Comprehensive Resources for NCSR Marine Fisheries Series

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NCSR Marine Fisheries Series

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

1. *PowerPoint* Presentations

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

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

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

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

3. *Comprehensive Resources for NCSR Marine Fisheries Series*

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

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

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

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

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

4. Activity-based Instructional Modules

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

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

- The course in which the module will be used

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

- The background of the students

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

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

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

Comprehensive Resources for NCSR Marine Fisheries Series

This document is designed to provide instructors with additional lecture support on the topic of marine fisheries with an emphasis on those that are commercially harvested in the United States. Detailed summaries are provided for six commercial video productions 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*
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In addition, complete citations and brief summaries of web, print and video resources are provided that can be used to:

- Enhance existing lecture topics
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This document also provides a comprehensive glossary of terms commonly used in marine fisheries.

General Lecture Outline

This outline provides a sequential listing of topics covered in the *Marine Fisheries Overview* presentation as well as *Marine Fisheries – Introduction and Status (I-III)*; *Marine Fisheries - Causes for Decline and Impacts (IV-VI)*; and *Marine Fisheries - Management and Proposed Solutions (VII-X)*.

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

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 (eg., *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.

Coleman, F.C., et al. 2004. The impact of United States recreational fisheries on marine fish populations. Science 305: 1958-1960.

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.

Fuller, et al. 2008. How we fish matters: Addressing the ecological impacts of Canadian fishing gear. Ecology Action Centre (Halifax, Nova Scotia), Living Ocean Society (Sointula, B.C., MCBI (Bellevue, WA). 25 pp.
www.howwefish.ca

This document provides a detailed examination of bycatch and habitat impact of fishing gear that is used in Canadian waters.

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

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

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

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

Marine Conservation Biology Institute
www.mcbi.org

MCBI has several comprehensive resources on a number of marine conservation issues including the ecosystem effects of various fishing methods, bycatch, and the sustainability of fishing deepwater species.

Morgan, L.E. and R. Chuenpagdee. 2003. Shifting gears: Addressing the collateral impacts of fishing methods in U.S. waters. Island Press, Washington, D.C. 42 pp.
www.mcbi.org

This document provides a detailed examination of bycatch and habitat impact of fishing gear that is used in U.S. waters.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

This text evaluates many fisheries (as well as sealing and whaling) from a perspective that stretches back hundreds of years. Roberts claims that, "Modern oceans have been so vastly altered by overexploitation of fishes as to be barely recognizable semblances of their pre-exploitation states." Historical accounts by early explorers are used to establish a baseline for population levels in the historic past. Fisheries have now penetrated the deepest and most remote parts of the ocean thus driving stocks below any level of sustainability. The author claims that a fundamental shift is needed in the approach to fisheries management and ocean conservation. His proposed solution is to manage fisheries in a global network of marine reserves and protected areas, a radical departure from traditional fisheries management.

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

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

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

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

Safina, C. 1998. Song for the blue ocean: Encounters along the world's coast and beneath the seas. Henry Holt and Co., NY. 445 pp.

This resource examines fisheries resources in the Northeast, Pacific Northwest and the western Pacific Ocean.

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

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

SeaWeb
www.seaweb.org

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

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

The Sea Around Us Project
www.seaaroundus.org

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

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

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

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

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

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

A hardcopy version of the FAO report is also available:

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

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

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

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

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

Watling, L. and E. Norse. 1998. Disturbance of the seabed by mobile fishing gear: a comparison to forest clearcutting. Conservation Biology 12: 1180-1193.

This is one of the first comprehensive scientific examinations of the effects of fishing gear on marine habitats. The authors come to the conclusion that mobile fishing gear exceeds all other natural and human-caused disturbances on marine continental shelf and continental slope habitats.

II. Single-issue Resources

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 issue that is addressed.

The Importance of Marine Fisheries to Society

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

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

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

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

The Status of Marine Fisheries

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Causes for Fishery Declines

Blander, K.M. 2007. Global fish production and climate change. Proc. Nat. Acad. Sci. 104: 19,709-19,714.

Booth, W. 1994. Turning the tide on dwindling marine resources. Science 263: 25-26.

Bunce, M., et al. 2007. Shifting baselines in fishers' perceptions of island reef fishery degradation. Ocean and Coastal Management 51: 285-302.

This comprehensive study of an island coral reef fishery presents evidence of shifting baselines. Older fishers recalled a greater former abundance of fish and reported more fish species as depleted when compared to young fishers.

Fabry, V.J., et al. 2008. Impacts of ocean acidification on marine fauna and ecosystem processes. ICES Journal of Marine Science 65:414-432.

Fairlie, S., M. Hagler, and B. O'Riordan. 1995. The politics of overfishing. Ecologist 25: 46-73.

Hardin, G. 1968. Tragedy of the commons. Science 62: 1243-1248.

Jackson, J.B.C., et al. 2001. Historical overfishing and the recent collapse of coastal ecosystems. Science 293: 629-638.

Richardson, A.J. 2008. In hot water: zooplankton and climate change. ICES Journal of Marine Science 65: 279-295.

Roberts, C. 2003. Our shifting perspectives on the oceans. Oryx 37: 166-177.

Safina, C. 1995. The world's imperiled fish. Scientific American (Nov1995): 46-53.

Ecosystem and Community Impacts of Fishery Declines

Alaska Fisheries Science Center. 2007. Resources Assessment and Conservation Engineering National Marine Fisheries Service. NOAA Fisheries.
www.afsc.noaa.gov

This site includes a number of unique resources that instructors may find useful. Downloadable underwater video clips, for example will give students a bird's eye view of fishing gear in operation. Some video footage can be used to assess the impact of bottom trawls on benthic habitats as "trawled" and "un-trawled" areas are compared. The site also includes a photo gallery of fish species, which could be used in presentations.

Anderson, C.N.K., et al. 2008. Why fishing magnifies fluctuations in fish abundance. Nature 452: 835-839.

Dayton, P.K., S. Thrush and F. Coleman. 2002. Ecological effects of fishing in marine ecosystems of the United States. Pew Oceans Commission, Arlington, VA.
www.pewoceans.org or www.pewtrusts.org

Estes, J.A., M.T. Tinker, T.M. Williams and D.F. Doak. 1998. Killer whale predation on sea otters linking oceanic and nearshore ecosystems. Science 282: 473-476.

Frank, K.T., B. Petrie, J.S. Choi and W.C. Leggett. 2005. Trophic cascades in a formerly cod-dominated ecosystem. Science 308: 1621-1623.

Fuller, et al. 2008. How we fish matters: Addressing the ecological impacts of Canadian fishing gear. Ecology Action Centre (Halifax, Nova Scotia), Living Ocean Society (Sointula, B.C., MCBI (Bellvue, WA). 25 pp.
www.mcbi.org

Guinotte, J. and V.J.Fabry. 2009. The threat of acidification to ocean ecosystems. Journal of Marine Education 25: 2-7.

Hagler, M. 1995. Deforestation of the deep. Ecologist 25: 74-79.

Heithaus, et al. 2008. Predicting ecological consequences of marine top predator declines. TREE 23(4): 202-210.
http://wormlab.biology.dal.ca/ramweb/papers-total/Heithaus_etal_2008.pdf

Hsieh, C.H., et al. 2006. Fishing elevates variability in abundance of exploited species. Nature 443: 859-862.

McClenachan, L. 2009. Documenting loss of large trophy fish from the Florida Keys with historical photographs. Conservation Biology 23: 636-643.

Morgan, L.E. and R. Chuenpagdee. 2003. Shifting gears: Addressing the collateral impacts of fishing methods in U.S. waters. Island Press, Washington, D.C. 42 pp.
www.mcbi.org

Myers, R.A. and B. Worm. 2003. Rapid worldwide depletion of predatory fish communities. Nature 423: 280-283.

Myers, R. et al. 2007. Cascading effects of the loss of predatory sharks from a coastal ocean. Science 315 (5820): 1846-1850.
www.fmap.ca/ramweb/papers-total/Myers_etal_2007_Science.pdf
www.sciencemag.org/cgi/content/abstract/315/5820/1846?hits=10&RESULTFORMAT=&FIRSTINDEX=0&maxtoshow=&HITS=10&fulltext=myers+shark&searchid=1&resourcetype=HWCIT

National Academy of Science. 2002. Effects of trawling and dredging on seafloor habitat. Committee on Ecosystem Effects of Fishing. National Academy Press, Washington, D.C. 126 pp.

This comprehensive publication examines the current literature on the impacts of bottom fishing methods (trawling and dredging) on seafloor habitats. The report was driven by the need for a synthesis of available information on the topic. It has been proposed that these fishing activities may impede the recovery of fish stocks and impact biodiversity over the long run even if fishing effort is curtailed.

NRC. 2002. Effects of trawling and dredging on seafloor habitat. Committee on Ecosystem Effects of Fishing: Phase I. National Academy Press, Washington, D.C. 126 pp.

NRC. 2006. Dynamic changes in marine ecosystems: Fishing, food webs and future options. Committee on Ecosystem Effects of Fishing: Phase II. National Academy Press, Washington, D.C. 160 pp.

Pauly, D., V. Christensen, J. Dalsgaard, R. Froese and F. Torres. 1998. Fishing down marine food webs. Science 279: 860-863.

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

Stenseth, N.C. and T. Rouyer. 2008. Ecology: Destabilized fish stocks. Nature 452: 825-826.

Rapid variation in fish populations that are targeted commercially are undesirable both economically (lack of predictability in fishing income) and ecologically (wide fluctuations may increase the probability of local extinctions). This study by fishery biologists at Scripps Institution of Oceanography finds support for the hypothesis that the observed variability in fish populations is the direct effect of changes in age structure caused by fishing. Such fishing pressure affects fundamental demographic parameters such as age at maturation and population growth rate. There was also some support for the hypothesis that fisheries selectively remove large, older fish that are better able to survive hard times better than younger fish. When these demographic changes are environmental, recovery is possible. However, if these changes become evolutionary, and fishing creates selection pressures in favor of smaller, slower-growing fish, they may be permanent.

Tillin, H.M., et al. 2006. Chronic bottom trawling alters the functional composition of benthic invertebrate communities on a sea-basin scale. Marine Ecology Progress Series 318: 31-45.

Trippel, E.A. 1995. Age at maturity as a stress indicator in fisheries. BioScience 45(11): 759-771.

Trzcinski, M.K., R. Mohn and W.D. Bowen. 2006. Continued decline of an Atlantic cod population: How important is gray seal predation? Ecol. Applic. 16(6): 2276-2292.

Ward, P. and R. Myers. 2005. Shifts in open-ocean fish communities coinciding with the commencement of commercial fishing. Ecology 86: 835-847.
http://www.soest.hawaii.edu/pfrp/reprints/ecol_86_420_835_847.pdf

Worm B, Myers RA. 2003. Meta-analysis of cod-shrimp interactions reveals top-down control in oceanic food webs. Ecology 84: 162–173.
http://myweb.dal.ca/bworm/Worm%20_Myers_2003.pdf

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

Watling, L. and E.A. Norse. 1998. Disturbance of the seabed by mobile fishing gear: A comparison to forest clearcutting. Conservation Biology 12: 1189-1197.

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

Why Are Marine Fishery Declines Allowed to Occur?

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

Several recent studies, including this one and Myers and Worm, 2003 (cited below), have provided us with the "missing baselines" by which we can compare current population levels and thus get a more realistic picture of population trends.

Helmuth, L. 2008. Our imperiled oceans: Seeing is believing. Smithsonian Magazine Sept. 2008.
www.smithsonianmag.com/science-nature/seeing-is-believing.html

This brief article written for general audiences describes some of the "shifting baselines" work being done by the History of Marine Animal Population (HMAP) project (cited below). Several historical photographs of fish caught on charter boats based in Key West, Florida are shown to illustrate.

History of Marine Animal Population (HMAP)
Census of Marine Life
www.hmapcoml.org

This program attempts to document historical population levels of marine organisms for comparison with current levels. Several photographs are available that can be used to illustrate "baseline levels" for marine fish.

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

Myers, R.A. and B. Worm. 2003. Rapid worldwide depletion of predatory fish communities. Nature 423: 280-283.

Pauly, D. 1995. Anecdotes and the shifting baseline syndrome of fisheries. Trends in Ecology and Evolution 10: 430.

This brief article by Daniel Pauly is the first description of shifting baselines syndrome as it applies to fisheries.

Sàenz-Arroyo, A., et al. 2005. Rapidly shifting environmental baselines among fishers in the Gulf of California. Proc. Biol. Sci. 272: 1957-1962.
www.pubcentral.nih.gov/articlerender.fcgi?artid=1559885

This is an easily readable article describing some recent research that quantifies the shifting baselines phenomenon among fishers in the Gulf of Mexico. It would be a good selection to assign for student reading.

Safina, C. 1995. The world's imperiled fish. Scientific American (Nov1995): 46-53.

Shifting Baselines
www.shiftingbaselines.org

The web site provides a description of the "shifting baselines" phenomenon and also includes an amusing video ("Fish Story") that students may enjoy.

Sumaila, U.R., et al. 2008. Fuel price increase, subsidies, overcapacity, and resource sustainability. ICES Journal of Marine Science 65: 832-840.

United Nations Food and Agricultural Organization (UN FAO)
www.fao.org/sof/sofia/index_en.htm

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. Species-specific Resources

A number of excellent accounts of single species have been published in recent years. They cover biological, economic and social aspects of the management of these commercially-important species.

Atlantic cod resources

ARKive – Images of Life on Earth
http://www.arkive.org/species/ARK/fish/Gadus_morhua

This is a good resource for video and still images of Atlantic cod.

Christensen, V., et al. 2003. Hundred-year decline of North Atlantic predatory fishes. Fish and Fisheries 4: 1-24.

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.

*Dybas, C.L. 2006. Ode to a codfish. BioScience 56(3): 184-191.

This is an excellent summary of the story of the Atlantic cod and is suitable to assign as student reading.

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, Atlantic cod, Patagonian toothfish and Atlantic salmon.

Frank, K.T., B. Petrie, J.S. Choi and W.C. Leggett. 2005. Trophic cascades in a formerly cod dominated ecosystem. Science 308: 1621-1623.

Fuller, S.D. and R.A. Myers. 2004. The Southern Grand Bank: A marine protected area for the world. World Wildlife fund Canada. 99 pp.

Hannesson, R. 1996. Fisheries mismanagement: The case of the North Atlantic cod. Blackwell Scientific Publications. Oxford, UK. 160 pp.

Harris, M. 1999. Lament for an ocean: The collapse of the Atlantic cod fishery - a true crime story. McLelland and Stewart, Inc. Toronto, Ontario. 389 pp.

Hsieh, C.H., et al. 2006. Fishing elevates variability in abundance of exploited species. Nature 443(7113): 859-862.

Hutchings, J.A. and R.A. Myers. 1994. What can be learned from the collapse of a renewable resource – Atlantic cod, *Gadus morhua*, of Newfoundland and Labrador? Canadian Journal of Aquatic Sciences 51(9): 2126-2146.

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

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

Kurlansky, M. 1997. Cod- A biography of the fish that changed the world. Penguin Books, New York. 294 pp.

Mackenzie, B.R. and D. Schiedek. 2007. Daily ocean monitoring since the 1860s shows record warming of northern European seas. Global Change Biology 13: 1335-1347.

Mackenzie, B.R. et al. 2007. Impact of 21st century climate change on the Baltic Sea fish community and fisheries. Global Change Biology 13: 1348-1367.

Warming of the Baltic Sea is documented in the first paper above. The second paper predicts an impact on fisheries in the Baltic Sea due to increased temperature and decreased salinity. Marine species will be most affected. Fishing fleets target marine species and will likely have to relocate or target those species that can tolerate lower salinity. The Baltic cod population is expected to collapse due to current fishing pressure and the temperature and salinity changes described above.

MarineBio
http://marinebio.org/species.asp?id=206

Description of Atlantic cod biology including behavior, life history, and conservation status. Links to images and video are also provided.

Mayo, R. and L. O'Brien. 2006. Atlantic cod – Status of Fisheries off the Northeastern U.S. NOAA. Northeast Fisheries Science Center. Woods Hole, MA.
www.nefsc.noaa.gov/sos/spsyn/pg/cod/

Myers, R.A., et al. 1997. Why do fish stocks collapse? The example of cod in Atlantic Canada. Ecol. Applic. 7: 91-106.

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

NEFSC. 2005. Assessment of 19 Northeast groundfish stocks through 2004. Northeast Fisheries Science Center Reference Document 05-13. Woods Hole, MA.
www.nefsc.noaa.gov/groundfish/#gs

NEFSC. 2008. Brief history of the groundfishing industry of New England. NOAA. Northeast Fisheries Center. Woods Hole, MA.
www.nefsc.noaa.gov/history/stories/groundfish/grndfsh1.html

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 (including Atlantic cod).

Righton, D., J. Metcalfe and G. Rose (eds.) 2009 (in prep.) Cod. Blackwell Publishing, Oxford, UK. 352 pp.
www.blackwellfish.com

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. Historical accounts by early explorers are used to establish a baseline for population levels in the historic past. Chapter 15 is dedicated to Atlantic cod.

Rose, G.A. 1993. Cod spawning on a migration highway in the northwest Atlantic. Nature 366: 458-461.

Rose, G. A. 2007. Cod: the ecological history of the North Atlantic fisheries. Breakwater Books, Ltd. St. John's, Newfoundland. 580 pp.

Rose, G.A. and R.L. O'Driscoll. 2002. Capelin are good for cod: can the northern stock rebuild without them? ICES Journal of Marine Science 59: 1018-1026.

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

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.

Swain, D.P., et al. 2007. Evolutionary response to size-selective mortality in an exploited fish population. Proc. Royal Society of London B 274: 1015-1022.

Trippel, E.A. 1995. Age at maturity as a stress indicator in fisheries. BioScience 45(11): 759-771.

Trzcinski, M.K., R. Mohn and W.D. Bowen. 2006. Continued decline of an Atlantic cod population: How important is gray seal predation? Ecol. Applic. 16(6): 2276-2292.

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.maweb.org

Valiela, I. 2006. Global coastal change. Blackwell Publishing, Oxford, UK 368 pp.

The fisheries chapter includes a good description of Atlantic cod history, management and the current situation.

Species other than Atlantic cod

Brooks, C. 2008. The most remote fishery on earth. Ice stories: Dispatches from polar scientists.
http://icestories.exploratorium.edu/dispatches/the-most-remote-fishery-on-earth/

This is a general account of the toothfish fishery as reported by a fisheries biologist conducting research on the species.

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.

Ellis, R. 2008. The bluefin in peril. Scientific American (March 2008): 71-77.

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

In addition to addressing most marine fisheries issues, this videotape also provides useful case study information for the following species:

- *Cod and haddock on Georges Bank off the New England coast*
- *Swordfish in the western and eastern Atlantic Ocean*
- *Bluefin tuna*
- *Salmon and Pacific halibut in the Gulf of Alaska*

Franklin, H.B. 2007. The most important fish in the sea – menhaden and America. Island Press, Washington, D.C. 253 pp.

This book examines the coastal role of menhaden, a small, oily pelagic fish food along the eastern seaboard. Menhaden are an important food source for predatory fish such as striped bass and bluefish. They also are filter feeders of phytoplankton and algae.

Levy, S. 2007. Cannery Row revisited. BioScience 57: 8-13.

This is a brief account of the decline of the Pacific sardine chronicled in John Steinbeck's, Cannery Row.

Lichatowich, J. 1999. Salmon without rivers - A history of the Pacific salmon crisis. Island Press, Covelo, CA 336 pp.

National Environmental Trust
www.net.org/council/

This site provides brief case histories for bocaccio, Atlantic cod and Red snapper including time series population graphs.

Russell, Dick. 2005. Striper wars: An American fish story. Island Press/Shearwater Books. Washington, D.C. 358 pp.

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 text is an examination of fisheries issues in the Northeast, the Northwest and the western Pacific Ocean by one of the most prominent fisheries scientists in the U.S.

IV. 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

V. 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.*

A Sheltered Sea – The Journey of the California Marine Life Protection Act. 2008. The Baum Foundation. 23 min.
www.thebaumfoundation.org
Distributed by Coyote Films
www.coyotefilms.net

This short film describes the establishment of a network of marine reserves off the California Coast beginning with the passage of the California Marine Life Protection Act in 1999. The rationale behind the network and its design are discussed as well as some of the controversy it generated. The viewpoints of major stakeholders are provided. The video will be of particular interest to those who teach in California, but the issues discussed are relevant to marine reserves anywhere.

A Sheltered Sea – The Southern Passage. 2009. The Baum Foundation. 25 min.
www.thebaumfoundation.org
Distributed by Coyote Films
www.coyotefilms.net

This film is a companion to the one described above. It provides more detail on the rationale for establishing a network of marine reserves off the southern California Coast. Interviews and historical photos are used to document the abundance of marine life in the past, which is then compared to the current condition. The importance of kelp forests as a diverse habitat supporting fish, marine mammals and marine invertebrates is illustrated with video of excellent quality. Although the film clearly supports the establishment of marine reserves, several different viewpoints are presented.

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 THIS MODULE.

Deep Sea Conservation Coalition
www.savethehighseas.org

The DSCC is an international coalition of conservation organizations working together to protect seamounts, cold-water corals and vulnerable deep sea ecosystems. The group has called upon the United Nations General assembly to adopt a resolution declaring an immediate moratorium on high seas bottom trawling. Their web site provides a number of resources that illustrate the effects of bottom trawling.

A deep sea photo gallery includes some before- and after-trawling photos and a video available at www.savethehighseas.org/video.cfm provides an overview of bottom trawling impacts.

The following short videos are also available:

- "Deep Sea Destruction" (4 minutes)

Bottom trawling in the North Atlantic and Tasman Sea (New Zealand) is illustrated in this 2004-2005 narrated video. Footage from a number of sources including Greenpeace is included.

- *Oceana* footage of impacts of bottom trawling using a net-mounted video (42 seconds)

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 THIS MODULE.

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

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

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

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

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

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

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 THIS MODULE.

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.

Marine Conservation Biology Institute
www.mcbi.org

See "Photo Library"→ "People"→ Effects of Trawling videos (Aleutian Islands, Alaska):
1. Untrawled reefs in Alaska
2. Trawled coral and sponge habitat in Alaska

These two short (30 sec.) videos recorded by NOAA show a comparison of trawled and untrawled bottom habitats off the Alaska coast.

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 THIS MODULE.

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 THIS MODULE.

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.

Detailed notes and student handouts on video resources

This section provides detailed notes on commercial video productions that illustrate various marine fisheries issues. Approximate elapsed time is given in minutes at the beginning of each section to facilitate the selection of excerpts or other planning. For some resources, following the summary, a student handout is provided that can be used to focus student attention on key issues.

1. EMPTY OCEANS, EMPTY NETS VIDEO

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

An abridged version that includes excerpts from *Empty Oceans, Empty Nets* is also available. It is 15 minutes long and entitled, *The Seafood Story*.

SUMMARY OF "EMPTY OCEANS, EMPTY NETS" VIDEO

Introduction
0:00

- In fishing communities around the world - from Senegal to Indonesia to Massachusetts fewer fish are being caught with more fishing effort.
- Most life in oceans is along shores - continental shelves
- Improved technology has resulted in increased catch rates
- Collapse of several marine fish stocks has resulted
- Overall catches have declined since the 1980s
- Larger fish disappear resulting in more effort on smaller species ("fishing down the food web")
- Approximately 20 million metric tons of bycatch is discarded each year (approximately equal to four times the total U.S. fleet catch). Shrimp trawling, for example, lands 5 pounds of bycatch for every 1 pound of shrimp.
- In tropics, cyanide and dynamite are used as a fishing method (especially around coral reefs)
- Population growth drives overfishing everywhere especially in Africa and Asia
- Japan, U.S. and Europe have become net importers of fish
- International fishing fleet has more than twice the capacity to fish the ocean in a sustainable manner
- Marine ecosystems are being altered as they have not been in the last 3.5 billion years on Earth.

Georges Bank off New England Coast, United States - Cod and Haddock Fishery

- Cod and haddock played an important historical role in the economic development of the region
- Dory fisherman (wind powered) came first
- Followed by technological improvements including sonar, engine-powered boats
- 1960s - international fishing in the region was intense
- 1976 - in response, the "200 mile limit" was established resulting in an increase in the number of domestic fishing vessels
- This increase was supported by government subsidy
- Resulted in record volumes of cod and haddock landings
- From 1976 to 1985 population declines became apparent
- New England Fisheries Management Council - sets "Total Allowable Catch" (TAC). Most members of the council are fishing industry representatives; therefore, the industry is largely self-regulated
- Is this in long-term interest of the fishery?
- "Maximum benefit to the nation" philosophy of New England Fisheries Management Council has led to demise of stocks
- Important to realize that these fish stocks are <u>public</u> resources
- Those who stay in the business invest in larger and more efficient boats - a trend that leads to more overfishing

"Overfishing happens because all of the incentives are there for it to happen" Suzanne Iudicello

0:20

- Climate change and ocean conditions also influence abundance of fish stocks
- May result in fluctuations in abundance of plankton
- Fishing removes larger fish with greater reproductive capacity
- We have made the environment more susceptible to change
- Sustainable Fisheries Act of 1996 was passed to address overfishing by identifying endangered stocks and reducing bycatch, but law has yet to be fully implemented
- Act requires identification and protection of habitat essential to healthy fish populations
- Intact ecosystem on sea floor is essential to juvenile fish
- Bottom trawling gear (trawler doors and rock hoppers) removes sea floor structure for juvenile cod
- Fish biologists think that we should not be allowing this practice "everywhere" and areas should be established where this type of fishing is not allowed (marine reserves)

0:27

- Marine reserves have been shown to restore fish populations
- Fish grow larger resulting in greater reproduction
- Overflow from reserves serves surrounding fishing grounds
- Rod and reel fishermen create no disturbance of habitat and command a higher price for their product due to quality of fish

0:30

Swordfishing

- Techniques include harpooning and longlining (developed in the 1960s)
- Fishermen claim "There's plenty of fish" but biologists ask, "Compared to what?"
- Swordfish travel long distances
- Catches reflect an average decline in size to now include juveniles that have not yet reached reproductive age.
- Sixty miles of baited hooks harvest millions of tons of tuna and swordfish
- Advanced technology includes GPS, temperature probes, acoustic technology
- Longline method is described
- In past, places that we didn't fish fed those areas we did
- Bycatch includes:
    - Marlin - include the most depleted of large fish in the Atlantic Ocean
    - Sea turtles - endangered worldwide
- Because swordfish migrate across the Atlantic, they are hunted by an international fleet
- Off the northwest coast of Africa swordfish caught by Spain enter the American market
- Japanese longlines catch tuna, marlin, swordfish and shark

0:45

Bluefin Tuna in Mediterranean

- Tonnara fish trap and ceremony, a 1000-year tradition, are described
- Seafood is a global commodity, therefore it is difficult for consumers to know whether or not the resource they purchase is being overfished
- Anchovy Fishery - briefly described

Gulf of Alaska - Salmon and Pacific Halibut

- One of the best examples of a sustainable fishery
- In earlier times, fishery was open access and an unlimited number of boats were involved in "derby fishing"
- At start of brief season all boats, regardless of weather, would race to fishing grounds to catch as many as possible in shortest amount of time.
- Ineffective resource management and not safe for fishermen
- Now, fishery is a "closed fishery." Individual Fishing Quotas (IFQs) are established (a pound limit for each licensed boat). These IFQs can be bought and sold like private property

0:52

- In the 1950s the salmon fishery was on the brink of collapse; fish traps were very efficient in capture of salmon runs
- In 1953, Alaska was declared a federal disaster area due to salmon population declines
- Now, greater escapement is allowed and the fishery is a limited entry fishery with only a limited number of licenses issued (like halibut fishery)
- Also, there are restrictions on amount of gear per vessel (purse seine, in this case)

0:55

Solutions

- "Charlie the Tuna" commercial touting "Dolphin-safe tuna"
- The Marine Stewardship Council certifies well-managed fisheries ("sustainably-caught fish")
- Also, chefs assist by selecting fish products only from sustainable fisheries
- Consumers want to know source of fish products. Seafood guides have been prepared for consumers so those who desire can make appropriate purchase decisions
- Aquaculture has the potential to take some pressure off of wild stocks. However, some farmed fish consume more resources than they create because they are fed fish meal pellets.

0:60

- Sound bites from various experts – perhaps a bit “preachy”
- Oysters, mussels, tilapia and catfish do not require fish meal to feed them and would seem to be better choices.

END

STUDENT HANDOUT

"Empty Oceans, Empty Nets"

This videotape explores the issue of declining marine fisheries. Causes, consequences and solutions are described for commercially harvested fish populations across the globe. The viewpoints of commercial fishermen, fisheries biologists, fisheries managers, merchants and concerned citizens are illustrated. The following major fisheries are emphasized:

- Cod and haddock on Georges Bank off the New England coast
- Swordfish in the western and eastern Atlantic Ocean
- Bluefin tuna
- Salmon and Pacific halibut in the Gulf of Alaska

As you watch the videotape you should focus on the following central questions:

1. What are the various factors that contribute to the decline of fisheries?

2. What are the various consequences of overfishing?

3. What steps have been taken to address the decline of various fisheries?

TERMINOLOGY:

You should be familiar with the following terms introduced in the videotape:

bycatch

sustainable fishery

total allowable catch (TAC)

New England Fishery Management Council

overfishing

Sustainable Fisheries Act

bottom trawling

marine reserves

longliners

harpooners

purse seiners

Tonnara fish traps

open access fishery

closed access fishery (="limited entry fishery")

individual fishing quota (IFQ)

escapement

Marine Stewardship Council

aquaculture

derby fishing

KEY TO TERMINOLOGY FROM “EMPTY OCEANS, EMPTY NETS” VIDEO

bycatch - capture of non-target fish or other marine animals in fishing gear

sustainable fishery - a fishery that does not harm the long-term condition of the fish stock

total allowable catch (TAC) - a weight or number limit of fish that can be harvested; once this limit has been reached, harvesting is stopped; limits usually established by a governing body such as a management council or federal agency

New England Fishery Management Council - governing body for New England Marine fisheries; establishes regulations, quotas, etc.

overfishing - harvest exceeds the natural rate of replacement resulting in a decline of the fish stock

Sustainable Fisheries Act - federal legislation passed in 1996 that attempts to address overfishing in the United States

bottom trawling - fishing method in which a weighted net is drawn behind a fishing vessel; used to capture groundfish (e.g., cod, haddock) and flatfish (e.g., flounder, sole)

marine reserves - conservation areas in which fishing is limited or prohibited

longliners - fishing vessels that use many baited hooks suspended from sometimes miles-long lines to capture fish; particularly common for tuna and swordfish but can be adapted for other species

harpooners - fishing vessels that use harpoons to capture large basking fish such as swordfish

purse seiners - fishing vessels that use a weighted net whose ends are drawn together much like a purse string to capture fish; typically used for pelagic fish such as herring and tuna

Tonnara fish traps - a traditional Japanese method of capture of tuna that guides fish into an elaborate system of nets

open access fishery - a fishery in which the number of licenses and or boats involved in the fishery is not limited

closed access fishery (="limited entry fishery") - a fishery in which the number of licenses and or boats involved in the fishery <u>is</u> limited

individual fishing quota (IFQ) - a limit on the number or weight of fish that can be harvested by a given vessel

escapement - those fish that are not captured by a given fishing method; some methods (e.g., increased mesh size in nets) are designed to increase escapement as a conservation method

Marine Stewardship Council - a non-governmental body that establishes sustainable certification criteria for a particular fishery

aquaculture - the cultivation of fish and other marine organisms for production; "fish farming"

derby fishing - a concentrated fishing effort in a limited time frame often due to a TAC-regulated, open fishery; fishermen race to capture as much as possible of their quota as quickly as possible

2. FARMING THE SEAS VIDEO

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 in minutes at the beginning of each section to facilitate the selection of excerpts or other planning.

SUMMARY OF "FARMING THE SEAS" VIDEO

Introduction
0:00

- Approximately one-third of all seafood consumed globally is raised in farms and cages.
- Increases production of these commodities but also creates some health and environmental concerns.
- Declining native fish stocks created the impetus for fish farming (**aquaculture**), which has been called the "Blue Revolution"
- 90% of large, predatory fish in oceans are gone and this depletion has occurred in a relatively short time
- Most farmed fish are fed other fish, so there is still pressure on wild fish.

0:05
Salmon Aquaculture - British Columbia, Canada

- Wild salmon declines occurred due to a number of factors
- New global industry has been developed based on farming salmon
- British Columbia is the biggest producer of farmed salmon in floating net cages
- The need for jobs must be balanced against the potential for environmental impact
- What is the impact of escaped farmed salmon on wild species?
- Most farmed salmon are Atlantic salmon (not native to western Canada)
- Over 1 million have already escaped in British Columbia and Washington and are now sometimes caught by commercial fisherman.

0:10

- Origins of salmon aquaculture are in Norway – 1970
- Parasites from these fish spread from farmed salmon to native species and in one case an entire watershed had to be poisoned to eliminate the threat.
- Diseases may also be transmitted from farmed to wild salmon (e.g. major outbreak in 1975 in Norway):
    - "Sockeye Disease" - viral disease of salmon
    - Transmission under high densities more likely
    - Industry now manages diseases with vaccinations reducing antibiotic use
- Sea lice are lethal to juvenile fish which pick up these parasites as they swim by fish farms
- Industry attempts to keep sea lice controlled in farmed salmon
- In Scotland, wild fish have been impacted by sea lice from farmed fish

0:15

- Tanks on dry land may serve as a safer, alternative method
- Less crowded densities also improves health – no major disease outbreaks
- Feed pellets are made from fish meal and fish oil
- One pound of salmon requires 3 pounds of food made from fish

0:20

- Food Safety and Environmental Issues:
    - High contamination levels in feed fish
    - PCBs (Polychlorinated biphenyl) and dioxins are suspected carcinogens and exposure to fetus may decrease IQ
    - Color is added dye - consumer concerns
    - Genetic modification of salmon to increase growth rates (not yet in markets)
    - Concerns for human health effects of consuming genetically modified salmon and ecosystem impacts of escaped fish (interbreeding with wild fish)
- David Suzuki asks, “What’s the rush?”

0:25

Aquaculture in China

- China is the birthplace of aquaculture, driven by overfishing of wild fish
- Carp have been farmed in polyculture with four different types of carp raised (phytoplankton feeders, zooplankton feeders, herbivorous grass carp and bottom-dwelling, detritus feeders)
- Waste products from these operations are used to fertilize fields
- Clams and oysters have less environmental impact due to filter feeding and lower trophic level
- Seeding with clam and oyster post-larvae in coastal areas is used in production
- With increasing wealth in China, recent efforts have emphasized shrimp farming

0:30

Shrimp Farming in Thailand

- The recent development of shrimp farming has been driven by demand for this preferred food in U.S. and Europe
- 2/3 of shrimp are caught by trawlers (5 pounds of bycatch for every 1 pound of shrimp)
- Some trawlers have excluder devices that reduce bycatch of sea turtles (but not all nations)
- 1/3 of shrimp are farmed, most in tropical countries (with few environmental or labor regulations)
    - target markets in U.S., Japan and Europe (vs. native countries)
    - purpose of agriculture in these countries has become to feed rich countries
    - operations transform coastal ecosystems (mangrove forests)
- Mangrove forests are breeding grounds for many fish and shellfish species

0:35

- Ecosystem was first impacted by charcoal industry and more recently by shrimp aquaculture
- There are 30,000 shrimp farms in Thailand alone
- Exponential growth of shrimp farms since mid-1980s has only recently stopped
- Provides economic opportunity but also brings a "way of life" to an end
- Waste from these farms goes into the sea and contaminates traditional fishing grounds
- Use of antibiotics is added to shrimp feed to control disease - can create antibiotic-resistant bacteria, which can pose a threat to human health
- Also, waste from these operations can contaminate aquifers and drinking water supplies for humans
- Water filtering function of mangrove forests and swamps is removed
- Some recent efforts have been made to make shrimp farming operations more sustainable in Hawaii

0:40

Bluefin tuna aquaculture in Spain

- Large enclosures are used to cage, feed and fatten wild-caught Bluefin tuna
- Fresh tuna has become a valuable commodity due to demand for sushi (tens of thousands of dollars per fish in some cases)
- Results in increased pressure on wild fish but these fish are <u>not</u> counted toward Total Allowable Catch
- Food to feed tuna is the limiting factor (anchovy and sardines)
- Operation is not sustainable in the long run
- 10-17 pounds of food required per 1 pound of tuna
- Pacific bluefin tuna are being farmed in Mexico in a similar operation

0:45

Offshore Aquaculture

- A new type of ocean fish farming in which offshore waters are leased to place submerged net cages
- Potential being explored by NOAA Fisheries for U.S.
- Concerns center on escape, disease and feeding carnivorous species
- New environmental standards will probably have to be established
- What are the most appropriate candidates for aquaculture?
- Oysters, clams and herbivorous fish (e.g., carp and tilapia) are probably the best choices
- Tilapia, for example, can be raised on plant-based food
- Also, in Mississippi Delta, catfish are farmed and food contains only 1-2% fish meal (versus 14% previously)
- This has made the product more affordable and decreased the environmental impact

0:50

- Shellfish are generally more appropriate than carnivorous fish for aquaculture operations
- 80% of shellfish produced today globally are farmed (e.g., Pacific Northwest and Mediterranean coast of France)
- Shellfish also improve water quality since they are filter feeders
- Marine Stewardship Council (MSC) certifies aquaculture operations and identifies sustainably-produced products
- Seafood guides inform and direct consumers toward more sustainable products
- Role of consumers and chefs in restaurants is discussed
- The American consumer would like to know where their food comes from
- Puts more pressure on retailers, wholesalers and producers
- Wild-caught fish can no longer keep up with demand for seafood
- Aquaculture can meet this increasing demand, <u>if</u> it is done well

0:56

END

STUDENT HANDOUT

"Farming the Seas"

This videotape explores the benefits and challenges of aquaculture ("fish farming") as a method for addressing increased global demand for seafood. Aquaculture is seen by some as way to reduce fishing pressure on declining stocks of wild-caught fish. However, marine biologists suggest caution as aquaculture operations can introduce new environmental impacts and some human health effects. The viewpoints of marine biologists, industry representatives, and consumers on the issue are illustrated. Aquaculture operations from around the globe are described including the following:

- Salmon aquaculture in British Columbia, Canada
- Carp aquaculture in China
- Shrimp farming in Thailand
- Bluefin tuna "ranching" in Spain
- Shellfish and offshore aquaculture in the U.S.

As you watch the videotape you should focus on the following central questions:

1. What benefits are provided by aquaculture in meeting the increasing demands for global food production?

2. What are the various environmental impacts of aquaculture?

3. Why does the choice of species being farmed influence the potential for environmental impact?

4. What are the potential human health and social impacts of large-scale aquaculture operations?

5. What changes in aquaculture operations would you offer that would make them a more sustainable alternative to fisheries based on wild-caught fish?

3. *DEEP CRISIS* VIDEO

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.

The notes that follow provide a summary of the content of the *Deep Crisis* video production. Approximate elapsed time is given in minutes at the beginning of each section to facilitate the selection of excerpts or other planning.

SUMMARY OF "*DEEP CRISIS"* VIDEO

Introduction
0:00

- Salmon and tuna are emphasized
- Distinction between wild caught and farm-raised fish
- Bluefin tuna are wide-ranging and difficult to study
- Increased demand by consumers (5X since 1950) drives fishing pressure on stocks

Pacific Salmon

- McNary Dam on Columbia River constructed in 1953
- Unlike the past, hydroelectric dams now consider fish passage in their operation
- Salmon smolts tagged and put through turbines to determine survivability
- Turbine speeds can be adjusted to minimize fish losses

0:05

- Spillway design also minimizes harm to fish
- Water below dam can become supersaturated with nitrogen creating a bends-like condition in fish
- Changes in dam structure is designed to minimize loss due to N-saturation
- Salmon life history described
- Over 50% of Columbia River salmon stocks are now extinct
- Historic causes for decline are illustrated as "America's conquest of the Columbia" – overfishing, logging, hydroelectric dams

0:10

- Fish hatcheries were built to compensate for losses due to historic causes
- Over 100 hatcheries now exist in Columbia River Basin
- Wild fish survive better than hatchery fish in both rivers and in the ocean
- Columbia River is slowed due to the dams
- Screens and diversions around the dam designed to assist smolt passage through dams – an expensive technology ($17 million at McNary Dam alone to put in smolt collection system)

0:15

- Smolt collection system detects PIT tags and diverts fish
- Tag is then read and recorded by a computer
- There are 26 endangered stocks of salmon in the Columbia/Snake River system
- Each dam causes 10% loss of smolts

0:20

- Electroshocking is used to capture potential smolt predators to evaluate this source of mortality
- Shad and walleye (a salmon predator) are captured and stomach contents of walleye are collected and evaluated
- Within dam, adult populations are monitored at counting window
- Two-thirds of adults are hatchery fish which may interbreed with wild fish
- It is important to preserve the diversity of salmon stocks as insurance against environmental change

0:25

Atlantic Salmon - "Down East – The Extinction Vortex"

- Atlantic salmon in Northeast face extinction
- Only 8 Maine rivers support wild fish
- Species was once abundant north of the Hudson river
- Logging, over-harvest, agriculture and water pollution all contributed to the decline
- Similar events occurred in Europe
- Acoustic transmitters are implanted in smolts to track migration

0:30

- Life history of the species is not well-known
- High mortality rates of smolts may be due in part to acid rain in Northeast
- Preserving unique stocks with unique local adaptations is important
- Captive breeding program using only wild fish from within the same stock are used to boost numbers (this was not done with Pacific salmon, thus mismatches were created)
- Tanks for raising fry are shown
- Spring fry stocking in Machias River as one example of stocking of about one million fry per year (in 6 Maine rivers) is shown
- Fry stay in river for 2 years and then exit river system for feeding grounds off Greenland; two years later they return to spawn as adults in original river

0:35

- Surveys for returning adults are conducted by counting "redds" – gravel disturbed by females to lay eggs
- Consumer demand for salmon met in part by farmed salmon
- Norway and Scotland account for about 80% of farmed salmon
- Maine also farms salmon but on a smaller scale
- Farmed salmon pose potential hazards to wild salmon
- Wild fish that pass near salmon farming operations ("salmon pens") carry a higher parasite load (sea lice)
- Also, escapes from pen-raised salmon may occupy same rivers as wild salmon and interbreed with them
- Extent of escaped farmed salmon in natural rivers is being studied in Norway using video in rivers to identify abundance of wild and farmed fish
- Silhouettes are compared to theoretical "wild" and "farmed" shapes using computer technology (98% accuracy)
- Some Norwegian streams get 90% farmed fish
- Genetic swamping (between wild and farmed fish) is a major concern in Maine

0:40

Bluefin Tuna – "Rocking the Bluefin Boat"

- Gloucester, Massachusetts recreational and commercial fishery for bluefin tuna
- Fish may grow up to 1500 pounds – very high value for sushi (tens of thousands of dollars per fish)
- Eastern Atlantic population in Mediterranean region (Sardinia) has long history of exploitation
- Pop-up tags are fixed to dorsal area of line-caught fish and used to monitor tuna movement
- Both recreational and commercial fishermen cooperate in tagging program
- Aerial surveys of tuna from airplanes resulted in upwards adjustments to estimated tuna population

0:45

- Bluefin tuna travel 24-30 miles per day and spend only about 10% of their time at the surface where they can be detected. This suggested that populations had been underestimated.
- Commercial harvest is usually by purse seine
- Western Atlantic bluefin harvest is probably now at a sustainable level
- Mediterranean fishing is probably not sustainable
- Tagging data suggest that these are not separate populations
- Tuna travel across the Atlantic and intermix
- Therefore, western Atlantic conservation efforts may be thwarted by harvest in eastern Atlantic
- This has political implications

0:50

- Tagged individuals that should be breeding are often detected in non-spawning areas during the spawning season. Thus, Bluefin tuna may also have an undiscovered spawning area or they do not breed every year. Requires further research.

0:55
END

4. STRANGE DAYS ON PLANET EARTH *(EPISODE #3) VIDEO*

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

NOTES FROM VIDEO
(this segment is approximately 20 minutes long)

- Marine predators are not as well-studied as freshwater and terrestrial predators. Do predators of the ocean control the marine ecosystem? Can missing predators be brought back? Research is underway.
- Discovery Bay, Jamaica in the 1970s - coral reefs were intact:
    - Top predators – sharks, snappers, groupers, jacks
    - Herbivores – surgeon fish, parrot fish and other herbivorous fish
- Current coral reefs are dying – covered/smothered with algae. Why?
- Researchers are looking at the geology of reefs to see if this has happened before. By coring sections of the reef, a 1000-year record of reef composition is obtained. Until 1980, the reef is healthy for 1000 years. Then, algae take over. Coral stops growing – something has happened in the last few decades.
- Is pollution the cause? Apparently, water quality is not an issue here.
- Daniel Pauly, a fisheries biologist with the University of British Columbia, looks for an alternative explanation in the fish market. Only small fish are available for sale in the Jamaican fish market. With the lack of large, predatory fish, small fish are now considered normal. This is an example of "shifting baselines."
- The impact of fishing is described – 90% of large fish have been eliminated in the last 40-50 years. Big groupers were the first to disappear. Until the 1970s off-shore banks were rarely fished. By "fishing down the food web" first predators are depleted, then herbivores (grazers) which, would ordinarily keep algae in check. Only urchins remained and when disease eliminated the urchins, algae populations increased.
- On St. Lucia coral reefs are healthier.
- Fishermen must travel further now to find large fish at greater risk to themselves.
- Will big fish ever return to the closer reefs?
- Jamaican government supported a new experiment that began in the mid-1990s. Marine reserves – a network of zones closed to fishing – were established and monitored. Prior, fish always had natural refuges because most fishing gear could not reach them. But, with improved technology these natural refuges disappeared. Scientists are monitoring the ecosystem in marine reserves and looking for interactions among species.

- Smaller predators are returning and some fish populations have tripled in a few years; large groupers are returning. Beyond the boundaries of the marine reserves, fishermen are catching some large fish.
- Predators are a force that keep ecosystems strong. Long ago, we had an “us vs. them” mindset. Now we are asking, “Can we live without them?”

5. STRANGE DAYS ON PLANET EARTH *(EPISODE #5) VIDEO*

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

NOTES FROM VIDEO
(this segment is approximately 60 minutes long)

0:00

- 90% of large predatory fish are gone
- Catch of fish has resulted in a cascade of events
- Ghana, Africa – story starts in the "bush" – antelopes start to disappear
- Grasslands are "devoid of life" – elephants, antelope, hippos, leopards, hyenas, wild dogs, warthogs, lions all declining
- Savanna looks intact, but occupants have changed
- In contrast, olive baboons are abundant; aggressive omnivores that perform nighttime raids on farms attacking livestock.
- There are both direct and indirect (disease incidence and education of children) effects
- Wildlife Division archives used as a source of historical information
- Records since the 1960s of wildlife patrols are kept species by species
- Declines documented – Elephants (70%), hippo (50%), lions (80%)
- Some question whether these populations are viable

0:10

- As large predators have declined, baboon numbers increase and they become more aggressive
- Where did the animals go? Bush meat hunting in protected areas is contributing to declines
- Bush meat is an important source of protein for people
- Hunters and rangers are in constant conflict
- Intense hunting is the main driver of wildlife declines but there is large variation from month to month
- What accounts for this variation?
- Fish are critically important to the economy and diet of Ghana. Are variations in fish populations and hunting intensity correlated?
- A 30-year record of both fish supply and large predator hunting is available and finds that:
    - as fish numbers increase there is less hunting and wildlife numbers increase
    - as fish numbers decline hunting increases and wildlife declines

0:20

- 16 rural, local markets were examined each week for the amount of fish and bush meat available for sale.
- A direct relationship was established. When fish are scarce they become more expensive and more bush meat is taken by hunters.
- This is proposed as a key factor for wildlife declines throughout coastal Africa.
- Suggests need for better fish management
- Two complicating factors are European fish subsidies that allows fishers to harvest from African waters and piracy/illegal fishing
- Seabird decline also linked to decline of fish populations
- Solutions include – Marine Stewardship Certification and a roll back of subsidies to the fishing industry
- Namibia – small town on coast
- Foul smells from sea reported ("sulfur event") – H_2S
- Color of ocean changes to yellow color
- Fish appear dead and dying by tons on shore

0:30

- Fish kills result from a series of events:
- Phytoplankton dies and decay
- H_2S in sediment is released
- Bottom sediment is sampled and found to have high levels of H_2S
- Methane is also found – a product of phytoplankton decay
- Methane "explosions" occur that release these pockets of H_2S and change water color and cause fish kills
- Satellite images detected sudden change in color (correlated with a fish kill event)
- Water samples taken after satellite detection of color change establish that a series of eruptions occurs resulting in mass emissions of sulfur
- Area is 200 km^2 in size (=thousands of square miles)

0:35

- Why all at once over a broad area? Deep sea eruptions occurred at high desert rain. Passage of a low pressure cell over the area uncorks the methane and the phenomenon spreads in all directions
- Fish role – by 1970s most fisheries were wiped out by foreign fleets
- 10 million tons of sardines (100 billion fish) were commonly harvested – these fish are no longer available
- Sardines are plankton feeders so as sardine populations declined, phytoplankton flourished (sardines were "keeping the lid on phytoplankton populations")
- Explosions kill large numbers of sardines
- Eruptions are also adding to global warming because CH_4 is a powerful greenhouse gas
- Therefore, mass removal of fish has impacts on global climate system

- Fishing pressure on plankton feeders is expanding throughout the world
- How do we assure a sustainable harvest?
    - Marine reserves – no-fishing zones (e.g., Baja, California; Sockeye salmon and Pacific halibut management)
    - Aquaculture has resulted in the "blue revolution"

0:40

- New Brunswick, Canada – Cook Aquaculture – Atlantic salmon
- 2001 – aquaculture expands beyond salmon to include a diversity of organisms that work together – kelp, mussels and salmon
- Maintenance of the aquaculture systems is more complicated but mussels serve as living filters of waste in pens
- Pollution from aquaculture operations can degrade water quality and habitat
- Kelp and mussels can be sold ($100,000/year improvement)
- "Integrated Aquaculture" – kelp and mussels absorb 40% of waste and create a marketable commodity (sold to Asian and local markets)
- Other species may be added to re-create a balanced ecosystem
- Future of aquaculture depends on innovations like this

0:45

- "Aquapod" – sphere in open ocean will dramatically increase production with less impact on close-shore ecosystems due to strong currents in open ocean
- Sea lice can spread in near shore pens but currents dissipate in these spheres
- Cobia – carnivores – feeding usually increases pressure on wild fish which must be harvested to feed predators
- Catfish, tilapia. Carp are more sustainable (can be fed non-fish food) or substitute fish protein with sustainably grown plant products
- Shrimp farming is problematic due to mangrove destruction

0:55

- But industry can evolve. What happens if aquaculture doesn't develop?
- Protecting fish will have other global impacts

END

6. JOURNEY TO PLANET EARTH – THE STATE OF THE PLANET'S OCEANS *VIDEO*

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

Introduction
0:00

- About 400 years ago Avero, Portugal was home to the world's largest long distance fishing fleet sailing to North America. Fisherman based in Avero would sail to the rich fishing grounds off the coasts of Newfoundland and New England where they would use dories and handlines to catch the abundant Atlantic cod.
- Soon, fleets from around the world gathered on these productive fishing grounds and by the end of the 20th century, the fishery collapsed. The history of fisheries around the world is marked by similar "boom and bust" cycles.
- Atlantic cod are now on the verge of extinction. The economic and social impacts on Avero, Portugal are described. Fishermen now collect snails and clams on the mud flats in an attempt to make a living. Younger residents are abandoning the seafaring way of life.

0:05

- Older fishermen share stories of past abundance. Portuguese fishermen emigrated to New Bedford, Massachusetts which also has been impacted by the collapse of the cod fishery. A University of Massachusetts research biologist is studying the impacts.
- The water was hiding the impacts of overfishing. Impacts go beyond economics – the community dies along with the fishery. The historical district has been turned into a tourist attraction.
- The loss of Atlantic cod is a "cautionary tale." Over 90% of the ocean's large fish are gone.

0:15

- High fish diversity and coral reef habitat occur in the Dry Tortugas off the Florida coast. In 2001, a 200 mi^2 area was protected as the Florida Keys National Marine Sanctuary.
- Marine protected areas of various types are established as a mechanism for protection of unique habitats and rare species and also to allow degraded ecosystems to recover. The marine sanctuary is patrolled by NOAA.
- Methods of law enforcement agents are illustrated as they board various vessels that are suspected of being in violation by fishing inside the sanctuary boundary. Turtle excluder devices (TEDs) are checked.

0:20

- Climate change caused by increasing CO_2 levels as a threat to oceans is examined in Greenland. Polar ecosystems are changing rapidly.

- Glacier measurements indicate rates of transfer of water and ice from ice sheet to the ocean. The current rate is 9 miles/year (125 feet/day). The rate has tripled in just 10 years.
- increasing rate flow from the ice sheets to the ocean. As meltwater lakes form, the water in them follows cracks and crevices to the base of the glacier. This lubricates the ice-land surface and accelerates the rate of movement to the ocean.
- If all of Greenland's glaciers were to melt, sea level would rise a catastrophic 23 feet (this is probably centuries away). However, far less severe increases in sea level could have devastating effects for some countries. Most of Bangladesh, for example, lies only a few feet above sea level. A 3 foot increase in sea level would cover most of the rice fields in that country resulting in widespread famine. Sea level rises of 5 feet are expected this century.
- Refugees from Bangladesh into India will create social disruption in both countries.

0:35

- Glacial retreat is particularly evident in the Andes Mountains of South America. All glaciers in Peru may be gone by 2015. Ice melt is the primary source of water for this country and without the glaciers there will be little water for irrigation or residential use.
- Without irrigation water, agricultural production will decline and people in rural areas will migrate to the coastal cities of Peru including Lima (a city of 9 million). In the ghettos outside Lima there is already little water and no sanitation. A family spends 25% of its income on water.
- With loss of agriculture, people will turn to the only other source of protein – fish. A fishery that is now sustainable will become overharvested and at the same time, increased pollution from coastal cities will create "dead zones" where fish cannot survive.

0:40

- Stephen Palumbi describes the impacts of global climate change on whale migration, penguins, coral reefs, salmon and sea otters. Solutions for global climate change include either switching to renewable fuels or capturing CO_2.
- Snapper and grouper gather in large spawning congregations in the Caribbean (Belize) during the spawning season. Whale sharks, the world's largest fish, gather to feed on the huge volume of eggs available during this time. Overfishing of grouper and snappers jeopardized the survival of both these fish and whale sharks.
- Marine reserves were established that prohibited fishing and within a few years the fisheries rebounded and whale sharks returned. A tourism industry has now developed that is centered on tourists who want to learn about and swim with whale sharks.

0:50

- Sylvia Earle describes an esthetic appreciation for oceans and what it is like to explore the ocean from a deep water submersible.

END

VI. Marine Fisheries Glossary

This glossary of terms frequently used in marine fisheries is adapted from a number of sources including the "Glossary of Fisheries Terms" developed by NOAA Fisheries. For those terms that do not appear in the glossary below, please consult this resource:

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

age structure – the distribution of the individuals of a population into age classes or cohorts

anadromous – those fish that migrate as juveniles from freshwater to saltwater and then return as adults to spawn in freshwater

area closure – the closure to fishing by particular gear(s) of a fishing ground for the protection of a population; closures may be seasonal or permanent

aquaculture - the cultivation of fish and other aquatic organisms such as mollusks and crustaceans for production; "fish farming"

benthic – describing a habitat or organism on the sea floor

biomass – the weight of living organisms, usually for a particular species or at a particular trophic level

bottom trawling - fishing method in which a weighted net is drawn behind a fishing vessel; used to capture groundfish (e.g., cod, haddock) and flatfish (e.g., flounder, sole)

bycatch – the capture of (or damage to) non-target fish or other marine animals in fishing gear; may include "economic discards" (species with low or no economic value), "regulatory discards" (e.g., prohibited species, illegal size, over quota captures) or "collateral mortality" (species killed by contact with active or discarded fishing gear)

capacity – the ability to sustain, harvest, or process fish products

carrying capacity – the maximum population of a species that an ecosystem can support indefinitely without deterioration of the population

catch – the total number or weight of fish caught by fishing operations

certification – the evaluation and designation of a seafood product as "sustainable" by an independent organization

cetaceans – marine mammals such as whales, porpoises and dolphins

closed access fishery - a fishery in which the number of licenses, gear or vessels involved in a fishery is limited; a “limited entry fishery”

closed season – the banning of fishing for a period of time to protect juveniles or spawners

codend – the end of a trawl net that retains the catch

commercial extinction – that point in the decline of a harvested species at which the species no longer occurs in sufficient numbers to support a fishery

commons – a resource owned by the public and usually regulated by the government to ensure its future benefits

continental shelf – the underwater portion of the continent, usually from the low tide mark to a depth of 200 meters

controlled access – a fishery management scheme that reduces or limits the number of participants in a fishery

demersal species – those species living in close association with the ocean floor (e.g. cod, grouper, lobster)

density-dependent limiting factor – an environmental factor that limits population growth and exerts greater control on population growth as population densities increase (e.g. food, habitat availability)

density-independent limiting factor – an external factor that limits population growth and exerts control on population growth regardless of population density (e.g. climate change, pollution)

depleted stock – a fish stock driven by fishing to a very low level of abundance compared to historic levels, with dramatically reduced spawning biomass and reproductive capacity

derby fishing - a concentrated fishing effort in a limited time frame often due to a TAC-regulated, open fishery; fishermen race to capture as much as possible as quickly as possible before the fishery closes

detritus – dead organic matter and the decomposers that live on it

developing fishery – a fishery in which investment, fishing effort and catches are low but rapidly increasing

directed fishery – fishing that targets a certain species or group of species

discards – those fish that are released, dead or alive, to the sea; discards include damaged fish, non-target species or fish that must be released to comply with a regulation

dredge – a heavy metal frame and mesh dragged along the seafloor usually to harvest shellfish (e.g., clams, scallops, cockles). The catch is held in a terminal bag that allows water, sand and mud to wash out, leaving shellfish behind.

ecologically sustainable yield (ESY) – a fishery management goal that allows harvest at a level that an ecosystem can sustain without shifting to an undesirable state

ecosystem-based management – a management approach that takes ecosystem components and services into account

ecosystem services – the benefits that humans obtain from ecosystem components and processes (e.g. food production, nutrient cycling, flood control); the value of ecosystem services generally do not enter into conventional economic systems

effort – the amount fishing gear of a specific type used on fishing grounds over a given unit of time (e.g. hours trawled per day)

El Niño – Southern Oscillation (ENSO) – abnormally warm ocean climate conditions occurring off the west coast of South America

escapement - those fish that are not captured by a given fishing method; some methods (e.g. increased mesh size in nets) are designed to increase escapement as a conservation method

estuary – a coastal ecosystem that receives freshwater input from land

eutrophication – the enrichment of a body of water with nutrients such as nitrogen or phosphorus resulting in the stimulation of the growth of aquatic plants and algae; excessive enrichment may lead to the depletion of dissolved oxygen

Exclusive Economic Zone (EEZ) – the area extending from the seaward boundaries of the coastal states (3 nautical miles) to 200 nautical miles off the U.S. coast; the U.S. claims exclusive fishery management authority in this area

factory trawler – a large stern trawler equipped to capture, process, freeze and store large quantities of fish

fecundity – the potential reproductive capacity of a population usually expressed as the number of eggs or offspring produced during each reproductive cycle

finfish – vertebrate fishery species not including crustaceans, cephalopods or other mollusks

finning – the practice of removing fins and discarding the carcass; usually pertains to sharks

fishery – the sum of all activity that leads to the harvesting, processing and sale of fish including the fished resource, fishermen, and related businesses

fishery management council – one of eight regional governing bodies for U.S. marine fisheries established by the Fishery Conservation and Management Act of 1976; the councils prepare fishery plans that establish regulations, quotas, etc. for a particular region

fishing gear – the equipment used for fishing (e.g. gillnet, trawl, purse seine)

fish meal – protein-rich, ground up fish and fish byproducts used mainly for animal feed

fixed gear – fishing gear that is stationary after it is deployed (e.g. gillnet, traps, longline)

fully exploited – referring to a stock that is being harvested at close to its maximum sustainable yield and thus, neither overexploited nor underexploited

gear restriction – a type of management tool used to limit a fishery by restricting the amount or type of fishing gear used by fishermen

ghost fishing – the accidental capture of aquatic organisms by fishing gear that has been lost or discarded

gillnet – a vertical, wall-like net that is usually set perpendicular to the flow of water; mesh size allows the heads of fish to pass through, but the gill covers get caught, trapping the fish

groundfish – a collective term loosely applied to demersal or semi-demersal species; includes most commercially-harvested fish other than salmon, herrings, tuna and their relatives

harpooners - fishing vessels that use harpoons to capture large basking fish such as swordfish

individual fishing quota (IFQ) - a limit on the number or weight of fish that can be harvested by a given vessel in a certain period of time; the sum total of all IFQs adds up to the Total Allowable Catch (TAC)

individual transferable quota (ITQ) – a type of individual fishing quota (IFQ) that can be sold or leased to others

landings – the number or weight of fish unloaded by commercial fishermen

limited entry – a fishery in which the number and size of fishing vessels is restricted through licenses or quotas to control the amount of fishing effort

longline – fishing gear in which many short lines, each with a single, baited hook, suspended vertically from a main line that is usually suspended between two floating buoys; longlines may extend from several hundred yards to over 40 miles long and contain thousands of hooks

longliners - fishing vessels that use many baited hooks suspended from sometimes miles-long lines to capture fish; particularly common for tuna and swordfish but can be adapted for other species

marine protected area (MPA) – a geographic area that has been designated to enhance the conservation of marine resources

marine reserve – a type of marine protected area that prohibits all extractive activities including fishing; marine reserves may be imbedded within marine sanctuaries

marine sanctuary – a type of marine protected area that allows fishing but prohibits other extractive activities such as offshore oil development

Marine Stewardship Council (MSC) - a non-governmental body that establishes sustainable certification criteria for a particular fishery

Magnuson-Stevens Fishery Conservation and Management Act – federal legislation originally enacted in 1976 that established U.S. marine fishery policy

mariculture – marine fish farming (aquaculture)

mature fishery – a well-established fishery with high, static catch rates at maximum sustainable yield

maximum sustainable yield (MSY) – the largest average catch that can continuously be taken from a stock under existing environmental conditions without compromising the ability of the population to regenerate itself

mesh size – the size of holes in a fishing net; minimum mesh sizes are often prescribed in regulations to reduce the capture of undersized fish

mollusk – invertebrates with a soft, unsegmented body, a muscular foot and usually a calcareous shell (e.g. oyster, clam, mussel, scallop)

National Marine Fisheries Service (NMFS) – federal agency within the National Oceanic and Atmospheric Administration (NOAA) responsible for fisheries science and overseeing the regulation of fisheries; now "NOAA Fisheries"

National Oceanic and Atmospheric Administration (NOAA) – a federal bureau within the Department of Commerce responsible for atmospheric, ocean and coastal sciences and management

native species – indigenous species found within their natural range; not introduced by humans

nearshore – shallow marine waters at a small distance from the coastline where water depths do not exceed 30 meters

nekton – free-swimming pelagic organisms whose movements are independent of tides, currents and waves (e.g., fish, whales, crabs, shrimp)

offshore – deeper marine waters located well beyond the shores

open access fishery - a fishery in which the number of licenses and or boats involved in the fishery is not limited

overcapacity – fishing capacity that exceeds that which is required to capture and process the allowable catch

over-exploitation – a rate of harvest that exceeds maximum sustainable yield

overfishing – rate of fish mortality (harvest plus bycatch) exceeds the natural rate of replacement resulting in a decline of the fish stock

pelagic species – marine fish and other species found in open water, inhabiting the water column rather than the sea floor (e.g. tuna, swordfish, herring, squid)

photic zone – the surface layer of aquatic habitats where there is sufficient light penetration for photosynthesis to occur

phytoplankton – small, usually microscopic algae in the upper layers of the ocean; photosynthetic organisms

pinniped – seals, walruses and similar marine mammals with flippers used for locomotion

pots – stationary traps usually attached by rope to a floating buoy designed to capture fish or crustaceans

purse seine – a large net usually set by two boats to catch open-ocean, pelagic fish such as tuna and herring; the boats encircle a school of fish and then draw the bottom of the net together much like a purse; mesh size regulates the size of fish that are allowed to escape.

purse seiners - fishing vessels that employ a purse seine to capture fish

quota – a specified number or weight of harvested fish that, when reached, results in the closure of a fishery

recovered fishery – a fishery that was once senescent but is now increasing and may be able to support a fishery

recreational fishery – a fishery in which fish are harvested for personal use or sport rather than for profit

recruitment – the amount or number of fish added to the stock each year due to population growth or migration of fish into the fishing area

resilience – the capacity of a fish community or ecosystem to recover from a disturbance such as intensive fishing

selective gear – fishing gear that allows fishermen to capture few, if any, species other than the target species

senescent fishery – a fishery in which catch rates have declined significantly from higher levels usually due to overfishing

shellfish – invertebrates such as mollusks (e.g., clams, oysters, cockles) and crustaceans (e.g., lobsters and crabs)

single-species management – a fishery management strategy based on the requirements and characteristics of individual species as opposed to entire communities or ecosystems

size distribution – a breakdown of the number of fish in various size categories in a population

spawning – the release of eggs to be fertilized

spill-over – the migration of fish outside the boundaries of a marine protected area

stock – a population of fish from which catches are taken in a fishery

subsidy - any government policy that alters market risks, rewards and costs in ways that favor certain activities or stakeholders; subsidies may include direct or indirect payments, tax benefits or other economic concessions to those involved in a fishery

Sustainable Fisheries Act - federal legislation enacted in 1996 that amends the Magnuson-Stevens Act to address overfishing, stock rebuilding and the protection of essential fish habitat in the United States

sustainable fishery - a fishery that does not harm the long-term condition of the fish stock or the ecosystem of which it is a part; sustainable fisheries persist from one human generation to the next

target species – those species primarily being sought in a fishery

ten percent efficiency rule – the idea that only ten percent of the available biomass at any one trophic level gets transferred into biomass at the next trophic level in food webs

total allowable catch (TAC) – the weight or number limit of fish that can be harvested; once this limit has been reached, harvesting is stopped; limits are usually established by a governing body such as a management council or federal agency

tragedy of the commons – the over-exploitation of a resource resulting from a lack of assigned and enforceable property rights

traps – species-specific (e.g., crab pots, lobster pots, tuna trap) stationary gear that allows the entry but not exit of the target species; the gear can take many forms such as baskets or cages

trawl – an open, cone-shaped net that tapers to a small "codend" where fish accumulate while the trawl is dragged behind the fishing vessel; a system of cables, net wings and "doors" keeps the net open while fishing

trawler - a fishing vessel that employs a trawl as its principal fishing gear

trolling - a hook-and-line fishing method with some similarity to rod and reel recreational fishing; fish are attracted by natural or artificial bait placed on a hook at the end of a line; trolling gear is composed of several unconnected lines slowly dragged behind the boat

trophic cascade – a series of community-level changes caused when the amount of biomass at one trophic level results in changes at other trophic levels; in fisheries, harvesting a single or few species of large predatory fish is the most common trigger for a trophic cascade

trophic level – the classification of organisms according to their position in a food web; primary consumer, secondary consumer, etc.

turtle-excluder device (TED) – a gear modification on shrimp trawls that allows the escape of sea turtles caught in nets

underutilized species – a species of fish that has potential for a greater harvest

undeveloped fishery – a fishery in its early stages of development with low fishing effort producing much lower catches than its potential maximum yield

unregulated fishery – a fishery that is not subject to any regulations

upwelling – the upward movement of cool, nutrient-rich water toward the surface; areas of upwelling tend to be very productive fishing grounds

wild-caught – referring to the capture of fish in natural bodies of water as opposed to aquaculture

wild fishery – the harvest and management of a fish population that is not farmed, also called a capture fishery

zooplankton – non-photosynthetic, heterotrophic planktonic organisms such as protists, small animals and larvae, which exist in the water column