Managing the North Carolina Blue Crab Fishery: Engaging Fishermen in the Analysis of Soft and Peeler Crab Regulations

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Abstract

In September of 2005, the North Carolina Marine Fisheries Commission approved regulations in the blue crab fishery for reducing wasteful fishing practices and preserving the spawning stock. Interviews of soft and peeler crab fishermen in Carteret County, North Carolina revealed the perceived effects of these and other regulations on their individual operations and on the health of the fishery as a whole. The results of these interviews are discussed in the following report. Additionally, the extent to which the 1998 and 2004 North Carolina Blue Crab Fishery Management Plans reflect the major findings of the interviews is considered and recommendations for future management plans are offered.
I. Introduction

The blue crab (Callinectes sapidus) fishery is North Carolina’s largest commercial fishery in terms of landings, value and employment. The North Carolina blue crab fishery can be divided into two sectors: the hard crab sector and the soft and peeler crab sector. The hard crab sector has historically been the larger of the two, in terms of both landings and value. The soft and peeler crab sector, while representing only a small portion of the total industry in landings, represents a disproportionately greater value. Given the recent fluctuations and overall decline in hard blue crab landings, and recognizing the overall increasing presence of a directed soft crab and peeler commercial fishery, the Marine Fisheries Commission has made a point of addressing the potential impact of the soft and peeler crab sector on the North Carolina blue crab fishery. These include management measures to reduce wasteful fishing practices and to maintain the spawning stock.

II. Industry Trends

Landing and Value Trends


Soft and peeler crab landings have generally increased since the 1980s, with some fluctuation (Appendix 1, Figure 1.1). This can be attributed in part, to the increase in the number of peeler pots and shedding facilities in use throughout the state (NC BCFMP, 2004). These increases indicate a shift in the nature of the soft crab and peeler industry from what was largely harvest as bycatch in hard crab pots, to a more directed fishery (see Appendix 3, for peeler pot explanation). This hypothesis is illustrated by trip ticket data which shows that in 1994, the percent of the total soft and peeler crab harvest landed in hard crab pots was 98% and by 2002 this percentage had declined to 60%. During this time there was a concomitant increase in the number of peeler pots used for harvest of soft crabs and peelers, from 4% in 1996 to 96% in 2002 (data was not collected for 1994-1995) (NC BCFMP, 2004).

Since 2001, a 50-year high of 2,240,896 lbs, the soft and peeler crab sector has shown a fluctuating trend. The 2001 high was followed by declines in 2002-2003 to a 10 year low
of 1,125180, followed by an increased catch in 2004. Percentage-wise, the peeler and soft crab landings accounted for approximately 3.2% of the total crab harvest from 1994-2004, and the most recent five years show that soft and peeler crabs represent 3.8% of the total landings.

The reader should be somewhat wary when interpreting these values, as unlike hard crab landings, which are reported on trip tickets by pounds, soft crab and peeler crabs are reported by number, and calculated to pounds at the DMF by multiplying by .33 (3 peeler or soft crabs are equal to one pound) (NC BCFMP 2004).


Similar to landings, the value of soft and peeler crabs has steadily increased since the mid 1980s (Appendix 1, Figure 2.1). Data from the Trip Tickets show that the current value of the industry increased, hitting a high of $7,153,706 in 2001, followed by a ten year low of $3,795,794 in 2002. The value has regained somewhat, since then, reaching a value of $4,217,510 in 2004. The reader should note that these numbers are not adjusted for inflation. While the soft crab and peeler total harvests represent a small proportion of the total blue crab catch, they represent larger percentages of the total value. Based on the blue crab average total value from 1994-2004, the peeler crab harvest accounts for approximately 11.9% of the total value versus 3.8% of the total landings. An average of yearly value in the last five years yields 14.3% of the total value. The reason for the higher value in comparison to landings can be attributed to the high market value of peeler and soft crabs in comparison to hard crabs. Averaged from 1994-2002, hard crabs sold for a value of $0.69 per pound, peelers for a value of $1.82 a pound and soft shell crabs for $3.86 per pound (See Appendix 2, Table 6.2).


Increasing from 1994, hard blue crab landings reached a 10 year high in 1996 with a total catch of 65,682,738 lbs. Since this year, the catches have declined with small fluctuations (Appendix 1, Fig 1.2). This is illustrated by comparing the 10-year average of 46,662,356 lbs with the most recent 5-year landings average of 39,240,026 lbs.
**State-Wide Hard Crab Value Trends (1994-2004)**

The value of the hard crab fishery has been more stable over this time period, but the 10 year average of $31,516,537 is higher than the most recent 5-year average of 28,859,776 (Appendix 1, Fig. 2.2).

**Effort Trends**

Effort trends are broken into total trips and total pots fished, by area (Albemarle, Core, Pamlico, and Southern). The number of dealers reporting in the Ocean was, in some years, very small, and thus confidential (A. Bianchi, personal communication, April 28, 2006). I have excluded this area from my discussion. A dealer may report landings from up to three types of gear; this data comes from trip tickets reporting the use of a single gear, only. Additionally, data collected for total crab pots fished was not recorded until 1996, and checks were not put in place until 1997 (ibid.), thus I have restricted my discussion of total pots fished to 1997-2005.

**Total Soft and Peeler Crab Trips (1994-2005)**

The number of trips taken for soft and peeler crabs in the Albemarle, Core and Pamlico areas increased from 1994 to the late-90s and/or early 2000s. In the years following these highs, the total annual trips have declined to near or below 1994 levels. The exception to this trend is the Southern area, which has maintained annual trip numbers above 1994 levels, despite an initial decline following a 2001 high (Appendix 1, Fig. 3.1).

**Total Hard Crab Trips (1994-2005)**

The total number of trips taken for hard crabs in the Pamlico area increased from 1994 through 1998, and has since declined to below its 1994 total. The Albemarle area experienced highs in 1995 and 2002, which in the first case was followed by a swift drop to its 1994 total in 1996, and in the second case has undergone a more gradual decline. The Core area experienced its greatest number of total trips in 1994 and has gradually declined since. The Southern area has shown a fluctuating trend, similar to Albemarle,
showing highs in 1995 and 2001, though its decline from 2001 appears to have stabilized above the declines following the 1995 high (Appendix 1, Fig. 3.2).

**Total Peeler Pots Fished (1997-2005)**

The total number of peeler crab pots fished in Albemarle and Pamlico areas increased from 1997 to 2001. In the years following this high, the total number of pots fished in the Albemarle area has declined to below its 1997 total. While also experiencing a decline in total number of pots fished following 2001, the number of pots fished in Pamlico area remains above the 1997 total. The total number of peeler pots fished in the Core and Southern Areas has fluctuated, but in 2005, both were above their 1997 totals (Appendix 1, Fig. 4.1).

**Total Hard Crab Pots Fished (1997-2005)**

The total number of hard crab pots fished annually in the Pamlico Area increased from 1997-1999, but has since declined to below its 1997 total. In the Albemarle Area, the total number of hard crab pots fished increased through 2002. In the years following this high, the total number of pots fished in the Albemarle area has declined, but has not fallen below its 1997 total. The total number of hard crab pots fished annually has fluctuated in the Core and Southern Areas, but remain above 1997 totals (Appendix 1, Fig. 4.2).

**Employment Trends**

Including both the harvesting and processing industries, the blue crab fishery employed 4,176 individuals, full-time and part-time, in 2002 (NC BCFMP, 2004). Of this total, 1,617 of these individuals were harvesting blue crabs. The number of individuals harvesting hard crabs declined from 1994 to 2002, and the number of individuals soft and peeler crab harvesting remained stable, with the exception of 2002, when the number of participants dropped. In both fisheries, the average amount earned increased yearly from 1994-2002 (with the exception of 2002, in the soft and peeler crab industry). The number of processing plants in the state has declined from 31 in 1998 to 20 in 2002. The DMF attributes this decline to several factors including; (1) a decrease
in the amount of crabs available for processing, due to a shift to the “live basket” market; (2) competition with processed crab meat imported from abroad; and (3) North Carolina crabs shipped out of state for processing (ibid.). When fishermen sell their crabs directly to the market, rather than to a processing plant they are sold to the “live basket” market. This is a high priced market that has grown in North Carolina (ASMF Report, 2004).

III. Legal Mandates

Federal Mandates:

There are no federal mandates affecting the North Carolina blue crab fishery.

State Mandates:

The Fisheries Management Act of 1997

The Fisheries Management Act of 1997 came after a three year moratorium on new fishing licenses, as managers created a fishery management scheme for the State’s fisheries. Among several new guidelines, the Act specified that the North Carolina Division of Marine Fisheries must create a fishery management plan for all the ‘commercially or recreationally significant species or fisheries that comprise the state marine or estuarine resources’, with the goal of maintaining their sustainability. It requires generally, that a fishery management plan:

(1) include management goals and objectives, status of relevant fish stocks, stock assessments, and water quality considerations consistent with Coastal Habitat Protection Plans

(2) recommend management actions pertaining to the fishery or fisheries

(3) specify a time period for rebuilding an over-fished fishery and achieving a sustainable harvest (G.S. 113-182.1)
General Statutes

These are state laws that provide the necessary authority for managing the North Carolina blue crab fishery. They specify how management schemes will be carried out, and who has the authority to make management decisions.

The North Carolina Administrative Code

Once recommendations in the fishery management plan have been approved by the Marine Fisheries Commission, they undergo the formal rule making process. The resulting laws can be found in the North Carolina Administrative Code (NCAC) under Title 15A “Department of Environment of Natural Resources, Chapter 3 “Marine Fisheries”. These laws are also known as “The Fisheries Rules for Coastal Waters” to which individuals in the commercial and recreational fisheries must abide.

IV. The Human Ecology
(Please See Appendix 2 for Flow Chart)

Public Policy and Management

The North Carolina General Assembly

The General Assembly is the formal law making body of North Carolina. It is made of two houses; the Senate and the House of Representatives (www.ncleg.net). As stated in the Legal Mandates section, these laws provide the authority to manage the North Carolina blue crab fishery. The General Assembly also retains the right to limit the number of fishermen participating in a fishery, so long as the Marine Fisheries Commission determines that ‘sustainable harvest cannot otherwise be achieved’ (G.S.113-182.1).

The Governor

The governor selects the members of Marine Fisheries Commission and signs major legislation; Governor Hunt signed the Fisheries Management Act into law in 1997.
The North Carolina Department of Environment and Natural Resources

The North Carolina Department of Environment and Natural Resources (DENR), is the lead agency for managing North Carolina’s natural resources. The mission of DENR is “to provide leadership, education and advocacy for the responsible stewardship of North Carolina’s environment and natural resources”. Through its 10 departments, DENR’s responsibilities include implementing regulatory programs, protecting habitat, and providing technical assistance to industry groups, government agencies, and the public (www.denr.state.nc.us/files/overview.pdf).

The Secretary of DENR is charged with monitoring the construction of fishery management plans, and reports this to the Joint Legislative Commission on Seafood and Aquaculture. Together they will review the final fishery management plan, before it is sent back to the Marine Fisheries Commission for final adoption (G.S. 113-182.1).

The North Carolina Division of Marine Fisheries

The North Carolina Division of Marine Fisheries (DMF) is the division within DENR whose mission is to ‘maintain, preserve, protect and develop’ North Carolina’s marine and estuarine resources, as determined by policies set by the Secretary of DENR and the Marine Fisheries Commission (www.ncfisheries.net). It is divided into nine departments; the Marine Patrol Division and the Fisheries Management division are highlighted here. The Marine Patrol Division is essential in monitoring and enforcing the rules that the Marine Fisheries Commission establishes. As part of the scientific community, the Fisheries Management Division carries out monitoring programs and research projects to determine the age structure, growth rates, mortality rate, and distribution of the state’s fisheries. Based on their data collection programs and scientific studies, the DMF then makes recommendations to the Marine Fisheries Commission during construction of the fishery management plan and prepares the plan according to the Commission’s direction (ibid.).

As head of the Division of Marine Fisheries, the Director of Fisheries is given the authority by proclamation to “suspend or implement, in whole or in part, a particular rule
of the Commission that may be affected by variable conditions”, according to G.S. 143B-289.52. Variable conditions are defined as: “the compliance with changes mandated by the Fisheries Reform Act and its amendments, biological impacts, environmental conditions, compliance with Fishery Management Plans, user conflicts, bycatch issues and variable spatial distributions” 15A NCAC 3H .0103. Proclamations issued by the Director hold the force of law. The Director must “make every reasonable effort to give actual notice of the terms of any proclamation to persons who may be affected by the proclamation”, such as public notices or communication through the marine patrol officers, and the public is responsible for keeping abreast of such proclamations (ibid.).

The Marine Fisheries Commission

The Marine Fisheries Commission (MFC) is a group of 9 individuals, holding specific experiences in the fishing industry; 2 current or recently retired commercial fishermen, one current fish dealer or seafood processor, two current recreational fishermen, one sport fishermen, two individuals with a general experience in some part of the fisheries management process, and one fisheries scientist. They are each selected by the governor and are authorized to license, regulate, prohibit, prescribe or restrict marine and estuarine resources with respect to:

a) time, place, character, or dimensions of any methods or equipment that may be employed in taking fish
b) seasons for taking fish
c) size limits and maximum quantities of fish that may be taken, possessed, bailed to another, transported, bought, sold, or given away.

The MFC meets these requirements by adopting Fisheries Management Plans, setting a time frame in which they should be developed, and setting ‘guidance criteria’ for their development (G.S. 143B-289.52). While the MFC grants the director the authority to alter rules by proclamation, they retain the right to “approve, cancel, or modify the previously issued or proposed proclamation”. It is important to remember that, “the decisions of the Marine Fisheries Commission shall be the final decision of the State” (G.S. 113-221.1).
Standing Advisory Committees

The chair of the MFC appoints four standing advisory committees: the Finfish, Crustacean, Shellfish, and Habitat and Water Quality Committees (G.S. 143B-289.57). These committees are made up of recreational and commercial fishermen, scientists, and other citizens with management knowledge. In the case of blue crabs, the Crustacean committee must review and make recommendations to any question the MFC might have. The committee may make recommendations of their own accord, so long as it is within the realm their expertise, and the MFC must consider their suggestions (ibid.).

Regional Advisory Committees

The Northeast, Central Regional, Southeast and Inland committees are appointed by the chair of the MFC and must have representation from commercial fishermen, recreational fishermen, and scientists (G.S. 113-182.1). The committees make recommendations to the DMF and are also consulted by the Commission during the development of the FMP. Before the FMP is submitted to the Joint Legislative Commission on Seafood and Aquaculture, the Regional Advisory Committees are granted the opportunity to review and make comment, and the MFC must consider them before adopting the plan or rule (ibid.).

Fishery Management Plan Advisory Committees

The Blue Crab Fishery Management Plan Advisory Committee is composed of scientists, recreational and commercial fishermen, an MFC member, and members of the DMF (G.S. 113-182.1). These individuals must possess expert opinion in the blue crab fishery and their advice guides the creation of the FMP.

Scientist Committee

This committee is unique to blue crab management. It is composed of academics from the University of North Carolina, North Carolina State University, East Carolina University, and Duke University. Their research, in combination with research conducted by DMF scientists, provides the necessary data for informed fishery
management decisions. The FMP must include a stock assessment (G.S. 113-182.1), and in 2004 this was conducted by individuals from this committee.

**Human Constituents**

The human constituents of the North Carolina blue crab fishery include individuals involved in the construction of blue crab management policies, individuals involved in harvesting, processing and marketing blue crabs, scientists, and consumers.

**Scientific Community**

The scientific community includes researchers from the social, economic, and biological fields. These scientists may be DMF researchers, academic researchers, or scientists from private consulting firms. As stated above, data used in constructing management plans is gathered by the Fisheries Management arm of the DMF. Additionally, DMF research needs are often taken up by academic researchers or in cooperation with individuals in the industry. Research in academia or in the private sector however, is also conducted independent of DMF needs. Additionally, any research conducted at the federal level or at other state agencies and academic institutions plays a role in guiding NC blue crab fishery management.

V. North Carolina Blue Crab Fishery Management Plan History

**The 1998 Blue Crab Fishery Management Plan**

The state’s first blue crab fishery management plan was approved in December of 1998. The plan included discussion and recommendations for maintaining habitat and water quality, curbing wasteful or damaging fishing practices, protecting the spawning stock, minimizing conflict, and controlling increasing effort.

The final recommendations in regard to protecting the spawning stock and curbing wasteful or damaging fishing practices in the soft and peeler industry included:
(1) Nearly all commercial fishing gear is prohibited in sanctuaries from March 1-August 31st.

(2) Harvesting male white-line peelers is prohibited from August 1-September 1.

(3) Peeler pots can only be baited with live legal male blue crabs.

(4) Peeler crabs must be separated from hard crabs where taken.

The 2004 Blue Crab Fishery Management Plan

Reconvening three years later, discussion on the best way to protect the spawning stock and reduce wasteful fishing practices ensued. New data had since been collected, giving managers the ability to make more informed recommendations. They did not repeal any of the previous laws, but did make additions as follows:

(1) Sanctuary boundaries should be modified.

(2) When the spawner index of mature females captured in the Pamlico Sound Fishery Independent Trawl Survey falls below the lower 90% confidence limit for two consecutive years, the director will, by proclamation, impose a rule stating that it is unlawful to harvest a mature female crab greater than 6 ¾ inches from September 1 through April 30. The regulation will be removed when the spawner index rises above the 90% confidence limit for two consecutive years.

(3) When the spawner index of mature females captured in the Pamlico Sound Fishery Independent Trawl Survey falls below the lower 90% confidence limit for two consecutive years, the director will, by proclamation, impose a rule stating that it is unlawful to harvest soft and peeler crabs from September 1 through April 30. The regulation will be removed when the spawner index rises above the 90% confidence limit for two consecutive years.
VI. Blue Crab Life History

The life history of a blue crab can be broken into three stages, a larval stage (6 months, roughly), a juvenile (12 months, roughly), and an adult stage, which is characterized by sexual maturity. In each stage, the crab will undergo several molts in order to grow; 6-8 times in its larval stage and 18-20 times in its juvenile stage. Over the course of its lifetime a crab molts approximately 27 times (Dudley and Judy, 1973).

While a male will mate between its last three molts, a female will mate only once, during her final molt (ibid.). It takes several weeks for a crab to form a new shell, and it is not until the very last hours of this process, that the old carapace is shed. Within 12 hours the shell has partially hardened, however it is 2-3 days before the hardening is complete (NC BCMP, 1998).

Blue crabs mate in low salinity, shallow areas of rivers and sounds, from late spring to early fall (Mense and Wenner, 1989). As the female nears her final molt she will begin to respond to male pheromones. After a short mating ritual, the male will take the female beneath him, and cradle her there for two or more days (ibid.). When the female sheds her carapace, sperm from the male is transferred to the female’s spermathecae, where it can be stored for a year or more. After a period of weeks to months (Turner et. al, 2003) the female will migrate to high salinity areas such as inlets and along ocean beaches in order to spawn (Dudley and Judy, 1973). The male will remain in the upper estuaries to mate with other females.

A female blue crab will mate only once, however she may spawn several times over the course of more than a year or more, and may not spawn in the same year in which she mates (Dudley and Judy, 1973). Rittschof concludes from a recent study that blue crabs
Studies in North Carolina conclude that spawning females are present at inlets from the spring through the fall and are seen in greatest abundances during the months of May and August (Eggleston and Johnson, 2004). Some studies show that female spawning is timed to occur with the ebb tide (Epifanio, 1988; Tankersley et al., 1998; Carr et al., 2004). Recent studies by Forward et al. (2005) suggest that a female crab may move into the ocean with each spawning event (Rittschof, 2004). The ebb tide may carry these larvae offshore as far as the inner continental shelf (Dudley and Judy, 1973; Epifanio, 1988). In the first larval phase, zoeae, a larva will live as plankton and undergo 7-8 different stages before it undergoes metamorphosis into the second phase, megalopae. Studies conclude that the greatest populations of zoeae occur off the coast of North Carolina from June through August, and megalopae from September through November (Eggleston and Johnson, 2004).

After approximately 30 days, these megalops and juveniles will begin to move back into the estuary by means of episodic atmospheric events, an inflowing lower-layer, surface slicks, and tidally forced internal waves, though studies are not conclusive (Mense and Wenner, 1989). Epifanio (1988) elaborates on the two most likely processes; the first suggests that younger megalops found in the surface waters are transported back into the estuary by strong onshore currents present in the fall months. However, this seems an unlikely agent against the strong outflows present at the inlets of large estuaries unless strong easterly winds, such as a hurricane, are present. The more likely process is a subtidal current transporting megalops found near the bottom of the water column. Other studies suggest that advanced stage megalopae may speed their reentrance into the estuary by coupling subtidal movement with flood tide currents. In this scenario, megalops ride these inflowing surface currents by migrating vertically into the water column during the flood tide (ibid; Forward, et al., 2003).
Upon returning to the estuary, most studies conclude that early juveniles will settle in high salinity and vegetated areas (Pile, 1996). This environment is thought to provide shelter from predators and nutrients for growth (Mense and Wenner, 1989). Perry (1975) suggests that 90% of juveniles in a given area are found in seagrasses or marshes (Heck et al., 2001). According to studies conducted by Orth and van Montfrans (1987), starting between the 3rd and 5th instar, juvenile crabs begin to disperse into unvegetated habitats. And at their 9th instar, most crabs are found in unvegetated habitats, in varying salinities (Pile, 1996).

VII. The Soft and Peeler Crab Fishery

A crab that is beginning to show signs of forming a new shell is known by fishermen as a ‘peeler’ crab. With time, the crab will shed its old shell and is then called a ‘soft crab’, until its new shell hardens. There are different methods for determining what stage of new shell development a peeler crab is in, but the system the North Carolina DMF uses, and that which has been adopted by many fishermen, breaks peeler crabs into three classes according to the number of days a crab is from shedding its shell. Development of the new shell is visible as a line on the last two segments of a crab’s swimmer leg. Roughly, a ‘white-line’ peeler is within two weeks of shedding, a ‘pink line’ is one week from shedding, and a ‘red line’ is one to three days from shedding (NC BCFMP, 1998). A blue crab fisherman in the peeler and soft crab fishery will catch a peeler crab, keep it until it sheds, and sell it as a soft crab.

In North Carolina, there are over twenty types of gear in which soft and peeler crabs are harvested, these include crab pots, peeler pots, crab trawls, shrimp trawls, skimmer trawls, float and sink gill nets, pound nets, crab dredges, oyster dredges, cast nets, trotlines, by hand, eel pots, channel nets, haul seines, gill nets, fyke nets, hand and bull rakes, and tongs. Hard and peeler crab pots make up 98% of landings. Crab trawls (which include both hard and peeler trawls) make up 1% of the harvest, shrimp trawls make up .4% of the harvest, and skimmers make up .03% of the harvest. All other gear makes up less than .5% of the harvest (NC BCFMP, 2004).
A peeler pot is similar to a hard crab pot, but is often constructed from 1 inch mesh, while a hard crab pot is constructed from 1 ½ inch mesh (NC BCFMP, 1998). Male crabs, called ‘jimmies’ are attached to the pot or placed in a separate compartment, in order to attract females who are approaching their final molt and are looking for a mate (See Appendix 3 for a picture).

A shedding facility consists of a number of tanks in which the crabs are kept. There are several different models; (1) a floating system, in which the tanks are kept in the water (2) a flow-through system, in which water is pumped from the bay or sound, through the tanks and deposited back into the body of water from which it came (3) a closed system, in which the water is treated and circulated within the tanks (Oesterling, 1984).

VIII. Fishermen Interviews

Introduction:
The importance of gathering fishermen’s opinions in fishery management

Social science plays an important role in fishery management as a means to gather fishermen’s biological and socioeconomic knowledge and as a means to engage stakeholders in constructively considering management decisions.

In order to maintain a healthy fish stock, managers must make decisions that often affect the fishermen who depend on the stock for their livelihood. Therefore, the knowledge needed for effective management must include biological data of the concerned fish stock and socio-economic data of the fishermen who harvest the fish (Jentoft and McCay, 1995).

Many fishermen have been harvesting for the majority of their careers or their lives. Their livelihood depends on understanding the behavior of a particular organism within a greater ecosystem, thus fishermen possess both practical and biological knowledge about fish populations and marine ecology in the areas that they are working (Scholz et al. 2004). This knowledge can provide insight into traditional biological data sets, or
provide information that traditional methods cannot provide (ibid.) such as stock assessments, geospatial analysis, and other forms of formal scientific study. An example where fishermen knowledge has been incorporated into management is in the Bay of Fundy, where long-term observations and anecdotal experiences from fishermen is an important component of groundfish management (Wiber et al., 2004).

Regulations may have social and economic effects on fishermen who harvest the targeted fish. Studies illustrate that regulations “while in theory are helpful, that they may be impractical in reality”. A rule which is effective in achieving a goal overall, may be very difficult to employ at the local level, or a rule which is economically efficient, may be socially harmful at the local level (Jentoft and McCay, 1995). In order for management to be effective, it is necessary that managers understand the economic and social conditions in which a regulation is operating (Noble, 2000). Studies in California show that when socioeconomic impacts are considered equally with the biological impacts, that regulations are more effective in achieving stated goals (Scholz et al., 2004).

The way in which a management structure incorporates stakeholders’ opinions into the development of a law varies. In some cases, managers will include varying numbers of stakeholders from the development through the implementation of that law. In other cases, managers will include varying numbers of stakeholders at distinctive points in the development of that law (Beierle, 2002). Each method has benefits and drawbacks, depending on the context, but it is not within the scope of this paper to debate.

The goal of my research was to improve our understanding of the soft and peeler crab fishery in North Carolina by determining the effects fishermen perceive new regulations will have on their operations and how they perceive these laws will affect the fishery. The products of my research include a summary of the results which I returned to fishermen for comment and will give to managers at the Division of Marine Fisheries.
Methods:

Selecting the Sample

This study was limited to individuals operating shedding facilities in Carteret County, North Carolina. This decision had to be made due to time and financial constraints. I felt my efforts would be better spent towards a more comprehensive study of a small region, rather than a spottier survey of a larger area (See Appendix 3 for map).

I began by interviewing a soft and peeler crab fishermen residing in Carteret County, who has ties with the Duke University Marine Lab. He approved of the subject material and provided suggestions that would improve the relevance of the interview. Additionally, he offered the names of other fishermen running shedding operations. At the end of each interview I asked if he could offer the names of other fishermen with shedding operations. Thus, my sample size was selected using a “snowball” technique. I considered my sample complete, when I no longer received new names.

In 2004, there were 53 peeler operation permits issued to individuals in Carteret County. It is important to note however, that these permits are free, suggesting that while a number of permits are distributed, the number of shedding facilities actually in operation are less. It should also be noted that larger shedding operations to which several fishermen sell their soft and peeler crabs exist in other areas of the state, but such was not the case of individuals with whom I interviewed. Based on the names offered to me, and estimates by fishermen, I concluded that the number of individuals actively soft crabbing in Carteret County is closer to 15.

I conducted interviews of 10 fishermen; I used 8 of these interviews in my analysis, as these respondents met my regional requirements and answered my core questions. The first interview took place on December 13, 2005, the other 9 were conducted between the dates of January 10, 2006 through February 1, 2006. Before interviewing I called each individual and explained my identity and the purpose of the interview. Four fishermen declined, stating that they did not have enough time, that they did not have the experience to comment, or that they were not interested in an interview.
Interview Structure

I chose semi-structured, in-depth interviews to gather fishermen’s opinions. To start the interview, I gave each fisherman a hard copy of the rulings and the questions I would ask, and encouraged them to follow along. In this way, each interview was guided by the same questions, but provided the space for expounding. As a result, each interview yielded a certain amount of unique information. When necessary, I asked fishermen to mark, on calendars, the dates during which they were harvesting and shedding peeler crabs.

Before beginning the interview, I explained the purpose of my research, and who the results would be available to. I explained that I would compile their responses and return a summary, if they so desired, and that this same summary would be passed to managers at the Division of Marine Fisheries. I also explained that their responses were strictly confidential, and that they were free to stop the interview at any point in time. Each interview was recorded, with the approval of each fisherman.

Interviews were one on one, with one exception, which was with two fishermen. I chose such a relationship with the belief that their responses would be uninfluenced by the presence of others. Interviews were held at a location most convenient to the fishermen. The length of the interview ran between 55 minutes to two hours.

Analysis

I transcribed each interview into Microsoft Word. I then coded the transcriptions in NVIVO, sorting responses into metacodes, codes and subcodes, according to major themes. Because I was working with a small number of interviews, I was able to go back through each interview and ensure that I had not missed or miscoded any responses. This recheck also allowed me to combine subcodes, where necessary.
Results:

Demographics

The fishermen are between 34 and 57 years of age, all of whom but one, are married. Their wives work as nurses or as teachers, at varying levels. All fishermen had between 2 and 3 children. All the fishermen have been in the industry for over 10 years, and most for over 20 years. Half of the respondents have been soft and peeler crabbing for all of that time. Their answers varied from 5 years to over 20 years. Some fishermen commented that they’d been crabbing since they were children, with their fathers. All of the fishermen participate in other commercial fisheries, including hard crabbing, clamming, oystering, shrimping, striped bass fishing, seining, long hauling, and pound netting for flounder, tuna, and mullet. Two fishermen participate in one other fishery, three participated in two other fisheries, and three participated in four or more other fisheries.

Operational Characteristics

Gear and Season Statistics:

Six fishermen participate in the early spring market. According to the weather, these fishermen begin trawling or setting their pots in early or mid March, and will shed crabs until early to mid May. Two fishermen soft and peeler crab from April to August. All eight of the fishermen I interviewed use peeler pots to catch their soft and peeler crabs, for at least a portion of their total season. Six of these eight use additional means; four use a modified crab trawl and two use hard crab pots. The number of peeler pots differs between fishermen; but 6 fish 200, 250, or 300 pots and one fisherman uses 500 pots. Those fishermen who also hard potted generally set 400 hard pots.

Value of Soft and Peeler Crab Harvest:

Four fishermen stated that the soft and peeler crabbing provides 40-50% or a large portion of their income, stating that it is ‘good money’. One individual stated that it composes 20-25% of his income, and three stated that it depends on the year and the weather. During my initial two interviews, I asked questions regarding the character of the market, and these individuals, soft and peeler crabbing March-May, stated that it is a
particularly profitable fishery as they are selling crabs on the market before more northern parts of the state and the country have introduced their crabs to the market, thus they receive high prices.

_Fishing Methods:_

As the water begins to warm in early to mid-march, four of the fishermen I interviewed begin trawling. Using small boats and small nets these men will fish in the shallow creeks and bays, catching both male and female peelers and soft crabs. The length of time trawling varied among fishermen, those who I interviewed varied from two to several weeks. Of the other four who do not trawl, two begin at approximately the same time peeler potting, and two wait until April to begin.

They will first set the pot ‘bare’, meaning without adding the jimmy to attract a crab. Peeler crabs, both male and female are caught in these pots. Then at a certain time, varying between fishermen, they will ‘jimmy up’ the pot, meaning, they will attach a male or several males to the pot. This attracts females approaching their final molt. For those fishermen who hard crab pot, they may continue to hard crab as they soft crab, I interviewed two such fishermen. The others stop their hard crabbing, and focus solely on soft crabbing, I interviewed two such fishermen.

While the length of time trawling or bare potting will vary, every fisherman I spoke with jimmies his pots sometime in early to mid April. When asked how they know when to start jimmying up, fishermen note a number of different signs. Some noted the first full moon and others noted the end of a period of intense male shedding. But the most common response of those with whom I spoke, stated that when crabs start ‘doubling up’ (when the male cradles the female), is when a peeler fishermen is wise to jimmy his pots. It is a delicate decision, as one who jimmies his pot will no longer catch male peelers, and if a fisherman jimmies his pots before the females are ready, he will catch very little.

How fishermen obtain their male crabs varies. Some fishermen will set smaller numbers of hard crab pots to catch jimmies for their peeler pots. Others will buy their jimmies, or
hope there will be some ‘walk ins’ during the bare period, that they can save. Others who are hard crabbing will save them for when it is time jimmy up.

The two fishermen who peeler and hard crab throughout the summer said that there are three periods of large numbers of shedding females, ‘runs’, as they are called: a spring run in April and May, a summer run in June and July, and a fall run in September and October. In between, they continue to catch female peelers, but in smaller numbers. These fishermen contend that crabs (but not necessarily females) will continue to shed into January.

_Shedding Facilities:_

Four fishermen have a flow through system and three work with a closed system. One uses a semi-closed system, stating that generally it was a flow through, but, when necessary, it could function as a closed system. The number of tanks fishermen had in operation at once varied between 10 and 38 tanks. Six fishermen use less than 20 tanks, two use 25 and 33. Two stated that they had 4 or 5 other tanks that they set up during busier periods.

_Assistance:_

All fishermen have help for some portion of their fishing operation. Three respondents stated that they hire part-time help, two respondents work together, and three used the help of family members.
Determining the effects fishermen perceive new regulations will have on their operations and how they perceive these laws will affect the fishery

15A NCAC 03L .0201 and 15A NCAC 03L .0206 were appended with the following regulations in September of 2005. At the time of my interviews, fishermen had not been peeler crabbing since the law was put in place. Thus, it is important to note that the questions are designed to determine the perceived effect of these laws. It is also important to note that the purpose of my interviews was not determine whether fishermen will or will not follow regulations. While fishermen comment on how a law will affect their operations based on past experiences, assumptions about their behavior under these new laws should not be drawn from these responses. Additionally, note that these are semi-structured interviews, yielding unique responses. Thus if four fishermen made one comment, it does not necessarily follow that the four others do not hold that view, rather they simply did not state it.

15A NCAC 03L .0201 Size Limit and Culling Tolerance

(b) All crabs not of legal size, except mature female and soft crabs shall be immediately returned to the waters from which taken. Peeler crabs shall be separated where taken and placed in a separate container. White-line peeler crabs shall be separated from pink and red-line peeler crabs where taken and placed in a separate container. A culling tolerance of not more than five percent by number shall be allowed for white-line peelers in the pink and red-line peeler container. Those peeler crabs not separated shall be deemed hard crabs and are not exempt from the size restrictions specified in Paragraph (a) of this Rule.

(c) The Director, may by proclamation, impose the following restrictions when the sum of the carapace widths of mature female blue crabs collected during the September cruise of the Division of Marine Fisheries Pamlico Sound Fishery Independent Trawl Survey divided by the total number of tows (adjusted catch per effort) falls below the lower 90 percent confidence limit for two consecutive years (spawner index):
(1) It is unlawful to possess mature female blue crabs greater than 6¾ inches from tip of spike to tip of spike from September 1 through April 30. A culling tolerance of not more than five percent by number in any container shall be allowed.

(2) It is unlawful to possess female peeler crabs greater than 5¼ inches from tip of spike to tip of spike from September 1 through April 30.

15A NCAC 03L .0206 Peeler Crabs

(c) It is unlawful to sell white-line peelers.

(d) It is unlawful to possess white-line peelers unless they are to be used by the harvester in the harvester's permitted blue crab shedding operation.

The effect of a maximum size limit of 5 ¼ inches on female soft and peeler crabs, from September 1 – April 30, on individual operations

Whether implicitly or explicitly stated, fishermen have not measured their soft and peeler crabs in the past, thus it is necessary to qualify fishermen’s responses as predictions. Four fishermen stated that they did not think such a law would affect them, as they catch very few soft and peeler crabs of 5 ¼ inches or greater. Three others stated that they did not know how many soft crabs they catch of that size and one said most likely. Three fishermen stated that this law might affect soft and peeler crab fishermen in more northern parts of the state, where the crabs are known to be larger. Three speculated that the hard crab portion would have a significant effect on their operations, two of whom specifically mentioned Northern parts of the state. Additionally, two fishermen working mainly outside of Core Sound stated that the hard crab portion of this law would have a significant effect on their hard crab operations, based on the fact that they are catching large mature females and the winter months bring higher prices for these crabs.

The effect a maximum size limit of 5 ¼ inches on female soft and peeler crabs, from September 1 – April 30, as a means of protecting the spawning stock

As to whether this law would effect the spawning population, two respondents felt that no, it would not affect the spawning stock and four respondents were not sure. Two
respondents who were unsure noted that the law would be worth trying. And two respondents did not comment on the effect of the ruling, as they were more concerned with the hard crab portion. However, whether a fishermen was unsure or felt firmly that no, this would not effect the spawning stock, the most frequently mentioned reasons were common among both groups. They can be broken into two categories: one, that factors other than fishing regulations affect the health of the spawning stock and two, that certain measures would (or might) be better than a maximum size limit on female soft and peeler crabs.

Other factors affecting the health of the spawning stock

Responses in regard to factors other than fishing regulations that affect the spawning stock can be split into five categories: (1) fishermen will leave the industry when conditions demand it, and will return with better conditions; (2) weather events, particularly hurricanes, play a major role in determining the presence or absence of crabs; (3) the presence of turtles in certain areas of the state prevent fishermen from setting pots during certain times of the year, thus effectively enlarging sanctuaries; (4) maintaining water quality is essential for a healthy spawning stock; (5) biological studies should be conducted to determine the effect of the law.

(1) Six stated that fishermen will leave the industry when conditions demand it, and will return with better conditions. These fishermen felt that in Carteret County, the fishery was currently experiencing this decline. I asked some of the fishermen why individuals were leaving the industry, and responses included gas prices, the burden of regulations, the presence or absence of crabs due to weather or unknown factors, seafood prices, and competition with imported crab meat.

Triggered in discussion on varying topics, four fishermen said that competing with cheaper imported seafood is making it especially difficult to maintain their livelihood. One fisherman stated that the price of imported crab meat, picked and ready for sale, is cheaper than the price he can sell his crabs for at the dock. Another fisherman noted a steep decline in the number of operating picking houses in the state, and lamented the apparent ignorance or apathy of consumers. He stated that the basket
market is helping to maintain the industry, as it is not possible to purchase unprocessed crabs from foreign countries.

(2) Six stated that weather events, particularly hurricanes, play a major role in determining the presence or absence of crabs. During five interviews, fishermen noted that weather determines a poor harvest year or a good harvest year. These fishermen contend that the frequency, duration or intensity of poor weather conditions will result in conditions producing poor harvests. Hurricanes and the direction of the wind play major factors in whether crabs will pot. One fisherman using flow through tanks noted a year in which he lost a large portion of his crabs due to bad weather conditions. Four of these fishermen contend that, regardless of regulations, weather cycles determine their success. One suggested that the DMF should consider looking more closely at the correlation between weather patterns and catch statistics. Three fishermen recalled specific periods following hurricanes Floyd, Fran, and Bertha when crabs were in major decline.

(3) Five fishermen stated that the presence of turtles in certain areas of the state prevent fishermen from setting pots during certain times of the year, thus effectively enlarging sanctuaries. They stated that, during the summer months, in Core Sound and the eastern parts of Pamlico Sound, sea turtles attracted to the bate, damage their pots. Due to the prohibitive cost of replacing damaged pots, they cannot set their pots in these areas. The fishermen argue that it is important to consider, as it has increased protection to migrating females, by effectively enlarging spawning sanctuaries.

(4) Four fishermen stated that maintaining water quality is essential for a healthy spawning stock. Three fishermen maintain that certain rivers, which had historically been highly productive, are now significantly less so. Two fishermen noted that, following Hurricane Floyd in 1999, they had very low catches, and they perceived this to be a result of increased runoff. These fishermen contend that if we cleaned up those waters, the crabs would rebound.

(5) Four stated that biological studies should be conducted to determine the proportion of soft and peeler crab females of 5 ¼ inches and mature females of 6 ¾ inches that successfully mate and the effects that fishing pressure on male crabs have on this proportion, before deciding whether such a law will be effective in maintaining the health of the spawning stock.
Some of the fishermen framed their responses as concerns about whether or not these factors are currently being considered within the context of general management decisions. These included comments such as whether or not regulations requiring that a portion of the catch be thrown back or a decline in the number of active fishermen are factored into overall catch statistics. Some also suggested that, while the state might be experiencing declining catches overall, that they have not experienced similar declines in their catches.

*Other measures would (or might) be better than a maximum size limit on female soft and peeler crabs*

Seven fishermen suggested alternative measures. It is important to note that no one alternative measure was mentioned as often as each of the factors discussed above. Of this total, responses can be broken between three measures: (1) enlarging or removing cull rings; (2) placing a law on the harvest of sponge crabs; (3) setting pot limits. Most fishermen that suggested an alternative rule also noted the economic burden that the regulation might place on others.

(1) Two fishermen suggested enlarging or removing cull rings. Each had a different argument, one that enlarging cull rings would allow larger crabs into the population, thus reducing the value difference between large and small female crabs. And two, that due to the cull rings, smaller crabs are mating more frequently, and as a result, have selected for a genetically smaller population. This fisherman reasoned that larger females have greater reproductive potential, thus allowing more to survive by increasing the size of cull rings, would improve the spawning potential of the stock.

(2) Four fishermen suggested prohibiting the harvest of sponge crabs as an alternative. There were three reasons for why the sponge law would be a more effective law. One, they are easy to identify. Two, the crab has undoubtedly mated and successfully made her migration without being predated upon or captured. Three, a sponge crab is worth relatively little in the market.

(3) Two fishermen suggested implementing pot limits as an alternative. The reasoning for implementing a pot limit included two arguments. One, that the difference
in the number of crabs a fisherman might catch with 500-600 pots is probably not significantly more than what he would catch with less, because fewer pots would mean that more crabs would be caught in each of the remaining pots. And two, that with less pots to tend to, a fishermen could devote more time to culling and tending to the crabs that are caught.

**The effects of separating white-line peelers from pink- and red-line peelers, where taken, on operations and as a means of reducing mortality in the soft and peeler crab fishery**

When asked to estimate their success shedding peeler crabs into soft crabs, three fishermen estimated that they have a success rate of 90-95%, two fishermen stated a success rate of 80-85%, and one estimated a success rate of 60-65%. One respondent stated that he had an ‘insignificant’ amount of crab mortality in his shedding operation, and one could not state his success rate, as his wife managed the shedding process.

Fishermen attribute high success rates to the care they give to their peelers, including care in removing crabs from gear, separating between peeler stages on the boat, and minimizing the time their crabs are out of water and in the sun. Four fishermen stated that separating peelers on the boat contributes to successful operations. Three fishermen noted that fishing near their docks contributes to successful operations. Three fishermen note that the added time this law will require fishermen to spend in the sun culling their crabs may cause mortality that is the same or greater than the crabs saved from separating the whites from the pinks and reds on the boat. Two suggested that this will certainly be the case in areas in northern parts of the state where fishermen are crabbing further from their docks, and in the hotter summer months. Six fishermen stated that such a law would not reduce mortality in the industry, overall.

All of the fishermen felt that discerning the difference between stages of peeler crabs lies in the eye of the beholder, whether it be between two fishermen, or between a DMF official and a fisherman. Three expressed concern that such a subjective observation should not be the basis for a decision that could result in a ticket.
The effects of prohibiting the sale of white-line peelers on individual operations and as a means of minimizing mortality in the soft and peeler crab industry

After reading this law, the discussion that followed included personal experiences with harvesting and shedding white-line peelers and the effect that preventing the sale of white-lines would have on the industry. Three fishermen stated that they harvest white-line peelers regularly, three stated that they take them only when the run is slow, and two take only carefully selected white-line peelers, or very light pink-line peelers.

I interviewed fishermen who soft and peeler crab throughout the summer and fishermen who soft and peeler crab only during the months of March-May. Six of the fishermen I interviewed fell into the latter category. Based on the response of fishermen in my initial interviews, white-line peelers make up a high percentage of their catch in the initial weeks of the harvest, and slowly make way to more pink- and red-line peelers as the season progresses. The most frequently stated response (4) was that there is higher mortality in white-line peelers, due to various reasons relating to the time the crabs are kept in the tank. However, one fisherman mentioned that red-line peelers are more likely to suffer mortality from the stress of capture and transport, and one mentioned that larger crabs take longer to shed, thus experiencing higher mortality than smaller crabs. Two fishermen harvesting white-lines or light pink-lines also stated that because they are peeler and soft crabbing in the cooler spring months, mortality is lower than in regions where peeler and soft crabbing for white-lines is occurring throughout the warmer months of summer. One response included that when properly selected, white-line peelers are successfully shed.

Four fishermen responded that they do not sell their peelers, so this law would not affect them. Three fishermen stated that not many people buy white-line peelers. Three mentioned that the law might reduce mortality in the industry, depending on the number of people this law would affect.

Communication between the Division of Marine Fisheries and Fishermen

Four of the fishermen I interviewed find out about laws solely by talking with other fishermen. Also, receiving mailings, reading posting boards, talking to DMF
officials, and reading the newspaper were each mentioned once. In regard to whether fishermen were aware of the size limit ruling, I interviewed some fishermen before the proclamation had been issued, and some after. Knowledge of the law varied among those who I interviewed before the proclamation was made. All of the fishermen I interviewed after the proclamation had been issued were aware of the law. However, during my last interview, fishermen noted that the proclamation dates are different than what my survey stated, reflecting a difference between the proclamation and the rulebook. In regard to the peeler crab law, the extent to which it was known and understood varied between fishermen.

Discussion and Management Analysis:
Management options for maintaining the spawning stock and minimizing wasteful fishing practices were considered in construction of the 1998 and 2004 fishery management plans. These options were analyzed by considering the potential effects to the biological health of the stock, the socioeconomic effects on blue crab fishermen, and the burden to law enforcement. How the 1998 and 2004 fishery management plans reflect the concerns that fishermen expressed during my interviews are considered in the following paragraphs.

Fishermen Leaving the Industry
Fishermen’s concerns regarding employment trends are addressed, in part, in the 2004 fishery management plan. As demonstrated in Section II of this paper, data concerning overall employment trends in both the hard crab and soft and peeler crab fisheries are included in the fishery management plan. The causes for trends in the processing sector are included in the 2004 fishery management plan. The causes for trends in the harvesting sector are not included.

Weather Events
In the 2004 North Carolina Blue Crab Fishery Management Plan, the biological and economic concerns that fishermen express concerning the effect of hurricanes are addressed in the Stock Assessment, the Environmental Factors section, and in a
discussion of 2000-2002 landing declines. In the Environmental Factors section, hurricanes are discussed in terms of their effects on the ecosystem and the fishery; short-term and long-term effects, localized and widespread effects, water quality and fish health effects, and differing impacts between regions of the state.

The stock assessment, included in the fishery management plan, suggests that the fall hurricanes of 1999 caused crabs to concentrate in areas of high salinity. In response, fishermen concentrated their harvest in these areas, which allowed for a very efficient and plentiful catch. This proved to decrease the number of recruits to the population the following year, thus explaining the declines in hard crab catch from 2000-2002 (Eggleston and Johnson, 2004). Additionally, the DMF suggests that 2002 declines in both catch and value in the soft and peeler crab sector could be attributed to an early warm spring, such that many soft crab and peeler fishermen did not have their gear in the water, and so missing a proportion of the catch.

Turtles

The 2004 fishery management plan recommended that studies to address sea turtle bycatch issues should be conducted and that information on diamondback terrapin bycatch be translated to fishermen. A discussion of the effects sea turtles have on where fishermen set their pots is not included. Significant attention was devoted to the biological and economic effects of spawning sanctuaries, in both the 1998 and 2004 fishery management plans. In this way, the concerns of fishermen are addressed, in part.

Spawning Sanctuaries

In 1998, debate in the fishery management plan centered primarily on the merits of sponge crab versus spawning sanctuaries, and included analysis of other state plans, scientific research findings, and fishermen comments. Rules that were discussed in regard to spawning sanctuaries included adding new spawning sanctuaries, expanding existing spawning sanctuaries (geographically or temporally), reducing existing spawning sanctuaries, and prohibiting the use of all fishing gear during March 1- August 31,
including or excluding gill nets. Laws prohibiting or reducing the harvest of all mature females and a law reducing harvest of male crabs was also addressed.

In the end, managers chose to strengthen existing sanctuaries with the additional rule that not just crabbing, but all commercial fishing- with the exception of attended gill nets- be prohibited. Managers reasoned that spawning sanctuaries afforded greater protection to the spawning stock by protecting all crabs within its boundaries, while a sponge law would protect females during the period during which they are ovigerous, which was viewed as being a shorter period.

Included in the 2004 fishery management plan was new research shedding light on the behavior of mature females in and around spawning sanctuaries. The results of these studies suggested that mature females are found in equal proportions up to 5 km outside of sanctuary and that females may spawn before reaching the sanctuary, and move out into the ocean following. In the 2004 plan, managers recommended that existing spawning sanctuaries be strengthened and expanded. The recommendation also states that this law would have the least economic impact on fishermen. It does not include a discussion of sea turtle and fishermen interaction.

**Biological Questions to determine the effectiveness of the law**

Many fishermen had questions regarding general biological trends in the population, such as the number of mature females vs. immature females, fertilized vs. unfertilized mature females, and how fishing affects these trends. This data was not included in the 2004 Fishery Management Plan, however studies addressing these questions are included in the Further Research section of the plan.

**Water Quality**

Both the 1998 and 2004 management plans state that water quality is essential to the health of the blue crab population and recommend that steps be taken to address water quality and its effect on the spawning stock. The 2004 plan also addresses the impact of
hurricanes on water quality and its effect on blue crab abundance. In this way, the concerns of fishermen are addressed.

The MFC states that “Maintenance and improvement of suitable estuarine water quality and habitat are probably the most important factors in providing a sustainable blue crab stock.” (NC BCFMP, 2004). While the MFC and the DMF do not have regulatory power over water quality issues, the 1998 fishery management plan touches on water quality issues, stating that they should “comment on activities that may impact estuarine water quality” and suggesting that water quality plans should be implemented. In the 2004 fishery management plan, the MFC set out specific goals to accomplish through the N.C. General Assembly and regulatory agencies like Division of Water quality and the Division of Environmental Health, who do have regulatory power. They also suggest that these guidelines will complement the Coastal Habitat Protection Plan. These goals include:

- Action 3: expanding the existing water quality plan in the Albemarle and Pamlico Sounds to the entire state
- Action 4: working with permitting agencies to enhance protection of water quality
- Action 5: continued research on the extent, causes, and impacts of hypoxia
- Action 10: research to document and quantify the influence of significant weather events on water quality and assess impacts on the blue crab resource and fishery.

**The Cull Ring Debate**

Crab pot escape rings, otherwise known as cull rings, were established in 1989 as a requirement for all hard crab pots. In 1994, the director was given the authority to issue proclamations allowing fishermen to close cull rings in order to catch small mature females or peeler crabs. Fishermen’s arguments concerning removing or enlarging cull rings as a more effective measure for protecting the spawning stock, both biologically and economically, were addressed in part, by the 1998 and 2004 fishery management plans.
Debate over the benefits and drawbacks to cull rings began with the 1998 Blue Crab Fishery Management Plan. The con arguments for cull rings included the economic loss to fishermen who harvest large numbers of small mature females and small peeler crabs in their hard crab pots, and the concern that by allowing smaller crabs to return to the population, that a population of smaller blue crabs would be selected for. There was also a concern that cull rings would not be effective, thus nullifying their purpose. The pro arguments attributed to cull rings included reducing the harvest of sublegally sized crabs, while also reducing the amount of time fishermen must spend culling crabs. They also reduce the stress associated with catching and releasing sublegal crabs and provide more space in the pots for harvesting larger crabs.

Management options included repealing the proclamation authority, repealing the existing cull ring law all together, and qualifying the regulation to pertain only in certain areas. Managers recommended that the law hold, due to the fact that studies did not show a declining stock size and that it is effective in protecting sublegal crabs.

The 2004 fishery management plan included fishery independent data showing that the size of mature female crabs is declining. Possible causes for this trend were discussed as functions of population size, environmental factors and selective fishing pressure. It stated that no literature exists on genetic control of size, but that fishery dependent data in certain areas supported the idea that fishing pressure could be causing more small crabs to remain in the population. In reaction to fishermen’s comments to remove the cull ring law, they discussed the benefits of a cull ring, which included protecting females and males from being harvested before they reach reproductive potential. A cull ring serves benefits to fishermen too, by reducing culling time. It did not include discussion on the merits of increasing the size of a cull ring.

**The Sponge Crab Debate**

The concerns that fishermen mentioned about sponge crabs are addressed, in part, through the 1998 and 2004 North Carolina Blue Crab Fishery Management Plans.
Debate in the 1998 fishery management plan focused primarily on the merits of a sponge crab law versus spawning sanctuaries, and included analysis of other state plans, scientific research findings, and fishermen comments. Options in regard to sponge crabs included a regulation prohibiting the take of sponge crabs, reducing the harvest of sponge crabs, and prohibiting the harvest of sponge crabs or prohibiting the harvest of crabs carrying eggs of a certain stage. Additionally, a spawning stock-recruit relationship for North Carolina blue crabs had not been established. Some discussion was also given to the importance of maintaining the male population for the health of the state’s blue crab reproductive potential.

In the end, managers chose to strengthen existing sanctuaries with the additional rule that not just crabbing, but all commercial fishing- with the exception of attended gill nets- be prohibited. Managers reasoned that spawning sanctuaries afforded greater protection to the spawning stock by protecting all crabs within its boundaries while a sponge law would protect females during the period during which they are ovigerous, which was viewed as being a shorter period. Additionally, the recommendation states that this law would also have the least economic impact on fishermen.

Since the management plan in 1998, data had been collected regarding the potential damage to sponge crabs in pot and trawl harvest, and the economic importance to certain regions harvesting sponge crabs. This new information was discussed in the 2004 Blue Crab Management Plan. The socioeconomic benefits of a sponge law, such as ease in identification, the minimal economic value of sponge crabs, and the assurance of an effect on the number of females spawning, where not included.

The Effort Management Debate

The North Carolina Blue Crab Fishery Management Plan has a long history of addressing fishermen’s concerns and suggestions regarding effort management. The 2004 North Carolina Blue Crab Fishery Management Plan included an appendix (summarized from the 1998 North Carolina Blue Crab Fishery Management Plan) outlining the different effort management options that were considered, but made no reference to the
issue in their recommendations. The recommended management strategy begins in this way, “It is likely that none of the traditional open-access management alternatives (for example seasons, time, and area restrictions) can significantly control or reduce the overall effort in the crab fishery without severely restricting individual landings or traditional fishing patterns. Therefore, some type of effort management system is needed to control and/or reduce effort in the crab fishery.” It goes on to summarize the steps that were taken during a two year process (1999-2000) to develop such a plan, which included establishing regional crab pot management areas and an advisory committee for each, charged with assisting in the creation of an effort management plan that reflected the character of their respective region. In the end, the committees decided that while the number of crab fishermen would likely increase, they did not feel that pot limits were necessary, unless it was to protect the blue crab population. Thus because of the regional committees’ recommendations, the Crustacean committee’s recommendations and a lack of support from the fishing community, the MFC did not implement an effort management strategy.

The Appendix also includes a timeline leading up to the plan development, which included scoping meetings and a series of three part workshops conducted to discuss the concept of limited entry with fishermen. It also includes a supplement which outlines the different effort management options that Regional committees discussed. In this way, the 2004 Blue North Carolina Blue Crab Fishery Management Plan addresses the concerns and suggestions that fisherman spoke of regarding pot limits as alternative measure to the maximum size limit law.

**Maximum size law**

The concerns that fishermen mentioned about the maximum size law are addressed, in part, in the 2004 fishery management plan. Discussion in the plan focused on the merits of a maximum size for the harvest of soft and peeler crabs and a maximum size limit for the harvest of mature female crabs. Concerns included an excess fall harvest of mature female crabs and declines in the size of not only females but male sizes. Managers considered studies suggesting that larger females provide more eggs
overall, thus protecting this portion of the stock would be particularly effective. Such a law would allow more large females to spawn, thus increasing the amount of egg and larval production, and boosting the spawning stock.

The size law will not affect the majority of soft and peeler crab fishermen in Carteret County economically, though the impact in other parts of the state may be different. Thus, the biological effects of the law will also be minimal in Carteret County. It will affect the hard crab harvest of a minority of fishermen in Carteret County, and this will have biological effects. This may also be the case in the hard crab fishery north of Carteret County.

Based on trip-ticket data, managers reasoned that the months of September through April are slow fishing periods, thus a limit on the harvest during this time period would minimize the economic hardship that fishermen would endure. The management plan does not include a discussion of the economic effect of such a law on fishermen participating in the growing basket market (see section I. employment trends). It does not include a discussion of the value of crabs during different months of the year.

**Prohibiting the sale of white-line peelers**

Fishermen expressed both biological and economic concerns regarding laws that regulate the white-line harvest, which were addressed in the 1998 and 2004 fishery management plans. Debate in the 1998 Blue Crab Fishery Management Plan centered on white-line mortality. Studies show that higher mortality occurs in shedding white-line peelers, due to the length of time spent in shedding tanks before they fully molt their shell, but fishermen argue that such mortality exists only with inexperienced crab shedders. Discussion also included the practice of taking sublegal hard crabs under the guise of white-line peelers, due to the fact that it is difficult to enforce a law based on determining the subtle difference between a white-line peeler and green hard crab.

In 1998, managers recommended that peeler pots only be baited with legal-sized male crabs, as a means of reducing the number of white-line crabs entering the pots. They also
mandated that peelers be separated from hard crabs upon harvesting, and prohibited the harvest of male white-line peelers during June through September. These options were viewed as having the least negative effects on enforcement and fishermen, while benefiting the blue crab population by reducing waste and protecting the spawning potential. Managers rejected options including the complete prohibition of white-line peelers and seasons for when white-line harvesting would be allowed.

New research conducted in the years following the 1998 Blue Crab Fishery Management Plan concluded that the greatest amount of waste in the blue crab industry is in the shedding sector. New research included evidence that white-lines have higher mortality than red-line peelers and that male peelers experience significantly higher mortality than females, and are especially vulnerable in the summer than during other months. This research also found that purchased crabs had a higher mortality at every stage than crabs shed by the harvester. They attributed this difference to the care that harvesters give to the crabs they will shed. White-lines were not tested, under the assumption that fishermen in North Carolina do not purchase them for shedding. Discussion continued between the ease in identifying white-line peelers, and their economic importance to the early soft crab market.

Managers again considered prohibiting the harvest of white-lines and establishing a season for the possession of white-line peelers. However, they also considered prohibiting the sale of white-line peelers, but allowing them to be harvested by those who held shedding permits. Other options included repealing the rule prohibiting baiting peeler pots with blue crabs, increasing education efforts targeting harvesters/shedders about white-line mortality, and increasing education efforts about handling peelers.

The final recommendations included prohibiting the harvest of white-line peelers unless they were to be shedded by the harvester in his licensed shedding operation. And that white-lines must be separated from pink- and red-line peelers where taken, with a 5% tolerance. They also recommended promoting education about white-line mortality and peeler handling for soft and peeler crabbers.
Half of the fishermen offered that they do not sell peelers, and I assume the rest don’t, given that they can shed them into soft crabs, themselves. Several fishermen, including one fisherman who buys peelers from northern parts of the state, agreed that most people who buy peelers do not buy white-lines, anyway. It appears that this law was aimed at a specific group of people. Therefore it may reduce mortality in that portion of the fishery.

**Separating Peeler Crabs**

Fishermen’s concerns that culling between peeler crab stages will increase the amount of time required on the boat, and thus increase crab mortality due to heat stress, is not addressed in the 2004 Fishery Management Plan. This is a concern particularly in areas where crabbing is occurring in the warmer months and in larger bodies of water, where trips are longer. The difficulties in discerning between peeler stages, in order to enforce such a law, are included in the discussion on selling white-line peelers.

**Public Education**

The 2004 fishery management plan addresses public education by stating the DMF’s dedication to delivering important information to fishermen by means of news releases, proclamations, brochures and fact sheets, newspaper and magazines, local radio and television stations, and a website. They focus on several key issues, including raising awareness about shedding system mortality, escape rings and protected species, and suggest that as research expands in these areas, that it could be provided to fishermen. They also mention collaborative workshops between managers, scientists, and fishermen. It seems that the means and the desire for communication between managers, scientists, and fishermen is present. However it seems that the methods of communication between managers and fishermen may not be sufficient. Additionally, while the focus areas may meet some of fishermen’s needs, they do not meet all of the interests that fishermen have.
IX. Recommendations

With the goal of protecting the spawning stock, reducing wasteful fishing practices in the soft and peeler crab fishery, while incorporating the biological and socioeconomic concerns and suggestions made by fishermen during my interviews, my recommendations are as follows:

Recommendation 1:

Research should be conducted to determine the causes of employment trends in the industry. If the fishery has historically gone through cycles in which individuals leave the industry and return, how did these trends correlate with gas prices, imported seafood statistics, weather events, seafood prices, or other factors?

Recommendation 2:

Further research conducted to characterize hurricanes and their affect on crab distributions in one region as opposed to another is very important. The plan mentions the need to improve existing levels of sampling in order to have a better understanding of how weather events affect water quality and fish resources. This knowledge might allow managers to predict the results of a hurricane, and a flexible management scheme might allow them to make proclamations according to the predicted outcome.

Recommendation 3:

Research should be conducted to determine the extent to which fishermen’s behavior is altered due to sea turtle conflict. If these areas of conflict prevent fishermen from potting, then perhaps they should be included as sanctuary areas.

Recommendation 4:

Governance by region was mentioned in the 1998 Blue Crab Fishery Management Plan. It is clear, based on landing trends and effort data in the hard crab and soft and peeler crab sectors, that the different areas of the state--Albemarle, Pamlico, South, Ocean, and Core--have uniquely different characters. Given fishermen’s concerns about employment trends, weather events, turtle effects, water quality and biological character,
managers should consider researching the viability and effectiveness of managing at the regional level.

**Recommendation 5:**

Studies should be conducted to determine the rate of crab mortality associated with separating peelers. Additionally, studies should be conducted in different areas of the state, where the fisheries may differ from one another. Until this data is collected, the effectiveness of such any law mandating the separation of peelers should be viewed with reservation.

**Recommendation 6:**

The soft and peeler crab market is a high-value market, based on fishermen comment and statistics in the 2004 fishery management plan. The basket market is also an important market, based on fishermen comment and employment trends noted in the 2004 fishery management plan. Based on fishermen comment, large females sold in the off-season command a high price.

Research should be conducted to determine how total landings in the months of April-September compare with total landings in May-August. The months of April-September were selected as being the slowest fishing months, but the biological impacts of a maximum size limit during this time period, may be equal to applying the same maximum size limit during months of high landings; May-August.

Additionally, the difference in value between crabs caught in the months of April-September and May-August should also be considered. Because while the total number of crabs caught during the months of May-August may in fact, be higher than April-September, the value of crabs on a glutted market is lower than the value of crabs in the off-season market.

Biologically speaking, the soft and peeler crab portion of this law will have questionable effect in terms of reducing the number of females that are being caught, for two reasons.
First, the soft and peeler crab catch represents a very small percentage of total blue crab landings, and while a high proportion of this catch is females, research should be conducted to compare the percentage of the catch in comparison with females caught in hard crab pots. Second, a female of 5 ¼ inches will be thrown back, but once her shell hardens, she will not be protected by the 6 ¾ hard crab regulation, thus nullifying the impact of the soft crab law.

Research should be conducted to determine whether a regulation limiting the harvest of hard crabs during the months of highest landings might be both a biologically and economically more beneficial option. A pot limit for example, during the months of May-August, would limit a low-value, high-landings market. Studies should be conducted to determine whether this law might provide an overall smaller negative economic impact on fishermen and an overall greater positive impact on the spawning stock.

**Recommendation 7:**

Two fishermen expressed interest about the results of a tagging study conducted some years ago. One fisherman mentioned that he would be interested in learning how catch trends correlate with weather events and one fisherman wondered how it was that the number of peelers caught could vary so widely between bodies of water in the same year. Given that scientists at the DMF, NC State, UNC and Duke are exploring these same questions, these may be opportunities to engage fishermen and scientists in cooperative research.

In general, fishermen are not sure about how the DMF determines the health of blue crab population. Some are concerned that managers are considering only overall numbers of pounds caught to decide that the blue crab population is in decline. They feel that the declining trend might be inaccurate if the exodus of fishermen from the industry, regulations mandating that portions of the catch be returned, or turtles that prevent fishermen from setting their pots are not also being considered as factors of the decline in overall pounds caught. Data including effort calculations such as yearly trips,
pounds/trip, pounds/pot fished, and average number of pots fished per trip is included in the fisheries management plan, as illustrated in the Trends portion of this paper. How these data are incorporated into management decisions could be better communicated to fishermen.

Additionally, a stock assessment was conducted and included in the fishery management plan (Eggleston and Johnson, 2004). How this information is used in making management decisions could be better communicated to fishermen, as well. Explaining how fisheries dependent and independent data are incorporated into management decisions, would relieve concerns that the economic effects of regulations are not being considered and might also relieve skepticism about the biological effects of regulations.

Additionally, stringent assessment indicators for determining the effect of regulation should be included in the blue crab management plan. Guidelines for when a ruling will be put in place and removed, such as the spawning stock indicator used for the maximum size rule, should be put in place for all laws. The presence of these guidelines should be clearly translated to fishermen. This may also ease concerns about excess laws, or ineffective laws.

While all of the participants I interviewed after the size limit proclamation were aware of the law, it is important to note that the proclamation does not convey the full extent of the regulation in the rulebook. The proclamation states the size limit stands from January 2006-April 2006. The ruling however, states that the size limit stands from September 1 to April 30. Upon recognizing this difference, two of the fishermen were very upset. These additional three months make for a significant portion of their income. Half of the fishermen were not aware of the second regulation, which was implemented this past September.

It seems that improved communication would improve fishermen knowledge of laws. This in turn, would better fishermen’s ability to follow the regulations, clear misconceptions concerning the reasoning and the aims of regulations, and perhaps most
importantly, would hold them accountable to the laws. Managers should begin by making sure that all fishermen receive mailings on rule changes. Alternatively, the majority of individuals I spoke with have access to email, either individually or through their wives. Fishermen could be encouraged to signup on the website to receive notices.

More importantly, the Division of Marine Fisheries could use these means of communication to not only inform fishermen of rule changes but also to reveal information such as the purpose of rules, the different alternatives considered, and the results of studies that are being conducted. This could increase understanding and improve rapport between the two groups.
Appendix 1:

All data is from the North Carolina Division of Marine Fisheries

Fig. 1.1 Lbs of Soft and Peeler Crabs Landed (1950-2004)

Fig. 1.2 Lbs of Hard Crab Landed (1994-2004)
Fig. 3.1 Total Soft and Peeler Crab Trips (1994-2005)

Fig. 3.2 Total Hard Crab Trips (1994-2005)
**Fig. 4.1 Total Peeler Pots Fished (1997-2005)**

**Fig. 4.2 Total Hard Crab Pots Fished (1997-2005)**
Appendix 2:

Table 6.2. Blue crab landings (pounds), and value by market group for North Carolina: 1984 - 2002.

<table>
<thead>
<tr>
<th>Year</th>
<th>Pounds</th>
<th>Value</th>
<th>Price per pound</th>
</tr>
</thead>
<tbody>
<tr>
<td>1984</td>
<td>52,260,169</td>
<td>$25,908,293</td>
<td>$0.51</td>
</tr>
<tr>
<td>1985</td>
<td>45,033,943</td>
<td>$33,053,805</td>
<td>$0.73</td>
</tr>
<tr>
<td>1986</td>
<td>65,862,500</td>
<td>$40,466,679</td>
<td>$0.61</td>
</tr>
<tr>
<td>1987</td>
<td>64,303,345</td>
<td>$33,165,972</td>
<td>$0.61</td>
</tr>
<tr>
<td>1988</td>
<td>60,402,332</td>
<td>$33,526,081</td>
<td>$0.67</td>
</tr>
<tr>
<td>1989</td>
<td>56,094,891</td>
<td>$32,190,114</td>
<td>$0.60</td>
</tr>
<tr>
<td>1990</td>
<td>38,806,273</td>
<td>$25,095,797</td>
<td>$0.63</td>
</tr>
<tr>
<td>1991</td>
<td>29,536,851</td>
<td>$25,095,797</td>
<td>$0.64</td>
</tr>
<tr>
<td>1992</td>
<td>36,401,344</td>
<td>$25,095,797</td>
<td>$0.64</td>
</tr>
<tr>
<td>Average</td>
<td>48,754,006</td>
<td>$25,095,797</td>
<td>$0.64</td>
</tr>
</tbody>
</table>

(NC BCFMP, 2004)

Human Ecology Flow Chart
Appendix 3:

FIGURE 10. Polder pot used for penney potting, with a separate holding chamber for male oysters. The pot is of standard construction using 1" mesh wire. However, there is no built well, and an additional piece of wire is placed across the polder divider, creating two additional compartments. Access to these holding chambers is through special doors in the sides or ends of the chambers.

(Oesterling, 1984)

Carteret County, North Carolina

(NC BFMP, 2004)
References:


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