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Fish and Fisheries of the Gulf of Mexico

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Additional information on various topics in this presentation can be found by clicking on pictures with a red border.

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Fish of the Gulf of Mexico

- **Anatomy and physiology**
  - **Mobility**
  - **Osmoregulation**
  - **Thermoregulation**
- **Life History**
  - **Stages of life**
  - **Habitat transitions**
  - **Importance to fishing of early-life history**
- **Different species of interest**
  - **Red drum, speckled trout, grouper, shrimp, crabs, oysters, red fish, triple tail, others**

In this section we will discuss the idea of what is a fish and how are the similarities and differences among organisms caught for food or profit

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What is a fish?

Def1: Ray-finned fishes
Most diverse vertebrate order on the planet
Over 23,000 known species worldwide
Tree of Life - Gnathostomata

Def2: Any aquatic animal caught by humans for consumption or sale.

The term fish can be used in two ways. From a taxonomic viewpoint the term “fish” refers to all fully aquatic members of the superclass Gnathostomata that contains all jawed vertebrates. However, most fish species belong to the order Actinopterigyii or the “ray finned” fishes. This is the most diverse vertebrate order on earth containing over 23,000 known species. A second and more functional definition of “fish” is any aquatic animal caught in a fishery for food or profit.

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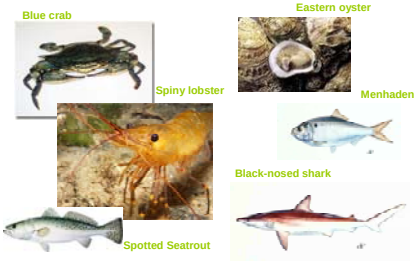
Includes molluscs, crustaceans, cartilaginous sharks, sponges, mammals, and fishes



Animals caught in a fishery include a vast array of organisms from sessile benthic animals such as oysters to large open water sharks and marine mammals. However as different as these “fishes” are from one another they do have important similarities that govern life in water.

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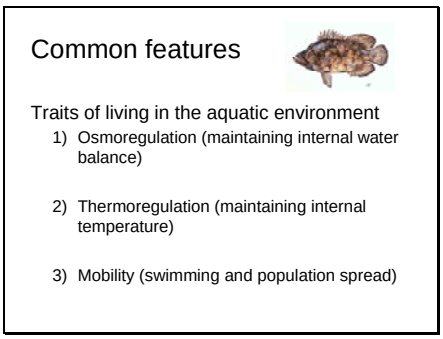

Water is 784 times more dense than air at sea level and all creatures that make a permanent home in water share traits that make them very well suited to an aquatic lifestyle. First is maintenance of a sufficient amount of internal fluid to sustain blood-flow and cellular activities. As we will see processes like waste disposal and even breathing are unavoidably much more strongly linked to osmoregulation in water than on land. Second is thermoregulation of the maintenance of an appropriate internal temperature. Most fishes are ectothermic meaning they do not expend energy to maintain a constant internal temperature. However, even ectotherms that live in water have adaptations to keep temperature fluctuations to a minimum. Finally there are adaptations for movement both swimming for the mobile fishes as well adaptations for passive dispersal usually of the eggs or larvae.

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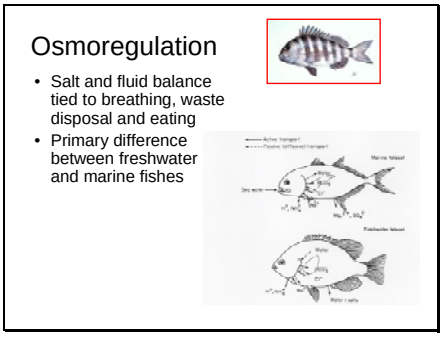

Because fishes are immersed in water, basic functions such as breathing, eating, and disposal of metabolic waste (i.e. urine) require contact with their external environment that is much more direct than is the case for terrestrial animals. As air and food pass into the body, and waste products pass out of the body, water is allowed in or out as well and this gain or loss must be counter balanced. This is a primary difference between freshwater and marine fishes as freshwater fishes must rid themselves of excess water and marine fishes must work to replace water lost. The term “drink like a fish” can really have either of two meanings depending on whether you mean a fish in a lake or a fish in the ocean. The freshwater fish actually drinks very little and instead excretes large volumes of water along with metabolic waste. Freshwater fish also actively reabsorb salt at the gill using a special cell called a “chloride cell”. Marine fishes drink copiously and excrete a semisolid urine. They also have chloride cells however these cells work in reverse by actively pumping salt out of the fishes body.

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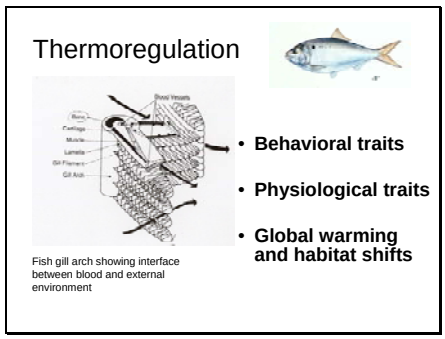

Water is much more heat conductive than air and this is why a person swimming in even cool water can become hypothermic very quickly. All fishes are adapted to living with large fluctuations in external temperature and fishes that live in extreme environments such as the Artic sea have very specialized traits for thermoregulation. The primary behavioral adaptation is inactivity and most fishes undergo a seasonal period of near inactivity in response to extreme hot or cold. The primary physiological adaptation in most fishes is a blood circulation loops at gills and in body regions generating large amounts of metabolic heat. These are called “rete” and allow for heat to be re-collected from the blood before it reaches the gills. The gills are where blood and water are closest together and thus is the primary site of heat loss. In extreme cases this is not enough and many fish species possess antifreeze agents in their blood to allow existence at near freezing temperatures. Thermoregulation is the primary factor limiting the range of most fishes and the effects of ocean temperature rise has been most evident as a range expansion of tropical fishes such as the Lionfish into areas that were thought to be too cold.

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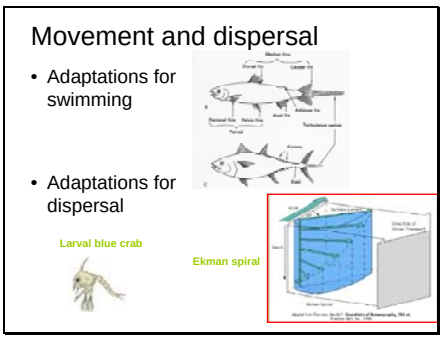

Water is 784 time more dense than air and moving through it can be difficult unless you are adapted for it. Fish do not swim so much as fly through the water. Fins and the tail serve the same role as airplane wings and tail in that they provide lift via the Bernoulli effect and stability for support in 3-dimensions. In addition fish have internal organs that provide buoyancy and allow fish to move without having to support their own weight. IN most fishes this is an air bladder which is a internal bag than can be filled or drained of air at will be adjust buoyancy for changes in depth. By controlling the amount of air in the air bladder a fish can move up or down without moving at all. More primitive fishes such as sharks lack an air bladder but can manipulate the fat content of their liver to adjust buoyancy. Even sessile fishes such as oysters exploit their aquatic environment for movement. Oysters, crabs, and many other fishes produce larvae that are buoyant and shaped to be carried long distances by ocean currents before they mature and become immobile. These dispersal adaptations can be very sophisticated such as in the Blue crab whose larvae are able to manipulate their depth to exploit directional currents headed in the direction they wish to go. Larval dispersal is analogous to pollen dispersal in terrestrial plants and serves the same purpose, namely to spread the population to new habitat and increase gene flow.

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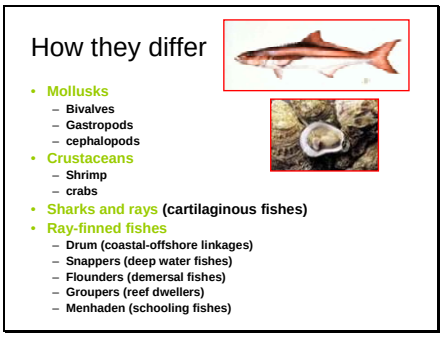

Fishes have similarities but they also as different as animals can be in other ways. Understanding these differences is vital to catching them as well as for managing the fishery. I am going to summarize some of the unique characteristics of fishes in the Gulf of Mexico with an emphasis on traits important to fishing.

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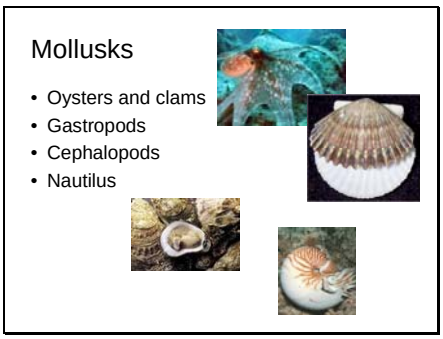

The first of two major groups of invertebrate fishes is the Mollusks which form their own phylum and contain bivalves such as oysters and clams, gastropods such as snails and cephalopod species such squid and octopus. Most mollusk fisheries involve sessile or non-motile species that are very long lived (> 10 years) and are only found in certain places such as reefs. The sessile mollusks are filter-feeders in that they suck water into their bodies and filter food particles from it as it passes though. The major exception are the cephalopods which are highly mobile and prey on smaller invertebrates and fish. Cephalopods are typically found where ever prey is abundant such as in the open water near prey fish schools.

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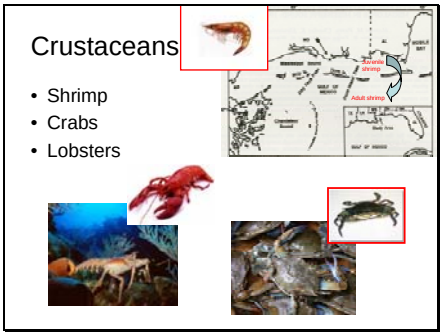

The second major group of invertebrate fishes are the Crustaceans. Most crustaceans that support a fishery are in the order Decapoda for their characteristic “ten legs.” Crustaceans are mobile but walk across the bottom better than they swim. They are most abundant near structure where they can hide but some, most notably shrimp, burrow in the mud so they are found in great numbers away from structure such as reefs. Most crustaceans are found in open water as adults but are highly dependent on shallow water habitat such as salt marsh when they are juveniles. The seasonal migration of newly mature adult shrimp from the nearshore juvenile habitat to deeper open water is a primary period shrimp fishing.

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The cartilaginous fishes belong to the Class Chondrichthyes and include large shark species such as the Great white and small shark species such as the Black tip which is commonly caught in the Gulf of Mexico. This class also includes the rays which are not as common fished but do get taken inadvertently by sport fisherman. While shark fishing is a popular recreational fishery, commercial shark fishing is a much more important removal. Sharks are territorial but the size of shark territories can be hundreds and thousands of square miles. They move freely between coastal and deep water areas and are usually caught in known foraging grounds. One unique aspect of the shark fishery is that the fins are typically the only part retained as they have a high resale value in Asia as a traditional medicine. The rest of the shark is through back overboard alive to bleed to death in the water. Shark steak is marketed in the US and Europe but far fewer species have a high food value. Cartilaginous fishes remain largely a mystery even to science and retain there stigma as man eaters, and this is the primary reason why shark finning is not more controversial.

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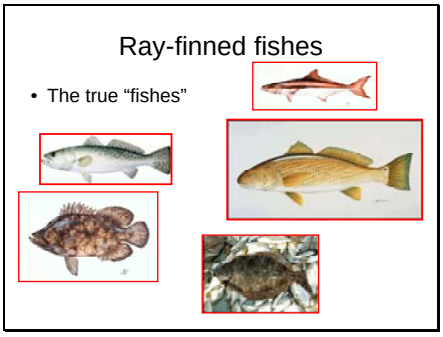

The true fishes are the most diverse group of vertebrates on earth including over 23,000 known species. This group also includes most of the better known sport fish in the Gulf of Mexico including red drum, cobia, flounder, and spotted sea trout. It also includes many lesser known species such as triple tail. Ray-finned fishes occupy a range of habitats but are generally found either in offshore feeding and spawning areas or in nearshore feeding grounds such as saltmarsh where they feed on the abundance of juvenile shrimp and crabs. They are most often found near structure which is the reason for the popularity of artificial reefs as a fishing spot. Click on the pictures to learn more about these important members of the Gulf of Mexico fishery.

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Fisheries of the Gulf of Mexico

- Economic value of fishing
  - Gulf in terms of $$ and tons
  - Major fisheries (importance of LA marshes)
- How we fish
  - Trawl, gill net, longline, hook and line, traps
- Managing our fish resources
  - Methods (size limits, catch limits, seasonal limits, limited entry, gear restrictions)
  - No fish is an island (Ecosystem-based management)
    - Cod case study, red fish issue

In this section we will explore how fishing is managed by state and federal agencies in the US waters of the Gulf of Mexico. Fisheries management is an interactive process involving both the government agencies and the stakeholders such as commercial and recreational fishers and private resource conservation groups such as the Nature Conservancy. The intent is that everyone get's to participate in the process of creating fishing regulations. We will first examine the economic and social value of fishing in the Gulf. Then we will look at how people fish and finally discuss the process of fisheries management.

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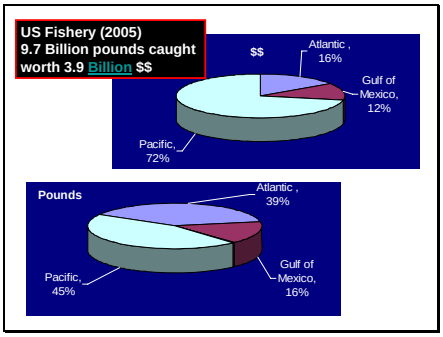

In 2005 9.7 billion pounds of fish were caught in US waters with a resale value of 3.9 billion dollars. Fish caught in the Gulf represented 12% of the catch by weight and 16% of the value. All fish landings in the US are reported to the National Marine Fisheries Service and you can access the data by state or species by visiting the NMFS website.

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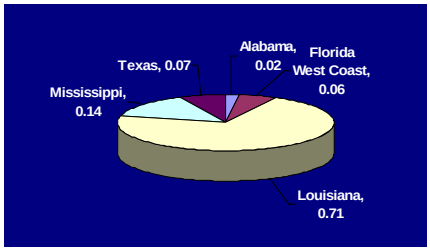
Gulf by state



Within the Gulf of Mexico 71% of the total fish landed come from Louisiana waters. Mississippi landings represent only 14% but this is twice as high as the next largest state with only 53 miles of coastline By comparison the Texas coastline is 357 miles long!

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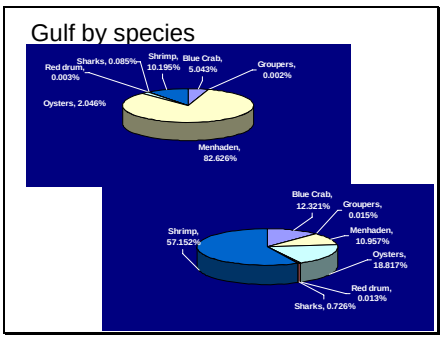

Within the Gulf of Mexico the most important fisheries are for shrimp and menhaden. In terms of pounds landed, Menhaden is by far the largest category of fish caught representing over 80% of the total catch in the Gulf. Menhaden are used to produce fish meal used in pet food and fish oil used for industrial purposes. The dollar value of menhaden is not high and when you look at value shrimp are the highest at 57% of the total value of the catch. The high value of shrimp is a major contributing factor to the bycatch issue. Ten pounds of other fish (bycatch) is caught for every one pound of shrimp and a lot of this fish is sellable. However the value of shrimp is so much higher that it is a waste of space to keep anything else and the bycatch is typically dumped back into the water dead.

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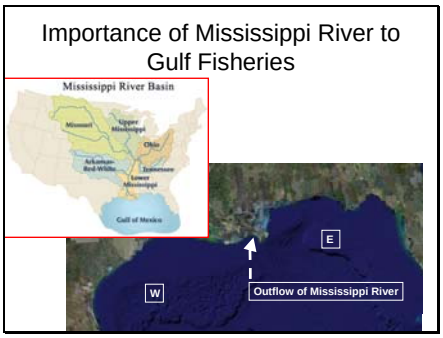

The major reason that Louisiana contributes so strongly to the total fishery for the Gulf of Mexico is the Mississippi river. The Mississippi river drains half the continental US and is the major source of freshwater and nutrients entering the Gulf and these nutrients support the prey communities that in turn support fish. In recent years the amount of nutrients entering the Gulf has exceeded use by a large amount in the summer resulting in the formation of the "Deadzone" or a large patch of water that contains no oxygen and therefore no fish. Click on the map link above to learn more about the Deadzone.

In addition the Mississippi river flood plain near its mouth is the largest single expanse of flooded wetlands in the Gulf and provides critical nursery and feeding habitat to fishes particularly invertebrates such as shrimp and crabs. The loss of these wetlands over the last fifty years due to levy construction and channalization is a primary concern for the health of the Gulf of Mexico fish community. The outflow of the Mississippi river also separates the Gulf in to an East and West portion with respect to fish production as many fish do not migrate across this barrier.

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In addition to the financial basis for fishing, there is a strong cultural connection for most fisheries. Fishing can have a multi-generational connection with skills being past from father to son. Further particular fisheries can have strong ethnic connections such as Native American fisheries for salmon and the importance of Vietnamese immigrant populations to the shrimp fishery in the Gulf. The capital investment in fishing can be high resulting in a strong dependence of families or ethnic groups on the continued health of the fishery. Finally the knowledge and skills of fishing are often stored in the experiences of the fishermen and when this is gone it is gone forever, making it hard to "recreate" a fishery once it has been stopped.

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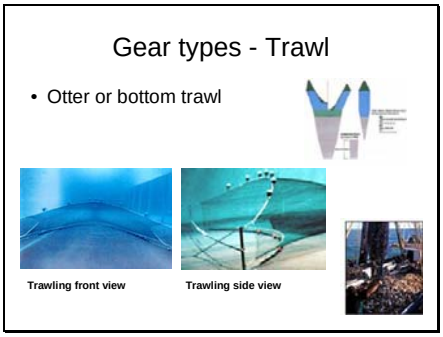

Fishers use a variety of gear types to catch fish. One of the more common ones it the trawl which is a large net that is towed through the water and captures everything in its path that cannot outrun it or is not small enough to swim through the holes in the net. The most common type is the "otter" or bottom trawl which gets its name from the otter boards used to keep the net mouth open while fishing. The otter trawl is pulled along the ocean bottom and catches primarily bottom-dwelling organism. This is the primary method of catching shrimp.

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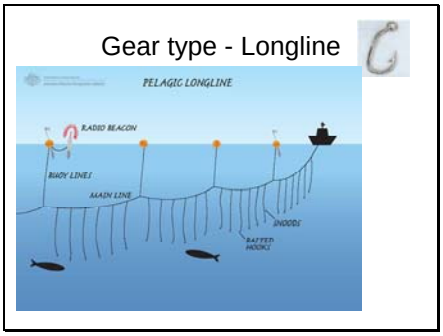

Another important fishing gear is the longline. The longline works of the same premise as traditional pole fishing except the pole to removed and the baited fishing lines are suspended from a float line. The float line can be miles long and contain hundreds of baited lines. The longline is deployed in deep water for 1-2 days at a time and then harvested by hand. This type of fishing is well-suited to large predator fishes such as sharks, swordfish and marlin.

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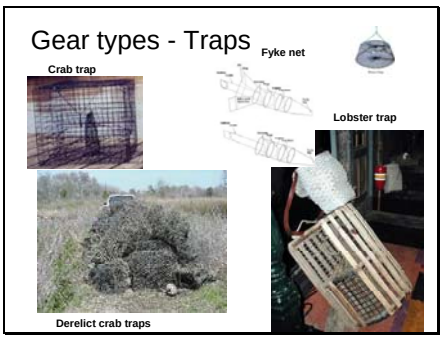

Another important form of fishing gear in the Gulf is the trap. A trap is any form of baited enclosure which is very easy for the fish to enter but hard for them to leave once the bait has been taken. Traps are typically set on the bottom with a marker float for retrieval and left for 1-2 days. Traps are usually very specific to a target fish based on mesh size, where and when they are placed, and the bait used. However, a major problem are derelict traps which are lost or damaged in the water and never retrieved. IN 2007 the state of Mississippi removed over 9000 derelict traps from coastal waters. The major trap fishery in the Gulf is for Blue crabs but there is an experimental shrimp trap being developed that could reduce the bycatch problem of trawls. Traps are also used to catch lobsters and finned fishes.

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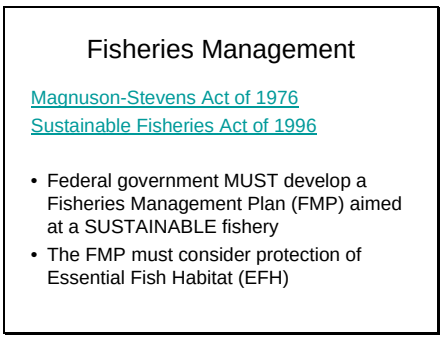

Fishery management in US waters is governed by two major pieces of legislation. The first is the Maguson-Stevens Act of 1976 which defined the Exclusive Economic Zone (EEZ) for fisheries and allocated responsibility for fishery management to a system of regional management councils. These councils were charged with forming Fishery Management Plans for each fishery. The Gulf of Mexico is managed by the Gulf of Mexico Fishery Management Council (GMFMC). The EEZ is defined as an area from the US coast to a line 200 nautical miles offshore. While the territorial waters of the US only extend twelve miles offshore the MSA established economic control over fishing in the EEZ. Foreign vessels that wish to fish in the US EEZ must adhere to US law as all US vessels fishing in the EEZ of another country must obey that countries rules.

The second major piece of legislation is the Sustainable Fisheries Act of 1996, which established what must go into an FMP and the overall objective of management. Under this act the management councils must develop plans for maintaining the sustainability of a fishery. This places the major focus on protecting the long-term health of the fishery over any short term economic gains. One key aspect of this approach is the protection of Essential Fish Habitat (EFH) as a part of the management plan. Habitat protection extends beyond how many fish are allowed to be caught and says that any human activity that harms fish habitat has to be dealt with as well. This represent a MAJOR shift in the emphasis of fishery management away from the fish and towards the ecosystem that supports the fish. This emphasis is referred to as Ecosystem-based management.

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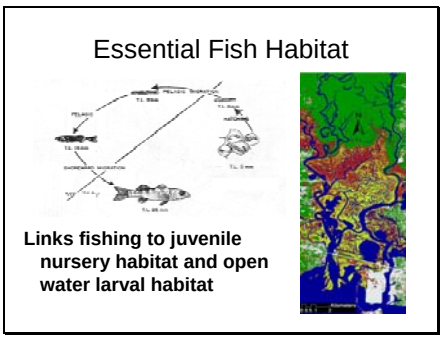

The Essential Fish Habitat paradigm of management links all life history stages of a fish to the fishery not just the adult fish that is caught. IN order to make a fishery sustainable we must have a constant supply of young fish of "recruits" entering the fishery each year to help replace those caught. This means that any harm to nursery or spawning habitat may imperil the fishery in later years and must to accounted for in management. This done by first defining what habitat is essential for a given fish and then assessing the amount of that habitat available. The use of Geographic Information Systems (GIS) and mapping technologies have been crucial to the process of defining EFH

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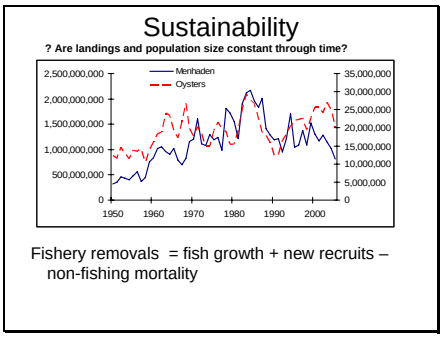

The concept of Sustainability is a key factor to setting rules and regulations for fishing. First we mast know how fast a fish population would be growing if no fishing occurred and then we must ask how much fishing can be allowed without resulting in a declining population. These are the core questions of "Stock Assessment" which is the major job of the National Marine Fisheries Service which provides data for management to the Regional Councils. The key is to discover if the population is declining in time to prevent it through management action. The examples above are landings data for menhaden and oysters in the Gulf and suggest that these two fisheries are healthy but have begin to decline in recent years.

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Traditional management actions

- Size and gear restrictions
  - Minimum size limits for capture
  - Mesh sizes of capture gear
- Fishing seasons
  - When can't you fish?
- Limited entry
  - Buy and sell the right to fish
- Marine Protected Areas (MPA)
  - Where can't you fish

Traditional management actions taken by the Management Councils are limits on how many or what size of fish can be caught. This is done is a variety of ways depending on how fishing occurs. For instance in a trawl fishery they can regulate mesh size to allow all fish below a certain size to escape. In a trap fishery they can limit the number of traps per person and the season of fishing to limit the total catch to a certain target value. One very successful but controversial management action is the limited-entry fishery in which one must but the "right to fish." Only a fixed number of fishers are allowed so the right to fish is a commodity that can be bought and sold. The advantage is that fishers value their right to fish and are generally very cooperative to management. This is in contrast to a common-use fishery in which anyone can fish who wants to and there is a general feeling that if you do not take a fish someone else will. A Management action that includes habitat protection is the Marine Protected Area (MPA) which defines an area (usually a spawning ground) where no fishing is allowed. The population living within the MPA then becomes a source of new fish for the areas outside the MPA and indirectly supports fishing.

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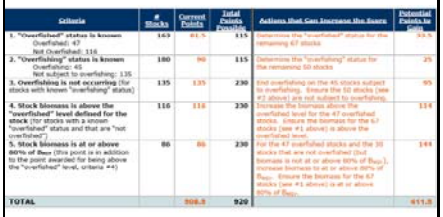
NMFS Fishery Report Card



Criteria	# Stocks	Current Points	Total Points Possible	Actions that Can Increase the Score	Potential Points to Gain
1. "Overfished" status is known Overfished: 47 Not Overfished: 116	163	81.5	115	Determine the "overfished" status for the remaining 47 stocks	33.5
2. "Overfishing" status is known Overfishing: 45 Not subject to overfishing: 135	180	90	115	Determine the "overfishing" status for the remaining 50 stocks	25
3. Overfishing is not occurring (for stocks with known "overfishing" status)	135	135	230	End overfishing on the 45 stocks subject to overfishing. Ensure the 50 stocks (see #2 above) are not subject to overfishing.	95
4. Stock biomass is above the "overfished" level defined for the stock (for stocks with a known "overfished" status and that are "not overfished")	116	116	230	Increase the biomass above the overfished level for the 47 overfished stocks. Ensure the biomass for the 67 stocks (see #1 above) is above the overfished level.	114
5. Stock biomass is at or above 80% of B_{MSY} (this point is in addition to the point awarded for being above the "overfished" level, criteria #4)	86	86	230	For the 47 overfished stocks and the 30 stocks that are not overfished (but biomass is not at or above 80% of B_{MSY}), increase biomass to at or above 80% of B_{MSY}. Ensure the biomass for the 67 stocks (see #1 above) is at or above 80% of B_{MSY}.	144
TOTAL		508.5	920		411.5

Overfishing – Currently catching more fish than are being added to the population each year.
Overfished – Continued overfishing has resulted in a measurable decline in population size.

The National Marine Fisheries Service maintains a report of how they are progressing towards their goal of sustainable fisheries. You can examine the current report by clicking on the link to the NMFS Office of Sustainable Fisheries website. The two terms used to describe Sustainability are "overfished" and "overfishing." Overfishing is a description of the fishing activity while overfished is a description of the fish population itself. We want to identify and correct overfishing before the population becomes overfished.

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Aquaculture

- Stock enhancement
- Commercial fish farming
- Value and issues to consider
  - Relief for natural populations
  - Commercial profit
  - Potential pollution issues
  - Fish fed to fish
  - Genetic concerns

One major tool for maintaining a sustainable fishery has been the use of Aquaculture to either enhance the natural population or relieve fishing pressure by providing an alternative source of fish for market. Two major areas of aquaculture include Stock enhancement and commercial fish farming. Stock enhancement is the practice of growing and releasing fish into the natural population in order to increase the number of new recruits each year. Sometimes referred to as 'stocking' this practice is sometimes controversial as it is very expensive and difficult to prove that the released fish contribute to the sustainability of the fishery. There are also genetic concerns with releasing cultured fish into the natural population, which may alter the natural gene pool.

Commercial fish farming involves the growing a fish in enclosures or ponds to a marketable size. Beyond the economic value of fish farming it is also thought to reduce the fishing pressure on the wild population and therefore helps with sustainability. Fish farming began in freshwater ponds but today occurs in marine systems as well as large enclosures that are anchored offshore. A controversial aspect of fish farming is that most commercial fish feeds used to grow fish contain fish meal which is made from wild caught fish. Therefore aquaculture is indirectly dependent on natural fish production to be profitable.

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Web sites to Explore

- NMFS
- World Aquaculture Society
- GMFMC
- GCCA
- EPA Gulf of Mexico Program
- Tree of Life Project

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Please feel free to contact me with any questions regarding this presentation.