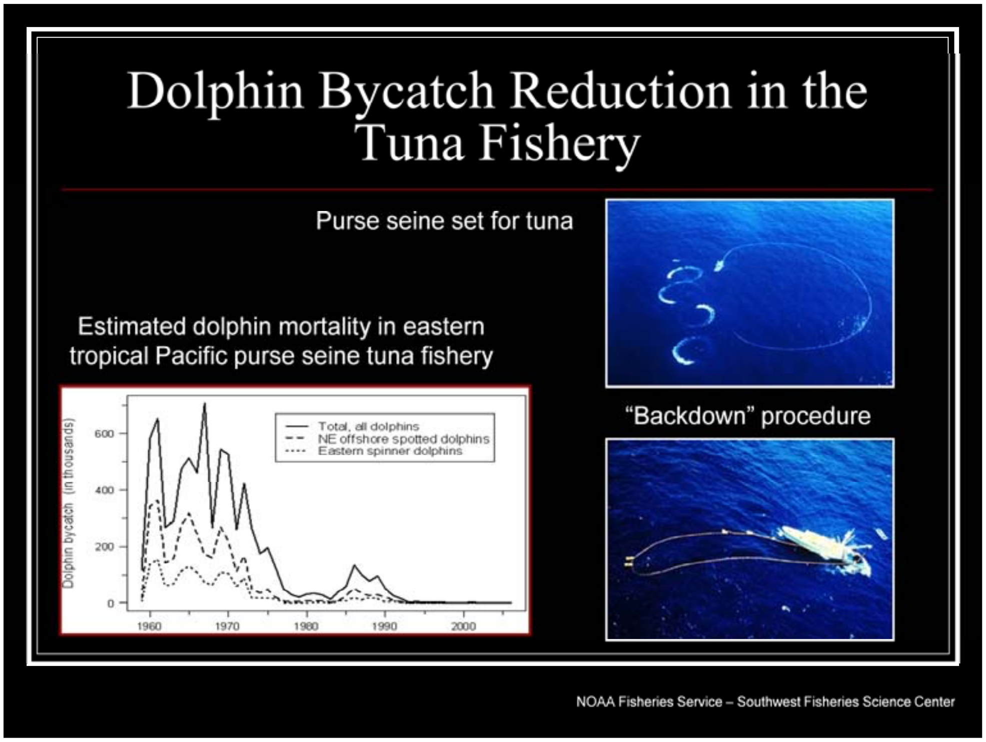
2. Technical innovations and operational modifications made by tuna fishers themselves (e.g., the "backdown technique" in which the vessel moves in reverse causing the top of the net to sink allowing dolphins to escape and the use of Medina panels)

3. International fleet is switching to alternative methods for setting nets – especially "floating object sets" where nets are set under objects that are floating on the ocean surface. This method is highly effective for excluding dolphins and catching skipjack tuna, but other species congregate there also – undersized yellowfin tuna and bigeye tuna, billfish, sharks, sea turtles and other fish, which become bycatch.

So – although dolphin mortality has declined, the ecosystem effect is probably greater than before (see table on page 14 of resource below for data).

We have much to learn about the ecosystem effects of unintentional harvest and discarded bycatch. For many fisheries we don't even know what the bycatch is.

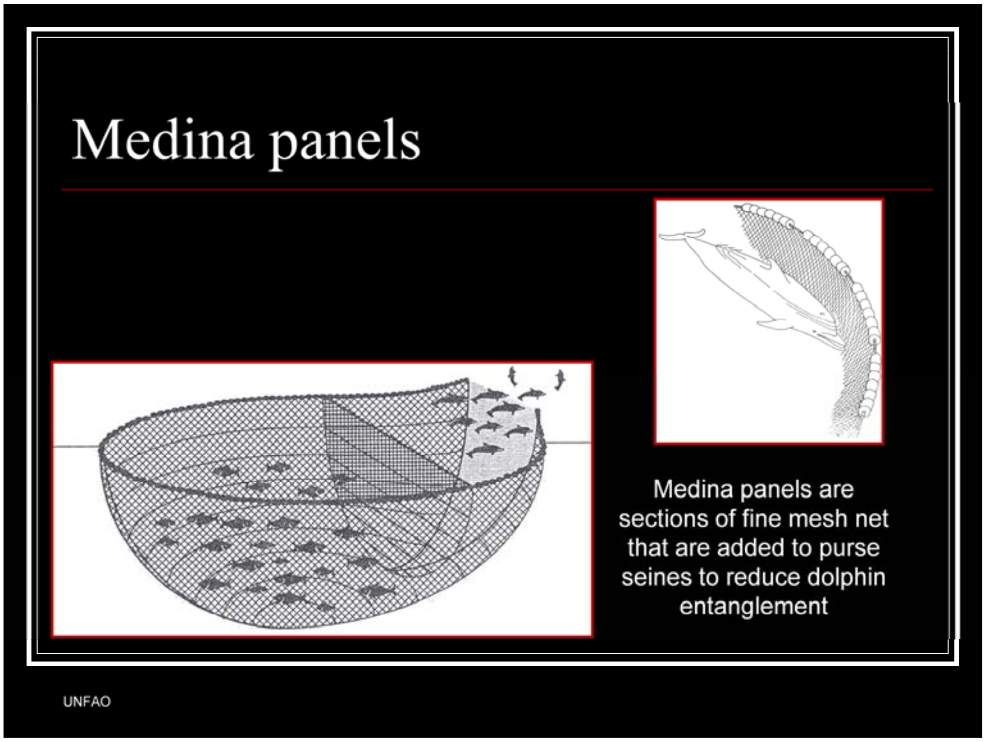
Source: Norris, S., et al. 2002. Thinking like an ocean – ecological lessons from marine bycatch. Conservation in Practice 3:10-19.



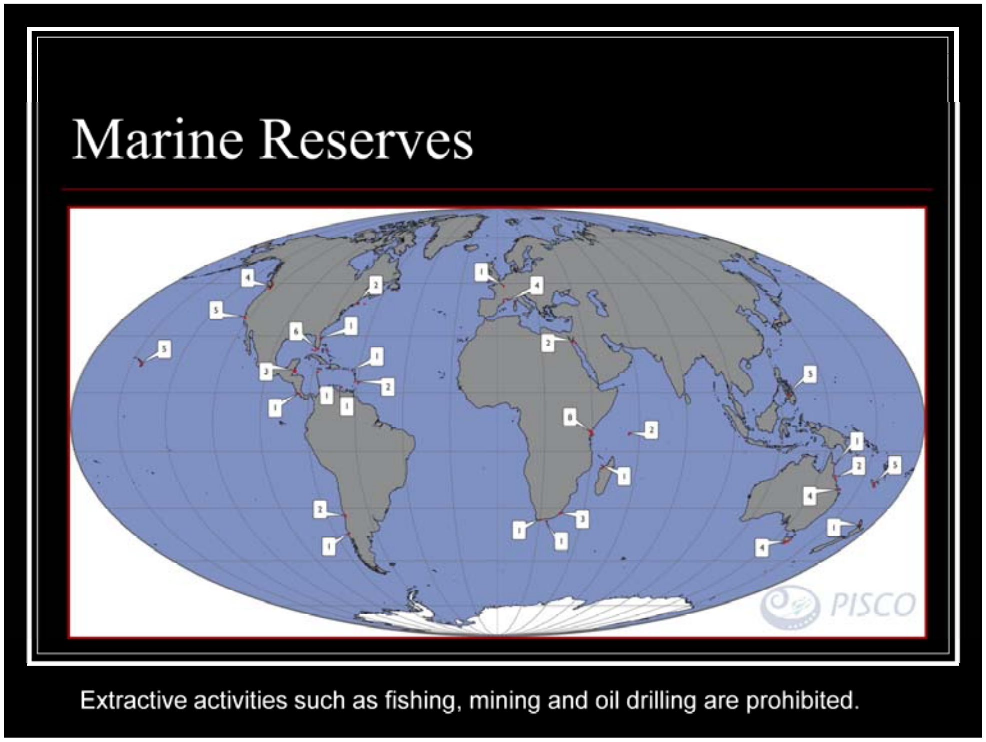

The purse seine in the photo at the upper right is being set on tuna and dolphins. The net is partially closed, and four speedboats are driving in tight circles near the opening to prevent the tuna from escaping.

The photo at the bottom right illustrates the "backdown procedure" for reducing dolphin bycatch. As the tuna vessel moves backwards to the right in this photo, the net is drawn into a long channel. The floating "corkline" at the far end (at left) is pulled under water slightly, and dolphins are able to escape. Speedboats are positioned along the "corkline" to help keep the net open.

The effectiveness of dolphin bycatch reduction efforts is illustrated in the graph. The graph shows annual trends in the estimated number of dolphins killed in the eastern tropical Pacific purse-seine tuna fishery from 1960-2005. The totals for <u>all</u> dolphins and separately for spotted dolphins and spinner dolphins, the two dolphin stocks with the highest number killed, are shown.

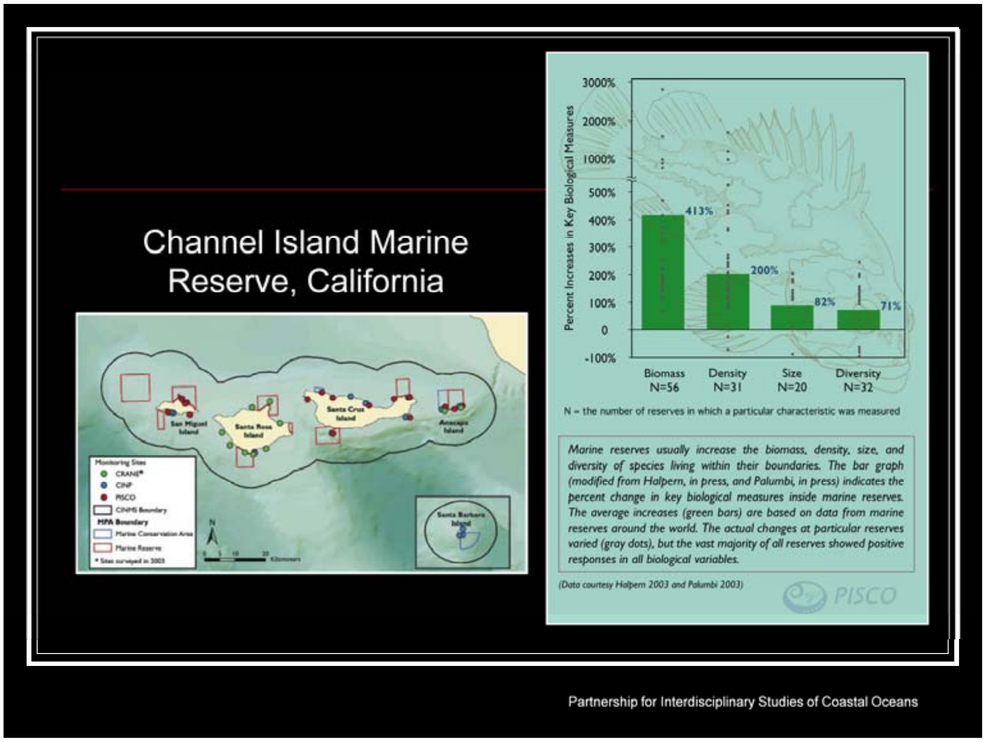



Medina panels, named after the California tuna fisherman who first used them, are sections of fine (1.25”) mesh netting that are sewn into the purse seine (4.5” mesh). They are positioned at the apex of the seine, in that area where dolphins are most likely to become entangled in the net during the backdown procedure. They are designed to reduce dolphin entanglement and thus increase escapement.

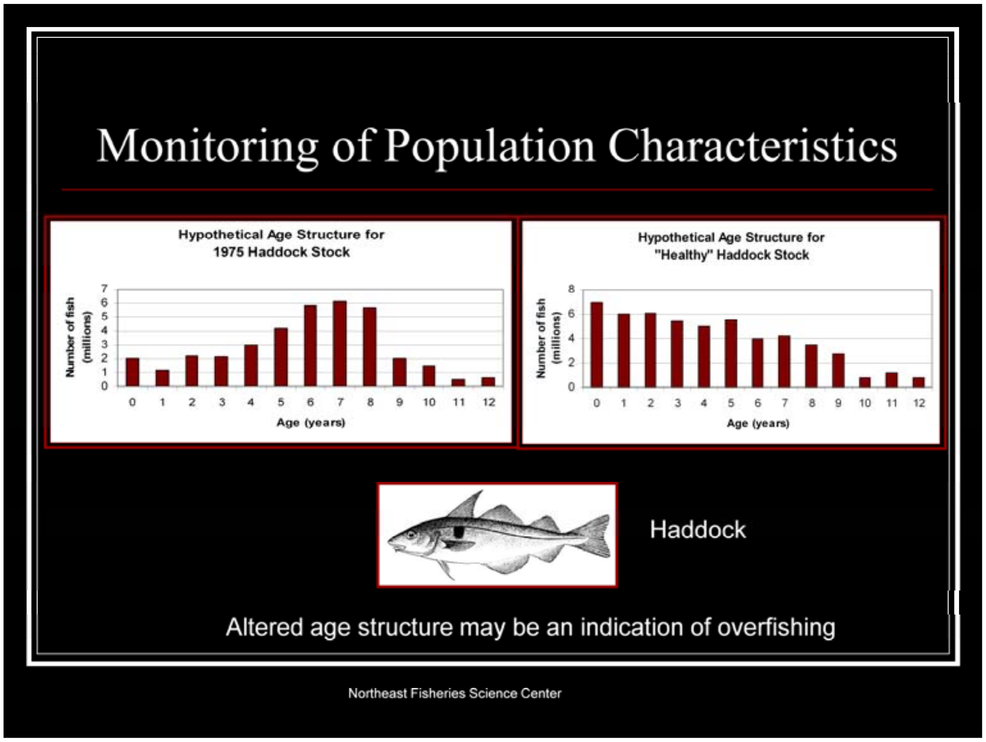



Marine reserves are ocean areas in which extractive activities such as fishing, mining and oil drilling are prohibited. They represent the most restrictive type of "marine protected areas," which may afford a wide variation in degree of protection. Map shows locations of some existing reserves. The numbers within each of the boxes indicate the number of reserves that have been established at that location.

Currently, less than 1% of territorial waters in the United States are in marine reserves including reserves off the coasts of WA, CA and FL.

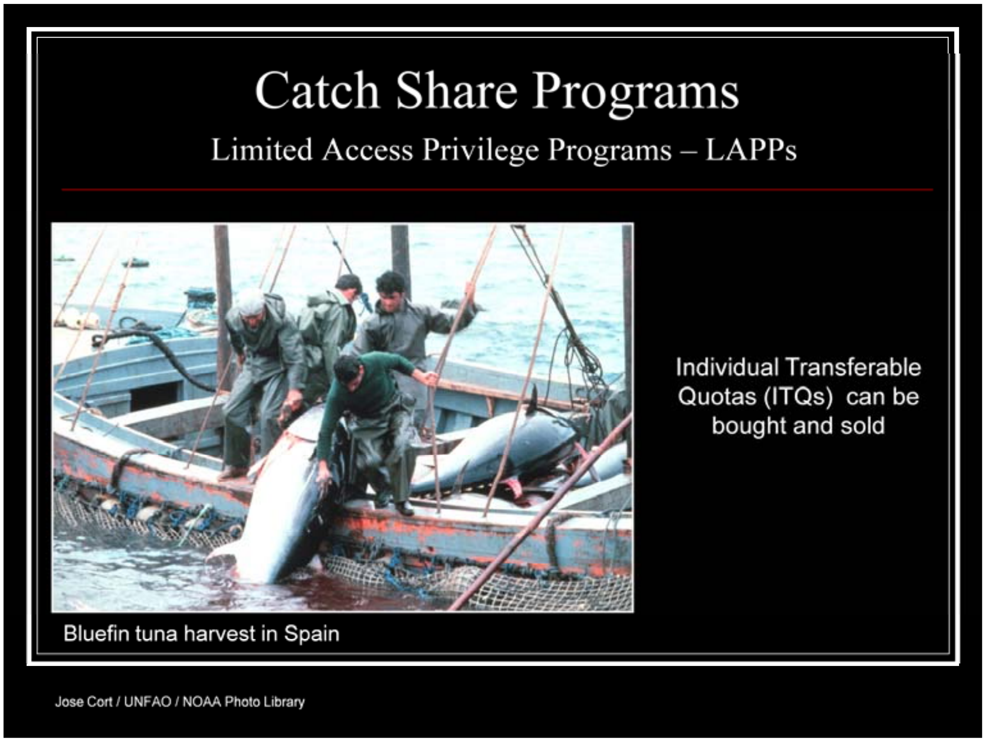



Channel Island Marine Reserve off the California coast as an example of a marine reserve. Marine reserves have been shown to increase the biomass, density, size and biodiversity when compared to non-reserve areas. For more detail on marine reserves, see NCSR's *The Role of Marine Reserves in Ecosystem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




The alteration of age structure can be used as an indicator of overfishing. In the most common scenario, the abundance of individuals in older age classes declines as these fish are targeted by a particular fishery. However, other atypical age distributions in a fish population can indicate a population in trouble and changes in harvest practices may be warranted.

In the late 1970s for example, a limited fishery for haddock (shown here) off the New England coast was allowed after it appeared that the species had begun a recovery after years of decline. Examination of the age distribution of harvested fish, however, indicated that the vast majority were large, mature adults that for reasons not completely understood, were not reproducing (see graph at left). Young individuals, which typically would make up a large portion of the population (see graph at right) were nearly absent. Fisheries regulators quickly shut down the fishery fearing that the loss of additional breeding stock would further compromise any recovery of the stock. A few years later, the population showed signs of recovery and since 2004, haddock stock size has increased dramatically. The species is no longer categorized as “overfished” by NOAA Fisheries. Thus, monitoring of the age distribution in fish populations can be a useful management tool.

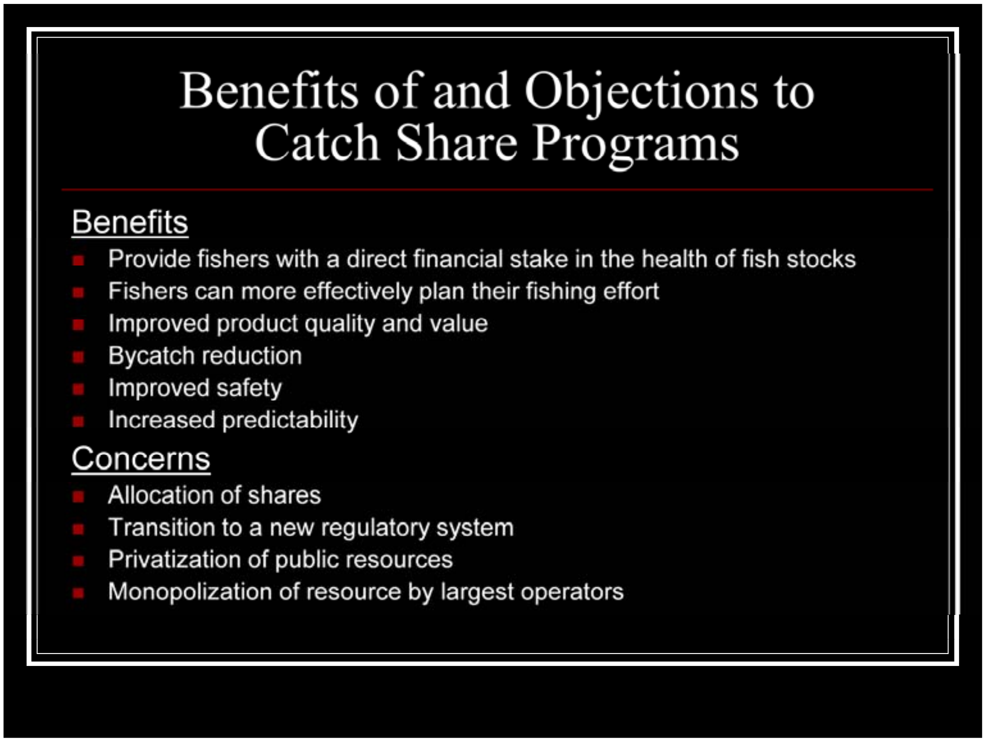



Some fisheries managers have suggested allocating portions of TACs with catch share programs (sometimes known as, Limited Access Privilege Programs – LAPPs). This type of system gives fishers a guaranteed portion of the catch and it is up to each individual to determine how and when that amount is harvested. Under some catch share programs (e.g., Individual Transferable Quotas or ITQs), allocations can be bought and sold like private property. The assumption is that with fewer time constraints on the harvest, more selective methods would be used resulting in less overall impact and a higher quality product will be brought to market. Also, fishers have an economic incentive to protect the resource to obtain the same or a higher quota in future years.

If fishermen exceed their share of the catch, they have to buy additional quota from willing sellers on the open market, or pay stiff fines if no quota is available.

Increasing fishing pressure on Alaska halibut in the 1980s prompted fishery managers to progressively shorten the season during which fishing was allowed. By the early 1990s, the “window of opportunity” to fish had been reduced to just a few days, creating a fishing derby-like atmosphere in which all vessels would race to fishing grounds regardless of weather to capitalize on the short season. This resulted in a glut of halibut on the market and an increased risk to fishers. ITQs were implemented in the Alaska halibut fishery in the 1990s bringing derby fishing to an end. A pound limit is now established for each licensed boat. In part, as a result of this management change, Pacific halibut is now assigned as a “best choice for consumers” by those organizations promoting sustainable fisheries.


This is a list of U.S. fisheries currently (2009) being managed under a catch share program. The most likely fisheries for future programs are also listed.



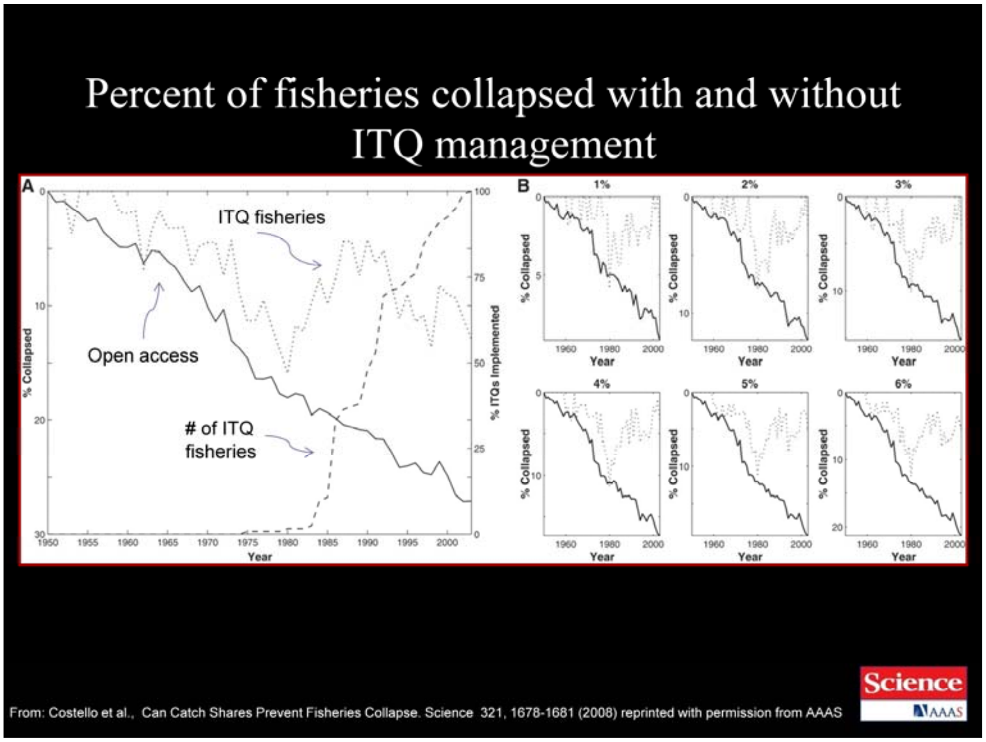

Benefits

Catch share programs provide fishers with a direct financial stake in the health of fish stocks and therefore, an incentive for conserving resources.  As the fish population increases, the shares increase in value as well.  Theoretically, fishers will select less damaging, more selective gear, thus reducing the environmental impact of fishing. Under a catch share program, the mindset of the fisher changes from one similar to a “renter” to a “homeowner.”

Fishers can more effectively plan their fishing effort, thus increasing market value of the fish (they can land fish when markets are optimal), avoiding bycatch (improving efficiency and selectivity of gear) and staying ashore when conditions are unsafe (eliminates “derby fishing”). Cost share programs should provide more secure jobs as the supply and value of the product becomes more predictable.

Concerns

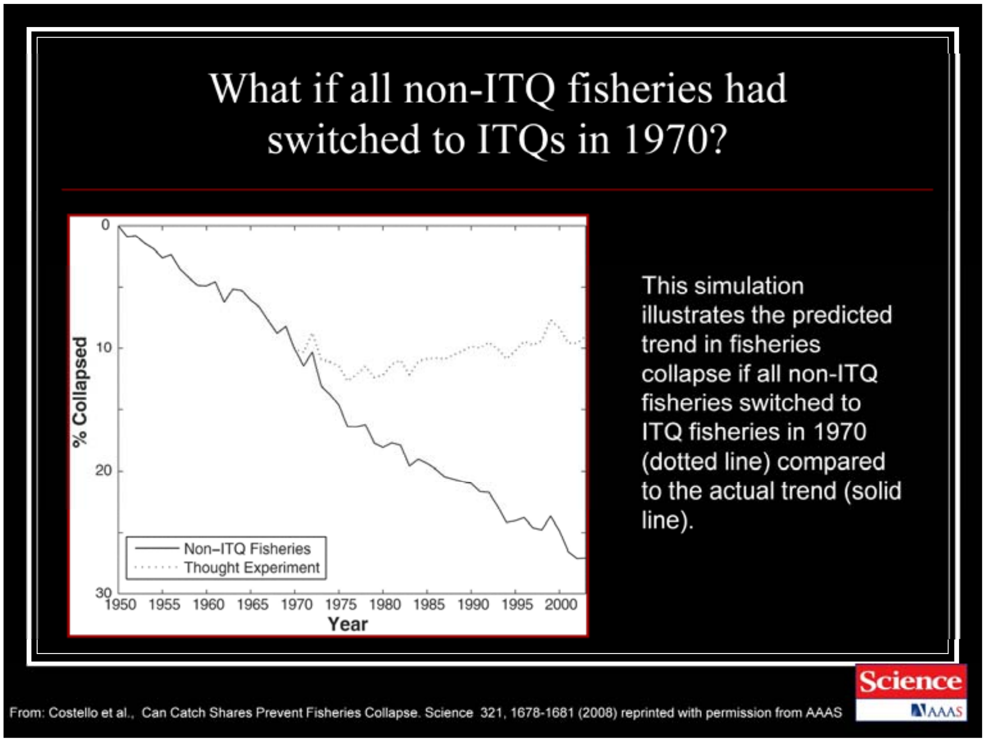
Rather predictably, there are a number of concerns and objections to cost share programs.  For example, some in the industry are heavily invested in the *status quo* and have concerns about how shares are allocated and the transition to an entirely different regulatory system.  Some object because they see cost share systems as privatization of public resources.  Catch share programs require vigilant monitoring of fishery stocks and some are concerned that scientific data to evaluate stocks are not yet available. Another concern with this system is that if individual quotas can be bought and sold, the largest and wealthiest operators within the fishery may accumulate the lion’s share of the quotas, eliminating smaller operators.




Can catch share programs prevent fisheries collapses? A 2008 study by resource economists from the University of California, Santa Barbara examined the impact of catch share programs on more than 11,000 fisheries over a 50-year time period. Researchers found that the implementation of catch share programs halted and even reversed the global trend towards fishery collapses.

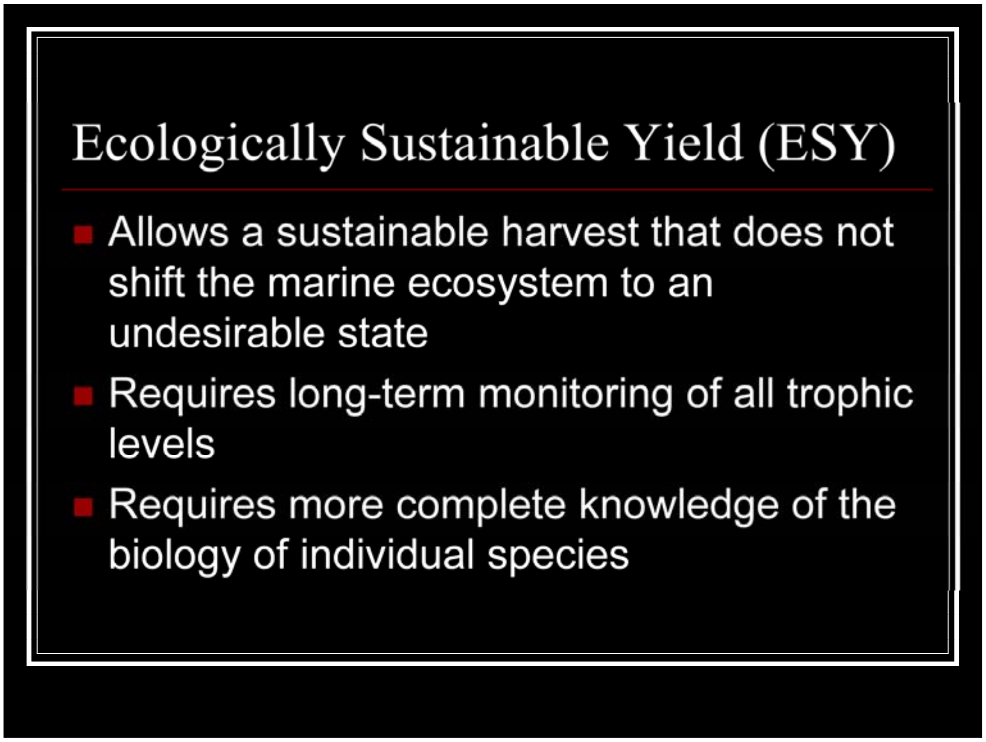
For the graph ("A") at the left, "collapse" is defined as a decline to 10% of the historical maximum catch. Note that while nearly 30% of open access (non-ITQ) fisheries (solid line) had collapsed by 2003, less than half of that amount of ITQ (catch share) fisheries (dotted line) had collapsed. Adoption of ITQ programs accelerated in the late 1970s (see dashed line and right axis). Since most ITQ fisheries have only been implemented for a relatively short time, it is expected that the divergence of ITQ and non-ITQ collapse rates will increase.

Smaller graphs at right ("B") illustrate the same relationship for more conservative measures of "collapse" from 1% to 6% of historical maximum catch. Note that the relationship between open access and ITQ fisheries remains roughly the same. This suggests that the relationship is not sensitive to the definition that is chosen for a "collapsed fishery."



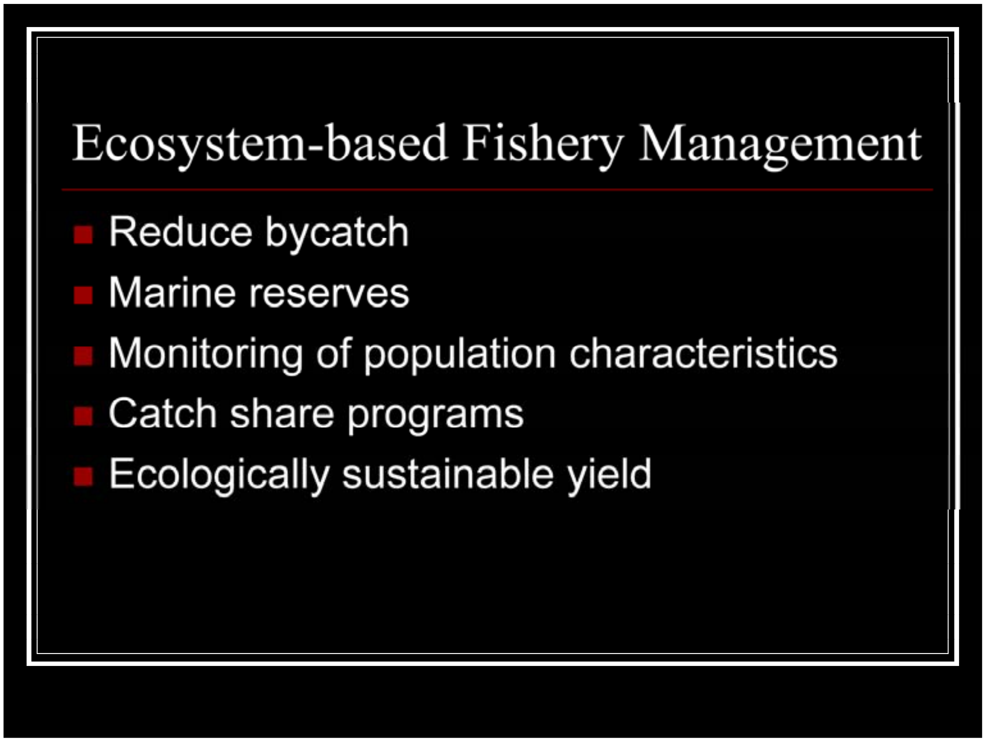

Although the rate of catch share adoption and implementation has increased since 1970, only a relatively small fraction of global fisheries are managed this way. The authors conducted the simulation above, which asks, "What if all fisheries switched to ITQs in 1970?" Note that based on this simulation, the percent collapsed fisheries is reduced to 9% by 2003.

Despite their apparent effectiveness in reducing fishery collapses, most fisheries biologists and managers see catch share programs as one of several tools that can be used in conjunction with one another to achieve sustainable fisheries and to conserve marine biodiversity.

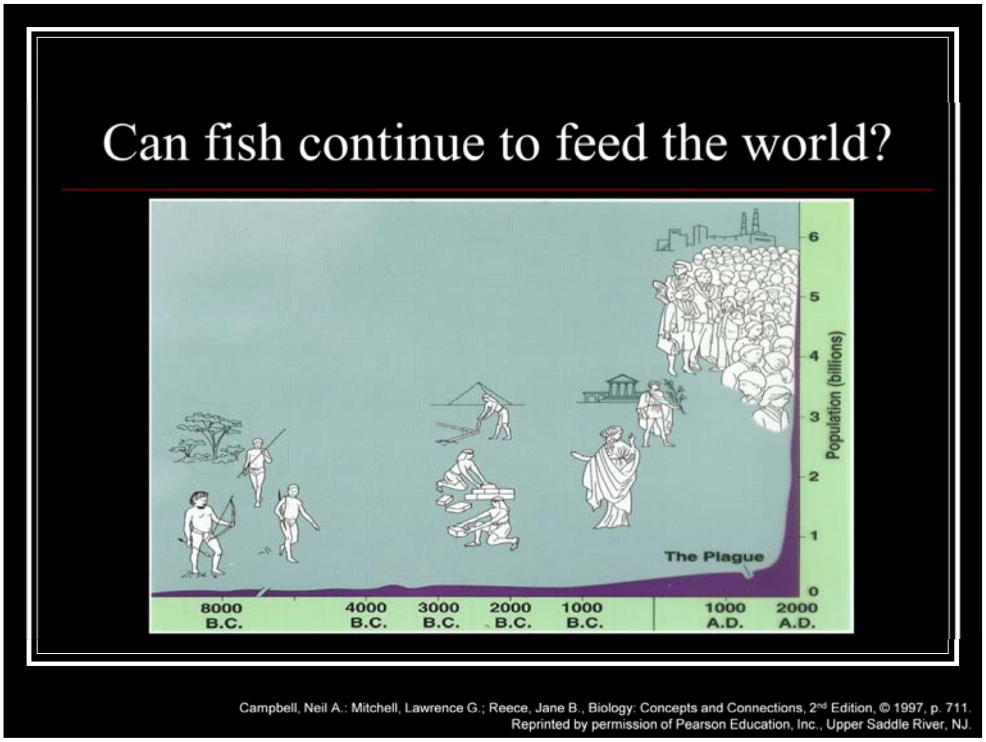



As part of an ecosystem-based approach to fisheries management, some fisheries scientists suggest replacing the traditional standard of "maximum sustainable yield" with "ecologically sustainable yield" (ESY) as a management goal. Rather than emphasizing the maximum yield of a single species, the goal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

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




Summary of the elements of ecosystem-based fisheries.




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

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

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


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

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

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


Summary of main points

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

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

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# 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.

## VII. Traditional fisheries management

- **The Challenge of Management**

Fisheries management is defined as the "manipulation of aquatic organisms, aquatic environments and their human users to produce sustained and increasing benefits for people" (Nielsen, 1993). A widely used textbook in the 1970s defined fishery management as “the application of scientific knowledge to the problems of providing the optimum yield of fishery products, whether stated in tons of commercial products or in hours of angling pleasure.” (Everhart and Youngs, 1975) Management efforts have traditionally been single species-based, targeting genetically distinct fish populations called **stocks.**

Fisheries management was founded on the basis of efficient production and the concept of maximum sustainable yield (MSY). Single-species management was, and continues to be, the norm. Most fisheries scientists now recommend a shift to ecosystem-based management. Converting to this type of thinking will be nothing short of a major revolution. This transition parallels changes in forest and wildlife management where we have had more success.

Traditional efforts that focus on maximizing the catch of a single species or population of interest often overlook the fish community and ecosystem in which the species lives. Current efforts that emphasize an ecosystems approach recognize that natural resources need to be managed in relation to their physical, chemical, biological and social environments.

Governments have two, sometimes conflicting, roles in fisheries management. They must first protect the fishery resource so that it is not depleted. At the same time however, they must secure the food supply, increase employment and provide for economic development. Successful fisheries management requires reconciling these two, often opposing, forces. When management efforts are delayed due to societal pressure to allow fishing, populations continue to decline. As a result, the effort to rebuild fish stocks may inflict more pain on the fishery because greater reductions in fishing effort are required over a longer period of time.

- **MSY**

The concept of maximum sustainable yield (MSY) has been a guiding principle of fisheries management since the 1950s. It is based on the relationship between fish population dynamics and fish harvest. The logic of MSY goes like this:

1. Population size is determined in part by growth rate

2. Growth rates are lowest when the population is small (the lag phase of logistic population growth) and large (population is near the carrying capacity and population growth is limited by density dependent factors like food availability)
3. Intermediate-sized populations have the greatest growth capacity and the ability to produce the greatest number of fish that can be harvested each year.
4. Therefore, fisheries can maximize production by keeping the population at an intermediate level (1/2 of carrying capacity).

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

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

The application of MSY is most effective as a management tool when stock estimates are reliable and harvest is seen as an "absolute maximum" rather than a "target."

- **Quotas (Total Allowable Catches)**

In the U.S., quotas or total allowable catches (TACs) are set by regional fishery management councils established by the Sustainable Fisheries Act of 1996. A TAC sets a maximum harvest in a fishery for specific species, area and time period. A fishery is shut down when that harvest level has been reached; thus, TACs are designed to prevent overfishing. Their effectiveness is dependent upon accurate information about the status of the stock being managed.

Most U.S. fisheries are "open access fisheries" and there is no effort made to allocate a portion of the TAC to any particular vessel or fisherman. As a result, over time TACs usually lead to the use of larger boats and more efficient gear to catch as many fish in the shortest period of time before the TAC is reached. Individual fishing quotas (discussed below) have been offered as an alternative that could lead to more sustainable fishing practices.

- **Relevant legislation**

The Magnuson-Stevenson Fishery Conservation and Management Act (1976) guides U.S. fishery management in waters from three miles to 200 miles offshore (Waters from the coastline to 3 miles are generally managed by the states). The Act established a 200-mile wide Exclusive Economic Zone (EEZ) along the U.S. coast in which the U.S. has economic jurisdiction. Foreign vessels are allowed to fish in this zone only under special permit issued by the U.S. In addition to the "200-mile limit," the Act established eight Regional Fishery Management Councils that monitor fish stocks and establish quotas to prevent overfishing. Critics contend that these councils are composed primarily of industry representatives whose main interest is in maintaining the status quo.

In 1996 the Act was reauthorized and substantially modified with the signing of the Sustainable Fisheries Act (SFA). The SFA required the National Marine Fisheries Service to develop a plan for ending overfishing and to begin re-building U.S. fishery stocks by September 1998.

The Magnuson-Stevenson Fishery Conservation and Management Act was most recently reauthorized in January of 2007. It strengthened protection against further depletion of dwindling fish stocks by providing market incentives to replenish fish stocks and enforce existing fishing laws. It also elevated the importance of ecosystem-based management by authorizing the regional fishery management councils to develop ecosystem plans. Implementation of the Act is intended to end overfishing in the United States by 2011.

In addition to the Magnuson-Stevenson Act, other federal legislation may be used to regulate fisheries. The National Environmental Policy Act (NEPA 1970) declares a national policy to promote a harmonious relationship between man and the environment and to support efforts to better understand and prevent damage to ecosystems and natural resources important to the nation. For fisheries, NEPA requires an assessment of both the biological and socioeconomic consequences of fisheries management decisions made by the federal government. The Endangered Species Act (ESA 1973) provides broad protection for fish and wildlife species that are listed as threatened or endangered. Provisions are made for the formal listing of species, development of recovery plans and the designation of critical habitats. The Marine Mammal Protection Act (MMPA 1972) establishes the conservation of marine mammals (whales, dolphins, seals, sea otters and polar bears) as a federal responsibility. The MMPA is most likely to be invoked when marine mammals are unintentionally caught in fishing gear as bycatch (e.g. dolphins) or when overfishing depletes their food resources (e.g. Steller sea lions).

- **Closures**

Closures are restrictions (usually temporary or seasonal) placed on fishing grounds to reduce fishing effort and to allow the recovery of a population. Following the collapse of the Atlantic cod fishery in the 1990s, for example, nearly 5000 square miles of prime fishing grounds from Long Island to Maine were closed primarily for cod and sea scallops in an attempt to rebuild these stocks. Paired with time restrictions, gear changes and crew limits, these closures resulted in a 20-fold increase in sea scallop biomass on Georges Bank from 1994-2002. The increase exceeded target rebuilding standards established by the National Marine Fisheries Service, allowing a re-opening of the scallop fishery. Unfortunately, the Atlantic cod population has not responded in a similar manner (see Atlantic cod case study for details).

Similarly, closures were used off the U.S. West Coast in 2002 to protect several species of rockfish (commonly marketed as "Pacific red snapper"). Bottom habitat deemed essential for juvenile red king crabs in Alaska was closed to bottom trawling in the 1990s and thought to be responsible for the recovery of that fishery. The largest fishery closure in U.S. waters was implemented in 2008 and 2009, when commercial salmon fishing along the entire Pacific Coast was closed to protect chinook salmon returns to the Sacramento River.

# VIII. Market-based solutions

- **Certification**

Green certification by independent organizations has been adopted in organic agriculture and forestry as a mechanism by which consumers can identify "sustainably produced" products and make corresponding choices in the marketplace. Seafood purchasers can now make similar choices in their selection of seafood. Fishing interests have an incentive to adopt less harmful practices to meet the criteria for certification. A fundamental assumption in this process is that the consumers (or at least some of them) are willing to pay extra for sustainably harvested fish.

The Marine Stewardship Council (MSC) based in London, England is the largest of these certifiers. Developed by Unilever, the Dutch food and consumer products company, in cooperation with the World Wildlife Fund, MSC promotes the use of market forces to promote behavior that helps achieve the goal of sustainable fisheries. At present this organization has certified 52 fisheries including North Sea herring, Australian mackerel and Baja California red rock lobster, and Oregon pink shrimp. Wal-Mart, the world's largest retailer, recently committed to purchasing all of its seafood from sustainably certified sources.

- **Consumer-based solutions**

In addition to certification, there have been a number of market-based solutions to declining fisheries implemented by various interest groups and the seafood industry. These include the development of seafood buying guides, the selection of sustainable seafood by chefs, and proper labeling of seafood to identify sustainably-caught fish.

Since 1998, a number of groups have produced simple reference guides designed to assist consumers who wish to make informed decisions about seafood purchases. The Blue Ocean Institute, Monterey Bay Aquarium and the National Audubon Society all produce these guides. Fish are placed in different categories based on their abundance, life history characteristics, habitat quality and the degree to which they are harvested using sustainable methods. Blue Ocean Institute's "Guide to Ocean Seafood," for example, assigns farmed shellfish and Alaska salmon to its preferred category, while Chilean sea bass and bottom-trawled cod receive its lowest score. In general, consumers make more sustainable choices when they choose seafood that is at a lower trophic level (e.g., clams and squid rather than tuna and swordfish). In 2008, the Blue Ocean Institute developed a free, text message service that lets consumers know immediately which seafoods are associated with overfishing, habitat loss or other problems. To access the service, dubbed *Fishphone*, consumers simply type the word "fish" and the name of a fish species into a text message and then send the message to the number 30644. The reply from *Fishphone* provides the current status of the requested species.

While these guides and services may have only a small impact on purchases, they may provide seafood companies and fishers with the incentive to adjust their habits towards more sustainable practices as they realize that the "consumer is watching."

Seafood choices made by restaurants and chefs also may play a role in which fish are served and ultimately harvested. On occasion, restaurants have boycotted certain items based on unsustainable practices (e.g., Chilean sea bass). In 1998, 27 chefs from prominent East Coast restaurants announced the removal of swordfish from their menus until a recovery plan was in place. One year later, over 700 chefs nationwide had done the same. In August of 2000, NOAA Fisheries announced a plan to protect swordfish nursery areas and the regional fishery commission reduced catch quotas. With these measures in place, the "Give Swordfish a Break" campaign was formally ended.

More commonly, chefs as individuals and in groups (e.g., the Chef's Collaborative) have committed to serve "sustainable seafood" in their establishments. Some seafood companies have committed to selling only sustainably-caught seafood. In China, some universities refuse to serve shark fin soup. The education of chefs, restaurant owners and consumers is an important part of such efforts.

Some seafood companies commit to identifying and marketing seafood that originates from sustainable practices. *EcoFish*™, for example, is a New Hampshire-based company that provides seafood to 1000 stores and 150 restaurants throughout the United States. The company buys species such as troll-caught albacore tuna, Pacific halibut and Alaskan wild salmon, all of which receive high sustainability scores. *CleanFish*™ markets high quality seafood that is "safe, sustainable and delicious" by purchasing from fishers who use the most selective methods of harvest.

- **Reduction in fishing effort by purchase of fishing rights**

Some studies suggest that a decrease in fishing effort by 30-50% will be required to attain sustainable harvests. Understandably, the fishing industry is not very excited about that prospect. However, there may be some ways to reduce fishing effort that would minimize the impact on the industry.

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

Fishermen usually obtain permits by purchasing them from other fishermen. In July of 2006, the first private buyout of commercial fishing permits occurred when the Nature Conservancy (an environmental group) purchased six federal trawling permits and four trawling vessels from fishermen in Morro Bay on the California Coast in an attempt to reduce fishing effort. This is probably the first private buyout of Pacific fishing vessels for conservation purposes.

- **Aquaculture**

Increases in total fish production for the past decade have been largely due to increases in aquaculture ("fish farming") production rather than increases in the harvest of wild-caught fish. Global aquaculture production increased from 13 million metric tons in 1991 to 42 million metric tons in 2003, a 340% increase. Since 1970, global aquaculture production has increased at an annual rate of nearly 9%. Aquaculture now supplies over 40% of fish consumed by the world's population. China and India are the world leaders in aquaculture production. Over 200 fish and shellfish species are grown in aquaculture. While freshwater fish such as carp and their relatives dominate global production, the most common marine species include shrimp, salmon, oysters, clams and mussels.

In the U.S., 5 of the top 10 species (shrimp, salmon, catfish, tilapia and clams) consumed in 2004 were at least partially produced in aquaculture operations. When wild salmon populations declined in the early 1990s, new salmon farming operations developed rapidly to meet consumer demand. These floating net pen operations off the coasts of British Columbia and Washington, in addition to salmon grown in Chile, also changed salmon from a "seasonal treat" to a product that was available year-round.

While aquaculture has the potential to reduce pressure on wild-caught fish, this has not yet been realized. Ironically, it may do just the opposite. When farmed fish are fed fish meal, additional fishing effort is often required to get enough food to feed these captive fish. To feed carnivorous fish (e.g., salmon, trout, sea bass) and shrimp, growers typically rely on wild-caught ocean fish. For example, about 3 metric tons of wild-caught fish are required to produce 1 metric ton of farmed shrimp.

Since farmed fish are typically raised at high densities and on restricted diets, disease transmission is a persistent problem. Antibiotics are often added to the feed adding to the potential for increased water pollution and the development of antibiotic-resistant strains of pathogens.

Farmed fish may occasionally escape and can potentially disrupt natural ecosystems. Escaped tilapia, for example, have been found to threaten native fish populations by eating the young of other species. Escaped fish may also jeopardize the genetic integrity of native fish populations. The consequences of genetic inputs by farm-raised fish into gene pools of native fish populations are not well understood and are currently under study. This risk can be reduced by raising native fish.

Additionally, large-scale aquaculture operations often replace coastal ecosystems such as estuaries, tidal flats and mangrove swamps. These coastal ecosystems often play a key role in the life cycle of other marine fish species. Aquaculture operations also may release large amounts of nutrient-rich effluent into natural waterways. Fecal material and waste food not eaten by the fish may concentrate around fish farming operations causing declines in dissolved oxygen levels and contribute to algae blooms. Aquaculture facilities in or adjacent to natural waterways may also promote disease and parasites in native fish populations. Native salmon that migrate past salmon pens, for example, have been shown to carry a higher parasite load of sea lice.

Despite its shortcomings, aquaculture is likely to play an increasing role in future seafood production across the globe. New innovations such as raising native species, building more secure pens and developing plant-based fish foods have reduced some of the environmental concerns associated with the practice. Additionally, some operations have adopted multitrophic aquaculture systems that use fish waste to fertilize marine algae, which can be used to feed filter feeders such as shellfish. Nutrient-rich waste water from aquaculture operations can also be used to supplement soil nutrient levels in rice fields or vegetable farms. Genetic modification of farm-raised fish has also holds some promise and has already been shown to dramatically increase growth rates for genetically modified Atlantic salmon. However, despite the obvious economic advantages of genetic modification, there are risks as well. Issues such as the escape of genetically modified fish into natural habitats and the loss of the genetic integrity of native species due to crossbreeding with genetically modified fish will have to be addressed by the aquaculture industry and government regulators. In the future, greater emphasis will also need to be placed on siting aquaculture operations to minimize the loss of coastal habitats.

- **Increased use and marketing of underutilized species**

In an effort to reduce bycatch, it has been suggested that markets could be developed for underutilized (and often discarded) species. One strategy, implemented since the 1970s has been to encourage use of underutilized species by assigning them market names that might be more attractive to the consumer. Silver hake, for example, is now marketed as “whiting,” Patagonian toothfish, as “Chilean sea bass,” deep sea angler as "monkfish," and slimeheads as “Orange roughy.” In some cases, fish that was once regarded as "trash fish" can now command over $10/pound!

At first glance, the renaming of fish species by the seafood industry may be seen as nothing more than a creative way to increase market share by giving a species a name that is somewhat more appealing to the consumer. In addition, improving the image of a fish that had not been routinely consumed may make use of a species that would otherwise be discarded as bycatch. As a result, fishing pressure may be reduced on species more familiar to the consumer, contributing to the sustainability of fishery stocks.

There is, however, a darker side to these “extreme make-overs.” Renaming species may provide consumers with a confusing message concerning the abundance of some species. “Pacific red snapper”, for example, is commonly seen for sale throughout the western United States. In reality, there is no such species. “Pacific red snapper” is actually represented by as many as 13 species of rockfish (*Sebastes* species), some of which have declined precipitously in recent years. Consumers who find “red snapper” routinely in fish markets may have a hard time being convinced that some of these species have declined to the point that they warrant special protection (Logan, et al. 2008). Additionally, some of these renamed fish with “American names” come from foreign waters where regulations either do not exist or are not strictly enforced. The American consumer may, as a result, unwittingly contribute to the decline of a species they know nothing about. Such an example is that of the Chilean sea bass, a fish that may live up to 150 years and does not reach full sexual maturity until about 30 years.

Seafood certification programs, much like organic certification programs, are based on the premise that the consumer will make sustainable choices if they are given good information. Independent third parties such as the Marine Stewardship Council (MSC) have gone to great lengths to research species and determine which ones are being sustainably harvested. Those that meet certain criteria are provided with their seal of approval. Consumers who choose to purchase sustainably-caught seafood need only look for the MSC seal, knowing that it has been independently evaluated. However, for certification to be an effective conservation measure, it is imperative that the species under consideration for certification be properly identified. Assigning new market names to species confuses the process and may provide the consumer with erroneous information.

Additionally, recent studies using sophisticated DNA analysis have found that fish products are frequently mislabeled in the marketplace even when more familiar names are used. Farmed salmon, for example, was often labeled as "wild", and tilapia, a farmed low quality fish, was sometimes substituted for fish of higher market value. A simplified DNA fingerprinting technique called "DNA barcoding" may make the identification of fish species in markets and restaurants available to almost anyone. Instead of sequencing an entire genome, barcoding examines the DNA sequence in a relatively short segment of mitochondrial DNA. These sequences are then compared to a public database of barcode sequences from known specimens. The Global Fish Barcode of Life initiative plans to collect samples from all 30,000 plus species of marine and freshwater fish species and to maintain this database. Identification to species is accurate, relatively cheap and takes only a few days. Two high school students from New York recently used the technique to verify the identification of fish found in local sushi restaurants and seafood markets. They found that 15 of the 60 samples they collected were mislabeled . Flying fish roe was determined to be from smelt and sushi being sold as "white tuna" was actually the much cheaper tilapia.

Unfortunately, some fisheries experts suggest that there is no such thing as "underutilized species" anymore. A small shark known as the spiny dogfish (sometimes marketed as "cape shark" or "rock salmon") provides an interesting case study. Once regarded as a trash fish by trawlers off the New England coast and discarded by the ton, dogfish became a valuable commodity in the 1980s. Most were exported to Great Britain where they were used for fish and chips. The fishery operated without a fishery plan from 1987 to 1996 and by 2000 the female population had declined by 80%. Realizing that the stock and the industry it supported were in imminent danger of collapse, a management plan was put into place in 2002 to reduce the total allowable catch and to begin rebuilding the stock.

- **Reduce government subsidies**

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

Despite the potential benefit to attaining sustainable fisheries, the political challenge of reducing or eliminating government subsidies cannot be underestimated. History has shown that, once established, these subsidies are often perceived as an "entitlement" by a strongly invested constituency that will lobby for their continuation. Politicians may be reluctant to raise the ire of these groups as the realities of our political system become apparent.

## IX. Ecosystem-based Fishery Management

A widely used textbook in the 1970s defined fishery management as "the application of scientific knowledge to the problems of providing the optimum yield of fishery products, whether stated in tons of commercial products or in hours of angling pleasure" (Everhart and Youngs, 1975). With overall declines in marine biodiversity including some high profile species, such as the Atlantic cod and several Pacific salmon species, the need to be more creative in fisheries management has become imperative. Recent reports by the National Research Council (2006), the U.S. Commission on Ocean Policy (2004) and the Pew Oceans Commission (2003) have documented the need for a new, ecosystem-based approach to the management of marine fisheries. A consensus statement on marine ecosystem-based management has been signed by over 200 academic scientists and marine policy experts (McLeod, et al. 2005).

In general, ecosystem-based fishery management (EBFM) attempts to sustain healthy marine ecosystems and the fisheries they support. This approach will require a better understanding of the ecosystem effects of fishing including impacts on food web interactions, life history strategies and trophic effects. Common recommendations of EBFM include reduction in mortality of both target species and bycatch, the use of fishery closures to initiate recovery of depleted species and the establishment of permanent reserves that are closed to fishing.

Successful implementation of ecosystem-based fisheries management is dependent upon the collection of appropriate data by fisheries managers responsible for stock assessment, bycatch monitoring, and other fishery monitoring programs. These programs are expensive and compete for funding with other priorities, most of which have more vocal constituencies ("Cod don't vote"). Politicians must be educated concerning the critical nature of these data and convinced to support and, if necessary, expand funding for monitoring programs.

An approach that attempts to apply ecosystem management to fisheries management may include the following elements:

- **Reduce bycatch**

Changes in fishing practices (gear alterations, closures of fishing areas, changes in the timing of fishing effort, etc.) that reduce bycatch is an essential part of achieving sustainable fisheries. Approximately 25% of the total world catch is discarded bycatch (12-20 billion pounds annually) and most is wasted. The requirement that bycatch be discarded is enforced to discourage fishers from circumventing laws and quotas.

There are two primary approaches to reduce bycatch:

A. Close a fishery

This method is mandated most often when charismatic species like sea turtles or dolphins are being unintentionally caught by fishing gear. It is also used to protect endangered runs of Pacific salmon, which intermingle with otherwise healthy runs of other salmon in the ocean.

B. Improve <u>selectivity</u> of fishing methods

1. Reduce contact between fishing gear and non-target species

Examples:

Seabird mortality has long been an issue in longline fisheries. When newly baited hooks are tossed into the water, fish-eating birds grab the bait and are pulled under the surface and drowned. Albatrosses, in particular, have been affected. Of the 22 known species, 10 are endangered, eight are listed as "vulnerable" and four are "near threatened"; only three species were considered threatened just 15 years ago. Although the accidental ingestion of plastic debris and introduced predators on breeding grounds have also contributed to their decline, fishing-based mortality is thought to be the major threat to this group of birds. The following modifications to longline fishing methods and gear have been made to address seabird bycatch:

- setting hooks at night when birds are not active
- using heavier lines so hooks sink faster
- using flapping, brightly-colored streamers on so-called "tori lines" to scare birds away from where the bait enters the water
- dying the bait blue to make it less visible in water
- using underwater chutes to set lines below water

The implementation of these methods by Alaskan fishing fleets has reduced the rate of accidental death of two albatross species by 80%. Also, an industry group representing vessels involved in the halibut and sablefish fisheries along the West Coast of the U.S. has recommended the use of tori lines for those fisheries.

A scallop dredge has been designed that uses hemispheric scoops (rather than a horizontal bar of heavy metal teeth) to dislodge scallops for the sea floor. The scoops direct water downward that stimulate scallops to move up from ocean floor but do not harm other species or habitat, particularly corals and other invertebrates.

2. Separating species on the basis of size

Examples – Turtle Excluder Devices (TEDs), mesh size regulations for trawls, traps and gill nets, hook size regulations for longline fisheries

Turtle excluder devices on shrimp trawls have reduced the number of sea turtles killed each year (estimated at 55,000 adults each year by the National Research Council). Oregon pink shrimp received Marine Stewardship Council certification in 2009, in part due to the requirement for the installation of excluder devices on shrimp trawls, which effectively eliminate the bycatch of rockfish (See NCSR Fisheries module entitled, *Shrimp Aquaculture,* for a more detailed description of bycatch reduction efforts in the Oregon pink shrimp fishery).

3. Exploiting behavioral differences among species

Example – The use of electric stimuli to raise shrimp from the seabed and harvest by trawls that are towed just above the ocean floor. Benthic fish are less responsive and remain on the sea floor avoiding capture.

Example - Pink snapper co-occurs with silver trevally (the target species) and although both enter fish traps, snapper will turn sideways inside the traps while travally do not. Capture of snapper can be minimized by orienting the trap mesh horizontally, allowing more snapper to escape.

Example – the use of "pingers" on nets, which send out acoustic signals to repel marine mammals.

- **Dolphin bycatch reduction in the Pacific tuna fishery**

Dolphin caught in tuna nets is one of the best known examples of bycatch. Public outcry over dolphin mortality in the 1970s and 1980s brought about significant changes in the industry, including gear improvements, new fishing techniques and the marketing of "dolphin-safe tuna". The practice of setting nets over dolphins to catch Pacific yellowfin tuna has been modified to reduce the number of dolphin caught in tuna nets from 400,000 per year prior to 1990 to 4,000 in 1993. Dolphin mortality due to tuna sets has decreased for three reasons:

1. U.S. regulations in response to public concerns about "dolphin sets" (i.e., dolphin-safe labeling)

2. Technical innovations and operational modifications made by tuna fishers themselves:
   - the "backdown technique" used by purse seiners, in which the vessel moves in reverse causing the top of the net to sink allowing dolphins to escape (see *PowerPoint* presentation for illustration).
   - the use of Medina panels to reduce dolphin entanglement in purse seines(see *PowerPoint* presentation for illustration).

3. The international fleet is switching to alternative methods for setting nets – especially "floating object sets" where nets are set under objects (usually, intentionally-placed "fish aggregation devices") that are floating on the ocean surface. This method is highly effective for skipjack tuna, but other species congregate there also – undersized yellowfin tuna and bigeye tuna, billfish, sharks, sea turtles and other fish, making them more vulnerable to becoming bycatch.

Ironically, data collected by on-board observers of the tuna fleet over the past two decades suggests that bycatch in the Eastern Pacific has increased since dolphin-safe protections became law in 1990. Dolphin mortality has decreased from an average of 12 per set to 0.2 per set. However, there has been a shift in bycatch from dolphins to undersize tuna (10-100 times more), sea turtles, sharks and several other species of fish. So – although dolphin mortality has declined, the ecosystem effect is probably greater than before (see Norris, 2002 for data).

Bycatch may be further reduced by providing economic incentives to develop more selective gear that harvests only the target species. Also, to reduce marine mammal bycatch, the placement of marine observers on fishing vessels has been shown to be an effective, albeit expensive, method.

We have much to learn about the ecosystem effects of unintentional harvest and discarded bycatch. For many fisheries we don't even know what the bycatch is.

For specific elements of the "National Bycatch Strategy" (a NOAA Fisheries effort to reduce bycatch), see www.nmfs.noaa.gov/bycatch.htm

In the past, catch data has been the most commonly used statistic to estimate population size of commercially harvested fish. As more regulations become implemented, these measures will become less reliable as an indication of population size. Declines in catch rates, for example, may be due to the establishment of a new quota or regulation that significantly reduces fishing effort, rather than actual decreases in population size. Conversely, actual species declines may go undetected if harvest data are not collected or intentionally underreported. For this reason, ecosystem-based fishery management will require additional efforts to monitor population sizes of harvested species using methods other than catch rates. Research surveys have been conducted for a number of commercially important species. These surveys will need to expand to monitor population trends and allow fishery managers to respond to them.

- **Gear restrictions**

Modification or restriction on use of specific fishing gear may be used to allow less efficient technology to take more fish. Many of these restrictions are designed to make the fishing method more selective and to allow escapement of under-sized fish or fish of non-target species (e.g., increased mesh size, elimination of gill nets, etc.) or to reduce benthic habitat impacts such as those created by bottom trawling or dredging.

For example, oyster-dredging boats in Chesapeake Bay are required to be powered by sail. Pair trawls (two vessels dragging a net between them) have been outlawed off the New England coast for catching cod due to their high efficiency. These restrictions have contributed to allowing a fishery to continue that probably would have become overfished with more efficient technology.

Note that this action actually creates more jobs since more fishing effort is required to catch the fish.

- **Marine reserves/marine protected areas**

Although land-based reserves have been part of national and international conservation strategies for decades, until recently the concept had not been broadly applied to marine environments. Networks of marine reserves are now widely viewed by scientists, managers and advocacy organizations as an important element of an ecosystem-based effort to preserve both marine biodiversity and sustainable fisheries.

Marine reserves are ocean areas in which extractive activities such as fishing, mining and oil drilling are prohibited. They represent the most restrictive type of "marine protected areas," which may afford a wide variation in degree of protection. Currently, much less than 1% (estimated 0.01%) of territorial waters in the United States are in marine reserves. The first marine reserves were established in the 1980s off the California and Washington coasts. Additional marine reserves are now under consideration for other coastal states.

Designing and designating locations of marine reserves can be challenging both scientifically and politically. Oregon has been in this process since 2005. After a lengthy process, Oregon's governor called for up to 9 marine reserves in state waters off the Oregon Coast provided they did not result in significant negative impacts to coastal communities (particularly fishing interests). The Oregon Policy Advisory Council was established to evaluate marine reserve proposals and in November of 2008 recommended the establishment of two pilot marine reserves – one off Port Orford and one off Depoe Bay.

The process can be monitored from:

www.oregonmarinereserves.net
www.ouroregonocean.org

In the past, large portions of the world's oceans functioned as *de facto* reserves due their inaccessibility to fishing vessels and fishing gear. However, with the development of large, sophisticated modern vessels, highly efficient fishing gear, and advanced technology such as sonar and GPS all but the most remote areas are now being fished. In recent years, even some of <u>these</u> areas have been exploited (e.g., Antarctic seas and seamounts in the Central Pacific).

Although our understanding of how marine reserves function is incomplete, two goals are universal. First, marine reserves, or systems of reserves, should preserve or assist in the restoration of natural functioning ecosystems. It is anticipated that as human-caused disturbances are removed, ecosystem composition and processes will recover. Second, as a result of spill-over from these reserves, yield to fisheries is expected to increase. Preliminary results from reserves established off the coast of California, for example, indicate that fish are twice as abundant and 30% larger on reserves as compared to non-reserve areas. An examination of the performance of more than 80 marine reserves in a variety of tropical and temperate areas found that on average, the density (2.4 X), biomass (5.5 X), body size (1.3 X) and diversity (1.2 X) increased over non-reserve areas. Also, there is increasing evidence that reserves replenish fish populations outside of reserves by exporting fish larvae and juveniles to other non-reserve areas. For these reasons, marine reserves appear to be a new tool that can be used in conjunction with other ecosystem-based approaches to enhance both fisheries and conservation values.

Many questions remain and research on marine reserves is fertile ground for investigation. For example: How large should marine reserves be and how should their location be selected? Will the benefit of more fish produced in reserve areas outweigh the increases in fishing pressure placed on non-reserve areas as a result of excluding fishing from reserve areas? How will climate change impact the effectiveness of marine reserves? How do systems of reserves function? Recent evidence from reserve monitoring programs suggests that networks of smaller reserves may provide more benefits to fisheries and marine biodiversity than a single large reserve.

In a marine reserve established in the mid-1990s near St. Lucia in the eastern Caribbean, fish in the reserve were found to live longer and grow larger. Catches near the reserve also increased by 46- 90%. Prior to establishing the reserve, the reefs had become almost barren. This illustrates one anticipated benefit of reserves in addition to increasing biodiversity– that extra fish will be transported out of reserves to areas where they can be fished. The reserve becomes a nursery for nearby fisheries in a phenomenon known as the "spillover effect."

In November 2006, California established a large network of 29 marine reserves despite vocal opposition from fishermen. Fishing is banned or severely restricted in marine reserves that cover 200 square miles from Santa Barbara to just south of San Francisco. The protection went into effect in early 2007 and similar protected areas are expected to be established for southern and northern California in the near future. All states, including California have jurisdiction over up to three miles from shore. California has established these reserves in the most sensitive and biologically diverse habitats including coastal bays, estuaries, kelp forests, undersea canyons, rocky reefs and seagrass beds.

In June 2006, President Bush established the world's largest marine reserve in the Northwestern Hawaiian Islands, an area covering 140,000 square miles. Commercial fishing on this reserve will be phased out over the next 5 years.

It is important to note that commercial and recreational fishing interests frequently are opposed to the establishment of marine protected areas as they see them affecting their livelihood.

The U.S. has established a National Marine Sanctuary system, but in most instances these do not prohibit fishing.

- **Monitoring of population characteristics**

In the past, catch data has been the most commonly used statistic to estimate population size of commercially harvested fish. As more regulations become implemented, these measures will become less reliable as an indication of population size. Declines in catch rates, for example, may be due to the establishment of a new quota or regulation that significantly reduces fishing effort, rather than actual decreases in population size. Conversely, actual species declines may go undetected if harvest data are not collected or intentionally underreported. For this reason, ecosystem-based fishery management will require additional efforts to monitor population sizes of harvested species using methods other than catch rates. Research surveys have been conducted for a number of commercially important species. These surveys will need to expand to monitor population trends and allow fishery managers to respond to them.

The alteration of age structure can be used as an indicator of overfishing. In the most common scenario, the abundance of individuals in older age classes declines as these fish are targeted by a particular fishery. However, other atypical age distributions in a fish population can indicate a population in trouble and changes in harvest practices may be warranted. In the late 1970s for example, a limited fishery for haddock off the New England coast was allowed after it appeared that the species had begun a recovery after years of decline. Examination of the age distribution of harvested fish, however, indicated that the vast majority of fish being harvested were large, mature adults that for reasons not completely understood, were not reproducing. Young individuals, which typically would make up a large portion of the population were nearly absent. Fisheries regulators quickly shut down the fishery fearing that the loss of additional breeding stock would further compromise any recovery of the stock. A few years later the population showed sign of recovery and since 2004, haddock stock size has increased dramatically. The species is no longer categorized as “overfished” by NOAA Fisheries. Thus, monitoring of the age distribution in fish populations can be a useful management tool.

- **Implementing catch share programs**

The quota system as it is currently implemented, first establishes a quota or total allowable catch (TAC) and then, once that level is reached, the fishery is closed. Thus, from the viewpoint of a single fisherman or boat owner, it is in their best interest to catch as many fish as possible before the quota is reached. This encourages the use of large boats and highly efficient gear that often includes catches high in bycatch.

In the case of declining fish stocks, fisheries managers often respond by shortening fishing seasons to reduce pressure on the resource. In an extreme case, the halibut fishery off the coast of Kodiak, Alaska was reduced from a season of 150 days to 90 days and finally, in the late 1980s, to just two 24-hour seasons each year. On these days, vessels would line up like a race to rush out to fishing grounds to catch as much as they could as quickly as possible. This so-called “derby fishing” flooded the market with halibut resulting in low prices and significant waste. Most of the fish was frozen resulting in a lower quality product. Since fishermen had tremendous incentive to fish this window of opportunity regardless of weather, accidents and deaths of fishermen also increased.

Some fisheries managers have suggested allocating portions of TACs with catch share programs (sometimes known as, Limited Access Privilege Programs – LAPPs). Under this system, the total allowable catch is established by government fishery agencies based on the condition of the fishery stock. Individual fishers, companies or communities are then allocated a guaranteed portion of the catch and it is up to each individual to determine how and when that amount is harvested.

Under some catch share programs (e.g., Individual Transferable Quotas or ITQs), allocations can be bought and sold like private property. The assumption is that with fewer time constraints on the harvest, more selective methods would be used resulting in less overall impact and a higher quality product will be brought to market. Also, fishers have an economic incentive to protect the resource to obtain the same or a higher quota in future years. Under a catch share program, the mindset of the fisher changes from one similar to a “renter” to a “homeowner.” Fishers can more effectively plan their fishing effort, thus increasing market value of the fish (they can land fish when markets are optimal), avoiding bycatch (improving efficiency and selectivity of gear) and staying ashore when conditions are unsafe (eliminates "derby fishing"). Catch share programs should provide more secure jobs as the supply and value of the product becomes more predictable.

ITQs were implemented in the Alaska halibut fishery in the 1990s bringing derby fishing to an end. A pound limit is now established for each licensed boat. In part, as a result of this management change, Pacific halibut is now assigned as a "best choice for consumers" by those organizations promoting sustainable fisheries. Other catch share program success stories include the surf clam and quahog fisheries in the mid-Atlantic States and the wreckfish fishery in Florida. Although they have been resisted by the industry and by the U.S. government, catch share programs are common in Australia, New Zealand, and Iceland.

A 2008 study by resource economists from the University of California, Santa Barbara examined the impact of catch share programs on more than 11,000 fisheries over a 50-year time period. Researchers found that the implementation of catch share programs halted and even reversed the global trend towards fishery collapses. While nearly 30% open access fisheries have collapsed, less than half of that amount of catch share fisheries have collapsed (see Costello, C, et al. 2008, for details).

Rather predictably, there are a number of concerns and objections to catch share programs. For example, some in the industry are heavily invested in the *status quo* and have concerns about how shares are allocated and the transition to an entirely different regulatory system. Some object because they see catch share systems as privatization of public resources. Catch share programs require vigilant monitoring of fishery stocks and some are concerned that scientific data to evaluate stocks are not yet available. Another concern with this system is that if individual quotas can be bought and sold, the largest and wealthiest operators within the fishery may accumulate the lion's share of the quotas, eliminating smaller operators.

- **Ecologically Sustainable Yield**

Sustainable fisheries has traditionally been defined as the long-term viability of target species. It is now clear that sustaining those species will depend upon protecting the vast biodiversity of the world's oceans. There have been a number of calls in recent years from fisheries scientists for an ecosystem-based approach to fisheries management as an alternative.

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

Also, since many more factors must be considered to implement ESY, a more complete knowledge of marine ecosystems and the biology of individual species is required to guide policy and to translate policy into practice. Much of the information on these essential elements is now lacking.

In most cases, ESY will reduce the allowable harvest to less than the amount allowed by MSY. However, sustainable fishing based on ESY will still lower fish populations below that of un-fished populations. Thus, ESY is not the same as the conservation goal of maintaining natural marine communities.

See Zabel, et al. (2003) for details.

## X. The future of marine fisheries

*"An ecosystem-based approach is founded on the notion that robust fisheries depend on healthy marine ecosystems… Ideally, ecosystem-based fishery management would shift the burden of proof that fishing would not take place unless it could be shown not to harm key components of the ecosystem."* (Pikitch 2004)

Recommendations for future management of marine fisheries have been made by the U.S. Commission on Ocean Policy (2004) and the Pew Oceans Commission (2003). These commissions as well as many fisheries scientists and managers call for a new, ecosystem-based approach to the management of marine resources. Ecosystem-based fishery management (EBFM) attempts to avert additional collapses of fish populations by focusing on managing the entire marine ecosystem rather than one species at a time. EBFM recognizes that robust fisheries depend on healthy ecosystems. Some suggest that EBFM is not necessarily a substitute for single-species management, but rather should be used to complement those practices in single-species management that have proven to be effective.

Specific elements of an ecosystem-based approach to management of marine resources include:

1. Establishing the protection of marine ecosystems as the principal objective of marine fishery policy
2. Separating conservation and allocation decisions in an effort to assure that ecological sustainability takes precedence over short-term economic or political considerations
3. Implementing ecosystem-based planning and marine zoning to determine how and where fishing will be allowed to occur
4. Regulating the use of fishing gear that is destructive to marine habitats
5. Requiring bycatch monitoring and management plans as a condition for fishing
6. Requiring comprehensive access and allocation planning as a condition for fishing to match the capacity to catch fish with the ability of the resource to sustain a harvest

Regardless of interest, "sustainable fisheries" appears to be a universal goal. So, what <u>is</u> a sustainable fishery? The Marine Stewardship Council, an independent organization that establishes certification criteria for fisheries defines a "sustainable fishery" as one that:

1. Can be continued indefinitely at a reasonable level
2. Maintains and seeks to maximize ecological health and abundance
3. Maintains the diversity, structure and function of the ecosystem on which it depends
4. Is managed and operated in a responsible manner, conforming with all applicable laws and regulations
5. Maintains present and future economic and social options and benefits
6. Is conducted in a socially and economically fair and responsible manner

Pauly, et al. (2003) predicts the future of fisheries based on different scenarios determined by different policy decisions made today. Four scenarios are proposed, representing what the future may hold rather than what it will hold:

1. Market considerations take priority in shaping policy

Under this scenario, government subsidies would be gradually reduced and an open market would determine price and costs. As a result, those fisheries dependent on traveling long distances (e.g., large trawler fleets) would probably decline. Small scale, more efficient fisheries would be favored by this scenario. With a reduction in distant off shore fisheries, fishing effort may be reduced in some areas creating *de facto* reserves. This may result in an increase in marine biodiversity, however pressure on high value species such as swordfish and tuna would probably continue.

2. Security takes priority and wealthy nations outcompete poorer nations for fish

Under this scenario, there is a continuation of subsidies, increased effort on fisheries and ultimately the collapse of traditional fish stocks and a large impact on marine biodiversity. Alternative fisheries including invertebrates (e.g., jellyfish and krill) will be developed for human consumption and other uses.

3. The implementation of governmental policies takes priority as nations attempt to balance economic and ecological concerns.

Policy changes would result in greater international cooperation on fishery policy, the establishment of marine reserve networks, some reduction of fishing effort, reduction in destructive gear and bycatch and reduction of coastal pollution. This would result in the return of many depleted fisheries and a reduction in the risk of extinction for many marine species.

4. A value system change occurs that emphasizes environmental sustainability

This scenario assumes the acceptance and implementation of international fisheries agreements, the creation of networks of marine reserves and careful monitoring and re-building of fish stocks. Large reductions in fishing effort would be required (to 20-30% of current levels).

The cost of fuel is an important factor in the determination of which fisheries will persist and which will decline or disappear. If fossil fuels become scarce and significantly more expensive, then those energy-intensive fisheries (such as deep-sea trawling) would be expected to decline. This may result in an increase in the human consumption of small pelagic species such as mackerels, herrings and sardines which are currently mostly reduced for fish meal and used in agriculture and aquaculture.

The continuation of fuel subsidies provided to the fishing industry by governments allows energy-intensive fisheries to persist longer than markets would otherwise dictate. This puts prolonged fishing pressure on some depleted fish stocks. For this reason, some fisheries scientists have called for an end to fuel subsidies as an important component of a sustainable fisheries plan.

It has become increasingly clear in recent years that wild-capture fisheries cannot keep up with consumer demand for fish. Over 70% of fish consumed in the U.S. is now imported and over 40% of that is farmed. Thus, it is likely that aquaculture will play an increasingly important role in future fisheries production. In 2005, NOAA Fisheries proposed a five-fold increase in domestic aquaculture production by 2025 to meet domestic demand for seafood. The proposal would establish a permitting process for off-shore fish farms (huge submerged fish pens) three to 200 miles off the coast. Suggestions have been made by fisheries biologists and environmental groups for reducing the environmental impact of all aquaculture operations and expanding their role to include wetland restoration, pollution mitigation and restocking wild fisheries.

# 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* <u>*why*</u> *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 – 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 (Management and Proposed Solutions)

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.

**Traditional Fisheries Management**

Botsford, L.W., J.C.Castilla, and C.H. Peterson. 1997. The management of fisheries and marine ecosystems. Science 277:509-515.

Everhart, W.H. and W.D. Youngs. 1975. Principles of fishery science. Cornell University Press, Ithaca, NY.

*This widely used fisheries text from the 1970s defined fishery management as "the application of scientific knowledge to the problems of providing the optimum yield of fishery products, whether stated in tons of commercial products or in hours of angling pleasure." Clearly, modern fisheries management has taken a broader perspective. Ecosystem-based fishery management maintains the integrity of aquatic ecosystems and preserves the diversity of aquatic species.*

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

Stewart, C. 2004. Legislating for property rights in fisheries. FAO. Rome.
http://www.fao.org/docrep/007/y5672e/y5672e00.htm

*This U.N. Food and Agriculture Organization report provides a detailed description of the history of legislation that regulates fisheries.*

Zabel, R.W. 2003. Ecologically sustainable yield. American Scientist 91:150-157.

**Market-based Solutions**

Blue Ocean Institute
www.blueocean.org/Seafood
*A text message service has been developed and implemented by the Blue Ocean Institute to rank seafood sustainability using cell phone technology and text messaging while standing at the fish counter. See web site:*
www.blueocean.org/fishphone.index.html

Browenstein, C., M. Lee and C. Safina. 2003. Harnessing consumer power for ocean conservation. Conservation in Practice 4(4):39-42.

Chef's Collaborative
www.chefscollaborative.org

Cooper, L. and M. Sutton. 1998. The Marine Stewardship Council: Sustainable fisheries through consumer choice. Endangered Species Update 15:59-65.

Curtis, R and D. Squires (eds.) 2007. Fisheries buybacks. Blackwell Publishing, Ames, IA. 244 pp.
www.blackwellfish.com

*Fisheries buybacks (i.e., government purchases of fishing rights, vessels or gear) are often used as an overall strategy to reduce fishing pressure on commercially-harvested fish populations. This publication, edited by two prominent fisheries economists, provides an overview of buybacks and a synthesis of the available literature related to this practice. Eleven case studies are provided that describe real world attempts to implement buybacks as part of a comprehensive fisheries management plan.*

Endangered Fish Alliance
www.endangeredfishalliance.org

*This group of chefs and restauranteurs, based in Toronto, Canada, provides information to consumers who wish to make sustainable seafood choices.*

Environmental Defense
www.oceansalive.org/home.cfm

*The Environmental Defense Oceans Program advocates for constructive solutions to issues in the world's marine environments. Sustainable choices for seafood selection, detail on harvest methods and conservation status are provided for most species. A gallery of photographs is also provided, which instructors may find useful.*

Fox, D. 2008. Imposter fish. Conservation 9:14-19.

*This brief article evaluates the conservation consequences of renaming fish species for the purpose of improving their appeal to consumers.*

Grescoe, T. 2008. Bottom Feeder – How to eat ethically in a world of vanishing seafood. Bloomsbury USA, New York, 336 pp.

*The author offers his views on humans feeding lower on the food chain (i.e., sardines and oysters rather than tuna and swordfish) to help address the decline of marine fisheries.*

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

*This document provides a detailed look at the successes and short-comings of various market-based methods that have been implemented to address fishery declines.*

Halweil, B. 2008. Farming fish for the future. WorldWatch Paper #176. WorldWatch Institute, Washington, D.C. 48 pp.
www.worldwatch.org

*This document provides an excellent overview of aquaculture as well as some suggestions for expanding the role of aquaculture to include wetland restoration, pollution mitigation and restocking wild fisheries. With more than 40% of the seafood we eat now being produced by fish farms, it has become clear that aquaculture will be an important component of how we choose to manage fisheries resources in the future. However, not all fish farming is created equal. Direct and indirect environmental impacts and human health issues are assessed in this well-researched document produced by the environmental organization,* WorldWatch Institute. *The characteristics of aquaculture that might be considered sustainable are clearly described and examples given.*

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

Kreeger, K. 2000. Down on the fish farm: Developing effluent standards for aquaculture. BioScience 50:949-953.

Logan, C.A., et al. 2008. An impediment to consumer choice: Overfished species sold as Pacific red snapper. Biological Conservation 141:1591-1599.

Marine Stewardship Council
www.msc.org

*The Marine Stewardship Council establishes certification criteria for seafood and provides independent accreditation for third party certification bodies that conduct the actual certification assessment. Its mission is "to safeguard the world's seafood supply by promoting the best environmental choices." Certification criteria and lists of species that have achieved MSC certification are provided.*

Matlick, J. 2008. RU Shopping 4 Fish? Conservation Magazine 9:33-34.

Monterey Bay Aquarium Seafood Watch Program
www.mbayaq.org/cr/seafoodwatch.asp

National Audubon Society – Living Oceans, Seafood Lovers Guide
http://seafood.audubon.org

National Public Radio. 2005. Fish farming headed for U.S. seas. *All Things Considered.* 7 June 2005.
www.npr.org/templates/story/story.php?storyId=4684393

*This audio broadcast produced by National Public Radio's news program,* All Things Considered *describes a Bush administration proposal to allow the operation of huge fish farms in the open ocean. The proposal would establish a permitting process for the establishment of submerged net pens in federal waters (from 3 to 200 miles) off the U.S. coast.*

NOAA Fisheries Fishwatch Program
www.nmfs.noaa.gov/fishwatch/

*This site describes the sustainability status of all U.S. commercial fisheries. Additional information on life history, habitat, stock biomass and management is also provided.*

Pew Oceans Commission. 2001. Marine aquaculture in the United States: Environmental Impacts and Policy Options. Pew Oceans Commission, Arlington, VA.
www.pewoceans.org or www.pewtrusts.org

Ryan, J.C. 2003. Feedlots of the sea. WorldWatch Sept./Oct. 2003:22-29.

*This brief article from an environmental group describes the environmental risks associated with aquaculture.*

Seafood Choices Alliance's Smart Choices Program
www.seafoodchoices.com/smartchoices.php

*This program was developed under* SeaWeb *by a global seafood trade association. Its purpose is to assist the industry to make the seafood marketplace environmentally and economically sustainable. The "Find Seafood" function allows consumers to determine the characteristics of different seafood products. A description of the fishery, conservation status, seasons available, forms product may take and buying tips are included.*

Simpson, S. 2009. Taming the blue frontier. Conservation 10:28-36.

*This article addresses some of the issues that we face as we look to aquaculture to augment wild capture of fish.*

Ward, T. and B. Phillips. 2008. Seafood Ecolabelling. Wiley-Blackwell, Indianapolis, Indiana. 472 pp.

*This comprehensive review of certification systems for seafood products includes:*

- *A description of the background and history of certification systems (labels, ratings, guides)*
- *Case studies in the use of certification labels*
- *The future of sustainable seafood*

*Unfortunately, its $200 price tag reduces the probability of it being used by most educators.*

**Ecosystem-based Fishery Management**

Allsopp, M., et al. 2007. Oceans in Peril: Protecting Marine Biodiversity. WorldWatch Report 174, WorldWatch Institute, Washington, D.C. 56 pp.

*This document published by the environmental group* WorldWatch Institute, *is a general treatment of biodiversity issues in our oceans. Fisheries issues and proposed solutions are well-covered in the publication in addition to marine pollution, climate change and ocean acidification.* WorldWatch *adds its voice to the many who have proposed an ecosystems-based approach to ocean management. Strong protection of marine ecosystems with a well-enforced network of marine reserves is the centerpiece of their vision for future management.*

Costello, C., et al. 2008. Can catch shares prevent fisheries collapse? Science 321:1678-1681.

*This article evaluates the effectiveness of catch share programs as a method for attaining sustainable fisheries. After examination of over 11,000 fisheries worldwide, the authors conclude that catch share programs halt and even reverse the global trend towards widespread fishery collapses.*

Easton, T.A. 2007. Taking sides: Clashing views on environmental issues, 12th ed. McGraw-Hill Co., Inc Dubuque, IA. 362 pp.

*This widely used publication presents opposing viewpoints on a wide variety of environmental issues. Issue #25 (pp. 260-276) in this edition presents the views of Robert R. Warner, professor of marine ecology at University of California at Santa Barbara who supports the establishment of marine reserves and Professor Michel J. Kaiser (University of Wales), who argues that limiting fishing effort is a more effective way to manage fisheries. The publisher maintains a web site for educators designed to support classroom use of this resource at:* www.mhcls.com/takingsides/.

Ecosystem Principles Advisory Panel. 1999. Ecosystem-based fishery management: A report to Congress by the Ecosystem Principles Advisory Panel, National Marine Fisheries Service, Washington, D.C.

Hastings, A. and L.W. Botsford. 1999. Equivalence in yield from marine reserves and traditional fisheries management. Science 284:1537-1538.

Hooker, S.K. and L.R. Gerber. 2004. Marine reserves as a tool for ecosystem-based management: The potential importance of megafauna. BioScience (Jan 2004).

Joint Nature Conservation Committee
http://www.jcc.gov.uk/page-1576

*This document describes the ecosystem-based approach to fisheries as envisioned by this British conservation agency. It includes a brief history of EBF and some general guiding principles for its implementation.*

Kennelly, S.J., ed. 2007. Bycatch reduction in the world's fisheries. Dordrecht (Netherlands). Springer.

Link, J.S. 2002. What does ecosystem-based fisheries management mean? Fisheries 27:18-21.

Marine Fish Conservation Network
www.conservefish.org/site/catch06/index.html

*The Media Center on this web site has a number of reports that cover most aspects of fisheries conservation issues from the perspective of an environmental group dedicated to marine conservation.*

Marine Protected Areas of the United States
http://mpa.gov/

*This site is managed jointly by the National Oceanic and Atmospheric Administration and the Department of the Interior. Information and additional resources concerning the U.S. system of marine protected areas is provided.*

McLeod, K.L., et al. 2005. Scientific consensus statement on marine ecosystem-based management. Signed by 221 academic scientists and policy experts with relevant expertise and published by the Communication Partnership for Science and the Sea. 21 pp.
http://compassonline.org/?q=EBM

Mumby, P.J., et al. 2006. Fishing, trophic cascades, and the process on coral reefs. Science 311:98-101.

National Center for Ecological Analysis and Synthesis. University of California, Santa Barbara.
www.nceas.ucsb.edu

*This center conducts research on marine reserves and has published a concise statement of the scientific consensus on marine reserves.*

National Fisheries Institute
www.aboutseafood.com

*The National Fisheries Institute is a U.S. seafood industry trade group. In addition to promoting the marketing and consumption of seafood, the group also provides an industry perspective on fisheries issues. Several concise "Position Papers" are available that describe the industry's position on fisheries management, bycatch, ocean sustainability and ecosystem-based management.*

NOAA National Bycatch Strategy
www.nmfs.noaa.gov/bycatch.htm

*See this site for specific elements of the "National Bycatch Strategy," a comprehensive effort by the National Marine Fisheries Service to reduce bycatch.*

NOAA National Marine Sanctuaries
www.sanctuaries.nos.noaa.gov

*This site describes the U.S. marine sanctuary system. It is important to note that while "marine reserves" generally prohibit all extractive activities including fishing, "marine sanctuaries" generally allow fishing but prohibit other extractive activities such as offshore oil development. Sometimes marine reserves are imbedded within marine sanctuaries.*

NRC. 1999. National Research Council. Sustaining Marine Fisheries. National Academy Press, Washington, D.C.

Norris, S. 2002. Thinking like an ocean – ecological lessons from marine bycatch. Conservation in Practice 3(4):10-19.

*This article addresses the complexity of bycatch reduction as a management strategy. The unintended consequences of single-species bycatch reduction such as the well-publicized efforts to reduce dolphin bycatch by the tuna fishery are discussed.*

Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO). 2002. The science of marine reserves. 22 pp.
www.piscoweb.org/

*PISCO is a marine research program conducted by scientists from four West Coast universities. This site presents summaries of their findings including the results of monitoring efforts in marine protected areas. This publication presents our current scientific understanding of marine reserves. Links to many other resources are provided. There is also an on-line video version of the document (available in eight 2-4 minute segments) on the PISCO web site.*

Pew Oceans Commission. 2003. Marine reserves: A tool for ecosystem management and conservation. Pew Oceans Commission, Arlington, VA.
www.pewoceans.org or www.pewtrusts.org

*This is an excellent review of marine reserves.*

Pikitch, E., et al. 2004. Ecosystem based fishery management. Science 305:346-347.

*This brief summary article, authored by 17 prominent fisheries scientists, provides a useful entry into the principles of ecosystem-based fishery management.*

Roberts, C., et al. 2001. Effects of marine reserves on adjacent fisheries. Science 294: 1920-1923.

Sobel, J. and C. Dahlgren. 2004. Marine Reserves: A guide to science, design and use. Island Press, Washington, D.C.

*This is a comprehensive general text on marine reserves that includes examples of implementation, rationale for their use and evidence of success.*

Tupper, M.H. 2002. Marine reserves and fisheries management. Science 295:1233.

Wickstrom, K. 2002. Marine reserves and fisheries management. Science 295:1233.

Wood, L.J., L. Fish, J. Laughren and D. Pauly. 2008. Assessing progress towards global marine protection targets: shortfalls in information and action. Oryx 42:340-351.

Worm, B., et al. 2006. Impacts of biodiversity loss on ecosystem services. Science 314(5800):787-790.
http://www.sciencemag.org/cgi/content/abstract/314/5800/787

*This article documents the effects of closures and marine reserves on biodiversity, ecosystem stability, tourism and other ecosystem services. The diversity-stability relationship is confirmed by experimental evidence.*

**The Future of Marine Fisheries**

Dayton, P.K. 1998. Reversal of the burden of proof in fisheries management. Science 279:821-822.

Knudsen, E.E., et al. (eds) 2004. Sustainable management of North American fisheries. American Fisheries Society, Bethesda, MD. 281 pp.

*This is a compilation of articles on sustainable fisheries management written by prominent North American fisheries biologists.*

Simpson, S. (ed.) 2007. Ten solutions to save the oceans. Conservation Magazine 8:22-32.

*Ten marine experts were asked by this journal to propose specific recommendations that address marine conservation. This article includes their responses.*

NOAA. Pacific Fisheries Environmental Laboratory – Climate and Marine Fisheries.
www.pfel.noaa.gov/research/climatemarine/

*Our understanding of the relationship between climate change and fisheries is in its infancy. This site provides a window into our current state of knowledge.*

Pauly, D., et al. 2003. The future for fisheries. Science 302:1359-1361.

Pew Oceans Commission. 2001. A dialogue on America's fisheries: Summaries of the Pew Oceans Commission focus group on fishery management. Pew Oceans Commission, Arlington, VA.
www.pewoceans.org or www.pewtrusts.org

*This document presents the viewpoints of individual fishermen from across the nation on various fisheries issues.*

McClanahan, T. and J.C. Castillo (eds.) 2007. Fisheries management: Progress toward sustainability. Blackwell Publishing, Oxford, UK. 352 pp.

*This text is a collection of case studies that describe solutions to fisheries issues around the world. Community-based fisheries, cooperative fisheries management and the future of sustainable fisheries are emphasized.*

Myers, R.A. and B. Worm. 2005. Extinction, survival or recovery of large predatory fishes. Phil. Trans. R. Soc. B 360:13-20.

Pikitch, E., et al. 2004. Ecosystem based fishery management. Science 305:346-347.

Tank, S. 2005. Seas of change: Ten recommendations for sustainable fisheries on the British Columbia Coast. David Suzuki Foundation. Vancouver, B.C. 6 pp.
www.davidsuzuki.org/oceans/fishing

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

Zabel, R.W. 2003. Ecologically sustainable yield. American Scientist 91:150-157.

## 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.*

*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.*