ABSTRACT

COMPARISONS OF ECOLOGICAL KNOWLEDGE ABOUT FISH STOCKS AMONG FISHERMEN, FISHERY MANAGERS, AND BIOLOGISTS IN THE SOUTH ATLANTIC

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The world's fishery resources are becoming depleted, threatening some commercial species with extinction. The Magnuson-Stevens Conservation and Management Act has been controversial with fishermen because of disagreements over stock assessments of fish. Fishermen argue that some fish stocks are still plentiful, and that the fishing regulations are too inflexible. Through interviews and surveys, I assess the perceptions of stock assessments of fishermen in North Carolina, and compare their Traditional Ecological Knowledge (TEK) with the Scientific Ecological Knowledge (SEK) of biologists. The knowledge gained from this study could help resolve this conflict between fishermen and biologists.

COMPARISONS OF ECOLOGICAL KNOWLEDGE ABOUT FISH STOCKS AMONG FISHERMEN, FISHERY MANAGERS, AND BIOLOGISTS IN THE SOUTH ATLANTIC

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CHAPTER 1: INTRODUCTION

The world's fishery resources are becoming depleted, threatening some commercial species with extinction (Durrenberger and King, 2000). According to Acheson (2006), approximately 70% of marine fisheries are in a state of crisis or being over-exploited. The Magnuson-Stevens Conservation and Management Act (1976), the federal law that requires U.S. fisheries management councils to strictly regulate saltwater fish species with the goal of rebuilding stocks, has been controversial with both recreational and commercial fishermen because of disagreements over stock assessments of fish. Fishermen argue that some fish stocks are still plentiful, and that the fishing regulations are too inflexible. Some of the controversial regulations include setting Overfishing Levels (OFLS), Acceptable Biological Catch (ABC) and Annual Catch Limits (ACLs) for species that are considered threatened (South Atlantic Fishery Management Council). As Griffith and Maiolo (1989) argue, in the development of fishery management plans, social and biological scientists are placed in a difficult position between political disputes and the need for objective information.

Regulatory notices define charter a charter boat as "a vessel whose operation is licensed by the U.S Coast Guard to carry paying passengers and whose passengers fish for a fee" (Holland et al. 1992: 21). Charter boats participated in a virtually unregulated recreational fishery prior to the 1980s, according to Holland et al. (1992); however, fishery management plans were created in response to increasing recreational and commercial harvest. The continuation of recreational charter operations is important in North Carolina and elsewhere because they provide access to offshore waters for people without boats. Charter boats are also an important sector of the marine recreational fishing industry, as well as the tourism economy in many communities of the South Atlantic, including Little River and Charleston, South Carolina, Savannah and Brunswick, Georgia, and Panama City Beach, Destin, and Orange Beach, Florida. Yet charter companies are facing various challenges, including the need to adapt to higher fuel costs, and regulatory limitations in recreational fisheries. The economic recession has also caused a decrease in the customer base of traditional anglers willing to pay for charter trips. Additionally, charter operations are important as a possible occupational alternative for commercial fishermen being displaced.

This study will be important in assessing the perceptions of stock assessments of commercial fishermen, including charter boat captains, and comparing and contrasting their Traditional Ecological Knowledge (TEK) with the Scientific Ecological Knowledge (SEK) of biologists and fishery managers. Its objectives and hypotheses are as follows: to assess perceptions of stock assessments among charter boat captains, and fishery managers/biologists in the South Atlantic (North Carolina, South Carolina, etc), to compare the Traditional Ecological Knowledge (TEK) of charter boat captains to Scientific Ecological Knowledge (SEK) of biologists and fishery managers to determine where they overlap and where they differ, and to assess how these perceptions are formed among charter boat captains, biologists, and fishery managers. For my first objective, I hypothesized that fishermen's knowledge would be based more on direct experience than learning from secondary sources, and that SEK is more specialized knowledge based on narrower and more intense exploitation and observation than TEK (Griffith 2006). I also predicted that with TEK, the behavior of fish is considered alongside other factors including geography and recent events (Griffith 2006). For my second objective, I hypothesized that both SEK and TEK systems are based on an accumulation of observations (Berkes et al. 2000), that the three groups' knowledge would correspond in terms of marine knowledge, and that the knowledge of the three groups would differ in terms of what steps should be taken in managing stocks.

The knowledge gained from this study could help provide insight for resolving this conflict between fishermen, biologists, and fishery managers. The following sections provide some background and examples of the conflict between fishermen and fisheries management, and an overview of North Carolina's historical and ecological importance. These chapters are followed by an overview of TEK and a chapter highlighting some case studies in regulation and TEK, after which I discuss the data from semi-structured interviews with fishermen and biologists/fishery managers and the results of cultural consensus testing. Finally, I discuss the findings in light of theoretical and practical concerns.

CHAPTER 2: BACKGROUND

On February 24, 2010 thousands of fishermen and charter boat captains met in Washington, DC, outside the Capitol, to demand changes to federal fishing limits. The rally was organized by the Recreational Fishing Alliance (Tolliver 2010). Fishermen were demanding a rewrite of the 2007 Magnuson-Stevens Act, which is the federal law that requires fisheries management councils to strictly regulate saltwater fish species with the goal of rebuilding stocks (Tolliver 2010). One example of fisheries management affecting charter boats is the fishery management plan for coastal pelagics, which includes king mackerel fishing (Holland et al. 1992). There were no restrictions on king mackerel before 1985 (Holland et al. 1992). Harvest restrictions can severely impact charter boats, according to Holland et al. (1992), because of relatively higher charter fees and their affects on angler expectations of catching fish. Holland et al. (1992) further argue that fisheries regulations have been mostly responsible for failures in the charter industry, with restrictions on species such as Spanish mackerel, red snapper, grouper, and amberjack. Charter operators have responded either by quitting the charter business, resisting regulations, and/or targeting new species. Differential impacts can be expected based on regional differences in species preferences, such as a preference for snapper in Alabama; for king mackerel, Spanish mackerel, and snapper are the focus in Mississippi.

Conflicts have arisen primarily over stock assessments: many fishermen claim that fish species, including cod, are abundant, while science-based assessments are used to impose regulations that many fishermen and environmental groups argue are too inflexible. As Jim Hutchinson Jr. of the Recreational Fishing Alliance argues, “the laws set unrealistic recovery goals based on flawed science, then impose harsh cuts on fishermen when those goals aren’t met” (Daly 2010: 1).

Similar protests occurred the same day in other parts of the country. One such protest took place in Stuart, Florida, on the southern end of the Roosevelt Bridge. There were about 75-100 fishermen in attendance, some from as far away as Massachusetts (Killer 2010). Commercial and recreational fishermen gathered to create public awareness of regulations they argue are too strict. Commercial and recreational fishers have traditionally been adversaries, but they seem to be coming together on this issue.

One form of regulation they point to are the seasonal closures put in place for shallow water grouper by the South Atlantic Fishery Management Council; the fishery is now closed to harvest from November 1 until March 31 each year (Killer 2010). Many of the fishermen argued against the restrictions based on their own observations of fish stocks. Tom Smith, a commercial fisherman, argued that "more and more fishing jobs are lost all because of bad science. A lot of the data being used by the scientists is anecdotal. It's garbage in, garbage out" (Killer 2010: 1). These regulations enforced by the Magnuson-Stevens Act have created an uncommon alliance between recreational and commercial fishermen.

In his statement about the "United We Fish" Rally, NOAA Assistant Administrator Eric Schwaab acknowledged the sacrifices made by recreational and commercial fishermen, but stated that rebuilding stocks "has already led to important successes and significant economic benefits for fishermen, coastal communities, and the nation" (Schwaab 2010: 1). At present, more than 20% of the nation's fish stocks are overfished, according to Schwaab (2010), and need to be rebuilt. NOAA and Congress have made a commitment of $18.6 million to assist in the transition to alternative fisheries in the Northeast away from the groundfish industry, and Schwaab (2010) argues that these regulations have led to success in the sea scallop, monkfish, bluefin, and Gulf of Mexico king mackerel fisheries. It is predicted that once all the nation's fisheries are rebuilt, dockside value of commercial fisheries will increase from $4.1 billion to $6.3 billion (Schwaab 2010). It is also believed that rebuilding the recreational fisheries will improve the economies of coastal communities. These predictions are disputed by fishermen, who argue that the current regulations will lead to the loss of fishing infrastructure that will be difficult to rebuild.

From the above discussion, it is clear that the Magnuson-Stevens Conservation and Management Act requiring U.S. fisheries management councils to strictly regulate saltwater fish species with the goal of rebuilding stocks, has been controversial with both recreational and commercial fishermen because of disagreements over stock assessments of fish. Fishermen, fishery managers, and biologists have come into conflict over stock assessments of fish because of different systems of knowledge and stock assessment. The goals of this study were to understand the perceptions of stock assessments among fishermen, fishery managers, and biologists, what kinds of knowledge these groups use to make these assessments, and how are they similar and different. Data were collected primarily in Carteret County, North Carolina, in the heart of a dynamic coastal environment with many fishing opportunities.

North Carolina's Coastal Ecosystem and Regulation

The North Carolina estuarine system, whose fresh and salt water meet, consists of rivers, tidal creeks, marshes, swamps, and sounds, for a total of 2.2 million acres (Spence 2002). This system has four functions. It serves as a nursery for fish and shellfish (providing shelter and food sources), as well as a storage basin for nutrients. Swamps and marshes soak up excess runoff from the land and filter out some of the nutrients and sediments, and barrier islands, estuarine waters, and fringing wetlands act as buffers to protect the mainland from storms and hurricanes.

The estuarine waters and fringing wetlands in North Carolina are held in the public trust, and belong to all citizens.

North Carolina's estuaries are located at the divide between temperate and subtropical systems, meaning they support a rich diversity and number of species. As a result, they are important to other Mid-Atlantic fisheries. For example, some commercial species spawn just outside Oregon Inlet and larval fish swim into Pamlico Sound nurseries, and then later migrate north into Chesapeake Bay and other more northern areas.

Spence (2002) also mentions that estuaries also include many short and complex food chains. The phytoplankton supports grazers, for example, at a basic level of production. Detritus-based food chains are also formed by decaying marsh grasses. Commercial species include spot, Atlantic croaker, Atlantic menhaden, penaeid shrimp, blue crabs, American eel, weakfish, and southern and gulf flounder. North Carolina was once famous for salty shellfish, but there was a great decrease in catch from turn of the century to late 1990s.

North Carolina's estuaries are facing a number of environmental problems. The sea level is rising four inches per century; Roanoke Island is shrinking, and some of the islands in Albemarle Sound are now shoals. Additionally, the process of glacial melting will continue to flood river systems, broaden estuaries, and erode shorelines. Spence (2002) also points out that we are in a warming trend since the last ice age approximately 15,000 years ago. The estuaries are also affected by seasonal rainfall.

Separate from natural processes of change, the coastal environments have also been impacted by anthropogenic effects, such as increased runoff. Other examples of pollution include municipal wastewater treatment plants, pulp and paper waste, aquaculture, boat and barge traffic, fishing practices, marinas, and seafood processing. Declining fisheries, poor water quality, harmful algal blooms, reduced habitats of wetlands, oyster beds, and seagrass meadows are some of the results of these anthropogenic affects. Destruction of the reefs has also been associated with the decline of the oyster industry. Harvesting methods as well as storms, parasites, and declining water quality are other factors which have led to its decline.

Measures have been taken for protecting estuaries, including the Coastal Area Management Act (CAMA) of 1974, which protects estuaries as areas of environmental concern (AECs). Any building or physical changes made to shorelines or affecting them required to have permits from the North Carolina Division of Water Quality. Several policies are in place to manage marine resources as well. For example, the South Atlantic Management Council is one of eight regional fishery management councils in the United States (South Atlantic Fishery Management Council 2010). These were created by the Magnuson Act, which was passed in 1974, and also extended U.S jurisdiction out 200 miles from the coast. The aim of the councils is to develop fishery management plans to manage fish species within this 200 mile limit, called the Exclusive Economic Zone (EEZ). The fisheries managed by the South Atlantic Fishery Management Council (SAFMC) are: coastal migratory pelagic, coral, dolphin/wahoo, golden crab, sargassum, shrimp, snapper-grouper, and spiny lobster. In 1996 the Sustainable Fisheries Act (SFA) passed and amended the Magnuson Act (becoming the Magnuson-Stevens Fishery Conservation and Management Act). The goal of this amendment was to protect marine stocks from overfishing through regulations. This was reauthorized on January 12, 2007, and included the establishment of Annual Catch Limits and Accountability Measures, and an expanded role of the Scientific and Statistical Committee in setting catch limits, which has a role in limited access privilege programs, strengthening law enforcement, and developing an ecosystem approach to management.

Council members in the SAFMC come from each of four southeastern states. Each member has some knowledge of fisheries, and serves a three-year term, and may serve a maximum of three consecutive terms. The members are appointed by the Secretary of Commerce. Directors of each state's marine resource management agency and the Southeast Regional Administrator of the NOAA Fisheries Service serve on the council as voting members, with a total of 13 voting members. Non-voting members also serve on the council, and include representatives from the U.S Fish and Wildlife Service, U.S Coast Guard, U.S Department of State, and the Atlantic States Marine Fisheries Commission.

The SAFMC meets up to four times a year, in each of the four states. The public is involved in public hearings and provides input at Council meetings before any final action or management changes is implemented. Proposed management changes are then sent to NOAA Fisheries Service for further review. Input is also received from other state and federal agencies, universities, and members of public involved in different committees and panels. Advisory panels may include recreational and commercial fishermen, headboat and charter operators, seafood buyers and sellers, conservationists, and knowledgeable consumers. Members are appointed and serve 3-year terms. The scientific and statistical committee consists of biologists, economists, sociologists, and those knowledgeable about technical aspects of fisheries in South Atlantic. SEDAR (South East Data Analysis and Review) is a process for determining the status of fish stocks, which involves Southeast Data, an assessment, and a review process. Scientists, researchers, and fishermen are all involved.

The Snapper-Grouper is one fishery that has been affected by the regulations of the Magnuson-Stevens Conservation and Management Act. The fishery management plan for snapper-grouper was first executed in 1983 (South Atlantic Fishery Management Council 2011).

Management of this fishery is difficult because it is a mixed species group; additionally, the species are slow-growing, late-maturing, and long-lived, so rebuilding stocks can take years for some species. Initial regulations focused on establishing minimum sizes, gear restrictions, and special management zones. Other methods have also been implemented, including bag limits, size limits, trip limits, commercial quotas, and spawning season closures.

Problems have arisen with the lack of data on fish and the fishery, even with improved data collection of the 1980s and 1990s. Some more extreme measures have also been taken, including the prohibition of harvest of the Goliath and Nassau Groupers. Amendment 14 also created eight deepwater marine protected areas (South Atlantic Fishery Management Council). Beginning in 1998, South Atlantic Fisheries Management Council (SAFMC) required anyone who wants to enter the commercial fishery must buy two transferable vessel permits in order to qualify for a newly issued permit; referred to as the "2 for 1" program, it has effectively reduced participation in the fishery and pressure on the resource (South Atlantic Fishery Management Council 2011). The Council has also considered the use of Limited Access Privilege programs. The 2006 Magnuson-Stevens Reauthorization Act includes mandates to end overfishing by giving authority to the Scientific and Statistical Committee to set Overfishing Levels (OFLS) and Acceptable Biological Catch (ABC), and the Council is required to set Annual Catch Limits (ACLs), Annual Catch Targets (ACTS), and Accountability Measures (AMs) for 10 species considered to be overfished by 2010, and all species managed by the Council in 2011.

As of June 2010 the recreational retention limits consisted of three grouper three grouper (including tilefish) per person a day, including misty grouper, red grouper, scamp, tiger, yellowedge, yellowfin grouper, yellowmouth grouper, blueline, sand tilefish, coney, graysby, red and rock rind (South Atlantic Fishery Management Council 2010). There is a maximum limit of one gag or black grouper (but not both), as well as a maximum of one snowy grouper and one golden tilefish. Additionally, there is a limit of one speckled hind and one warsaw grouper per trip, but they may not be sold or traded, and no transfer at sea may take place. The Goliath grouper has been closed to harvest or possession since 1990, and the Nassau grouper since 1992. Only ITQ shareholders or designees may harvest or possess wreckfish. The Shallow water grouper fishery is closed, from January to April during the spawning season. There is also a prohibition on recreational and commercial harvest of gag, black grouper, red grouper, scamp, rock hind, red hind, coney, graysby, yellowfin grouper, yellowmouth grouper, and tiger grouper. For-hire and charter vessels captain and crew have a bag limit of zero.

For snapper, there is a limit of ten snappers (excluding vermilion) per person a day with certain exceptions. For example, the red snapper fishery is closed to both commercial and recreational harvest as of January 4, 2010. An interim rule was in effect until December 5, 2010, with a possible extension (South Atlantic Fishery Management Council 2010). A maximum of two cubera snapper per person is set for fish 30 in TL (total length-tip of snout to tip of tail) or larger off coast of east Florida. Red snapper and cubera are not included in the 10 snapper bag limit, but cubera less than 30 in TL included in 10 fish bag limit. Fishermen may keep, greater amberjack (one per person), black sea bass (15 per person), hogfish (five per person off east Florida), and red porgy (three per person/day or per/trip--whichever is more restrictive). Vermilion snapper is limited to five per person, with a recreational closure November through March. For-hire and charter vessels' captain and crew have a bag limit of zero.

For other snapper grouper complex species, there is an aggregate bag limit of 20 fish per person/per day inclusive to all under management plan not currently under a bag limit, with the exception of tomtates and bluerunners. The snapper grouper multi-day possession limit, requires that a person aboard a charter vessel or headboat for trips over 24 hours may possess no more than two daily bag limits of species other than red porgy. On trips spanning more than 48 hours and fishing documented for at least 3 days may possess no more than 3 daily bag limits of species other than red porgy. Goliath and Nassau Grouper must be released.

Amendment 17A is an important and recent change to snapper-grouper fishery management. The final rule occurred on December 3, 2010 (South Atlantic Fishery Management Council 2011). It continued the closure of red snapper fishery in federal waters in South Atlantic (3-200 miles). There is an area closure off of southern Georgia and northeastern Florida (from 98-240') where fishing for all snapper grouper species is prohibited, but trolling for pelagic (e.g. tuna, dolphin, billfish) is allowed. A fishery-independent monitoring program was also created to track recovery of the red snapper stock.

Proposed measures in Snapper Grouper Amendment 17B were approved by the Council in December 2009 for submission to Secretary of Commerce, and were approved on December 21, 2010 (South Atlantic Fishery Management Council 2011). This amendment prohibits harvest and possession of speckled hind and warsaw grouper, and also prohibits fishing for, possession, and retention of deepwater species seaward of 240 ft depth in South Atlantic federal waters, including snowy grouper, blueline tilefish, yellowedge grouper, misty grouper, queen snapper, and silk snapper. It also reduced the recreational bag limit of snowy grouper to one per vessel per trip.

In terms of the snapper grouper commercial fishery, a limited entry program went into effect on December 14, 1998 (South Atlantic Fishery Management Council 2010). Those not meeting qualifying criteria must purchase two valid, transferable limited entry permits, and exchange them for one new, valid transferable permit to gain entry. Allowable gear for the commercial snapper grouper fishery is the vertical hook and line including hand-held hook-and-line and bandit gear. Spearfishing gear (without rebreathers) is also acceptable. Powerheads are allowable, where prohibited in special management zones and in the EEZ off South Carolina. Bottom longlines can be used in depths of 50 fathoms or more, and only north of Cape Canaveral, Florida. Only North Carolina sink-net fishermen can make multi-gear trips, and all legal species harvested with black sea bass pots and/or vertical hook-and-line gear may be kept. Vessels with long-line gear aboard may only keep snowy grouper, warsaw grouper, yellowedge grouper, misty grouper, and golden, blueline, and sand tilefish, and possession of a hooking device required

There are three bills in Congress to amend the Magnuson-Stevens Conservation and Management Act. H.R. 1584, cited as "The Flexibility in Rebuilding American Fisheries Act of 2009", was introduced in March 2009 by U.S Rep. Frank Pallone, Jr. (D-NJ), a senior member of the House Insular Affairs, Oceans and Wildlife Subcommittee (United We Fish 2010). One of its goals is to amend the Magnuson-Stevens Fishery Conservation and Management Act to extend the authorized time period for rebuilding of certain overfished fisheries (Library of Congress 2010). U.S Senator Charles E. Schumer introduced this legislation in the Senate in 2009 as S.1255. As it is written, the Magnuson-Stevens Act requires any fishery designated as "overfished" by the Department of Commerce's National Marine Fisheries Service be completely rebuilt within 10 years, which Schumer argued is arbitrary rather than based on available science (United We Fish 2010).

In 2010, H.R 4634, also known as the "Transparency in Job Loss from Fishery Closures Act of 2010", was introduced by Congressman Henry E. Brown. It calls for an evaluation of the economic impact of the recent fishing ban on red snapper and shallow-water grouper; in addition, it intends to prevent future closings of fisheries in the South Atlantic (United We Fish 2010). Rep. John Mica introduced H.R 3307 in 2009, which would allow the South Atlantic Regional Fishery Management Council sufficient time to pursue “all available” science concerning any fishery before a closure can take place.

History of Fisheries in North Carolina

The earliest widespread human occupation of humans in North Carolina, along with the rest of North America, is generally believed to have taken place approximately 13,000 years ago, in the Paleoindian Period (Daniel 2002). Unfortunately, there is little archaeological evidence until the Archaic Period, from, 8,000 to 1000 B.C. More modern climactic conditions developed, and Archaic peoples adapted their hunting-gathering subsistence to these conditions. Fish and shellfish resources became greater food resources in the Later Archaic. More sedentary lifestyles are evidenced by large middens along inland waterways along the Tennessee, Savannah, and Green rivers. Plants were also increasingly harvested, and the cultivation of plants began. These trends of increased sedentism, population growth, and political complexity continued into the Woodland Period (1000 B.C-c.a. A.D. 1550).

The Algonquins occupied the North Carolina coast before the Europeans, living along the tidewater and Outer Banks (Cecelski 2000). The Croatan chiefdom extended from present-day Buxton to the Ocracoke Inlet. According to Cecelski (2000), this area was important in diplomatic relations between the English and Native Americans between 1584 and 1587. It may also be the location of the Lost Colony. The Tuscarora were another Native American group neighboring the Algonquins, living along the Tidewater coast (Daniel 2002). The North Carolinian coast was largely uninhabited by the English until after 1650, when they began pushing south from Virginia. The Algonquins and Iroquois strongly resisted invasion, but gradually succumbed to Old World diseases such as smallpox and influenza.

In his book *The Estuary's Gift* (1999), David Griffith describes the development of coastal fisheries in North Carolina. European fisheries began in two separate social locations along the Outer Banks, Albermarle, and Pamlico, both within the plantation system, and the edges of colonial power. Within the plantation system, hundreds of men and women operated haul seines, and also landed, cut, salted, and packed up to 250,000 pounds of river herring and shad a day. In contrast, Griffith describes fisheries on the periphery of colonial powers as household economies. These involved families on the Outer Banks selling fish and oil from beached whales as part of a diverse survival strategy involving fishing, trapping, hunting, and part-time work in towns and plantations. This also included the slaveholding planters who developed large shad and herring fisheries. This was an economic system for importing and exporting, which shipped tobacco, cotton, wheat, and corn as well as salted fish. David Stick (1987), who moved from New Jersey to the Outer Banks with his parents in the late 1920s, describes how multiple livelihoods continued in the area into the twentieth century. Fishermen, he explains, also doubled as carpenters, farmers, and doctors. Wives fulfilled multiples roles including seamstresses, cooks, nurses, and teachers. The self-sufficiency of this area was later affected by the building of bridges

According to Griffith (1999), two fishing traditions developed from these two locations. One required large, centralized coordination, large numbers of workers (slaved, indentured, and hired) and a factory-like regimen. The other was small, family-rooted, and diverse. This represented an early distinction between big, capital-intensive enterprises and small family-oriented fishing operations. The herring and shad industries developed alongside plantation agriculture, using the same workers. The most productive early herring fisheries established on rivers running into the western and northern areas of Albemarle Sound in the eighteenth century. Elizabeth City, Edenton, and Plymouth were important port cities for these early fisheries. Within the herring fisheries dip nets were used, capitalizing on earlier traditions, such as the long-hand dip nets fashioned from Algonquin and Iroquois. Large fishery owners were able to restrict net usage besides their own haul seines in choicest locations, and Griffith argues that these ties to power let them gain a monopoly. An example of this was the Lords Proprietors, who were rewarded by King Charles II for political support during the royal family's exile and for re-establishment of the English monarchy.

By the mid-1600s large plantations were established: cotton, wheat, and tobacco farming, which eventually led to herring fishing. However, Griffith (1999) points out that slave plantations never grew between Jamestown and northern Albemarle Sound as with the rest of the American South. This was due to the fact that waterways were complex, dangerous, and shallow, yet Somerset plantation was a notable exception. Many early Carolinians were kept in debt and indenture to the British Empire, and complex networks of legal and informal relations developed throughout the Albemarle region, including relations between fugitive slaves, Indians, pirates, watermen, and small independent farmers.

Herring and shad were springtime operations, peaking 6-8 weeks from March through April. Forty to eighty workers were involved in the process of cutting, salting, and packing fish in barrels, as well as draught animals which hauled seines. Families were gathered around fishing. People bought whole shad or barrels of salted herring; also cut, bagged, and packed fish for themselves. Women cleaned herring for around 50 cents a day; according to Griffith (1999) the process has literally not changed in the past 350 years. These networks serve as a representation of society from the mid-eighteenth century to the Civil War, Griffith (1999) argues.

Whaling was another major industry in North Carolina. Whale migrations began in spring, peaking between April and May. Griffith (1999) describes two types of whaling in this area: pelagic and coastal-shore based. Pelagic ports were located outside North Carolina, in places such as New England. Home-grown ports never became pelagic. Whaling was significant in that it was involved in the earliest commercial fishing licensing issues along the Atlantic. Whale oil and bone were extremely important for a wide number of products, including lubricant, fuel, whips, shirt collars, and women's skirts. Whales were disputed as coastal resources (e.g. access to beached whales), and access to the whales belonged to the Crown and its representatives, dependent either on a license or going beyond authority. Bottle-nosed dolphin fisheries were also extant in North Carolina in the nineteenth and early twentieth century (Cecelski 2000). As with whales, dolphins were valued for their oil and skin. The market for dolphin oil fell in the 1890s, but as recent as the 1920s a dolphin fishery still operated in Hatteras. Coastal groups also pursued live whales, such as mothers with their young. They used rowboats in the chase, which was followed by landing and processing the whale. The descendants of these whalers in Beaufort and Morehead City areas still claim this heritage, call themselves Ca'e Bankers.

At the end of the season, people moved on to mullet fishing, clamming, gigging flounder, crabbing, raising livestock, and farming (Griffith 1999). Yet these fisheries never became industrialized, and never went far from the North Carolina coast, creating distinct Tidewater English accents, and carving and boatbuilding traditions still extant today.

The planter-fishers who organized the herring fisheries were, by contrast, export and import-oriented. The fishery was revolutionized by the introduction of the pound net (also called the pod or Dutch net) by Union soldiers they learned to use in the Great Lakes. This, Griffith (1999) argues, undermined the dominance of the plantations in the herring harvest, and created court disputes, with the small fisher farmer versus the industrialized fishery. As opposed to haul-seines, pound nets only required one or two men to operate, and was less expensive (Griffith 1999). These factors, along with the productivity of the net, created conflict with the haul-seine fisheries, which had dominated the fishery until the Civil War (Griffith 1999). Additionally, this increased opportunities for slaves to escape or be liberated.

Confederate politicians outlawed herring fishing in 1863, concerned that high-protein would fuel the Union armies (Griffith 1999). Haul-seines returned in reduced numbers after the war, but it took 25 years of court battles, changes in legal definitions and laws about commons and private property for haul seines to give up hold on herring stocks. One example of a legal dispute were the Hettick brothers lawsuits. The court ruling in this case and the 1874-75 law supported haul-seines. Yet these measures could not stop pound net trends, and by the mid-20th century most haul-seine fisheries were either out of business or specialized in herring salting and packing facilities. Pound and gill nets were too efficient, and required fewer workers, which had become difficult to recruit since the Civil War and World Wars I and II.

The North Carolina oyster industry was greatly successful in the past, but now is nearly gone. Cecelski (2000) states that nearly 2.5 million were harvested a century ago, but now the harvests collect only about 2% of that. Cecelski (2000) goes on to describe the oyster fishery, explaining that there are no oyster canneries left in North Carolina; oysters are now imported from the Gulf of Mexico. In 1880 the U.S oyster industry was concentrated in Chesapeake Bay.

A bartering system was in place, with most of the Outer Banks fishermen catching oysters just to feed their own families, and bartering for corn with mainland farmers. The rise of the North Carolina oyster industry came in the 1880s, with its first real success with Moore and Brady in New Bern in 1881 (Cecelski 2000). Ten-thousand acres of oyster beds in state waters were mapped by the surveyor Francis Winslow in 1886 (Cecelski 2000).

North Carolina's oyster boom took place between 1889 and 1890. Canneries were built in Beaufort, Vandemere, Washington, Belhaven, Southport, New Bern, and Elizabeth City. The oyster beds were overwhelmed as Chesapeake boats came into North Carolina, and oyster dredges and longer tongs were introduced. New life emerged in the coastal villages as locals mixed with immigrants from Chesapeake and Eastern Europe, creating conflict over issues such as oyster poaching and smuggling. Oyster dredging was prohibited by the North Carolina General Assembly after the 1890 season, as local oystermen resisted the monopoly created by Chesapeake companies (Cecelski 2000). Chesapeake canneries moved to the Gulf of Mexico, and the number fell to two by 1898 (Cecelski 2000). Despite this transition, Cecelski (2000) argues that the oyster boom continued in North Carolina with packing houses in Belhaven, Elizabeth City, Orientel, New Bern, Beaufort, Davis Shore, and Morehead City.

The oyster industry depleted the North Carolina coast; the poor were hurt first, according to Cecelski (2000), as the oyster beds were taken out of the public domain and placed into private hands. The health of the oystermen was affected by the working conditions involved, including working in wintery conditions. The boom ended by 1909, and in the winter season of 1994-1995 only 228,485 pounds were gathered (Cecelski 2000). Several different factors have prevented the recovery of the oyster industry. Estuarine pollutants have been one reason in the form of freshwater runoff from agribusiness and timber. The silt from land clearing is one example. Another factor preventing recovery has been the rise of shellfish diseases since the 1980s.

At one time, the menhaden fishery was also important in North Carolina, but in recent years it has moved to Virginia. Menhaden is used for animal feed, and accounts for approximately 40% of all U.S commercial landings of fish and shellfish (Blomo et al. 1988). The fishery is focused in three states: New Jersey, Virginia, and North Carolina, and harvested by companies running from Maine to Florida (Blomo et al. 1988). The stock migrates annually along the coast to the south in the fall and winter, and north in the spring and summer. Fishing effort has increased, and catches have gone down since they peaked in the 1950s (Blomo et al. 1988). The catch decreased in the 1960s, but there was an upward trend from 1969 to 1972, followed by another decline from 1972 until 1975, but have increased since 1975 (Blomo et al. 1988). These fluctuations are caused by climatic and environmental conditions, according to Blomo et al. (1988).

There are two general seasons in the menhaden industry: summer and fall. The summer fishery occurs all along the coast from North Carolina to Maine from May to September. The fall fishery takes place mostly off the North Carolina Coast and a section of the Virginia coast south of the Chesapeake Bay entrance, from November to February (Blomo et al. 1988). The fall fishery in North Carolina grew for several reasons. One reason was the desire of menhaden firms to use their vessels from other areas as much as possible. The early enclosure of the Virginia waters and its tight purse seine mesh size regulations since the late 1970s are another factor, which increased the availability of menhaden. Menhaden are available in commercial amounts near the coastline, within bays, rivers, and estuaries. Jurisdiction for management within three nautical miles falls with the individual states. Regulations vary state by state (e.g. closed time periods, prohibited areas) (Blomo et al. 1988). The structure of the Atlantic menhaden industry consists of two large firms which can operate fishing vessels over large areas of both the Atlantic and Gulf coasts.

The snapper-grouper fishery in North Carolina is relatively new; until the mid-1960s fishing operations were mostly exploratory and limited to headboats in the 1970s (Rudershausen et al. 2008). North Carolina's continental shelf waters make up the northern range of the snapper-grouper fishery in the Atlantic. Some of these species are vulnerable to overfishing, Rudershausen et al. (2008) argue, due to slow growth, late maturity, high value, and ease of capture. Additionally, most groupers are protogynous hermaphrodites, meaning size-selective fishing may skew sex ratios (Rudershausen et al. 2008). Lack of stock information for the snapper-grouper complex is also an issue, as this data is only available for 22 out of 73 reef fish species off the U.S coast in the Atlantic (Coleman et al. 2000).

Over the past thirty years increasing development is threatening the fishing way of life (Griffith 2002). These coastal regions are attracting more seasonal visitors, residents, and settlers. As mentioned earlier, bridges began to be built in the early twentieth century, with a mixed reception by the community. The first bridge was built by Dare County, and the second was a 3-mile expanse across the Currituck Sound in 1931 (Stick 1987). Nags Head became further developed as a result, with hotels, stores, and cottages being built. A 1998 UNC-Wilmington study reported sediment contamination in the North Carolina estuaries, with the Albemarle being the most polluted (West and Garrity-Blake 2003). Pollutants included lead, mercury, and zinc. Foreign factory trawlers appearing in the 1950s were also responsible.

Sportfishing development may lead to the creation of new jobs, supplement current incomes from fishing, and add to local tourist economies (Johnson and Griffith 1995). Johnson and Griffith (1995) also argue that development involving small-scale fishermen can contribute to sustainability and more balanced growth which is less dependent on casinos and hotels.

Importance of Traditional Ecological Knowledge

Traditional ecological knowledge has generated interest for its potential contributions to resource conservation and general knowledge about marine resources. One working definition of Traditional Ecological Knowledge is "a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes et al. 2000: 1252). Berkes et al. (2000) also point out that Traditional Ecological Knowledge is a characteristic of societies "with historical continuity in resource use practice" which are typically nonindustrial or less technologically advanced. Knowledge collects over time and is passed to future generations either orally or through shared experiences (Berkes et al. 2000. According to Kimmerer (2002), in TEK the observers tend to use the resources themselves (e.g. hunters, gatherers, fishers) whose success at harvesting is tied to the caliber of their ecological observations. SEK, on the other hand, tends to be quantitative, qualitative, and synchronic, broader than it is deep (Kimmerer 2002). SEK and TEK do share some characteristics, however. Both traditions depend on systematic observations of nature, giving detailed empirical information of natural phenomena and relationships between different factors in an ecosystem and overlapping on several fronts (Kimmerer 2002).

Carlos Garcia-Quijano (2009) studied Local Ecological Knowledge (LEK) in small-scale fisheries in Puerto Rico, and found that habitats were particularly important to them as organizational tools for knowledge. These fishermen, Garcia-Quijano (2009) argues, equate survival with the health of the ecosystems they rely on. Reciprocity networks have also developed out of these uncertain conditions; fishers become the starting point of networks focused on the marketing and sharing of fish and fish products. Garcia-Quijano (2009) found that the strongest correlations of LEK scores with success ratings occurred when the LEK questions involved matching fishery species with ecological parameters, including habitat type and aggregation patterns; this suggests that competency in cultural knowledge about fish and fishing has an impact on success.

Christopher Dyer and Richard Leard (1994) present an indigenous model of resource use with the oyster fishery of the U.S Gulf of Mexico (Florida, Alabama, Mississippi, and Louisiana). They argue that because folk management is community-focused, there is stability in resource use and the economic benefits to the community (Dyer and Leard 1994). The natural community structure combines both folk and state management (consisting of scientific ecology). According to Dyer and Leard (1994), kinship is an important factor in identification as a legitimate user of area resources, and achieving this status can take several generations. Collective integrity is valued in this structure, and there is a system of reciprocity shown in ways including the sharing of labor, child-care, and income. Dyer and Leard (1994) assert that even though competition between families within the community can be intense, outsiders' access to resources is curbed, thus access is communally controlled.

David Griffith (2006) examined the local knowledge and multiple livelihoods of fishers in North Carolina. These groups often fall back on other livelihoods, including welding, mechanical work, and carpentry, to meet their income and household needs when problems arise which prevent them from earning enough income through fishing. This continued reliance on multiple livelihoods, Griffith (2006) argues, has created local knowledge bases that include knowledge on ecological relationships, environmental health, and political and economic processes. These knowledge systems differ from the specialized knowledge of SEK which is based on narrower and more intense exploitation and observation of natural resources.

Within the fishing economy, it is common for families to rely on one fishery (e.g. blue crab or shrimp) for most of the year, and then move to other fisheries at other times of the year. Griffith (2006) points out that it is also common to move in and out of the fisheries from year to year. The TEK of fishers is layered: the conditions that influence the behavior of fish (e.g. phases of the moon, time of the year) are considered against various social and natural phenomena including specific geographical formations and recent events. This knowledge is also situated in larger understandings, or folk theories, including the idea of fish populations occurring in cycles, and the idea of water having layers. Management decisions contrast this kind of knowledge with theory focusing on individual species or specific gear types rather than accepting the complexities of fishing. Griffith cites the *Pfisteria* case as an example: in this situation the focus was on a small part of the environment, not considering the relation of individual parts to the whole or vice versa. Fishers expressed skepticism toward the hysteria over this toxic dinoflagellate since they were on the water daily and not experiencing any symptoms that the algae supposedly caused. This skepticism, according to Griffith (2006), is symptomatic of the way fishers put together natural and social phenomena in the context of multiple livelihoods. This knowledge is complex, recognizing that any problems facing the estuary the result of a variety of social and natural factors.

Berkes et al. (2000) continue to identify a number of management practices based on traditional ecological knowledge, and identify some of the social mechanisms behind these practices. Monitoring the status of a resource is one practice cited; closeness to the resource gives users the ability to observe daily changes, either by the entire group or specific individuals.

Some groups may also completely protect certain species. According to Berkes et al., there can be a number of reasons for this: avoidance of poisonous species, those used for medicinal purposes, or preserving keystone species in an ecosystem. An example is the prohibition against catching lobsters with eggs in the Maine fisheries (Acheson 2006). Another practice mentioned is temporal restriction of harvest, which is common in conventional fish and wildlife management (Berkes et al. 2000). Resource rotation is another practice which is very common and widespread; Berkes et al. (2000) cite the James Bay Cree hunters who rotate beaver trapping areas on a four-year cycle. Practices at the local level have also been found to be potentially beneficial for managing at multiple levels. One example is the creation of range reserves within the annual grazing areas of African herders. These reserves produce "an emergency supply of forage that functions to maintain the resilience of both the ecosystem and the social system of the herders" (Berkes et al. 2000:1256). They also serve as buffers against conditions such as droughts.

Traditional Ecological Knowledge is different from scientific ecological knowledge, according to Berkes et al. (2000), in that it depends largely on social mechanisms, which they describe as a hierarchy from local ecological knowledge, to social institutions, to mechanisms for cultural internalization, to world views. Two social mechanisms are folklore and knowledge carriers (who may be local stewards or mythical heroes), who help maintain ecological practices. A second group of mechanisms include taboos and other regulations for resource conservation. Cultural internalization, including rituals and ceremonies, make up a third mechanism that helps people remember the rules and understand changes in the ecosystem. The fourth mechanism discussed involves world views and cultural values. World views or cosmology includes basic beliefs concerning religion and ethics and "structures observations" that create knowledge and understanding. "Thus," Berkes et al. (2000: 1259) argue, "an essential component for traditional knowledge and practice for ecologically sustainable outcomes is a worldview that provides appropriate environmental ethics."

Locally created rules are seen in James Acheson's (2006) study of the Gulf of Maine lobster and groundfish fisheries, with the goal of trying to understand why one industry (the lobster fishery) has been able to develop more effective management. Acheson (2006: 241) describes the industry as highly territorial, with its own subculture, where people developed general rules and many "harbor gangs" also have local rules. Those who want to fish on a commercial basis have to gain entry into a "harbor gang". After gaining membership, one is only allowed to place traps in traditional areas of that harbor (Acheson 2006). First time-offenders are warned, and the second offenders will likely have their traps destroyed. Gang members are also capable of sanctioning members who break the rules or don't meet expectations. Lobster management is also based on size regulations, prohibitions on taking juveniles or female lobsters with eggs, and the rule mandating the use of traps. The "double gauge law" specifies a minimum and a maximum lobster size, and with the "V-notch" program fishermen who catch females with eggs may cut a notch in the side flipper before releasing the female. The female must not be taken as long as the notch remains visible. The fishery is relatively sedentary, trapping is highly selective, the organization of the fishermen into "harbor gangs" means gangs can monitor their own members, and the lobster fishery is highly homogenous. It is argued that these characteristics that are beneficial for solving a common problem.

Traditional Ecological Knowledge practices often agree with adaptive management, because it admits that environmental conditions change, requiring societies to adjust (Berkes et al

2000). Adaptive management, as well as some traditional knowledge systems, also stresses processes that are part of ecological cycles and assumes nature cannot be controlled or predicted. For these reasons, Berkes et al. (2000) argue that Traditional Ecological Knowledge can complement scientific information; more specifically, fisher's knowledge can supplement scientific knowledge in fisheries management.

Douglas Medin, Norbert Ross, and Douglas Cox (2006) conducted a study examining the differences in fish knowledge and information categorization between the Menominee and culture-majority fishermen in Wisconsin (the authors use the term "culture-majority fishermen" in lieu of "European Americans"). They predicted that different ways of looking at nature and the species which constitute nature make up different frameworks used to evaluate activities and practices. Medin et al. (2006) explain that meanings and their associated judgments can result in stereotyping, misunderstanding, and intergroup conflict. However, even though there may be similarity or agreement in categories, it doesn't always mean identical bases for categorization. For example, there can be different sources of information. Categories other than a set of features may also be used to identify category members. Conversely, different groups may use the same set of features but have different conceptualizations of information catalogues. There can also be differences in how knowledge is stored in memory. "One hypothesis summarizing the current literature," according to Medin et al. (2006:75), " is that correspondence of expert sorts to general-purpose scientific taxonomy is driven by the relationship between that taxonomy and how experts' goals structure the domain."

Medin et al. (2006) believed that if goals had a large influence on sorting, then the patterns of sorting and their associated reasoning or explanations could be used to learn about these goals. The informants in their study were given three tasks: free-sorting, reporting of fish-

fish interactions, and ecological sorting of fish (according to shared habitats). Common goals and practices were found between the two groups, and also important differences. For the Menominee, fishing for food was a higher priority, and they also considered a broader range of species appropriate for eating than the majority-culture experts. In contrast, the majority-culture fishermen focused more on fishing for sport rather than food. Medin et al. (2006) also found differences in the species targeted; for example, catching muskies was associated with prestige among majority-culture fishermen. Differences were also seen between the two groups when informants were asked to name local fish species off the top of their heads. These differences in the species targeted could possibly result in differences in knowledge; however, Medin et al. (2006) argue that it is unlikely that differential experience with a particular species could lead to differences in the overall conceptual organization. Cultural factors may also have a role in the conceptualization of nature. Cultural beliefs may act as a framework theory either as "skeletal principles" or more concrete stories or examples (Medin et al. 2006:77). Therefore, even though individuals from different groups may share many activities and experiences, they may still not have a common way of thinking about fish.

The first study examined spontaneous, hierarchical sorting of fish species of the Menominee and culture-majority fishermen groups. The purpose was to see what (if any) cultural differences there were in the way informants organized fish into categories. Medin et al. (2006) also explain that they thought it might also give an indirect measure of cultural differences in goals and orientations toward nature. They chose 16 informants from both groups similar in age, fishing experience, and education, and English as their native language. The method used was to present each fish name in a card to an informant and have them say a sentence or two about it to show familiarity with it; additionally, the informants were asked to sort the fish into meaningful categories and to explain the basis of their catagories.

On average, experts indicated considerable familiarity with 144 species, and there were no reliable in-between group differences (Medin et al. 2006). The cultural consensus model was also used to examine patterns of consensus within and across groups, and the results showed an overall consensus. The justifications of categorization given by the majority-culture fishermen mostly taxonomic, then goal-related, but ecological justifications were rare (Medin et al. 2006). In contrast, the Menominee experts, according to Medin et al. (2006), gave more ecological justifications, were about as likely to give goal-related reasons, and less likely to give taxonomic justifications. Justification data also suggested that evaluative dimensions (e.g. prestigious sport fish) more likely to be used by majority-culture fishermen to organize categories.

It is possible for scientific ecology and Traditional Ecological Knowledge to work together. Conventional resource management has been criticized for its underlying assumption of ecological stability, which can result in a loss of resilience and decrease in variability and opportunity (Berkes et al. 2000). Berkes et al. (2000) argue that Traditional Ecological Knowledge and practice offer a “resilience” point of view toward resource management. This is shown in different ways including flexible resource use (e.g. land rotation), diversity of resource use, and locally created rules enforced by the users themselves. There are some potential pitfalls with TEK, however. Moller et al. (2004) describe some of the possible limitations of traditional population monitoring. One concern is that harvesting only at high-density areas of prey presents a problem when using catch-per-unit-of-effort (CPUE) to monitor changes in overall population abundance. Other nonrandom sampling problems can arise from temporal variations in resource availability and the resulting adjustments by harvesters. According to Moller et al.

(2004), science can complement TEK by providing data from large areas, providing a study of causation, and by establishing more spatial generality. Science and TEK can also complement each other, because science is good at acquiring synchronic data (short time series) over a large area, where TEK is good at collecting diachronic data (long time series) in small areas (Moller et al. 2004). Science is often focused on collecting numerical data, which TEK can supplement with observations of extreme events, variations, and abnormal patterns. Unlike science, which strives to be objective, TEK includes people, emotions, relationships, and sacredness, which Moller et al. (2004) argue helps to connect science with community. As Kimmerer (2002) argues, TEK can offer a cultural framework that involves human values in solving environmental problems.

Social scientists are not the only ones who have found TEK potentially useful. Price and Rulifson (2004) conducted a study of TEK related to striped bass bycatch in the white perch gillnet fishery in the Currituck Sound. Striped bass populations plummeted in the mid-1970s, resulting in stricter limits in the fishery, which helped the population to increase to the point where the species is considered to be recovered (Price and Rulifson 2004). Bycatch-related mortality in commercial fishing gear is still a concern; some commercial fishermen, according to Price and Rulifson (2004), argue that bycatch mortality can be reduced by 1) knowledge of the target species (e.g. white perch), 2) knowledge of the estuarine environment where gill nets are used, 3) commercial fishing experience, and 4) use of the appropriate mesh size in gill nets. The goal of the study was to evaluate the TEK of the commercial fishermen, with the possibility of incorporating it into fishery management practices.

For their methodology, sampling was divided into two fishing seasons, one from September to December 2000 (the fall fishery), and the other from January to April 2001 (the spring fishery) (Price and Rulifson 2004). Each area in the study was also divided up into ten regions which were further divided into four sections. Gillnets were used, and on a given fishing day nets were set in one of the ten regions chosen by a white perch fisherman. In each region one net would be set in a random location, and another in a location selected by the fisherman. To compare the catches, paired t-tests were used, and correlations used to relate the composition of species caught in the nets to environmental parameters.

Price and Rulifson (2004) found that the commercial fishermen reduced striped bass catches in white perch nets compared to randomly placed nets in the same region of Currituck Sound. White perch constituted 33% of the total fall fishery, and approximately 36% of the spring fishery. Striped bass only made up 12% of the fall fishery and 1% of the spring fishery. During the fall fishery there was a 33% reduction in striped bass bycatch and a 4% increase in white perch catch in the commercial nets as compared to the randomly placed nets. Striped bass and white perch catches were not statistically significant in the spring fishery, as striped bass are not as plentiful during that time of year. In light of these results, Price and Rulifson (2004) argue that the integration of TEK into management could aid in developing management alternatives, including increasing the number of fishing days and removal of net attendance rules.

TEK, as with other types of knowledge, can change over time. Murray et al. (2006) performed a study of fishermen in Newfoundland and Labrador, and as part of their study chose an informant, “Jack”, to help understand the web of forces influencing his fishing patterns, and how that has affected his knowledge. Through this informant, the complexity and dynamism of socioecological network of these fishermen was shown.

The authors discuss changes in Jack’s life in terms of the transition from local ecological knowledge to globalized harvesting knowledge. Harvesters once knew area through remembered experiential knowledge and wisdom gained over decades, and hesitated to move anywhere else. Now, they are more reliant on mobility and know larger areas less intimately through technology. Murray et al. (2006) found that behavior used to reflect local ecology and customs formed by more egalitarian social relations, but now knowledge and practices have moved harvesters where deep knowledge of species is replaced with intimacy with various policies, industry practices, and constantly evolving technologies. Networks are also more heterogenous that post-WWII fisheries. Murray et al. (2006) argue that Jack's story demonstrates how a fishery and LEK can evolve.

It is important, however, to use care when using TEK. Murray et al. (2006) point out that it is important to understand potential relationships between different forms of management (both local and otherwise), technology, and behavior to avoid misinterpretation. They also argue that information about the evolution of TEK of active harvesters as well as the unsuccessful ones is needed (in addition to ecological information provided by harvesters) to fully understand human impact on marine ecosystems, how it has occurred, all possible options for recovery, and the politics of conservation.

In their paper discussing the importance of identifying "experts" when studying local ecological knowledge, Davis and Wagner (2003) express concern to the inattention to methodology in how "experts" are identified and selected in anthropological research. After reviewing some of the recent literature, the authors found that social researchers are focusing less on "method" than the issues associated with the study of TEK, particularly when it came to the process of identifying "experts" (Davis and Wagner 2003). In order to move forward from a preoccupation with theoretical issues towards higher involvement with applied problems, it is required that LEK researchers describe in detail their methodologies so others can build off on their mistakes and strengths.

TEK and SEK are both based on an accumulation of observations, but come from different approaches (Berkes et al., 2000). Kinship and other social ties are an important aspect of some folk management systems (Acheson 2006; Dyer and Leard 1994). These social ties can help identify legitimate users of a resource and also help to enforce laws. TEK also depends on other social mechanisms including taboos, cultural internalization, and folklore and knowledge carriers (Berkes et al., 2000). These mechanisms can benefit conventional management, and cultural and worldviews can help develop environmental ethics. In turn, science can complement TEK by providing data from wider areas, and a study of causation. Thus, fishermen's knowledge of marine resources can supplement science and the management of fisheries.

Anthropology and Fish Regulation

The problems currently facing federal fisheries management include declining resources and changes in coastal environments (Colburn et al. 2006). Coastal communities are also struggling, according to Colburn et al. (2006), in that they are caught between restoration and conservation efforts, the social and economic impacts of coastal development, and the effects of climate change. Fisheries management has become a topic of interest for anthropologists in recent years. Fisheries research is important, according to Durrenberger and King (2000), because of the decreasing availability of fish, with some species becoming commercially extinct.

Anthropologists have become involved in order to provide understanding to the different relationships involved in fisheries resource systems (Durrenberger and King 2000). Social impact assessments (SIA) began to develop in the 1960s along with concerns about human impacts on the environment (Pollnac et al. 2006). The National Environmental Policy Act (NEPA) of 1969 was enacted in an effort to analyze the human impact of development on the environment. The Magnuson-Stevens Fishery Conservation and Management Act (previously the Fishery Conservation and Management Act of 1976) was an act calling specifically for analysis of fisheries. According to Pollnac et al. (2006), the National Marine Fisheries Service has been working with social scientists since the 1980s to develop SIA systems. The 1990s brought a greater emphasis on social and cultural dimensions involved in resource management, and the U.S Forest Service met with social scientists to create common approaches to SIAs. The Sustainable Fisheries Act of 1996 was passed after difficulty with changes to fisheries management.

James M. Acheson was the first anthropologist hired at NOAA in 1974, and over the course of the following four years anthropologists' role advanced from research and policy creation to tasks such as policy implementation and regulatory work (Colburn et al. 2006). The field has typically been dominated by biologists and economists, using conceptual tools including the theory of common property resources, and models based on "Schaeffer curves" (Acheson 1981). The goal of fisheries management is to lower fishing effort; biologists see this as a way to obtain maximum sustainable yield (MSY), while economists believe that producing maximum economic yield should be the aim of reducing effort (Acheson 1981). In the 1970s the extent of national jurisdiction extended from 3 to 200 nautical miles; in the U.S this was part of the process resulting in the Magnuson Fishery Conservation and Management Act, which McCay (2000) argues "domesticated" fisheries.

Until this act, anthropological studies of marine environments were mostly "academic", but afterwards anthropologists were hired by the National Marine Fisheries Service (NMFS)

(McCay 2000). Some tasks taken on were “impact-assessment” studies and reports on the effects of increased state intervention on the lives of fishers and coastal communities and resistance to the powers of the state (McCay 2000). The production of ethnographies centered on the fisheries management process was another task taken on by anthropologists at this time (McCay 2000). There was a need to create a model for fisheries social impact assessment that was more compatible with the approaches used by biologists and economists; this in turn has led to the development of a conceptual model for predicting social impacts of fishery management alternatives (Colburn et al. 2006). Micro-level analyses of specific fisheries have also been used to assess the roles of user groups in user conflicts (Griffith and Maiolo 1989). Colburn et al. (2006) also mention plans to develop “long form” community profiles for a set of communities which represent different regional community subtypes. These are based on key informant interviews, unobtrusive methods, rapid assessment techniques, previously collected data, and ethnographic field visits.

Pollnac et al. (2006) outline some of the objectives needed in SIAs. First, they argue that it should be possible to compare SIA data across space and time, and also with biophysical and economic data. Additionally, data variables need to be consistently identified, defined, and operationalized. Operationalization, as defined by the authors, means “measuring variables in a way that is replicable, reliable, accurate, and valid…comprehensible to all researchers conducting SIA” (Pollnac et al. 2006:2). Within this SIA approach, humans are considered an important factor of marine ecosystems. The final objective is to create an SIA approach that is compatible with ecosystem-based approaches to fisheries management.

The SIA model in marine fisheries management is intended to predict changes in well-being, which refers to “the degree to which an individual, family, or larger social grouping (e.g.

firm, community) can be characterized as being healthy (sound and functional), happy, and prosperous" (Pollnac et al. 2006:2). The first step in the SIA procedure is to determine the sociocultural variables important to management. Pollnac et al. (2006) argue that special attention needs to be given to how the well-being of participants will change. This is followed by operationalizing the variables to facilitate measurement, and determining the relationships between them. Relationships between variables can exist within single levels of analysis (e.g. the community) and multiple levels (e.g. the individual, the family, and the community).

Three different types of fisheries are identified by fisheries managers: commercial, subsistence, and recreational. Various external forces affecting fisheries management include population pressure, declining fish stocks, environmental activism, and climate change. Management, in turn, influences variables including fishing targets, times, techniques, the number of fishermen. Impacts vary based on the level of resilience of the fishery, fishermen, and community. Pollnac et al. (2006) argue that resilience is not a fixed quality, but is a result of interactions between family and individual attributes and external circumstances. Community structure can also be affected by such variables as job dissatisfaction, as well as community solidarity and levels of compliance with fisheries regulation. Well-being, in turn, is affected by individual attributes, social problems, and community structure. Changes in communities have resulted in greater social stratification, with IFQ holders gaining more power in the community and management. Those unable to purchase multiple permits and unemployed crew members then lose power.

Within subsistence fisheries, fishing is typically for direct consumption, yet in more complex cases producers may also gain prestige and social security for providing for a network of consumers. The act of sharing, Pollnac et al. (2006) explain, also reinforces intra-group solidarity and cooperation important to subsistence groups. Additionally, a subsistence lifestyle may also be important for cultural identification. Recreational fishing also has social and cultural value to its participants. The sociocultural value can be measured on multiple levels, including the experience of fishing (with friends or family), distribution of the catch, and discussion about fishing, or "fish talk" (Pollnac et a., 2006).

Pollnac et al. (2006) describe the SIA model as a heuristic model, which can be used to develop a quantitative model; nevertheless, they argue that some kind of causal modeling needs to be used to test the heuristic model. Further, fishery SIA should not depend completely on one model, but change methodologically based on changes circumstances. The SIA should not be used to political advantage, for the results are simply one set of factors. Data has to be collected on many different variables for which there is no data at present at all levels. Finally, Pollnac et al. (2006) argue that the SIA method needs further development in its process and ability to evaluate relationships between variables.

The "tragedy of the commons" is one concept discussed and critiqued in maritime anthropology. Hardin (1968) illustrates the tragedy of the commons with the hypothetical example of a field open to all. In this scenario each herdsman is expected to try to keep as many cattle as possible on the commons; this situation works well for a long period of time until social stability is finally achieved. After this point, Hardin (1968) explains, the rational herdsman arrives at the conclusion that he should add another animal to his herd after weighing all the possible factors. Each herdsman continues to add more animals to his herd without limit, when the world is limited, leading to the destruction of the field from overgrazing. A similar scenario can occur in fisheries. One explanation for why fishermen overexploit is that fish are a common resource protected by no one (Acheson 1981). Fishermen under these conditions are not encouraged to conserve, for fish not caught by one individual will be caught by someone else. The result in the fisheries has been overexploitation, damage to the breeding stock, lowered catches, higher prices for consumers, inefficient use of capital resources, and in some cases, the acceptance of low incomes (Acheson 1981). According to Acheson, there are certain assumptions that lie behind the tragedy of the commons (1981). It is assumed that fishermen are motivated to catch as many fish as possible simply for monetary reasons, and operate independently in a situation termed "competitive withdrawal" (Acheson 1981:302). Acheson (1981) argues that although these assumptions may hold true for some fisheries, they are inaccurate in others. Access is also constricted by cost and experience.

Co-management is one solution advocated by some researchers to deal with issues concerning fisheries management, defined as "the collaborative and participatory process of regulatory decision-making among representatives of user-groups, government agencies and research institutions (Jentoft et al. 1998:423-424). Jentoft et al. (1998) discuss co-management as a possible solution to legal pluralism, which occurs in certain management systems. Legal pluralism is defined as different legal ideas, principles, and systems applied to the same situation (Jentoft et al. 2009). However, for co-management to succeed, Jentoft et al. (2009) argue that it must be developed with legal pluralism in mind. Fisheries and coastal managers often assume that without any action by the state no system of regulation is developed, and chaos results (Jentoft et al. 2009). Yet user-groups and communities actually will create their own regulatory systems, and state interference can prevent these systems from working more effectively. Jentoft et al. (2009) refer to these non-state systems as "folk" or "traditional law", which exist in the absence of state law. Law is defined as a mix of norms and authorities; folk law is found in actions, social practices, and people's knowledge (Jentoft et al. 2009). A study by Pomeroy and

Pido (1995) in the San Miguel Bay in the Philippines found that informal management practices are typically based on religious holidays and fishers' beliefs, such as abstaining from fishing during Holy Week. One question raised by the issue of legal pluralism is which rules take precedence, as state law and folk law can clash and create conflict (Jentoft et al. 2009). According to Jentoft et al. (2009), social scientists' role could be to make managers more sensitive to legal pluralism and how it operates.

The San Miguel Bay in the Philippines is one area that has struggled from ineffective fisheries management (Pomeroy and Pido 1995). According to Pomeroy and Pido (1995), problems have arisen and persisted due to poor execution, and a lack of fisher participation in planning and management. The government now advocates community-based resource management (CBRM) to curb resource depletion and diversify income sources of low-income fishers. The fisheries of the bay are open access, and historically the institutional controls on decision-making and interactions within the bay were limited due to plentiful resources (Pomeroy and Pido 1995. Informal regulation systems were also not common. Greater development in fisheries management arose as a result of increased population growth and technical changes due to the introduction of trawlers and government credit.

The major problems identified through surveys were trawling, use of illegal or inappropriate fishing techniques, too many fishers, conversion or harvesting of mangroves, and water pollution (Pomeroy and Pido 1995). Institutional problems identified were lack of government funds, ineffective enforcement of laws and regulations, lack of community participation in government management of the bay, insufficient laws, and weaknesses in the judicial process (Pomeroy and Pido 1995). The concept of shared responsibility for management between fishers, their respective association, and government was desired by many of those surveyed. One belief held by some informants was that fishers are more knowledgeable in some ways about the bay and are more dependent on it, so they should have more responsibility (Pomeroy and Pido 1995).

Fisheries in Miguel Bay are managed mostly through the municipal government; Pomeroy and Pido (1995) describe how fishers' informal and traditional systems have a limited role in management. The reason for a lack of informal systems is that there was no need in the past, for there were few coordination and access problems in the fishery (Pomeroy and Pido, 1995). Progress toward a more effective management system can be seen in two different ways: greater participation of fishers and their associations in fisheries management, and the development of the San Miguel Bay Management Council. This council was created with the idea that it would acknowledge the open access characteristics and interdependent nature of the bay, which had previously not been taken into account (Pomeroy and Pido 1995). Another aim of the Council is to formalize local community and fishers' organizations participation in management and authorize their specific legal rights for management. The SMBMC will consist of 31 members, including 16 'actual' fishers or individuals with knowledge of fisheries, government officials, NGO representatives, people's organizations, academics, and the police (Pomeroy and Pido 1995). Through the restructuring of fisheries management through greater participation of fishers, the development of the SMBMC, and recognition of the common property attributes of the bay, Pomeroy and Pido (1995) argue that management can become more effective.

Despite the possible benefits of a co-management system, Jentoft et al. (1998) argue that there are valid concerns and factors which need to be considered. One necessary condition they mention is that institutions must be understood as socially constructed and changeable (Jentoft et al. 1998). Four different institutional variables must be considered; first, is how community is defined (Jentoft et al. 1998. Jentoft et al. (1998) describe a “territorial” or “local” community in contrast to a functional understanding of community, which involves shared activities over a larger geographical area. Co-management at the present typically involves functional communities, where representatives of fishing industry organizations or other groups of harvesters are given co-management rights and responsibilities (Jentoft et al. 1998). The local concept of communities has its pitfalls, Jentoft et al. (1998) argue, in that it can marginalize sections of the population if it is believed that their use in management would cause “local” communities to be overlooked. Recreational fishermen may occupy a given geographical area for a period of time, they are often widely dispersed. As a result, they are often better analyzed within fisheries management as a community of interest versus as a place-based community (Pollnac et al. 2006).

Griffith et al. (2007) conducted a study of fishing communities in Puerto Rico. They define community as “a group of people living and working together, exchanging services and goods, who share some common interests while diverging at times according to different class backgrounds, where many also share a common cultural and linguistic background.” (Griffith et al. 2007: 9). Social fields consist of overlapping networks of kin, neighbors, friends, co-workers, and those interacting on a regular basis. Communities may be place-based, network-based, knowledge-based, and may transcend geographic locations, but individuals often share attachments to a specific place. Fishery communities are labeled as place-based, network-based, or knowledge-based, with the first becoming less common, and the second two increasing in importance. As a result, the authors argue, the significance of coastal areas as places where fishers exchange knowledge has increased (Griffith et al. 2007). In addition, network-based communities are often repositories of social capital—or relationships among community members that can be marshaled for political and economic purposes –and, as such, could facilitate either organized opposition to fishery regulations or cooperation between charter boat captains and fishery managers.

Kathi Kitner (2006) examined the issue of mobility and marginalization of fishermen in the South Atlantic Snapper Grouper Fishery. Kitner hypothesized that fishing crews' high mobility was closely connected with being the most economically and culturally marginalized workers in the fishing industry. Marginalized fishermen, Kitner (2006) argues, are less likely to participate in management forums due to lower literacy rates and a less "mainstream" lifestyle. Despite their marginalization, fishermen can be very knowledgeable about topics including the ocean, weather patterns, and fishery stocks; however, this knowledge takes a different form than Western science.

Traditionally, the snapper-grouper fisheries of the South Atlantic have been dominated by white males. Although the Hispanic population has grown rapidly, Kitner explains that it has not really permeated the snapper grouper fishery very much. While on land, most of the owners and operators of boats stayed in permanent dwellings, such as houses and mobile homes, on their own land; the most common structure for captains and some of the fishing crew was ownership of a small lot where a "mobile home" was placed. In terms of kinship, women at the fish house included wives, girlfriends, mothers, and daughters of the men in the group, although women historically have participated little in fishing. Most of the men had been married at least once and had children from at least one relationship; some had had multiple marriages and multiple partnerships. This instability in interpersonal relationships, according to Kitner (2006), may result from the nature of the fishermen's work and long absences out at sea. The effects of long absences at sea have been noted by other anthropologists as well. Acheson (1981) points out that long hours on crowded boats with only other men may cause physical and psychological problems for the fishermen and their families. Kitner (2006) found three arrangements of household composition: first were nuclear households where fishermen returned to a wife or domestic partner and their children or as an unrelated guest or tenant on a temporary visit. The second type consisted of short-lived households formed by two or maybe three male, unrelated fishermen in a roommate or housemate rent-sharing arrangement. A couple or single household formed the third group, where fishermen rejoined their girlfriends at a place they either rented together or that the girlfriend secured herself. Some fishermen, Kitner (2006) explains, were not connected to any habitation, but stayed rent-free on the boats, or occasionally in inexpensive hotels.

Terms used by informants to describe fishermen included “drunks”, “crackheads”, uneducated, and “too free and independent” (Kitner 2006:300). Fishing managers also described fishermen as “unmanageable” (Kitner 2006:301). Mobility reinforced these stereotypes. Fishermen also assumed these perceptions, and used them to construct their identities as marginal subcultures apart from the larger community. The majority of the fishermen had been fishing to some degree since they were teenagers; some had dropped out of high school to fish full-time. Others started as recreational fishers and became commercial fishermen in their late 20s. Common past occupations Kitner (2006) found were plumbing, welding, and carpentry; none of them had advanced degrees, even though some studied beyond high school. Another characteristic found was a criminal history. Most of the fishermen had spent over a month in jail or prison, usually on charges related to violence, drug use, or failure to pay child support. Thus, fishing may be the only legal occupation open to them.

Understanding weather patterns and lunar cycles, Kitner (2006) argues, is necessary to understand fishermen mobility. Kitner explains that the fishermen were very mobile in switching boats, which was called "boat-hopping". When fishermen change boats they change their associations, thus work networks constantly fluctuate in membership. Crew recruitment and kinship is also covered in the anthropological literature on fishing (Acheson 1981). Kinship is an important issue, Acheson (1981) argues, because many crews are organized around kinsmen. Some believe that crews built around a core group of kinsmen are more stable, and it has been hypothesized that the skipper's goal is to recruit a crew that has the right combination of skills.

Kitner's (2006) hypothesis was confirmed in some ways. The geographic area of the fish house did not exist in the census databases, and the vessels and fish house were not cited. Additionally, most of the study participants were omitted from the census. Individuals of the study who best fit the census categories and "matched" census enumeration showed more markers of "middle class" values and systems in the southeastern U.S. It is hypothesized that many fishery regulations have dislocated thousands of fishermen and others in the seafood industry. The current working conditions of commercial fishing in the South Atlantic have created a marginalization of the working class.

Julia Olson (2006) performed a study of the sea scallop fishery in New Bedford, Massachusetts, examining the issue of property rights and fisheries management. Olson (2006) argues that the sea scallop fishery in the northeastern U.S gives insight into issues between market and community-based management. The fishery currently consists of both limited access and a smaller open-access fishery. According to neoclassical models, private property rights are the ideal means to economic efficiency; economists have theorized that efficiency is improved if the resource-user both reaps and benefits and contains the cost of resource use (Olson 2006). Under this paradigm, the ideal management tool is the Individual Transferable Quota (ITQ); its means of efficiency is working through the market rather than other social relations (Olson 2006). Its transferability, according to Olson (2006), is its theorized source of efficiency as well as controversy. The sea scallop fishery is regulated partly though days-at-sea (DAS), in which permitted vessels are given a number of days to fish during a fishing year, according to certain criteria including fishing history (Olson 2006). This system provides opportunities, but does not guarantee a certain catch of fish. This presents a problem, Olson (2006) points out, due to the issue of equality-as-sameness versus equality as opportunity; the U.S follows the latter idea, which creates problems with other cultures.

New Bedford is the most important port in the northeast for landing scallop, and is also an important port for groundfishing, especially yellowtail flounder, winter flounder, and haddock (Olson 2006). The New England Fishery Management Council has managed the Atlantic Sea Scallop Fishery since 1982, when it implemented its first fishery management plan (Olson 2006). It established a minimum average scallop meat count that regulated the size of the scallops that could be landed, which was very controversial among fishermen (Olson 2006). In 1994, Amendment 4 divided the fishery into a limited access fishery and an open access fishery (Olson 2006). The limited access fishery was regulated through DAS. Olson (2006) explains that Amendment 4 also imposed gear restrictions in the size of scallop dredges, and limited the crew size to seven. Amendment 10 to the Atlantic Sea Scallop Fishery Management Plan sought to integrate area-based forms of management with fishery management by establishing opening and closing rotating areas. Olson also mentions council meetings on using ITQs to address overcapacity. The lack of well-defined property rights in the present governance system, Olson

(2006) argues, has resulted in rent-seeking behavior, over-capitalization, high management costs, and affected the livelihood of scallop fishermen.

Another "paradigm shift" Olson (2006) mentions that has had an impact on management is ecosystem-based management, which is similar in that it also depends on spatially specific environmental information and management, yet it is believed to be able to further possibilities for management. This is where the knowledge of fishermen might become useful, since they tend to consider a variety of ecosystem variables that influence fishery cycles. Olson (2006) argues that fishing patterns are also important, for there can be many cultural meanings and practices inherent in them. Through the opening and closing of areas it was believed that fishermen would fish where the stock as high, and variation was attributed to profit maximization; this belief, Olson (2006), asserts, relied on a homogenous view of fishermen. The bioeconomic model is flawed because it does not take into account other rationales in fishing practices. In addition, the DAS, as an equality-as-opportunity system is not actually equal to all; it has created stability for those already owning capital in the fishery already.

Berkes and Pocock (1981) conducted a study of self-regulation of commercial fisheries of the Outer Long Point Bay in Lake Erie. The purpose was to investigate self-regulation among commercial fishermen of the Outer Long Point Bay in connection to management problems and conflicts. Commercial fishermen practices were also examined in relation to possible answers to the problems in fisheries management. Issues were divided into three categories: conflicts among commercial fishermen and between commercial fisheries and other uses of Outer Long Point Bay, present fishery management regulations, and other possible fishery management regulations. The main species caught were rainbow smelt (caught with otter trawls) and yellow perch (caught with gillnets). Few conflicts occurred between gillnetters and trawlers despite potential for problems.

The main dispute was between commercial fishermen and sports fishermen over fish resources; commercial fishermen accused sports fishermen of damage and harassment, and sports fishermen complained that commercial fisheries took too many valuable fish and often violated the sport fishing zone. In addition, gas wells, shipping, and industrial discharges were also possibly at odds with commercial fishing.

The smelt quota of 20 tons per week per boat was in effect, and had been for 20 years at the time of publication. The government was considering removing it, and Omstead Foods Ltd wanted the quota lifted, arguing that there was a harvestable surplus of smelt. Additionally, some fishermen in other ports argued it was a nuisance species. However, Berkes and Pocock (1981) found that Outer Bay fishermen disagreed, saying smelt quota should not be lifted. Smelt is a schooling species, so it can be trawled in large numbers, so lifting the quota would mean that competition would become more intense between the two processors. This increased competition could encourage the development of bigger boats which could carry more fish; larger boats could also increase the fishing pressure on perch. If the quota were lifted, boats could also come from other places. Berkes and Pocock (1981) suggest that fishermen wanted to maintain the status quo, rather than protect stocks in the sense of biological management.

The Outer Bay fishermen's attitude toward the 8-inch size limit of perch was another example of conflict Berkes and Pocock (1981) found. A tolerance of 10% undersized perch was allowed for fishermen; however this can run as high as 30% for fishermen in the summer. Fishermen suggested greater tolerance in the summer months, although almost all agreed there needed to be a limit, to avoid progressively smaller fish.

License limitation had been in practice since the 1950s in the Canadian section of Lake Erie. Some described it as a “limited access” program rather than an actual limited entry program, arguing that it had failed to control over-capitalization or overfishing. Attempts by the Ontario government to control overfishing included eliminating inactive licenses; their method was to try to prevent large producers from obtaining inactive or small-boat licenses, which did not make sense to the fishermen, who saw their entire “fishery” or fishing operation (which includes the boat, the gear, and the license) as their only long-term financial security. According to Berkes and Pocock (1981), closed seasons were also unpopular with fishermen, since gillnetting was only possible about 7 months out of the year due to ice in the winter. Regulation of gillnet mesh sizes were also rejected by most of the fishermen; a 2 3/8 inch mesh is used through most of the year, and 2 5/16 inch in the summer.

Most fishermen approved of royalties or a tax on landings, but they wanted the funds to be used to benefit the fishing industry. A fish stocking program was suggested by the Outer Long Point fishermen, stocking native species such as walleye, and not species such as salmon which could create conflict with sportsfishermen. It was expected that a perch quota would be put in place; according to Berkes and Pocock it was viewed by fishermen as a mechanism for price protection and stabilization.

Ultimately, Berkes and Pocock (1981) found that there was evidence of self-regulation among commercial fishermen, in that crowding amongst gillnetters was avoided, conflicts between gillnetters and trawlers was also avoided, and their opinions of smelt and perch quotas, perch size limits, and gillnet mesh size. Self-regulation was connected to the maintenance of good catches and good income, and long-term self-interest of members, not from altruism or concern for the environment. Most of the fishermen had some understanding of the vulnerability of the fish stocks, and were aware that complete self-regulation would be impossible to achieve; Berkes and Pocock (1981) suggest that regulations be designed so they make sense to the fishermen.

Berkes (1984) also conducted a study of the competition between commercial and sports fishermen. According to Berkes, in situations where both commercial and sports fishermen utilize the same fish stocks, conflicts between the two groups can arise. The goal of the study was to apply some of the approaches used in ecological competition studies of animals to human ecology. The North American Great Lakes have been intensively used to the point that demand has exceeded the supply of resources. Methods to rehabilitate the lakes have included the control of accidentally introduced species (e.g. sea lamprey) and this has been followed with the introduction of non-native species such as Pacific salmon. Sports fishing had also expanded, to the detriment of commercial fishing.

Commercial fishermen are licensed to harvest and sell fish commercials, and sport fishermen catch fish for pleasure and personal consumption (Berkes 1984). Competition between the two groups was evident, but still unclear whether it was "real" in an ecological sense. Berkes (1984) found that for all the Lake Erie north shore on the Canadian side, the catches of the commercial and sports fishermen were fairly separate from each other, and according to the Horn index the amount of overlap that occurred was insignificant. The recreational fishery of the Long Point Bay area was focused mainly on perch, while the commercial fishery was based largely on smelt. In terms of the distribution of boats, all but 4% of commercial boats operated at least 1.6 km offshore, whereas sport fishermen tended to stay inshore. The results seemed to indicate that the competition between the two groups in eastern Lake Erie was not significant. Two ways in which the overlap between the two groups was reduced by exploiting different fish species in different areas; the differences in the areas used was partly due to government regulation. Commercial gillnet and trawlers were not allowed to fish in the Inner Long Point Bay, and were also not permitted in the inshore area of the northeastern end of the Lake during the summer months. Time was also a factor, as commercial boats tended to start very early in the day and return by mid-morning if the fishing is good, whereas sport fishermen were typically more active around midday.

Despite these findings, Berkes (1984) still found that the two groups still claimed that conflict existed. Berkes gives two possible explanations: first, that conflict may have existed in certain areas and certain times of the year, and may have affected more specialized groups such as walleye fishermen. Second, the conflict may have been perceptual, and cultural rather than ecological in origin, so ecological models would have been insufficient tools for analysis (Berkes 1984). Competition was probably more complex than just taking fish from the same place at the same time; each user group may be changing the food web and exploiting important phases of the life histories of certain species which affects the other fishing group. According to Berkes (1984), this study suggests that there is a better chance for regulatory agencies to reduce conflict between groups if the groups are separated in space and time, and by what species they exploit.

These studies suggest that user-groups and communities are an important aspect of management, since they often create their own regulatory systems, in the form of “folk” or “traditional” law (Jentoft et al. 2009). The bio-economic model is flawed, as Olson (2006) argues, because it does not take the cultural meanings and practices within fishing patterns into consideration. More effective management systems can thus be developed through greater participation of these groups. One major concern in a co-management system, however, is the definition of community. “Local” groups need to be understood along with larger “functional” groups, to avoid marginalization (Jentoft et al. 2009). Marginalized fishermen are less likely to participate in management (Kitner 2006). With these things in mind, the increased involvement of fishermen and their knowledge into fisheries management can create more effective regulations.

CHAPTER 3: DATA COLLECTION

I worked primarily in the Morehead City, Beaufort, and Atlantic Beach regions of Eastern North Carolina. These are heavy tourist and fishing destinations because of the fishing grounds both in-shore and in the Gulf Stream. The fisheries have faced some of the same problems including gentrification and stress on fish stocks. The sample represents fishermen of a variety of ports in the South Atlantic; however, these sites are not representative of all fisheries because of the access to the Albemarle and Pamlico sounds and a greater number of species targeted. Additionally, the Duke Marine Laboratory is located at Beaufort, and the Division of Marine Fisheries has offices in Morehead City. The NC State Fisheries and Wildlife Sciences program also has ties to this area with their involvement in research with the Division of Marine Fisheries. My research project consisted of two phases: an exploratory phase followed by an explanatory phase to increase the validity and reliability of data.

Semi-Structured Interviews to Elicit Opinions

I conducted interviews with charter boat captains, biologists, and fishery managers, both in-person and over the phone. My sample size consisted of 15 fishermen including charter boat captains, and 7 biologists. I visited the area, took note of where the charter boat captains tie up their boats, and then used a purposive sampling strategy. Within purposive sampling, as Bernard (2006:189) explains, "you decide the purpose you want informants (or communities) to serve, and you go out to find some." It is similar to quota sampling, except there is no overall sampling design describing the number of each type of informant one needs for a study; the researcher takes what he or she can get (Bernard 2006). This sample represents Morehead City (not charter captains as a whole).

A total of fifteen fishermen from the Morehead City, Atlantic Beach, and other surrounding areas were interviewed. Most informants are charter boat captains, but some also fish recreationally and commercially. One is a shrimper, another is a crab fisherman. Most have been chartering or fishing in some form for at least about ten years; some have been chartering and fishing for twenty years or more. The amount of time spent out on the water fishing varied, but most claimed that they spend approximately 100 days or more a year fishing. One informant reported that he spends 250 days commercial fishing alone, another that he fishes recreationally almost daily. The peak season appears to run from approximately April through October. Of those who have family who fish, one has family in recreational fishing, three in commercial fishing, and another three have family members in both sectors.

Table 1: Characteristics of Fishermen Interviewed

Occupation	**Gender**	**Length of Experience**	**Location**
Charter Boat Captain	Male	24 years	Morehead City, NC
Charter Boat Captain	Male	30+ years	Morehead City. NC
Crab Fisherman	Male		South River, NC
Shrimp, crab, and commercial fisherman	Male	14 years	
Charter Boat Captain	Male	5 years (part-time); 5 years (full-time)	Morehead City, NC
Charter Boat Captain	Male	50+ years	Atlantic Beach, NC
Charter Boat Captain	Male	30 years	Atlantic Beach, NC
Charter Boat Captain	Male	Full-time for 16 years	Morehead City, NC
Charter Boat Mate	Male		Morehead City, NC
Charter Boat Captain	Male	43 years	Morehead City, NC
Charter Boat Mate	Male	3 years	Morehead City, NC
Charter Boat Mate	Male	8 years	Morehead City, NC
Charter Boat Captain	Male	40+ years (since 1970 as a mate, full-time for 15 years)	Morehead City, NC
Commercial fisherman	Male	40 years	Atlantic Beach

To recruit biologists I relied on a snowball a sampling strategy. With this strategy, key informants are used to locate one or two people in a population, who are then asked to recommend others in the population to interview (Bernard 2006). This process repeats, and the sampling frame grows with each interview, until the sampling frame is saturated (i.e. no new names are offered) (Bernard 2006). The biologists came from East Carolina University, the NOAA lab located in Beaufort, and Division of Marine Fisheries in Morehead City. The initial interviews were semi-structured, starting with a few questions, but allowing the informants to roam freely in their answers during the interview (Bernard 2006: 212).

Structured Interviews to Establish Cultural Consensus

Cultural consensus analysis was then used to find explanations for the data after the exploratory phase. The interviews were analyzed to find themes within the data. Media, including newspapers and fishermen group and federal websites, were also used in my background research and to find themes for analysis. Cultural consensus theory (CCT), according to Weller, "is a collection of analytical techniques and models that can be used to estimate cultural beliefs and the degree to which individuals know or report those beliefs (2007: 340). The purpose of CCT is to estimate culturally correct responses and the cultural knowledge or accuracy of informants (Weller 2007: 341). Weller argues that three assumptions must be met in order to use CCT: (1) each informant should give answers independently of other informants, (2) questions should all be on the same topic and at the same level of difficulty, and (3) CCT is only applicable if there is a single set of answers to the questions (2007: 341). For each group of informants I had two datasets. I divided the fishermen based on length of experience, and I divided biologists based on whether or not they work in fisheries management.

Structured interviews were developed from statements drawn from the semi-structured interviews to find differences and similarities in stakeholders' perceptions of fishery science and regulation. I used the grounded theory approach to analyze the text of the first set of interviews to find any potential themes or categories (Glaser and Strauss 1967). According to Bernard (2006), the grounded-theory approach is a set of techniques which identify categories and concepts which arise from the text, and then link the concepts into substantive and formal theories. To do this, transcripts of interviews are produced, and potential themes are identified by reading through small samples of text (Bernard 2006). As themes emerge, all the data from the themes is pulled together and compared, and the themes are then linked together (Bernard 2006). The themes are then compared, and the relations between them used to create theoretical models (Bernard 2006). Finally, according to Bernard (2006), the results of the analysis are presented using quotes from the interviews which highlight the theory.

Using these models I developed structured interviews consisting of a set of true-false or yes-no statements and returned to the same areas and interview 15 to 20 members of each group again, for a total of 45 to 60 individuals. Afterward I interpreted the data using SPSS.

CHAPTER 4: FINDINGS

Discussion of Semi-Structured Interviews with Fishermen

In the following section, I discuss several key themes that emerged from the interviews with fishermen, including factors that account for where fish may be found and critiques of fishery management and fish stock assessment procedures. Part of the analysis of these interviews involved considering probable differences between fishermen with more than 20 years of experience and fishermen with fewer than 20 years, given that TEK is based on long-term direct experience with natural resources combined with knowledge that is acquired via interactions with other, older fishermen. I point out where experience seems to have played a role in differentiating fishermen from one another, but in most cases this was not a factor.

Fish Behavior and Characteristics

When asked what species they were most familiar with, the most frequently mentioned were Spanish mackerel, mahi mahi, dolphin, tuna, snapper, and grouper (see species index in Appendix A). Other species included king mackerel, porgies, bluefish, marlin, and wahoo. One charter captain in Atlantic Beach also told me he runs shark trips a couple nights a week for four-hour trips. Rod-and-reel, such as a 50W pin reel, trawling, and sink and channel nets for shrimp were commonly listed as gear types used for fishing. For example, one charter captain from Morehead City uses trawling and rod-and- reel when fishing for wahoos. Ballyhoo was one type of bait mentioned, but tackle and bait constantly change due to fishing a variety of species. Fish species are caught at different times of the year; according to a charter mate in Morehead City mahi "make up the bulk of the catch in the summer" while wahoo is caught in the fall.

Environmental Factors

My informants gave a variety of responses as to what environmental factors are important to the species that they fish. I attempted to analyze the fishermen's responses by age, dividing informants into two groups: those with twenty or more years experience in the charter business or other fishing experience, and those who have been in the industry for less than twenty years. According to the interviews, three main factors seem to influence fish location: temperature, salinity, and wind.

Pollution was one environmental factor mentioned frequently across both age groups, by six informants. Various anthropogenic answers were given, including different pollutants, such as runoff, trash, and the oil spill in the Gulf. Others mentioned suburban sprawl, oil, litter, construction, agricultural runoff, and the spread of pollution from Raleigh and Kinston. As one informant explained, "[Things flow] all the way up from the mountains downstream. [which] affects things that breed in the water. With the inshore, there's not a lot of tidal turnover." Litter can directly harm species, for example, "six-pack holders get in the gills, [and] kills fish and turtles." However, a few others appeared to disagree, saying that runoff from local farms do not really have an effect, and we will see in the cultural consensus discussion below that the impact of indirect sources of pollution on fish stocks was a point of contention between fishermen and biologists, as well as an issue about which fishers did not share a common point of view. "Construction affects water quality," one argued, "but not necessarily to the extent that people think." Another informant, a charter captain in Morehead City who has been chartering since 1970, explained that offshore there is not much pollution as inshore, and the charter boats have very little impact. Another respondent, a younger shrimper, argued that at least with shrimp, good shrimping has occurred after construction as well as bad, even though construction affects the water quality. Overall, there appeared to be some disagreement on the extent of pollution or its source, although no one denied its existence. There was not a clear distinction between more and less experienced fishermen regarding pollution either.

Certain types of gear were described as either beneficial or detrimental to fish. Long-lines were considered detrimental by one informant who argued that they are unselective.

Figure 1: Pelagic Longlines (Australian Fisheries Management Authority)

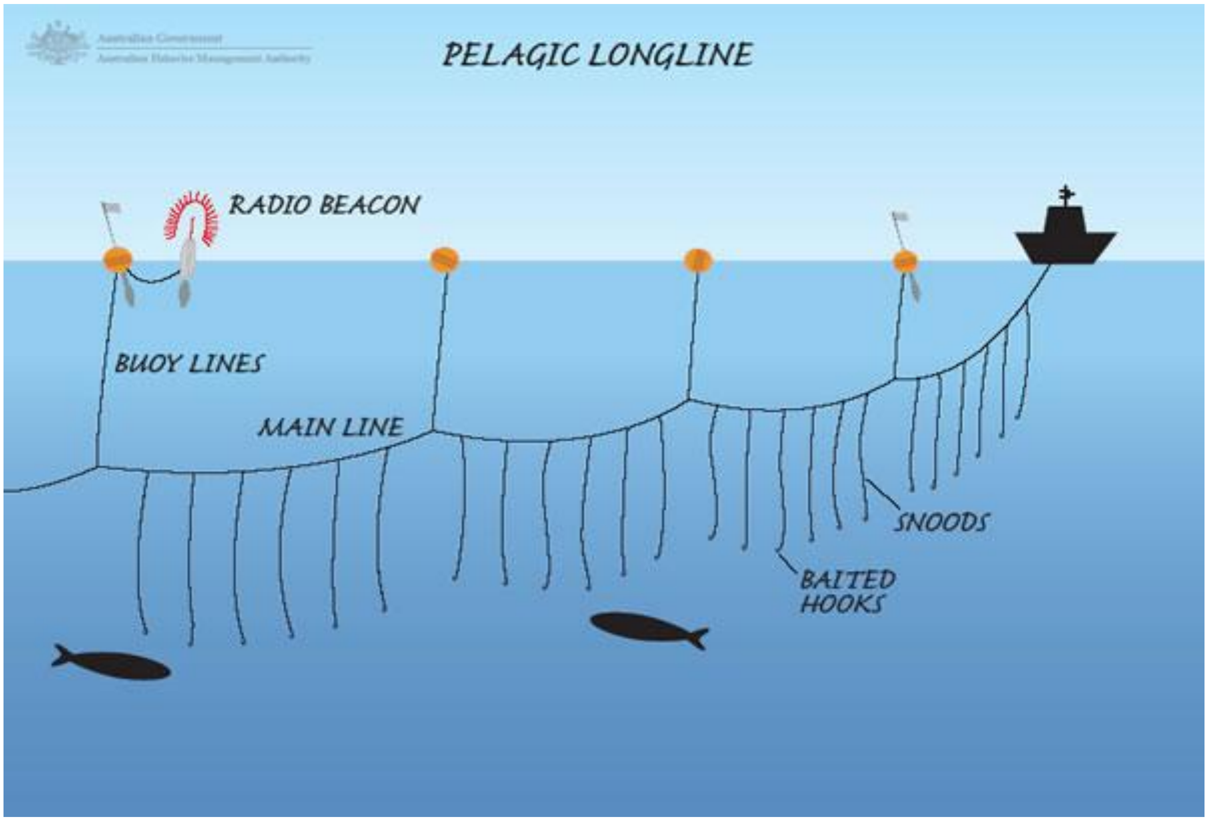


Figure 2: Circle Hook

Circle hooks, in contrast, release billfish, thereby having a higher release rate.

Other environmental factors commonly brought up were water temperature and good bottoms and reefs (i.e. habitat). Water temperature is important, because it plays a part in fish location. According to a commercial fishermen from Atlantic Beach who has bottom-fished for about forty years, fish move closer inshore when the water is warmer. “If it’s not the right temperature the fish won’t be there,” another informant, a charter captain from Morehead City, explained, the correct temperature for the species he caught being 76-85 degrees. He further described to me how the temperature of the water is affected by the Gulf Stream. “In the summer [the water] heats up way inshore from the sun. There is a hard edge (5-7 degrees break in 10ft) or a blended break of about a half a mile. This hard edge is caused by a strong current, [which] varies around 3-3.5 knots, and sometimes runs backwards.” Another charter captain explained that warmer water “brings the bait fish in” and “controls spawning.”

Reefs are also needed for hiding and spawning. Fish need them, one informant argued, “to maintain growth, size…fish can [also] hide in there from other fish. [They] can lay eggs and live a little longer by hiding in reefs.” Artificial reefs are also good, one charter mate pointed out, because they attract bait fish. Other things mentioned were sea grass, food, wind, and rain. Wind can effect where bait drifts, and in the case of shrimp can stir up mud sentiment with the food, so according to the shrimp fisherman I spoke with, “the faster the wind, the faster the growth”. Currents also make fish harder to catch, according to one of the charter captains. The shrimp fisherman also explained that rain can affect salinity; shrimping is not good after heavy rain because the water is too fresh. In terms of food, smaller fish are needed by larger fish. As one charter mate described, “[important environmental factors] start at the ground level, [with] the condition of food and bait [such as] menhaden for bluefish. [You] need enough food to keep [the fish] here. The bottom structure [is also important]…artificial reef programs…attract bait fish.”

Based on these interviews, three factors seem to influence fish location: temperature, salinity, and wind. These factors appeared across both age-groups of fishermen. If this is the case, then these observations are important from a management perspective because they are the beginning of a folk model which could influence where biologists might consider sampling to assess fish stocks. This is not a trivial point. Fishermen routinely criticize biologists for sampling in locations where they, the fishermen, know there are no fish they often further conclude that biologists’ sampling in areas without fish lead to faulty estimations of fish population levels. Of course, biologists sample in places where there may be no fish because of the demands of random sampling designs; however, if they were to incorporate fishermen’s ideas about fish locations into their sampling designs, they could add legitimacy, in fishermen’s eyes, to their conclusions regarding fish stocks.

Problems with Fishery Science

Some informants, mostly those who had been in the fishing industry longer, brought up government regulations when asked about environmental factors important to fish species. They argued that with the increased cutbacks with the NOAA size limits and bag limits, a lot of fish have to be thrown back (e.g. red snapper). Differences of opinion emerged when I asked the fishermen how they make judgments about the health of fish stocks. Two informants (both younger or less experienced) rely on what the scientists communicate to them based on email proclamations and websites, such as tagagiant.com. Others argued that they know more than "the people behind the desks." Federal assessments were criticized for supposedly not understanding that the fish have just moved on (again feeding into the folk model); they are assigned to sample the same area over and over again. An example given by one individual was the yellowfin tuna: "there were very few in the last three years. Instead of going north on the east side of the Gulf stream [they were] bypassing us," this fisherman argued. With shrimp, according to one informant, recorded fluctuations may not be happening; samples might be taken at the wrong time of day (e.g. day vs. night, three days after a full moon). Their judgments are based on being out on the water and fishing all the time, going out to different places. "We fish 2,000 to 3,000 places," one informant reported, "and don't fish [the same place] every day." Another fisherman agreed with this statement, arguing that "most people that [fish] for a living go to different places to give [the fish] a chance to grow up." Catch numbers were another way mentioned to gauge the health of the fish stocks.

Government regulations were again brought up when I asked what factors affect the health of fish stocks. Among the more experienced informants, it was commonly argued that fish numbers vary by year and season. For example, a Morehead City charter boat captain explained that "dolphins migrate every year in May and June…[in] July and August [the numbers] are low…[you have to] go by migration…Federal assessments don't understand that they may have just moved." Federal limits on one species, another fisherman argued, create pressure on others. As he explained, "[you need to] fish evenly. [For example] if you have ten species [you need to] be able to fish all ten species." Another added that it is important that marine fisheries work with the fishermen. Among those fishermen who had not been in the industry as long, it was also believed that stocks go in "circles", with fluctuations in stock numbers. Some of the informants with less experience, however, mentioned that they have not noticed any depletion in fish stocks.

Importantly, not all fishermen admitted to knowing how to assess fish stocks. A long-term Morehead City charter boat captain reported that there is "no indication…just what the scientists say through e-mail proclamations and websites." Other experienced charter fishermen criticized the government for cutting back too much, and emphasized that the way to determine if the fish stocks are low or stressed is "seeing for yourself." However, there was a bit of a contradiction among this group, as at least one older informant explained that he doesn't have the equipment to determine if the fish stocks are low, and that one "can't tell just by catching [fish]." Informants reiterated the idea that federal regulations are too tight; various environmental elements including current and the weather may cause fish to spread out. As one fisherman explained, "men in statistics pick a single reef…and sample it." Migratory patterns also affect the location of fish.

Younger or less experienced fishermen echoed some of the same sentiments. Some also admitted that they do not know how to determine if fish stocks are low or stressed, believing that fish stocks move up and down based on weather patterns. As with the previous question, they responded that researchers or those taking samples do not take the time to talk to people, only fish once, and base assessments on that. "Raleigh fishermen only fish once," another charter captain stated, "don't find anything, and don't take the time to talk to anyone." Another argued that "one boat goes out along the coast and makes judgments down the entire east coast." One has to look at overall patterns and get about ten years of information from boats everywhere, according to one informant. The issue of scientific sampling and representation was a common theme throughout these interviews, as there appeared to be different ideas about the method of random sampling between scientists and fishermen.

Past and Present Conditions of Fishing Opportunities

A decrease in fishing opportunity was another theme associated with the economy and government regulations. Some of my informants claimed that many people can't afford to go out anymore. One estimated that fishing was down by about 50%, due to the economy. One informant explained that he only goes out about 120 days a year, down from 170 in the past due to government regulations. Others mentioned that they were not chartering as much; one said that the business is "not as good as it used to be at one time." Another who used to fish about 200 days out of the year only goes out about 100-150 days. This seems to have influenced how much fishing has remained a family enterprise. Only about half of the informants have family members in the fishing industry. One explained that those in his family who had previously worked in the fishing industry had to get other jobs "in order to make a living," and that government regulation played a decisive role in this. For example, "you have to throw a lot back" including red snapper, due to NOAA size and bag limits. An informant mentioned that proper limits are needed for each species, meaning that those in marine fisheries research need to work with the fishermen to determine these limits. An example he gave involved bottom fishing. There is a limit of one snowy grouper, but "whatever eats your hook eats your hook", and the changes in water pressure as the fish is brought up often kill it. This raises the question of what to do if more than one snowy grouper is caught. This individual continued to describe the decrease in business by claiming that "there is no reason to go [since] government is taking away the opportunity."

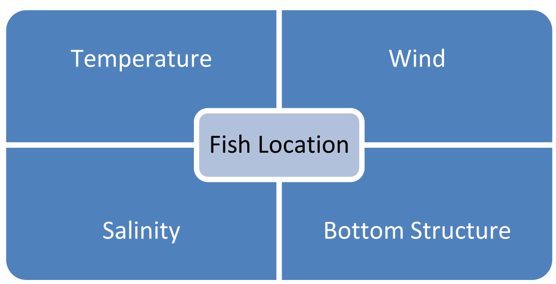
At least one informant argued that the decrease in fishing trips has been beneficial for the stocks. Yet one informant, a charter captain and boat builder in Morehead City for over forty years, *did* argue that overfishing is occurring. He stated that there are too many boats, about 400-500, when back in the 1960s there were only about thirty. People have faster boats and navigating equipment such as GPS, so they're all going to the same spots. Tournaments were also a problem for this reason, according to the informant, who also added that there are no king mackerel anymore. A second informant argued that commercial fishing has slowed down due to overfishing all over the world, including the Mediterranean.

Some informants claimed the fish may be spread out, or may have moved on due to migratory patterns. Some argued that they are catching good, healthy catches, and that others are catching their bag limits. One can tell what the stocks are like by being out there, and seeing what you and others are catching, which seems to correspond with approaches to assessing fish stocks. Some informants explained that some years you see fish, others you do not. One example given by a crab fisherman was fish kills, where fish die from a lack of oxygen in the water due to the heat. Alternating fishing spots gives the fish a chance to mature; one charter captain from Atlantic Beach described a system of alternating between fishing sites, telling me that they "stop in one place, catch fish there [and then return] 2-3 weeks later to allow stocks to go back up, [which] gives stocks time to rebuild." One charter mate felt that he has seen more marlin this year "than in the past 20 years." Stock assessments are related to fishing behavior and alternating fishing locations. These factors, combined with other information about wind, salinity, and temperature help to further develop a folk model.

Yet some informants argued that overfishing is occurring, at least to some degree. Commercial fishermen fishing with 60 miles of hooks south of North Carolina was one reason given for lower mahi numbers. According to another the king mackerel has actually been killed off in the Morehead area because of the tournaments; Morehead City used to be known for them. One informant also discussed overfishing of the bluefin tuna, and how it is being overfished in the Mediterranean, not just here.

With this data from the interviews, a folk model can be developed. It appeared that charter captains and fishermen believed that salinity, temperature, and wind (and perhaps bottom structures as a fourth variable) influence fish location. Consequently, fishermen fish in a variety of locations based on these factors, as well as the idea of allowing the resource to replenish itself (an example of a folk strategy of resource rotation). They argue that this enables them to catch fish in a way that represents the fish population better than the methods of scientists.

Figure 3: Folk Model of Environmental Factors Affecting Fish



Discussion of Semi-Structured Interviews with Biologists

Important Environment Characteristics

Attempts were made to compare and contrast the responses from biologists in academia, and those involved in fishery management. Some of the environmental factors that biologists mentioned for fish species overlapped with those that fishermen listed. Water temperature was mentioned across both groups of biologists. According to one of the professors I spoke with, oxygen along with salinity (another factor mentioned across both groups) “dictate where fish live” (i.e. location). Another similarity between both groups of biologists was the mention of the importance of habitat, which differs by species. Access to spawning areas and nursery habitat was brought up by two informants, one an ECU professor, a NOAA biologist, and a DMF Commissioner, who gave the example of red drum, stating that “when spawning red drum need a hard bottom.” Another DMF biologist mentioned vegetation, explaining that submerged aquatic vegetation is needed by spotted sea trout, which live in estuaries. Interestingly, oxygen level was a common response from biologists within academia (mentioned by all three ECU professors), but was only mentioned by one informant in the DMF. One university professor argued that dissolved oxygen dictates how much oxygen there is in the water; fish can sometimes tell how much there is and leave if there isn’t enough. In terms of how much they need, another professor specified that fish need about 5 ml per liter of water or more. Therefore, fish mobility is also key to survival (they will suffocate and die without enough oxygen in the water). The DMF commissioner also pointed out that oxygen is important for spawning; for example, “red drum go into deeper water for spawning…just above the bottom where there’s more oxygen.”

Water turbidity was one factor mentioned solely by the university biologists. Turbidity refers to the cloudiness of the water, with low turbidity being clear water, and high turbidity being cloudy water. One NOAA biologist mentioned several factors not mentioned by anyone else. He discussed current as another important water-related factor. Another was competition with different species, which especially affects, since their niche can be filled by other species. Anthropogenic influences were not often mentioned, brought up only by one university biologist and one NOAA biologist. Sedimentation from agricultural runoff was mentioned by an ECU professor, which appears to echo some of the same sentiments of fishermen concerned with pollution from local farms and runoff from inland rivers. A NOAA biologist argued that "you can’t take people out of fisheries management. Fisheries management is predicated on regulating take yields, understanding dynamics of recruitment, cycles and rhythms of nature." Overall, biologists from both sectors appeared to agree on important environmental factors, which overlapped with some of the more important aspects of environment discussed by fishers, including temperature, salinity, and habitat.

Methods to Monitor Fish Stocks

Biologists from both groups described two basic types of data used to monitor fish stocks: fishery independent and fishery dependent data. Fishery independent data were defined by a university professor as biologists' own samples, e.g. sonar, acoustic, hook and line, hydrophones, etc. One example given was gillnet surveys of adult fish, such as striped bass. Other examples include beach seine surveys, hassle trawl surveys, and young-of-the-year indices. Fishery dependent data include samples from fish houses, and trip tickets from commercial fishermen to determine effort and catch in certain areas.

Another determining source of fish stock assessments mentioned was the management councils. Respondents from both sectors mentioned this process, but from different angles. An ECU professor described looking at the "grey literature", referring to the NOAA, DMF, and SAFMC stock reports. A NOAA biologist briefly described the management by the councils by explaining how they manage through the representation from different sectors including industry, NGOs, and government. The research findings are then reviewed, and fishing limits are set based on them. Two additional factors were also brought up only among those involved in fisheries management: maximum sustainable yield (MSY), and the analysis of historical levels. Maximum sustainable yield is defined as "the largest average catch that can be continuously taken from a stock under constant environmental conditions" (Cooper N.d.: 43). One NOAA informant explained that determining MSY is one goal when scientists get together to make stock assessments and projections. These differences between the two groups may not actually reflect differences of opinion, but differences in perspective as a result of working in two different sectors.

Awareness of TEK

All my informants were familiar with the concept of TEK. The belief that fishermen have detailed knowledge of marine resources was one theme consistent in all the interviews across both groups of biologists. One university professor argued that “they may not know the correct scientific terms, but those who have been around a while know where and when fish show up, timing, when not to go out fishing, since they need to minimize effort, maximize profits.” The same informant explained to me that “we try to be very neutral. I have a good reputation with them, I try to support them. [I] tell them things may not come out the way they want, don’t hold any punches. They may talk about other scientists, [and] tell me how stupid they are. [I] try to instill in students importance of working with fishermen. Some of them read a lot about laws, etc.” Another professor of biology admitted that fishermen “may even be more knowledgeable than scientists” when it comes to information such as certain patterns of fish movement specific to the region where they work and knowing when something has changed in their water. Another professor agreed that TEK is “very important” and a “good scientist will use it as a foundation.”

Another university informant described the scientific approach or method as more systematic than TEK. This informant also noted that although TEK does not depend on the scientific approach, it is not intuition but comes from physical observation. It may borrow scientific knowledge, without using the whole method to support their findings. Scientists then have a hard time accepting TEK, because it’s “not the scientific approach…[They] may borrow scientific knowledge, but [are] not using the whole method to support their findings.” One biology professor stressed listening to recreational and commercial fishermen, “since they are out a lot more, and can tell if the stock is low/high or changing. [They’re] better at it than we used to give them credit for.”

Opinions about the Usefulness of TEK

The dependability of fishermen’s knowledge was another common theme. Most informants across both groups appeared to find TEK useful, but still believed it to have its limitations. According to a NOAA biologist, fishermen don’t always fill out forms correctly. This may be intentional, or they may not know directions, or may only give one depth when they fished at several depths. This sentiment was echoed by another informant who explained that fishermen may underreport their catch to avoid getting into trouble. A biologist at the DMF added that although they do rely on anecdotal information from fishermen, they still have to verify it. According to another informant, although fishermen are experts, they may not have the ability to understand management of resources. One reason given by a NOAA biologist for this is that scientists who do stock assessment “can speak a different language”, for “fishermen often do not have any baseline knowledge of mathematical modeling”. Yet a university professor explained that modeling itself is limited, giving the example of the smooth dogfish. There is no information on this species, so the available information on a similar species, the spiny dogfish, is entered into models. One NOAA biologist argued that they try to obtain fishermen’s trust in science, but it could be difficult if the fishermen catch a species in abundance; overall it could be insignificant to the health and protection of the maximum sustainable yield. Just as TEK may be incomplete, biased, or flawed, so too scientific models suffer from problems that make them suspect.

One professor also argued that some things fishermen believe to be true about fish are not, for their reasoning for movement may be based on false assumptions. They notice processes of fish abundance, and may know more in some areas than others. As this informant argued, "fishermen know where fish congregate, but tend to have a simplistic view of how ecosystems function. [Their] knowledge falls rapidly after abundance. [I] respect [their] knowledge about movement, but not necessarily their reasons for movement. Some things they believe to be true about fish are not true. [Their] reasoning for movement may be based on false assumptions…if it is in their best interests economically to believe something is not true they will." The informant gave the example of female grouper in Dominican Republic; "spear fishermen claim they do not shoot the fish if they are fat or pregnant, and blame nets for catching juveniles" he explained. They claim to target only the largest fish. This informant, however, has doubts that they can tell gravid from non-gravid specimens. "Groupers are hermaphrodite; they start off as male and become female. If [the fishermen] are taking only the largest, then they're taking females, so what they said made sense to them internally, but from what my informant gathered they are actually targeting females." Therefore, my informant concluded, "they have a very focused view on the number of fish given the place and time and how to make enough money to pay for expenses, which limits their knowledge." This contradicts what the fishermen say about fishing multiple locations, and fails to recognize folk models of fish behavior that, in fact, correspond significantly to scientific models in terms of important factors influencing fish behavior (e.g. temperature and salinity).

A NOAA biologist stated that TEK is "inherently important in [the] management process. Fishermen sit in councils" (e.g. SAFMC). "TEK needs to be verified by science," argued another informant from the DMF, "but science benefits from it." Another agreed that it is valuable information, but it can be “hard to assimilate.” Data gets better over time, one NOAA informant explained; data from the 2000s is fairly good, but it gets worse the farther you go back. Reasons for this include changes in methods over time, lack of reporting from every fisherman, and fish being lumped into groups. It can also depend on how much money is put into the monitoring programs, according to one of the professors. Another gave the analogy that “studying fish is not like studying squirrels (one can do simple mark-recapture with squirrels), since you can’t see the resource so you don’t know if you’re in the ballpark or not. Modelers can only model what’s available, need information on fecundity, maturity, recapture, migration, mortality….In generating questions and answers, it’s better to get commercial fishermen involved.”

Summary of Findings from Interviews

There appeared to be a fair amount of consensus between the two groups on environmental factors important to fish. Both biologists and fishermen mentioned the importance of the water quality, including its salinity, temperature, and oxygen levels. These factors are important for spawning; as one biologist explained, red drum seek water with higher oxygen levels for spawning. Temperature affects the location of the fish; according to one fisherman, fish move closer inshore when the water is warmer. Reef structure was also cited as important for spawning and protection from predators. There was some disagreement, however, at least among the fishermen, concerning certain pollution sources and the extent of pollution created by fishing. In terms of the relationship between the folk and scientific models, both groups seem to share similar ideas about what environmental factors are important for fish, and influence their location.

Several fishermen informants claimed that there are limitations in the sampling methods used by biologists trying to determine the health of the fish stocks (an example mentioned being the one-time sample taken from a single reef). As a result, charter captains feel their businesses are being hurt, as tight regulations on species such as red snapper and grouper require them to throw back some of their catch. Yet there seemed to be some disagreement on the condition of the fish stocks, which were described by some as “fine” but at least one other informant described the fish stocks as overexploited, due to an increase in the number of fishermen and improvements in navigation technology. Interestingly, for a number of species (e.g. wahoo, mackerel), fishermen and biologists were in complete agreement regarding their health.

The biologists I spoke with stated that TEK and other resource user groups are important in research and management. However, this knowledge needs to be utilized in conjunction with other indices such as historical stock data. Fishermen can be helpful in their observations of fish abundance, some argued, but may have a “simplistic view of how ecosystems function.” Scientists benefit from working with fishermen, but they explicitly state that TEK still needs to be “verified by science.”

Cultural Consensus Analysis

For the next stage of fieldwork, I took 44 statements from both the fishermen and biologist interviews (one statement was accidentally duplicated) and created a survey where informants indicated whether they agreed or disagreed with each statement. Twenty fishermen and 19 biologists were interviewed, for a total of 39 individuals. There was considerable disagreement within both populations. On 22 of the statements, the fishermen do not appear to share the same knowledge, with approximately a quarter disagreeing with the majority.

For the following five statements, it seems that biologists disagree with a significant proportion of the fishermen, but within the group of fishermen there was little consensus:

Table 2: Statements of Disagreement between Biologists and Fishermen

Statement	% Fishermen Agree	% Biologists Agree
"Even minor weather events (e.g. rainstorms) can impact the health of fish populations"	40%	73.7%
"Weather doesn't affect the health of fish"	40%	5.3%
"Suburban sprawl is affecting coastal water quality."	70%	100%
"Litter is not a problem in Morehead City/Atlantic Beach/Beaufort area"	50%	5.3%
"Pollution from Open Grounds is not a problem for the fish"	50%	5.3%

Despite the higher level of agreement among biologists, most of the fishermen agreed with a few of the above statements. Less agreement among the fishermen may be caused by a number of things, including how they define terms (e.g. "suburban sprawl" and "health") used in the statements. For example, with statements about fish stocks, there is a considerable difference between biologists and fishermen, but the fishermen are divided, sometimes nearly in half (e.g. 45-55). These disagreements appear to be significant because the two groups tend to agree on general statements regarding the relationship between weather and the ecosystem. However, three of these statements refer to the influence of shore-based sources of pollution. It is possible that since fishermen often fish far off-shore, they may see less effects of offshore-based pollution.

The next four statements concern the direct effect of things, such as artificial reefs and charter fleets, on fish stocks and health:

Table 3: Statements Concerning the Direct Effect of Factors on Fish

Statement	% Fishermen Agree	% Biologists Agree
“Charter boats in Morehead City don’t affect the ecosystem that much.”	85%	26.3%
“Mercury levels in pelagic fish are not a problem”	45%	0%
"All fish need reefs for spawning”	40%	5.3%
Artificial reefs are good because they attract bait fish”	100%	52.6%

The second and third statements are important because in both a majority of fishermen agree with biologists. Using the word “all” in the third statement may explain why 60% of fishermen agreed with biologists. Obviously the fishermen’s agreement with the first statement derives from their vested interests as charter boat captains. Yet it is unclear why there was disagreement among biologists with the fourth statement concerning artificial reefs, since they do attract bait fish. It may be that they may agree that artificial reefs are good, but for other reasons than attracting bait.

The third major theme was the politics of fishing. Included in this section are statements about communication between fishermen and biologists or their views of one another, since these are important to what these groups will consider legitimate.

Table 4: Statements Regarding the Politics of Fishing

Statement	% Fishermen Agree	% Biologists Agree
"The government is taking away fishing opportunities with size and bag limits"	95%	47.4%
"Fishermen (or fish-dealers) sometimes under-report or misreport catches"	45%	84.2%
"Many research biologists think fish stocks are stressed because they don't know how to find fish."	85%	15.8%
Researchers taking samples don't talk to fishermen"	75%	21%

The second and third statements are interesting because they show that biologists think fishermen are behaving inappropriately, and vice versa. The issue of trust arises, which is crucial in developing effective communication and creating legitimacy. Trust is also critical for the creation of "social capital", or the ability of social groups, by virtue of their membership, to gather resources (in this case, regulatory decisions or political action) toward positive social outcomes (e.g. healthier fish stocks). If the two groups cannot considers themselves as one group, they cannot work together create or utilize social capital.

There were also some statements centered on fish behavior and the influence of fish behavior where fishermen were divided, with the substantial proportions (20 to 65%) agreeing with biologists:

Table 5: Statements on Fish Behavior and the Influence of Fish Behavior

Statement	% Fishermen Agree	% Biologists Agree
"Fish stocks seem low because the fish are migrating"	35%	5.3%
"Fish tend to spread out in hot weather"	65%	21%
"There are low numbers of yellowfin tuna because they're bypassing us in their migration"	80%	5.3%

It is interesting that only 35% of fishermen agreed with the first statement about migration, yet 80% about the tuna statement about migration, which seem to contradict one another, the former contrasting with a common fisherman belief that migration influences perceptions of fish stocks and the latter conforming to this belief.

Again, with statements on fish stock statuses, there is far less agreement among the fishermen than within the biologist group:

Table 6: Statements on Fish Stock Statuses

Statement	% Fishermen Agree	% Biologists Agree
"There are more marlin now than there were 20 years ago"	45%	15.8%
"All the fish stocks appear to be healthy"	60%	5.3%
"Looking at the catch is the main measuring stick of health"	55%	5.3%

There were five categories of general agreement between the two groups: general ecosystem relationships, means of assessing fish stocks, the health of specific species, the political economics of fishing, and gear:

Table 7: Statements of General Agreement between Fishermen and Biologists

Statement	% Fishermen Agree	% Biologists Agree
"Weather affects where the fish can be found"	95%	100%
"Clean water is important for fish"	90%	94.7%
"The temperature of the water is not affected by the Gulf Stream"	0%	0%
"You have to look at overall patterns over a long period of time to determine if fish	85%	100%

stocks are low”		
“The longevity of species is an important component in assessing the health of fish stocks”	90%	89.5%
“Indices besides landings data are needed for fish stock modeling”	85%	94.7%
“Wahoo numbers are poor”	15%	15.8%
“Morehead doesn’t have king mackerel anymore”	0%	0%
“King mackerel have been overfished”	15%	15.8%
“Dolphin stocks are low”	5%	5.3%
“Government regulations on one species create pressure on other species”	90%	89.5%
"Fishermen’s knowledge is critical for fisheries management"	95%	89.5%
“Fishermen can tell if the fish stocks are low, high, or changing”	70%	68.4%
“Long-lines are a problem because they’re unselective about what fish they catch”	35%	26.3%

These statements suggest that there are several areas of agreement between fishers and biologists, which could be further developed by fishery managers to create further consensus. As others have suggested (Johnson and Griffith 2010), it is important to identify specific areas of agreement and disagreement among resource user groups and variation within them. Some similarity may be found with previous studies, such as that of Johnson and Griffith (2010) who found in their study of the conflict between commercial and recreational fishermen, that greater disagreement about facts occurred less with underlying environmental values than with more specific facts about environmental problems. This may also be the case in the conflict between fishermen and biologists, who agree on important environmental factors for fish but may disagree on regulation and other issues.

Chi-Square Analysis

At least eleven statements were found to be significant through chi-square analysis using SPSS. For this analysis, results were considered significant at the $p<.05$ level. The significant statements are indicated by an asterisk in the full list of statements in Appendix D.

CHAPTER 5: POSSIBILITIES FOR RESOLUTION: A DISCUSSION

North Carolina is a valuable area for the fishing industry due to its environment and diverse fishery resources, including herring, shad, whale, oyster, menhaden, and snapper-grouper species. Some fisheries, such the oyster fishery, have already been depleted or nearly depleted (Cecelski 2000), while others, such as the whale fishery, ended long ago and cannot be revived due to marine mammal protections. As with other areas, North Carolina's coastal communities and estuarine systems are suffering from environmental changes, including anthropogenic changes such as the effects of development, and climactic changes such as sea level rise and increased frequency and violence of storms.

Approximately 70% of marine fisheries are in a state of crisis or being over-exploited (Acheson 2006). In an effort to help replenish fish stocks, the U.S government has established the Magnuson-Stevens Conservation and Management Act and other fishing regulations. Conflicts have arisen between fishery managers and fishermen, with the fishermen questioning the legitimacy of regulations based on scientists' assessments of fish stocks. Both recreational and commercial fishermen argue that some fish stocks are still plentiful, and that the fishing regulations are too rigid. The snapper-grouper fishery is one example of a fishery that has been deeply affected by the regulations of the Magnuson-Stevens Conservation and Management Act. This is a mixed species group consisting of species which are slow-growing, late-maturing, and long-lived, thus management can be difficult, and rebuilding stocks can take years for some species.

Some anthropologists, in light of the problems and conflicts within resource management, have studied and argued for the importance of TEK of resource users into management practices. Anthropologists have found systems of folk management used by different communities. Dyer and Leard (1994) found that within the oyster fishery of the U.S. Gulf of Mexico community-focused folk management existed, which meant more stable resource use and economic benefits to the community. Kinship was important in having access to the fish, thus the authors argue that it is communally controlled. Similar management was found in a study by Acheson (2006) of the Maine lobster fishery. Acceptance into a “harbor gang” is required in order to catch lobster. These harbor gangs also work to enforce rules among their members, including the prohibition against taking females with eggs or juveniles. While this study did not discover similar social groups governing North Carolina’s fishery resources, the sharing of knowledge about some aspects of those fishery resources could serve as a basis to construct social controls within the charter boat fishery that could serve as examples to fishery managers.

TEK can also potentially benefit SEK and fisheries management through a broader or more diverse knowledge base. Griffith (2006) found multiple livelihoods among fishing families in North Carolina. Families rely on a number of different professions to supplement their fishing income. This creates local knowledge bases of several realms including social and biological relationships, environmental health, and political and economic processes. This knowledge is different from SEK, Griffith (2006) argues, in that SEK is based on narrower and more intense exploitation and observation of natural resources. In this study, the semi-structured interviews clearly showed that fishermen and biologists both consider marine resources with reference to the politics and governance of fisheries.

Despite their differences, Berkes et al. (2000) argue that TEK and SEK can be used together to improve resource management. TEK is often in agreement with adaptive management in the idea that environmental conditions change, and require adaptation. Nature is also seen as something which cannot be controlled or predicted, and an emphasis is placed on the processes that are part of ecological cycles (Berkes et al. 2000). One criticism of conventional resource management is its assumption of ecological stability; Berkes et al. (2000) argue that TEK can provide a "resilience" point of view, represented through measures including flexible resource use, diverse resource use, and locally created rules. In turn, SEK can help correct any potential problems with TEK, such as nonrandom sampling problems which may arise from traditional population monitoring (Moller et al. 2004). According to Moller et al. (2004), SEK can also complement TEK by providing data from larger areas, providing a study of causation, and establishing spatial generality. These studies address the concern among biologists in this study regarding verifying TEK with SEK, as well as provide ideas about how to combine the two in fisheries management.

Coastal communities, as Colburn et al. (2006) explain, are divided between attempts at restoration and conservation, and the social and economic effects of coastal development. Anthropologists have gotten involved in fisheries management to provide better understanding of different relationships within fishery resource systems, and such efforts include impact-assessment studies and ethnographies (Durrenberger and King 2000). Co-management has been one solution suggested by researchers (Jentoft et al, 1998), which would conform to my informants' beliefs that both fishermen and scientists have something to bring to management.

A few other observations relevant to this study come from Kitner, Olson, and Berkes and Pocock. The mobility and marginalization of snapper-grouper fishermen in the South Atlantic is one example of a study undertaken by an anthropologist (Kitner 2006). Kitner found that mobility and fishermen's working conditions may cause marginalization. Olson (2006), in a study of the sea scallop fishery in Massachusetts, argues that the knowledge of fishermen may be useful for ecosystem-based management, due to their consideration of a variety of ecosystem variables influencing fishery cycles. Additionally, Berkes and Pocock (1981) found evidence of self-regulation among Lake Erie commercial fishermen, including the avoidance of crowding among gillnetters. It is further argued that fishermen have an understanding of fish stock vulnerability, and that stock regulation is associated with the maintenance of good catches and good income.

This study's findings support some of the ideas presented in the literature. Resource rotation, a method used in TEK as described by Berkes et al. (2000), was mentioned by some of my charter captain informants. Fishermen reported fishing in multiple areas, as many as several thousand different places, to order to give fish a "chance to grow up." "The location depends on the time of the year" explained one respondent, who listed Cape Shoals and Cape Pointe as examples off-fishing locations (describing Cape Pointe as a good place for mackerel). Bog Rock is another popular place for fishing, which one informant described as "good for dolphins." Fishing locations, another mentioned, cover a "wide range that depends on the current." Other factors which determined offshore location were the day and weather. Little to no difference in knowledge between longer and shorter-term fishermen might suggest historical continuity, an idea that TEK collects over time and is passed to future generations (Berkes et al. 2000).

The concept of multiple livelihoods (Griffith, 2006) is also possibly present, as shown in the knowledge of fish behavior within larger understanding, as with the idea of fish populations occurring in cycles (i.e. numbers fluctuating over time) and the concept of water having layers. Respondents also displayed knowledge about seasonality of species, and where certain species can be found. For example, one charter captain argued that dolphin and mahi are found mainly off-shore, whereas Spanish and king mackerel and found inshore. Knowledge of marine resources also appears to change over time, as Murray et al. (2006) argue. According to one informant, the technology used in fishing has changed. Fishermen used to navigate with compasses, and now use GPS equipment.

Some of my informants' responses appeared to reflect sentiments in Jentoft regarding co-management (the collaborative and participatory process of user groups, management agencies, and research institutions). Most informants argued that TEK is important in management, as it is good for developing questions and answers in fisheries management. This idea is also consistent with that of ecosystem-based management, where fishermen's knowledge may be helpful since they consider different ecosystem factors that influence fishery cycles (Olson 2006). The involvement of commercial fishermen's TEK in fisheries management was studied in Price and Rulifson's study (2004), and found that striped bass bycatch in white perch nets was reduced with commercial fishermen's participation. "Management is the main thing [influencing the health of fish populations]," argued one biologist. "[We] need to balance a sustainable fishery with the wants and needs of user groups. When those two are in harmony, that's a healthy fishery." Yet another general sentiment felt by my informants was that TEK cannot be considered alone; as one biologist pointed out, "[TEK] is very useful, but can't be the only way to look at the stock… [It's] useful for overall trends." Another argued that "I know for a fact that they are mis-reporting."

Solutions to resource user conflicts is difficult for a number of reasons, including the questioning of legitimacy by both groups, and individual variation within them. Both of these issues emerged in this study. These conflicts are also compounded by issues such as population growth, which has led to real estate development and in increase in tourism (Griffith 2002; Johnson and Griffith 2010). Therefore, as others have suggested (Johnson and Griffith 2010), it is important to identify specific areas of agreement and disagreement among resource user groups and variation within themThis may also be the case in the conflict between fishermen and biologists, who agree on important environmental factors for fish but disagree on regulation and other issues.

This study only covered a small number of fishermen and biologists from a single regional area, so future research over a wider area with a greater number of informants could provide a better sense on overall trends. Based on the cultural consensus and interview data the two groups shared some ideas about ecosystems important to fish, but there are some areas that could be explored further; for example, wind was an important environmental factor mentioned by fishers, but not biologists. Additionally, it would be interesting to determine why biologists were divided on the importance of artificial reefs. There was also a wide amount of disagreement within fishers about certain issues, including the extent of pollution and its effects on fish stocks, and the current status of certain species. Yet the cultural consensus showed wide agreement between fishers and biologists on some statements including those about specific species and methods of stock assessments. One possible reason for disagreement or incongruities may be the fact that the biologist informants were estuarine biologists who focus on habitat. Future studies could provide greater insight into variation within groups of fishermen and biologists based demographic information such as age, gender, or location. Thus, analyses such as the methods used in this study can assist in identifying areas of agreement and disagreement between and within each group. This could aid in improving communication between these groups, and further understanding about the stock assessment process (i.e. biologist's method of random sampling). Further research into fishers' knowledge into factors not already considered by science (e.g. wind's effects on fish location) can also help to improve scientific understanding and fishing policy.

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APPENDIX A: IRB APPROVAL LETTERS

EAST CAROLINA UNIVERSITY
University & Medical Center Institutional Review Board Office
1L-09 Brody Medical Sciences Building• 600 Moye Boulevard • Greenville, NC 27834
Office **252-744-2914** • Fax **252-744-2284** • **www.ecu.edu/irb**

Date: June 17, 2011

Principal Investigator: David Griffith, PhD
Dept./Ctr./Institute: Dept. of Anthropology
Mailstop or Address: ECU—250 Flanagan Building

RE: **Exempt Certification** KK
UMCIRB# **10-0258**
Funding Source: Unfunded

Title: "Comparisons of Ecological Knowledge about Fish Stocks among Fisherman, Fishery Managers, and Biologists in the South Atlantic Region"

Dear Dr. Griffith:

On 6.15.11, the University & Medical Center Institutional Review Board (UMCIRB) determined that your research meets ECU requirements and federal exemption criterion #2 which includes research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects and any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

It is your responsibility to ensure that this research is conducted in the manner reported in your Internal Processing Form and Protocol, as well as being consistent with the ethical principles of the Belmont Report and your profession.

This research study does not require any additional interaction with the UMCIRB unless there are proposed changes to this study. Any change, prior to implementing that change, must be submitted to the UMCIRB for review and approval. The UMCIRB will determine if the change impacts the eligibility of the research for exempt status. If more substantive review is required, you will be notified within five business days.

The UMCIRB Office will hold your exemption application for a period of five years from the date of this letter. If you wish to continue this protocol beyond this period, you will need to submit an Exemption Certification Request at least 30 days before the end of the five year period.

Sincerely,

Chairperson, University & Medical Center Institutional Review Board

EAST CAROLINA UNIVERSITY
University & Medical Center Institutional Review Board Office
1L-09 Brody Medical Sciences Building• 600 Moye Boulevard • Greenville, NC 27834
Office 252-744-2914 • Fax 252-744-2284 • www.ecu.edu/irb

TO: David Griffith, PhD, Dept of Anthropology, 250 Flanagan Building, ECU—Mailstop-568

FROM: UMCIRB kzk

DATE: May 11, 2010

RE: Expedited Category Research Study

TITLE: "Comparisons of Ecological Knowledge about Fish Stocks among Fisherman, Fishery Managers, and Biologists in the South Atlantic Region"

UMCIRB #10-0258

This research study has undergone review and approval using expedited review on 5.10.10. This research study is eligible for review under an expedited category number 6 & 7. The Chairperson (or designee) deemed this **Department of Anthropology, ECU** sponsored study **no more than minimal risk** requiring a continuing review in **12 months.** Changes to this approved research may not be initiated without UMCIRB review except when necessary to eliminate an apparent immediate hazard to the participant. All unanticipated problems involving risks to participants and others must be promptly reported to the UMCIRB. The investigator must submit a continuing review/closure application to the UMCIRB prior to the date of study expiration. The investigator must adhere to all reporting requirements for this study.

The above referenced research study has been given approval for the period of **5.10.10** to **5.9.11**. The approval includes the following items:

- Internal Processing Form (dated 4.30.10)
- Informed Consent (dated 7.19.08)

The Chairperson (or designee) does not have a potential for conflict of interest on this study.

The UMCIRB applies 45 CFR 46, Subparts A-D, to all research reviewed by the UMCIRB regardless of the funding source. 21 CFR 50 and 21 CFR 56 are applied to all research studies under the Food and Drug Administration regulation. The UMCIRB follows applicable International Conference on Harmonisation Good Clinical Practice guidelines.

APPENDIX B: COMMON AND SCIENTIFIC NAMES FOR MENTIONED FISH SPECIES

Common Name	**Scientific Name**
King mackerel	*Scomberomorus cavalla*
Atlantic Spanish mackerel	*Scomberomorus maculatus*
Northern red snapper	*Lutjanus campechanus*
Yellowtail amberjack	*Seriola lalandi*
Greater amberjack	*Seriola dumerili*
Lesser amberjack	*Seriola fasciata*
Atlantic croaker	*Micropogonias undulates*
Atlantic menhaden	*Brevoortia tyrannus*
American eel	*Anguilla rostrata*
Weakfish	*Cynoscion regalis*
Southern flounder	*Paralichthys lethostigma*
Gulf flounder	*Paralichthys albigutta*
Common dolphinfish	*Coryphaena hippurus*
Wahoo	*Acanthocybium solandri*
Goliath grouper	*Epinephelus itajara*
Nassau grouper	*Epinephelus striatus*
Great northern tilefish	*Lopholatilus chamaeleonticeps*
Misty grouper	*Hyporthodus mystacinus*
Red grouper	*Epinephelus morio*
Scamp	*Mycteroperca phenax*
Tiger grouper	*Mycteroperca tigris*
Yellowfin grouper	*Mycteroperca venonosa*
Yellowmouth grouper	*Mycteroperca interstilitialis*
Blueline tilefish	*Caulolatilus microps*
Sand tilefish	*Malacanthus plumier*
Coney	*Epinephelus fulvus*
Graysby	*Epinephelus cruentatus*
Red hind	*Epinephelus guttatus*
Rock hind	*Epinephelus adscensionis*
Gag grouper	*Mycteroperca microlepis*
Black grouper	*Mycteroperca bonaci*
Snowy grouper	*Epinephelus niveatus*
Golden tilefish	*Lopholatilus chamaeleonticeps*
Speckled hind	*Epinephelus drummondhayi*
Warsaw Grouper	*Epinephelus nigritus*
Vermilion snapper	*Rhomboplites aurorubens*
Red porgy	*Pagrus pagrus*
Queen snapper	*Etelis oculatus*
Silk snapper	*Lutjanus vivanus*
Penaeid Shrimp	*Litopenaeus setiferus, Farfantepenaeus duorarum, Farfantepenaeus aztecus*
Yellowtail flounder	*Limanda ferruginea*

Winter flounder	*Pseudopleuronectes americanus*
Haddock	*Melanogrammus aeglefinus*
Spiny lobster	*Panulirus argus*
Golden crab	*Chaceon fenneri*
Sargassum	*Sargassum fluitans, Sargassum natans*
Yellowfin tuna	*Thunnus albacores*
Ballyhoo	*Hemiramphus brasiliensis, Hemiramphus unifasciatus*
Marlin	*Makaira nigricans* (blue marlin), *Tetrapturus albidus* (Atlantic white marlin)
Red drum	*Sciaenops ocellatus*
Mahi mahi	*Coryphaena hippurus* (common dolphinfish), *Coryphaena equiselis* (Pompano dolphinfish)
Spiny dogfish	*Squalus acanthias*
Smooth dogfish	*Mustelus canis*

APPENDIX C: INTERVIEW INSTRUMENTS

Fishermen Interview Instrument

- How long have you been involved with the fishing industry? In what capacity?
- How often do you fish, are out on the water, or otherwise experience the marine environment?
- What species of fish are you most familiar with? How do you fish for them (e.g. with what gear, where, what time of year, etc).
- What environmental factors are important to the species of fish you are most familiar with (for example, habitat, feeding behaviors, ranges or territories, substrates, etc.)? How are they important?
- How do you make judgments about the health of fish stocks?
- How do you determine if fish stocks are low, in danger of becoming low, or otherwise stressed?
- Do you have any relatives (brothers, sons, daughters, sisters, fathers, uncles, etc.) involved in the snapper-grouper fishery? Recreationally or commercially involved? Are any of your kin involved with other fisheries?
- What factors influence the health (mortality and survivorship) of fish populations?

Biologist Interview Instrument

- How long have you been involved with the fishing industry? In what capacity?
- How often do you directly experience/ interact with the marine environment?
- What species of fish are you most familiar with?
- What environmental factors are important to the species of fish you are most familiar with? (for example, habitat, feeding behaviors, ranges or territories, substrates, etc.)?
- How do you make judgments about the health of fish stocks?
- How do you determine if fish stocks are low? [assumes they are low]
- What factors influence the health (mortality and survivorship) of fish populations?
- What methods do you use to monitor fishery stocks?

APPENDIX D: COMPLETE LIST OF CULTURAL CONSENSUS FINDINGS

Statements	**% Fishermen Agree**	**% Biologists Agree**
“Suburban sprawl is affecting coastal water quality.”*	70% (14/20)	100% (19/19)
“Even minor weather events (e.g. rainstorms) can impact the health of fish populations”	40% (8/20)	73.7% (14/19)
“Weather doesn’t affect the health of fish”	40% (8/20)	5.3% (1/19)
"Weather affects where the fish can be found”	95% (19/20)	100% (19/19)
“The government is taking away fishing opportunities with size and bag limits”*	95% (19/20)	47.4% (9/19)
“There is no reason to go out fishing anymore”	0% (0/20)	10.5% (2/19)
“Recreational fishermen don’t fish as intensively as commercial fishermen”	40% (8/20)	26.3% (5/19)
“Bluefin tuna are in trouble from overfishing”*	55% (11/20)	78.9% (15/19)
“Fish stocks seem low because the fish are migrating”*	35% (7/20)	5.3% (1/19)
“Mercury levels in pelagic fish are not a problem”	45% (9/20)	0% (0/19)
“Charter boats in Morehead City don’t affect the ecosystem that much”	85% (17/20)	26.3% (5/19)
“You have to look at overall patterns over a long period of time to determine if fish stocks are low”	85% (17/20)	100% (19/19)
“There are more marlin now than there were 20 years ago”	45% (9/20)	15.8%(3/19)
“Wahoo numbers are poor”	15% (3/20)	15.8% (3/19)
“Morehead doesn’t have king mackerel anymore”	0% (0/20)	0% (0/19)
“King mackerel have been overfished”	15% (3/20)	15.8% (3/19)
“All the fish stocks appear to be healthy”	60% (12/20)	5.3% (1/19)
“Clean water is important for fish”	90% (18/20)	94.7% (18/19)
"All fish need reefs for spawning”*	40% (8/20)	5.3% (1/19)
“Strong currents make it more difficult to fish”	80% (16/20)	68.4% (13/19)
“Researchers taking samples don’t talk to fishermen”*	75% (15/20)	21% (4/19)
“Tournaments have led to overfishing”	5% (1/20)	21% (4/19)
“Alternating fishing spots gives fish a chance to mature”	50% (10/20)	26.3% (5/19)
“The use of long-lines in Charleston has led to overfishing (or low fish numbers?)”	35% (7/20)	26.3% (5/19)
“Litter is not a problem in Morehead City/Atlantic Beach/Beaufort area”*	50% (10/20)	5.3% (1/19)
“The longevity of species is an important component in assessing the health of fish stocks”	90% (18/20)	89.5% (17/19)

“Fish tend to spread out in hot weather”	65% (13/20)	21% (4/19)
“Fishermen (or fish-dealers) sometimes under-report or misreport catches”*	45% (9/20)	84.2% (16/19)
“Government regulations on one species create pressure on other species”	90% (18/20)	89.5% (17/19)
“Historical data from the 1900s and earlier is important for fish stock modeling”	50% (10/20)	73.7% (14/19)
“Dolphin stocks are low”	5% (1/20)	5.3% (1/19)
“Many research biologists think fish stocks are stressed because they don’t know how to find fish.”	85% (17/20)	15.8% (3/19)
“Indices besides landings data are needed for fish stock modeling”	85% (17/20)	94.7% (18/19)
“Pollution from Open Grounds is not a problem for the fish”*	50% (10/20)	5.3% (1/19)
“Long-lines are a problem because they’re unselective about what fish they catch”	60% (12/20)	57.9% (11/19)
“Fishermen can tell if the fish stocks are low, high, or changing”	80% (16/20)	57.9% (11/19)
“Circle-hooks have a higher release rate”	45% (9/20)	47.4% (9/19)
“The temperature of the water is not affected by the Gulf Stream”	0% (0/20)	0% (0/20)
“Fishermen have a very focused view on the number of fish given the time and place”	75% (15/20)	68.4% (13/19)
“Artificial reefs are good because they attract bait fish”	100% (20/20)	52.6% (10/19)
“There are low numbers of yellowfin tuna because they’re bypassing us in their migration”	80% (16/20)	5.3% (1/19)
"Fishermen’s knowledge is critical for fisheries management"	95% (19/20)	89.5% (17/19)
“Looking at the catch is the main measuring stick of health”*	55% (11/20)	5.3% (1/19)
“Fishermen can tell if the fish stocks are low, high, or changing”	70% (14/20)	68.4% (13/19)
“Fishermen have a very focused view on how to make money which limits their knowledge”	10% (2/20)	26.3% (5/19)

*=significant with chi-square analysis at $p<.05$ level.