

# **What Can Be Done To Save The East Coast Blue Crab Fishery?**

by

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## Abstract

The blue crab (*Callinectes sapidus*) is a decapod crustacean that inhabits estuarine and marine ecosystems of the western Atlantic Ocean. Blue crab is the largest and most valuable fishery for Maryland, Virginia and North Carolina. In 2007 the blue crab fishery in the Chesapeake Bay crashed. Maryland and Virginia experienced the lowest landing levels since landings data were first recorded in 1950. As a result, I chose to investigate the east coast blue crab fishery and develop recommendations to improve blue crab populations of the Atlantic states.

I analyzed blue crab landings data and management for all east coast states that report commercial landings to the National Marine Fisheries Service. In 2007 approximately 81.5 million pounds of blue crabs were landed by New York, New Jersey, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia and the east coast of Florida. The Atlantic coast landed almost 14 million pounds less blue crabs in 2007 than in 2006. Maryland saw the largest drop between 2006 and 2007 at almost seven million pounds, while Virginia and North Carolina both saw a drop of over three million pounds each. Most of the states analyzed showed a recurring pattern of a peak harvest in the mid-1990's followed by a profound crash to the low landings seen today.

As a result of the crashing blue crab populations, I developed a suite of recommendations to improve populations coast wide as well as coordinate blue crab management. First, blue crabs should be managed in two regions, North and South, split at Cape Hatteras, North Carolina. Second, female crabs need to be protected from harvest pressures, especially sponge crabs. Third, dredging for crabs disproportionately targets fecund females so crab dredging should be banned coast wide. Finally, coastal ecosystems are severely degraded and tougher regulations and enforcement is required to preserve blue crab habitat.

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## **Introduction**

The blue crab, *Callinectes sapidus*, is an icon in the mid-Atlantic region of the United States. Only two states have official state crustaceans, Louisiana has the crawfish and Maryland has the blue crab. Crab feasts of steamed crabs are a summer ritual throughout Maryland and “Maryland-Style Crab Cakes” are world famous. But east coast populations of blue crabs are severely depleted. The majority of blue crabs now come from North Carolina and Louisiana (Rittschof, pers. comm., 2009). The Chesapeake Bay had one of the worst recorded harvests of blue crabs in 2007. As a result, Maryland and Virginia worked cooperatively to enact emergency regulations to reduce the harvest of female blue crabs by 34% in 2008. This paper will examine the entire east coast blue crab fishery from individual state regulations to the current level of landings up and down the coast. I will then provide some personal management recommendations to help save this regional icon and commercially valuable crustacean.

## **Blue Crab Ecology**

Effective management is rooted in biology and it is essential that managers understand the biology and ecology of species they are entrusted to manage. *Callinectes sapidus* is a decapod crustacean of the family Portunidae (swimming crabs). Blue crabs range in color from brown to olive-green on their carapace. The front pair of claws are blue, but females have orange/red tips on their claws referred to by fishermen as painted nails or lipstick (Ernst, 2003).

Blue crabs are found from Nova Scotia throughout the Caribbean and as far south as Argentina (Millikin and Williams, 1984). They inhabit multiple habitats as adults including seagrass beds, oyster reefs, mud bottoms and sand bottoms, but are heavily

dependent on submerged aquatic vegetation as they settle into estuaries as larvae. Blue crabs are both predator and prey. There are over 101 species documented to consume blue crabs including fish, sharks, sea turtles, alligators, birds and other blue crabs (Hines, 2007). Blue crabs are also indiscriminate foragers, consuming bivalves, fish, detritus, plant material, carrion and other crabs (Hines, 2007). Blue crabs are highly cannibalistic which is one of the reason aquaculture attempts have been unsuccessful for the species (Marc Turano pers. comm., 2008).

Mating occurs from early spring through the fall depending on water temperature. For example, crabs in Florida will begin to mate earlier than crabs in the Chesapeake Bay (Jivoff et al., 2007). Male crabs grow to be much larger than female crabs because males grow and molt several more times than females. Prior to the female terminal molt, a male crab will briefly court then grab and protect the female until her final molt. Only after the female has molted and her gonopores are still soft is she receptive for sperm. After copulation has occurred, the male continues to hold and protect the female for about 2 days then she is released (See Appendix 1 Graphic 1 for photographic sequence of mating) (Rittschof pers. comm., 2009). Females only mate in one 10 day interval, generally only mating once in that time. But females may mate multiple times until her spermathecae (sperm storage organ) is full (Rittschof pers. comm., 2009). Females store enough sperm to produce multiple clutches of fertilized eggs (Dickinson et al., 2006).

A single sponge produced by a female crab can have up to eight million eggs (Ernst, 2003). Female crabs will migrate to, or remain in, the higher salinity waters near the mouth of estuaries to release their salinity dependent larvae (Dickinson et al., 2006). Time between mating and larval release is temperature dependent, but the average

duration to larval release for females mating in spring and summer is approximately three to eight weeks in North Carolina (Darnell et al., Duke University, unpublished data). Females release larvae during falling tides, which allows the subsequent ebb tide to transport the larvae offshore. Offshore larval development may be advantageous due to reduced predation pressure and higher survivorship due to physiological limitations of the larvae (Dickinson et al., 2006). Larval development occurs in surface waters of the continental shelf, which consists of seven zoeal stages and one megalopal stage (Epifano and Garvine, 2001). Development from zoea through megalopa may take 5-8 weeks offshore and the megalopa are eventually transported back to estuarine nursery grounds where settlement and metamorphosis to juvenile crabs takes place (Epifano and Garvine, 2001) (See Appendix I graphic 2 for a general blue crab life cycle). The exact mechanism for the return of megalopa larvae to coastal estuaries is still highly debated and will be covered later.

### **East Coast Blue Crab Fishery**

The blue crab fishery has an extensive history throughout the east coast (Kennedy et al., 2007). Today two life stages of crabs and a handful of different gears dominate the fishery. The main life stages harvested along the east coast are hard and soft crabs. Blue crabs have hard exoskeletons thus they are required to molt to grow. Hard crabs are crabs in between molts and their carapace and other body parts have hardened and they are full of meat. Soft crabs are crabs that have recently emerged from their old carapace. There are actually two harvested forms of soft crabs: the soft crab with a shell that has not yet hardened and peeler crabs that have not yet emerged from their previous shell, but emergence is imminent within the next few days. Peeler crabs are sometimes retained in

“shedding houses” and held until the crab molts at which time they are sold as soft crabs. Soft crabs receive a higher market price than hard crabs.

A variety of gears are used to catch blue crabs. The most common is the crab pot. Crab pots are cube shaped and constructed of 18-gauge double galvanized or vinyl-coated wire with hexagonal or square mesh. The most common crab pots measure 24” x 24” x 24”. Pots are baited with dead fish, eels or chicken. Crabs enter through openings or funnels on the side of the pot and are retained until the crabber comes and removes them. Each trap has cull rings that allow undersized crabs to escape and the size of the cull rings and funnels on pots are regulated by individual states. Most states require an escape panel on a single side of the trap, but not the bottom. The fasteners for the panels deteriorate over time and when it opens there is an unobstructed opening that allows crabs to escape. Pot loss is a problem in pot fisheries and these panels help eliminate ghost pots. Ghost fishing is the process of lost pots continuing to capture organisms by re-baiting themselves with organisms caught in the trap that die. Depending on the pot material, specific instructions are provided by the states to ensure that the material will degrade and allow crabs to escape.

There is one particular by-catch problem that has been addressed in the blue crab pot fishery, the bycatch of the diamondback terrapin, *Malaclemys terrapin*. Roosenburg et al. (1997) estimated terrapin catch rates of 0.17 terrapins per pot per day in shallow waters of the Chesapeake Bay. Most of the terrapins caught were male, 3:2 male biased sex ratio, with an estimated 15-78% of local terrapin populations caught per year in crab pots (Roosenburg et al., 1997). To alleviate the problem of terrapin by catch, Roosenburg and Green (2000) tested the effectiveness of a terrapin bycatch reduction device (BRD).

A 4.5 x 12 cm wire BRD placed in an entrance funnel was found to reduced terrapin bycatch by 82% and did not have any effect on the amount or size of crabs caught in the pot (Roosenburg and Green, 2000). In response to this evidence many states now require the use of terrapin BRDs in their pots and Georgia even distributes them for free to anyone who requests them.

Another gear used on the east coast is a crab dredge. Dredging is the process of pulling a large metal basket with metal teeth through the top few inches of the benthos and collect shellfish and crabs. Dredges are used during winter seasons to capture crabs lying on or buried in estuary bottoms (Kennedy et al., 2007). Crab dredges are legal only in New York, New Jersey, Delaware, and the Pamlico Sound in North Carolina. Virginia has historically had the most productive dredge fishery, but when the Chesapeake crab harvest recently crashed, the winter dredge fishery was eliminated in 2008 and will most likely be banned in 2009 as well. Dredging and environmental consequences of this practice will be discussed in more detail later in this paper.

There are other gears used in the east coast crab fishery. Trot lines are long bottom set lines of bait that are pulled gently to the surface and crabs are collected off the bait. Many recreational crabbers use dip nets to catch crabs out of the water. Baited traps are similar to pots, but only capture crabs that are attached to the bait when the trap is retrieved from the bottom. These are the main gears used in the fishery, but there are many modifications to each of these gears.

The next section reviews the current condition of individual states blue crab fisheries and the regulations that are currently in place for harvesting blue crabs.

## *New York*

The state of New York no longer supports a large blue crab fishery, but commercial landings are still collected by the National Marine Fisheries Service Statistics division. In 2007, almost 600,000 pounds of blue crabs were landed in New York. That is over 250,000 pounds below 2006 landings and almost 300,000 pounds below the average landings from 2000 to 2005. Figure 1 of Appendix II shows landings and value data from 1980-2007 for the blue crab fishery in New York (Personal communication from the National Marine Fisheries Service, Fisheries Statistics Division, Silver Spring, MD, 2009). There is an obvious declining trend seen in figure 1 where landings have dramatically decreased from 1996 to 2007. Over 2 million pounds of blue crabs were landed in 1996 and the 2007 harvest level was a little over one fourth of that level (Personal communication from the National Marine Fisheries Service, Fisheries Statistics Division, Silver Spring, MD, 2009).

The state of New York implements blue crab regulations through the Department of Environmental Conservation. Blue crab fishing regulations are addressed under Title 6 (Environmental Conservation) of New York Codes, Rules and Regulations (NYCRR). Part 44 of 6 NYCRR is the section of the regulations concerning lobsters and crabs, including American lobsters, horseshoe crabs and blue crabs. The state of New York has only a minimum size for blue crabs. Effective June 1, 2006, the minimum size for hard shell blue crabs is a carapace width no less than 4.5 inches, 3.5 inches for soft shell crabs and 3 inches for peeler or shedder crabs (NYCRR, 2008). There are no separate regulations concerning male and female crabs, but there are regulations pertaining to the marking of pots and traps and their location; blue crab pots cannot be placed within 25

feet of designated navigation channels. New York allows the use of crab dredges, but has no regulations in place to manage dredge use (Kennedy et al., 2007).

### *New Jersey*

New Jersey shares Delaware Bay with Delaware for their blue crab fishery. In 2007 over 4.8 million pounds of blue crabs were landed in New Jersey, which is almost a million pounds below the 2006 harvest (Personal communication from the National Marine Fisheries Service, Fisheries Statistics Division, Silver Spring, MD, 2009).

Compared to the average harvest between 2000 and 2005, the 2007 harvest was down approximately 45,000 pounds. Figure 2 of Appendix II is a graph of New Jersey's blue crab landings and value from 1980-2007. New Jersey's decline in landings is not as pronounced as New York's decline, but there is still a downward trend since the peak harvest in 1993 of 7.5 million pounds (Personal communication from the National Marine Fisheries Service, Fisheries Statistics Division, Silver Spring, MD).

New Jersey crabbing regulations are promulgated through the Division of Fish and Wildlife under the New Jersey Department of Environmental Protection. The 2008 minimum size for commercial sale of blue crabs is 3 inches for peeler or shedder crabs, 3 ½ inches for soft crabs, 4 ¾ inches for hard crabs and 4 ½ inches for mature female crabs (NJDFW, 2008). Taking of female crabs with eggs attached (sponge crabs) or crabs with eggs (sponge) removed is prohibited. There is no commercial quota for blue crabs in New Jersey, but a one-bushel limit is in place for recreational crabbers (NJDFW, 2008).

Three types of gear are commercially regulated in New Jersey, crab pots, trotlines, and dredges. The crab pot and trotline season varies depending on the area fished. In Delaware Bay and its tributaries, the season for pots and trot lines is between

April 6<sup>th</sup> through December 4<sup>th</sup>. For all other New Jersey state waters the season is March 15<sup>th</sup> through November 30<sup>th</sup> (NJDFW, 2008). The minimum mesh size for all crab pots is 1 inch and must have a biodegradable panel or mechanism that is 6 ½ inches wide and 5 inches tall that permits the escape of crabs when the pot is lost or abandoned. Terrapin excluder devices are required in all funnels when crab pots are placed in any body of water less than 150 feet wide at mean low water or any man-made lagoon. Crab dredging is still permitted in New Jersey, but like trotlines and pots, there are seasonal restrictions. Dredging for crabs is allowed in Delaware Bay between November 15<sup>th</sup> and April 15<sup>th</sup> and December 1<sup>st</sup> through March 31<sup>st</sup> in all other New Jersey state waters (NJDFW, 2008). It should be noted that New Jersey now has a moratorium on all new commercial crab licenses. In 2008, no new commercial crab pot, trot line or dredge permits were issued and only those renewing (in possession of) a license could receive a permit to fish the 2008-2009 season.

### ***Delaware***

Delaware is one of two states where blue crab fishery landings have increased over the past few years, but that does not imply that the fishery is doing well. Over 3.5 million pounds of blue crabs were landed in Delaware in 2007 (Personal communication from the National Marine Fisheries Service, Fisheries Statistics Division, Silver Spring, MD, 2009). The 2007 harvest was over 700,000 pounds above the 2006 harvest and approximately 600,000 pounds above the average harvest level between 2000 and 2005 (Personal communication from the National Marine Fisheries Service, Fisheries Statistics Division, Silver Spring, MD, 2009). Figure 3 of Appendix II shows this recent increase in landings, but the overall downward trend in landings between 1980 and 2007 is obvious.

The peak harvest of approximately 7.5 million pounds occurred in 1995 and has decreased down to 3.5 million pounds a reduction of approximately 4 million pounds (Personal communication from the National Marine Fisheries Service, Fisheries Statistics Division, Silver Spring, MD, 2009). Managers should cautiously interpret recent increases in landings in Delaware cautiously as more crabs have been removed in the past few years from a struggling population.

Blue crab regulations in Delaware are issued through the Division of Fish and Wildlife of the Department of Natural Resources and Environmental Control. Commercial minimum sizes for blue crabs caught in Delaware state waters are 5 inches for hard crabs, 3 ½ inches for soft crabs and 3 inches for peelers (DNREC, 2008a). The commercial crab pot season lasts from March 1<sup>st</sup> through November 30<sup>th</sup>. Crab dredging is still permitted in Delaware waters of Delaware Bay as well as state waters of the Atlantic Ocean. The 5 inch minimum size limit for hard crabs still exists for the dredge fishery, but there is no minimum size for mature females (DNREC, 2008a). The commercial dredge season lasts from December 15<sup>th</sup> through March 31<sup>st</sup> (DNREC, 2008a).

Recreational crabbing is permitted with the possession of a recreational tidal fishing license. The same size limits for commercial pots apply to recreational crabbers using pots; 5 inch minimum for hard crabs, 3 ½ inches for soft crabs and 3 inches for peeler crabs (DNREC, 2008b). The recreational pot season also lasts from March 1<sup>st</sup> through November 30<sup>th</sup> and a one-bushel limit per licensed crabber is in place (DNREC, 2008b).

### *Chesapeake Bay: Maryland And Virginia*

Two thousand and seven saw one of the worst crabbing seasons for Maryland and Virginia watermen (commercial fishermen) in recent history. In 2007, Maryland harvested almost 21.5 million pounds of blue crabs from the Chesapeake Bay. This number is about 3 million pounds below the 2006 harvest level and just above the lowest recorded harvest of 21 million pounds harvested in 2000 (Personal communication from the National Marine Fisheries Service, Fisheries Statistics Division, Silver Spring, MD, 2009). Figure 4 of Appendix II shows the pattern of a mid-1990's peak in landings (over 59 million pounds were landed in 1993) and a steady decline to 2007. Virginia watermen fared much worse. The total harvest in Virginia in 2007 was 18.5 million pounds, which was over 3 million pounds lower than the 2006 harvest (Personal communication from the National Marine Fisheries Service, Fisheries Statistics Division, Silver Spring, MD, 2009). See figures 4 and 5 in Appendix II for graphical displays of Maryland and Virginia landings data.

The combined Bay-wide harvest of around 40 million pounds is the lowest on record since 1945 (CBSAC, 2008). Both Maryland and Virginia's 2007 harvest was over 5 million pounds less than the average landings between 2000-2005. The economic impact of such a low harvest was drastic as well. In 2007, the dockside value of the Chesapeake Bay blue crab harvest was approximately \$125 million, dramatically falling to about half of the previous annual value of \$250 million (Baker, 2008).

### *Emergency Regulations*

The extreme drop in both the harvest and dockside value of the Chesapeake blue crab prompted unprecedented cooperation between Maryland and Virginia. The Bi-State

Blue Crab Advisory Committee identified the need to reduce the harvest of female blue crabs in the Chesapeake Bay by 34% in 2008. Because the harvest of crabs is split evenly between males and females, the 34% reduction in the harvest of females translates into an overall 17% reduction in crab harvest (CBSAC, 2008).

In Maryland, emergency regulations were approved by the Administrative, Executive and Legislative Review Committee (AELR) on May 22 and went into effect on June 1<sup>st</sup> 2008. The regulations included prohibiting the recreational catch of female blue crabs, no commercial harvest of female crabs after October 23<sup>rd</sup> and a new special female harvesters permit that authorized a limited number of crabbers a daily allocation of mature females that could be harvested up to October 23<sup>rd</sup> based on previously reported landings (Fegley, 2008).

The Virginia Marine Resources Commission approved sweeping cutbacks on April 22<sup>nd</sup>, 2008, with the regulations going into effect on May 1<sup>s</sup> (VMRC, 2008). Virginia abolished the controversial winter dredge fishery, closed the fall season for female crabs on October 27<sup>th</sup> (five weeks early), eliminated the five-pot recreational crab license, required two additional larger cull rings on crab pots and set up a percentage-based pot reduction schedule (VMRC, 2008). Virginia recognized that closing the winter dredge fishery would put economic hardship on the 50 dredge permit holders in the Bay and they agreed to ask for federal financial assistance to help out the affected watermen.

#### *2008 Maryland Harvest Reports*

Controversy surrounded the 2008 harvest levels reported by Maryland watermen. The Bi-State Blue Crab Advisory Committee and the Chesapeake Bay Stock Assessment Committee manages the fishery for an annual 46% removal rate, the estimated maximum

sustainable yield (MDDNR, 2008). As previously discussed, the 2008 harvest levels of female blue crabs were reduced in response to the low population estimates . The two primary management actions included daily female catch limits beginning September 1, 2008 based on individual catch histories and prohibition on taking female crabs on October 23, 2008. Between 1997 and 2007 40% of Maryland's female crab harvest occurred after October 1<sup>st</sup> and 19% of the female harvest was landed after October 23<sup>rd</sup> (MDDNR, 2008). As a result of the management decisions being based on historical catch reports, fishermen saw the opportunity to alter their reporting habits to position themselves for future report based management actions.

Maryland has employed reporting validation measures since 2001. These measures include mandatory dealer reporting and a reference fleet of crabbers that is representative of all commercial crabbing sectors (i.e hard pots, peeler pots, trot lines, etc.) (MDDNR, 2008). Between 2003 and 2007, the difference between estimated crab catch from the reference fleet and the actual commercial reports were 18% for male crabs and 15% for females (MDDNR, 2008). In 2008, the reported harvest of male crabs was 30% higher than estimated and 60% higher for female crabs (MDDNR, 2008). There was also a 30% discrepancy between dealer reports and commercial harvester reports for female crabs landed in Maryland. Also in place in Maryland is a Commercial Crabbing Effort Survey, which did not find a significant increase in the number of pots deployed in 2008 or an increase in the number of days spent crabbing compared to previous years; in conclusion, the reported increase in male and female harvest was not a result of increased effort (MDDNR, 2008).

The female crab harvest was over-reported in 2008 by Maryland commercial watermen so they could better position themselves for future management decisions based on past landings. This is blatant distrust that has grown between Maryland watermen and the fishery managers that has led to a hostile relationship between two very connected groups.

### *2009 Regulations for Chesapeake*

Maryland's Department of Natural Resources has established new regulations for the 2009 crabbing season. These new commercial regulations include: 1) establishing daily bushel limits for mature female hard crabs (exact numbers are dependent on the 2008 annual winter dredge survey results available in April); 2) closing the harvest of mature female hard crabs between June 1<sup>st</sup> and June 15<sup>th</sup>, September 26<sup>th</sup> through October 4<sup>th</sup> and November 11<sup>th</sup> through December 15<sup>th</sup> and 3) freezing unused licenses until the blue crab population recovers (Chesapeake Bay Program, 2008). Newly proposed regulations are in addition to the size limits previously in place. Maryland commercial crabbing season lasts from April 1<sup>st</sup> through December 15<sup>th</sup>; all season soft crabs must be a minimum of 3 ½ inches however there is no minimum size for mature females. Between April 1<sup>st</sup> through July 14<sup>th</sup> minimum sizes for hard males are 5 inches and 3 ¼ inches for peeler crabs. From July 15<sup>th</sup> through December 15<sup>th</sup> minimum size for hard crabs is 5 ¼ inches and the minimum size for peeler crabs is 3 ½ inches. Also, no commercial crabbing will be permitted on November 12<sup>th</sup> and November 19<sup>th</sup> (Chesapeake Bay Program, 2008).

Recreational crabbing is permitted seven days a week without a license when using dip nets or hand lines. Coastal property owners are allowed to set a maximum of 2

crab pots from a privately owned dock/pier located on their property without a crabbing license. A recreation crab license is required for any one using a trotline (<1,200 feet only) or 11 to 30 collapsible traps or rings (any trotline larger or more traps would require a commercial license).

Virginia's crabbing season lasts from March 17<sup>th</sup> through November 30<sup>th</sup> (VRMC, 2009). A 5 inch minimum size exists for male hard crabs and immature female crabs, but like Maryland, Virginia has enacted sliding minimum sizes depending on the time of the year. From March 17<sup>th</sup> through July 15<sup>th</sup> minimum size for peeler crabs is 3 ¼ inches and between July 16<sup>th</sup> and November 15<sup>th</sup> the minimum size is 3 ½ inches in the Virginia portion of the Chesapeake Bay and its tributaries (VRMC, 2009). For the ocean side of the Eastern shore the limit for peeler crabs is 3 ¼ inches (VRMC, 2009). A 3 ½ inch limit is in place for all soft shell crabs caught in Virginia state waters (VRMC, 2009). There is no minimum size for female hard crabs. Virginia does allow a possession limit for undersized crabs; 10 undersized crabs are allowed per bushel of both hard and peeler crabs. Dark sponge female crabs only need to be returned to the water between March 17<sup>th</sup> and July 14<sup>th</sup>, but a 10 dark sponge allowance per bushel is allowed (VRMC, 2009). This means that Virginia crabbers are allowed to harvest orange sponge crabs all season long and dark sponge crabs from July 15<sup>th</sup> through November 30<sup>th</sup>. A 51 bushel (17 barrel) daily catch limit per vessel is in effect for the Virginia pot fishery, no other gears have a daily limit (VRMC, 2009).

Virginia has implemented crab sanctuaries, a novel approach to blue crab management. The Lower Bay Crab Sanctuary Area and the Virginia Bay-wide Blue Crab Spawning Sanctuary are closed to commercial crabbing between May 1<sup>st</sup> and September

15<sup>th</sup>. Virginia has also instituted a 30% reduction in the allowable number of pots per commercial pot license for the 2009 season (i.e. 100 crab pots or less can now only employ 70 pots, 150 pots are reduced to 105, 200 pots are reduced to 140, etc) (VRMC, 2009). A 255 pot limit is in place for all of Virginia tributaries of the Chesapeake Bay and Potomac River, and a 425 hard crab pot limit for the Chesapeake Bay and coastal waters. As previously mentioned, the Virginia winter dredge fishery was eliminated for the 2008 season and the prohibition is still in effect for the 2009 season. A moratorium on new commercial crab licenses is in effect through 2010 (VRMC, 2009).

The commercial size limits, dark sponge regulations and season lengths are also in place for the recreational crabbing sector. For recreational fishermen, it is illegal to take any female crabs from Virginia tidal waters between the dates of October 27<sup>th</sup> through November 30<sup>th</sup>. There is a two pot limit for all licensed recreational crabbers. The harvest limit for recreational crabbers using dip nets, hand lines or two crab pots is one bushel of hard crabs and two dozen peeler crabs (VRMC, 2009).

### ***North Carolina***

Like Maryland and Virginia, North Carolina's most valuable fishery in terms of pounds landed and dockside value is the blue crab. North Carolina landed 20.5 million pounds of blue crabs in 2007, almost four million pounds below the 2006 harvest (Personal communication from the National Marine Fisheries Service, Fisheries Statistics Division, Silver Spring, MD, 2009). North Carolina has the largest difference on the east coast in harvest levels between 2007 and the average harvest level from 2000 to 2005 of 13 million pounds (Personal communication from the National Marine Fisheries Service, Fisheries Statistics Division, Silver Spring, MD, 2009). Figure 6 in Appendix II

chronicles the decline of the North Carolina fishery and the pattern persists of landings peaking in the mid-1990's and declining to some of the lowest levels in the history of the fishery. The decline of Maryland, Virginia, and North Carolina's most valuable fishery is undeniable.

Commercial crabbing regulations for North Carolina are promulgated through North Carolina Marine Fisheries Commission. North Carolina manages all pot fisheries (crab, finfish, shrimp) under the same seasonal closures. Pots are permitted in coastal fishing waters (0-3 miles offshore) between December 1<sup>st</sup> and May 31<sup>st</sup>, but all pots need to be removed from the water between January 15<sup>th</sup> and February 7<sup>th</sup> (NCMFC, 2007). From June 1<sup>st</sup> through November 30<sup>th</sup> crab potting is permitted in all areas North and East of the Highway 58 Bridge to Emerald Isle (NCMFC, 2007). Areas West and South of the Emerald Isle Bridge and the Atlantic Ocean are open for crab potting from May 1<sup>st</sup> through November 30<sup>th</sup> (NCMFC, 2007). A 150 pot limit exists for Newport River crabbers, but no other pot limits exist for crabbers in any other area. A 5 inch minimum size exists for hard male crabs from March 1<sup>st</sup> through October 31<sup>st</sup>, but no minimum size limit exists for mature females, soft crabs or peeler crabs (NCMFC, 2007). Sponge crab harvest is still allowed in North Carolina. If the NC Division of Marine Fisheries Pamlico Sound Fishery Independent Trawl Survey finds a shortage of large female crabs, maximum size limits for mature female crabs can be enacted through Fisheries Director proclamation. A 6 ¾ inch maximum size would be enacted between September 1<sup>st</sup> through April 30<sup>th</sup> for female blue crabs and a 5 ¼ inch max size for female peeler crabs would also apply during that time (NCMFC, 2007). Crab dredging is permitted from January 1<sup>st</sup> through March 1<sup>st</sup> in Pamlico Sound. Crabs are allowed to be retained as

bycatch in the oyster dredge fishery as long as the weight of the crab catch is less than 50% of the total weight or 500 pounds, whichever is less (NCMFC, 2007). North Carolina has established Crab Spawning Sanctuaries (See Graphic 4 in Appendix I) in which it is unlawful to take crabs using any type of commercial fishing gear from March 1<sup>st</sup> through August 31<sup>st</sup>, but the Fisheries Director has the authority to declare other spawning sanctuaries through proclamations.

Recreational crabbers are required to obtain a Recreational Commercial Gear License (RCGL) from the Division of Marine Fisheries if they intend to pot for blue crabs in North Carolina waters. This license permits the crabber to use up to 5 crab pots; however, the catch cannot be sold and a 50 crabs per day limit exists (not to exceed 100 crabs per vessel) (NCMFC, 2008). The recreational crabbing sector is subject to the same size limits as the commercial sector. There is an exception to the RCGL requirement and that is that a single crab pot can be deployed from private property (shore or pier) without a RCGL (NCMFC, 2008). As with the commercial sector, no crab pots can be in the water between January 15<sup>th</sup> and February 7<sup>th</sup> of each year (NCMFC, 2008).

### ***South Carolina***

Blue crabs are much smaller fisheries, in terms of landings, below North Carolina. South Carolina, Georgia, and the east coast of Florida have similar harvest levels and histories of their blue crab fisheries. South Carolina landed four million pounds of blue crabs in 2007 only about 83 thousands pounds below the 2006 harvest (Personal communication from the National Marine Fisheries Service, Fisheries Statistics Division, Silver Spring, MD, 2009). The difference between 2007 and the 2000-2005 average harvest was almost seven hundred thousand pounds (Personal communication from the

National Marine Fisheries Service, Fisheries Statistics Division, Silver Spring, MD, 2009). Figure 7 of Appendix II shows blue crab landings data in South Carolina from 1978 to 2007. Nineteen seventy-eight data was included in this figure because that was the year of the largest harvest in South Carolina, over nine million pounds Personal communication from the National Marine Fisheries Service, Fisheries Statistics Division, Silver Spring, MD, 2009). South Carolina does not fit the trend of the mid-90s peak and subsequent crash, yet the landings have dramatically declined since the harvest peak of 1978.

South Carolina has no seasonal limitation for the blue crab fishery (SCDNR, 2008). A minimum size limit of 5 inches exists for all blue crabs, regardless of sex or life stage (SCDNR, 2008). The exception to this rule is that a commercial crabber can obtain a written acknowledgement from an authorized peeler dealer in which the dealer will knowingly accept undersized peeler crabs, but that is the only instance when the taking of undersized blue crabs is permitted. No sponge crabs, regardless of the color of sponge, may be taken, bought, sold or attempted to be sold and must be immediately returned to the water (SCDNR, 2008). The crab pot license enables a commercial crabber to employ up to 50 pots, but additional pots can be added to the license at the cost of \$1 per pot (initial license costs \$25.00 for South Carolina Residents) (SCDNR, 2008). No limit exists on the amount of crabs that can be daily.

Recreational crabbers can fish up to two crab pots without a license, but any more requires the purchase of a commercial license (SCDNR, 2008). Like commercial regulations, the minimum size for all crabs is 5 inches with no limit on daily catches in

state waters; taking of sponge crabs is illegal. Blue crabs can be taken from South Carolina waters all year long (SCDNR, 2008).

### ***Georgia***

Georgia crabbers landed almost 4 million pounds of blue crabs in 2007 (Personal communication from the National Marine Fisheries Service, Fisheries Statistics Division, Silver Spring, MD, 2009). The 2007 harvest was approximately 200,000 pounds less than the 2006 harvest level, but over a million pounds greater than the average harvest between 2000 and 2005 (Personal communication from the National Marine Fisheries Service, Fisheries Statistics Division, Silver Spring, MD, 2009). Figure 8 of Appendix II shows that the 2007 harvest was above the lowest recorded harvest of 1.6 million pounds in 2003, but well below the maximum harvest recorded in 1981 of 13 million pounds (Personal communication from the National Marine Fisheries Service, Fisheries Statistics Division, Silver Spring, MD, 2009). Figure 8 shows the undeniable collapse of the Georgia blue crab fishery from 1981 to 2007.

The Georgia blue crab fishery is regulated through a controlled access system; only 159 licenses are issued each year for the commercial harvest of blue crabs. A commercial license is required for anyone who fishes more than 6 pots (GADNR, 2007). If a license is not renewed by May 1<sup>st</sup>, the license is expired and is placed a lottery for new applicants. The commercial crabbing license enables the crabber to employ a maximum of 200 pots/traps. The minimum size for hard crabs is 5 inches, the peeler minimum size is 3 inches and there is no size limit for mature female crabs (GADNR, 2007). There are no quotas or quantity limits on the harvest of commercial crab catches. Soft shell crabs may be harvested, but they can only be sold to a licensed soft-shell crab

dealer; only commercial crabber or licensed soft-shell dealer may possess peeler crabs in commercial quantities (a bushel or more) (GADNR, 2007). The state of Georgia sticks with the trend of prohibiting the harvest of sponge crabs. The Georgia commercial crab season is open all year long.

Regulations for recreational crabbing in Georgia are in line with the commercial regulations. Recreational crabbers can employ up to 6 pots/traps without a license at all times of the year (GADNR, 2008). Minimum size is 5 inches for hard crabs, no size restrictions for mature females, 3 inches for peeler crabs, and the taking of sponge crabs is strictly prohibited (GADNR, 2008).

### ***Florida***

NMFS Fisheries Statistics Division separates the state of Florida into two separate reporting areas: the gulf coast and the east coast. This paper is reviewing east coast blue crab fisheries so only the east coast of Florida blue crab harvest data has been obtained. Blue crab harvest levels are much greater for the entire state of Florida than what is reported here due to the Gulf of Mexico blue crab fishery.

The East Coast of Florida landed four million pounds of blue crabs in 2007 (Personal communication from the National Marine Fisheries Service, Fisheries Statistics Division, Silver Spring, MD, 2009). The 2007 harvest was almost one million pounds above the 2006 harvest and close to nine hundred thousand pounds above the average landings between 2000 and 2005 (Personal communication from the National Marine Fisheries Service, Fisheries Statistics Division, Silver Spring, MD, 2009). The east coast of Florida has seen increase in their landings since the lowest recorded harvest of two million pounds in 2003, but the 2007 landings data is well below the maximum recorded

harvest of almost 8 million pounds in 1987 (Personal communication from the National Marine Fisheries Service, Fisheries Statistics Division, Silver Spring, MD, 2009). Figure 9 of Appendix II is a graphical display of Florida landings data between 1980 and 2007.

The Florida Fish and Wildlife Conservation Commission set fishing regulations for all commercial and recreational fisheries in the state. The blue crab season is open all year long in Florida except for rotating 10-day closures for certain areas of the state (FFWCC, 2008). A 5-inch minimum size for hard crabs exists, but no minimum size exists for peeler crabs (FFWCC, 2008). Harvesting sponge crabs is strictly prohibited. Florida recently implemented an effort control system for their blue crab fishery, beginning with the 2007-2008 license season, with only a certain amount of licenses issued each year (FFWCC, 2008). Three different crabbing endorsements exist in Florida permitting commercial crabbers to harvest hard and/or soft crabs. Each endorsement allows a specific number of pots to be employed in specific areas (i.e. Gulf of Mexico or state waters). There is no daily quota for commercial crabbers, but a 10-gallon limit exists for recreational crabbers with the same 5-inch minimum size (FFWCC, 2009).

### **East Coast Summary**

Regulations are rather uniform up and down the Atlantic coast. The minimum size for hard crabs ranges from 4.5 inches to 5.25 with only New Jersey having a minimum size for females of 4.5 inches. For the states that actually have a peeler/soft crab minimum size the range is between 3 and 3.5 inches. Only Maryland and Virginia have sliding minimum size requirements. Taking sponge crabs or removing the sponge from female crabs is prohibited in all states except Virginia and North Carolina. Blue crab seasons vary state to state possibly to the temperature dependence of crab activity; when

the water temperature is colder they are less active, do not feed and can only be dredged rather than baited to pots (See Appendix I table 1 for a summary table of east coast regulations).

The east coast blue crab fishery is bottoming out. A little less than 81.5 million pounds of blue crabs were landed in 2007, but that number is almost 14 million pounds below the 2006 coast wide landings. Only two states saw increases in their blue crab landings between 2006 and 2007 (Delaware and Georgia) with both of those increases being less than one million pounds. The three states that depend most on the blue crab fishery, Maryland, Virginia and North Carolina, landed 14 million pounds less in 2007 than in 2006. The decrease in landings is nothing new, with most states sharing a comparable declining trend. East coast blue crab fisheries have been declining for years (See Figures 1-9 in Appendix II), but the recent crash in the Chesapeake Bay has brought attention to this problem on a coast wide scale (See Appendix I for a summary table of east coast landings). If it is not too late to save the fishery, major management shifts need to occur.

### **Management Recommendations**

Individual states have done a poor job managing their blue crab resources to this point; therefore, I believe regional management of the blue crab fishery is required. A regional management structure will promote unified, cooperative management of this coast wide resource. Biological justification for regional management will first be addressed then specific regulations and management structure will be discussed.

Roughgarden et al. (1988) described the complicated life cycle associated with many marine organisms, specifically benthic marine invertebrates. Most marine

organisms have a complex life cycle with at least two developmental stages involving spatially different habitats and processes that are linked by a transport mechanism to and from distinct habitats (Roughgarden et al., 1988). Roughgarden et al. (1998) used barnacles along rocky intertidal habitats of central California to describe open populations composed of separate population cells, or metapopulations, connected by the migration of larvae. I argue that this same system of open system population dynamics is observed in east coast blue crab populations.

As described earlier, female blue crabs generally mate once, migrate to higher salinity waters at the mouths of estuaries, and release their larvae at high tide to be carried offshore by the subsequent ebb tide. Epifano (1995) generated a conceptual model for the transport of blue crab larvae off Mid-Atlantic States. Blue crab larvae are flushed to the continental shelf where transport is dependent on wind-driven surface currents; northward winds keep the larvae in the Mid-Atlantic bight during the summer and southward wind events are believed to transport larvae from the shelf back to estuarine settlement sites (Epifano, 1995). These wind-driven currents keep the larvae in Mid-Atlantic estuaries, but there is little doubt that there is mixing between Delaware Bay, Chesapeake Bay and the North Carolina Albemarle-Pamlico sound estuary systems. Etherington and Eggleston (2000) reported strong relationships between Atlantic hurricanes and settlement of larvae further up stream in the Croatan-Albemarle-Pamlico Estuarine System (CAPES) in North Carolina then during non-hurricane settlement episodes. Hurricanes coming from the southeast in fall months cause better recruitment of blue crab larvae into the CAPES (Etherington and Eggleston, 2000).

A similar mechanism is most likely occurring in the South Atlantic Bight states (South Carolina, Georgia, Florida). The Gulf Stream is just offshore of the southern Atlantic coast and veers sharply out into the Atlantic at Cape Hatteras, NC. If any blue crab larvae were to become entrained in the Gulf Stream, I hypothesize that the larvae would be carried far out into the Atlantic Ocean and “wasted”. Enough conceptual scientific evidence exists to shift the view from individual estuary populations of blue crabs to a connected coastal population where reproductive females in one estuary produce larvae that settle in other local estuaries as well as parent estuaries.

In light of the scientific evidence indicating connected blue crab populations along the east coast, I propose two management units for the east coast blue crab fishery. A northern and southern region would be created separated at Cape Hatteras, North Carolina. The United States National Oceanic and Atmospheric Administration (NOAA) also recognizes Cape Hatteras, NC as a break point between two Large Marine Ecosystems (LMEs): the Southeast U.S. Continental Shelf and the Northeast U.S. Continental Shelf large marine ecosystems.

My proposed Northern Blue Crab Management Unit would encompass North Carolina, Virginia, Maryland, Delaware, New Jersey and New York. Two of the most important shared estuaries, Chesapeake Bay and Delaware Bay, would then be under unified management regimes. The Southern Blue Crab Management Unit would contain representatives from North Carolina, South Carolina, Georgia and Florida. North Carolina would serve on the boards of both management units much like they have representatives on the Mid-Atlantic and South Atlantic Fishery Management Councils.

The organization responsible for regional management of fishery resources in state waters is the Atlantic States Marine Fisheries Commission (ASMFC).

The ASMFC should be in charge of managing the east coast blue crab fishery. The above discussion regarding the connectedness of blue crab populations should be enough to qualify the species for regional management. The ASMFC manages one other crustacean, the American lobster (*Homarus americanus*) through a similar regional structure off the coast of New England. If blue crab management would come under the ASMFC individual states would have equal representation in the fishery management plan development process as well as members of academia, commercial and recreational fishing interests and conservation voices. A unified independent organization such as the ASMFC has the potential to greatly improve the blue crab fishery if certain measures are taken to protect the species.

### **Three recommendations to improve recruitment**

A cohesive east coast fishery management plan for blue crabs would be a great start, but specific changes in blue crab management are required. To save the blue crab fishery from further decline and improve population sizes female crabs need to be protected, dredging should be eliminated and habitat restoration needs to become a direct focus. These three changes should increase east coast recruitment and allow blue crabs to rebound from their currently historic low level.

#### *Protect female crabs*

East coast blue crab populations are recruitment limited (Dave Eggleston pers. comm., 2009). Recruitment limited populations are commonly open systems connected by migrating larvae (Hughes, 1990). Open systems are recruitment limited because of

sporadic larval settlement into the population and not just the normal density-dependent controls such as predation and competition. Thus, if open population systems are expected to grow, recruitment needs to increase and mortality needs to decrease. This is a simple fix for the blue crab population: do not harvest female crabs, especially egg bearing females.

Protection of female crabs should occur in two stages: 1) coast wide elimination of sponge crab harvest and 2) protection of all mature females. Virginia and North Carolina are the only two states that still permit the harvest of sponge bearing crabs. The elimination of the sponge crab harvest is an obvious way to, at minimum, increase the chance of recruitment into two of the most valuable populations. Sponge crabs are holding millions of eggs and/or larvae (depending on their developmental stage) that are soon to be released. Removal of fertile females from any population will in no way increase the size of the population.

All female crabs deserve protection, not just the ones that are caught carrying eggs. Recent investigations have shown that female crabs produce multiple clutches of eggs over multiple seasons (Darnell et al., Duke University, unpublished data). Darnell et al. (Duke University, unpublished data) showed that mature female blue crabs have the ability to produce up to seven clutches of eggs. Over 80% of the crabs in the experiment produced multiple clutches of eggs, over 40% produced more than five clutches of eggs and the average number of clutches was  $4.14 \pm 0.26$  (Darnell et al., Duke University, unpublished data). This evidence is enough to warrant protection for female blue crabs through a moratorium on their harvest or at least a conservative minimum size requirement. A minimum size requirement could be one of the negotiated regulations in

the FMP development process and would most likely be different between the two regions.

### *Eliminate dredging*

In North Carolina, blue crabs mate from early spring through summer. Elapsed time until first clutch production is heavily dependent on time of year and water temperature of when mating occurred. If mating occurs in early summer (April – June) then the female will spawn that same year multiple clutches of eggs and most likely perish that year (Darnell et al., Duke University, unpublished data). When mating occurs mid summer (June – August) the female crab will spawn over two seasons with a clutch or two in September or October, then she will bury in mud to overwinter. Once the water temperature warms back up, the female will again become active, resume spawning and perish in the second season (Darnell et al., Duke University, unpublished data). If mating occurs between September and November, the female will not produce a clutch that year and overwinter almost immediately. When the water warms back up she will begin to spawn in March or April of the following year and most likely not survive that second spawning season (Darnell et al., Duke University, unpublished data). The discovery of this reproductive schedule has important management implications.

Few Atlantic coast states still allow some form of crab dredging or trawling. In Virginia's winter dredge fishery, 80% of the harvest is estimated to be recently impregnated females around two years of age (Kennedy et al., 2007). Dredging occurs most commonly in deep waters near the mouths of estuaries and catches are highest in the Chesapeake Bay around edges of broad banks next to the Bays deeper channels (Kennedy et al., 2007). Darnell et al. (Duke University, unpublished data) further indicates that

most of over wintering crabs are reproductively active females. By allowing the use of dredging to harvest crabs, crabs that will spawn or continue to spawn the following season are being disproportionately targeted. When Maryland and Virginia implemented emergency regulations to prevent the harvest of female blue crabs, one of the first practices to go was the Virginia winter dredge fishery. By banning the winter dredge fishery, the Virginia Marine Resource Commission (VMRC) determined that they would reach half of the 34% female harvest reduction goal (17%) and Dr. John McConaugha, a blue crab biologist from Old Dominion University and VMRC board member, called the move a “no-brainer” (Harper, 2008). Although the winter dredge fishery was closed in the 2008 season, there is no guarantee that it will be banned forever. A Norfolk, VA judge ruled that the VMRC could ban the dredge fishery, but only one year at a time (Harper, 2009). The VMRC must go through management proposals and public hearings each year they want to ban dredging for crabs, the normal procedure for any regulatory change. In addition to biological reasons for eliminating crab dredging, some people claim that crabs removed from the mud have a less desirable taste than those caught in pots (Dave Eggleston pers. comm., 2009). By eliminating the dredge fishery for blue crabs, fecund females will further be protected and an improvement in recruitment should follow.

### *Habitat protection*

An aspect of blue crab recruitment that needs to be addressed is habitat quality. Habitat regulations have started to become standard in fishery management plans, a regional fishery management plan could address essential habitat for blue crabs.

Estuarine water quality and submerged aquatic vegetation levels need to be improved if blue crabs are expected to continue to survive in our national estuaries.

Marine ecosystems worldwide have been severely degraded across the globe as a result of human activities and the North American eastern seaboard has been identified as an area of high impact (Halpern et al., 2008). Lotze et al. (2006) showed that human impacts have degraded estuarine and coastal environments worldwide leaving them far from historic baselines of rich, diverse, and productive ecosystems. Using paleontological, archaeological, historical, and ecological records Lotze et al. (2006) examined changes in species composition, water quality, and species invasions across 12 coastal ecosystems (including Delaware Bay, Chesapeake Bay and Pamlico Sound, NC) from the onset of human settlement to present day. Wetland loss was estimated to be 67%, sea grasses have been reduced by 65% and 48% of other submerged aquatic vegetation (SAV) has been lost worldwide because of reclamation, eutrophication, disease, destruction and direct exploitation (Lotze et al., 2006).

Blue crabs depend directly on submerged aquatic vegetation. Megalope larvae are transported back into estuaries where they need to settle in seagrass beds to be protected from predators and have access to ample food supplies. Thirty times more juvenile crabs have been found in seagrass beds than on barren bottom (Chesapeake Bay Foundation, 2008). The loss of SAV from coastal ecosystems coupled with severely degraded water quality leaves the blue crab with sub-standard habitats. The Chesapeake Bay Foundation (2008) linked the decline of the Chesapeake blue crab harvest with bad water in a 2008 report. Benthic low-oxygen dead zones kill organisms that blue crabs depend on with an estimated loss of 75,000 tons of clams and worms per year (Chesapeake Bay Foundation,

2008). “Crab jubilees” occur when dissolved oxygen levels are so low in the water that crabs literally crawl out of the water in search of oxygen. Two crab jubilees were documented in the Chesapeake Bay in 2008, but many more are believed to have occurred (Chesapeake Bay Foundation, 2008). Sediment runoff coupled with increased nitrogen and phosphorous levels (eutrophication) causing algal blooms has caused the Bay’s water to darken, preventing sunlight from reaching the bottom and choking out the underwater grasses. Since the early 1970’s, eelgrass in the Bay has been reduced by more than 50% (Chesapeake Bay Foundation, 2008).

It is not just the Chesapeake Bay that has habitat and water quality problems. North Carolina has estimated a loss of over 50% of low-salinity aquatic grasses in the Western Pamlico, Albemarle and Currituck Sounds (NCDMF, 2009). The 2005 NC Coastal Habitat Protection Plan included an entire chapter on SAV abundance, distribution and restoration. Recent work (Micheli et al. 2008) has shown that there is a shift in the dominant SAV species in Bogue Banks, NC. Sea level rise and increased water temperature associated with climate change and local anthropogenic impacts has caused a reduction in eelgrass (*Zostera marina*) and an increase in shoal grass (*Halodule wrightii*) (Micheli et al. 2008). Micheli et al. (2008) quantified significant decreases of invertebrate and fish assemblages associated with shoal grass compared to eelgrass. The loss of eelgrass and subsequent replacement with shoal grass will cause losses of important habitat functions and decreases in secondary production in North Carolina waters (Micheli et al., 2008).

Vital blue crab habitat is decreasing up and down the coast due to anthropogenic impacts and climate change. Through tough regulation, incentives to reduce pollution,

and enforcement of environmental laws submerged aquatic vegetation and, and ultimately blue crabs, may be saved (CBF, 2008). Quick action is required and the longer actions are delayed, the less chance the fishery has of recovering.

### *Fishermen*

My proposed regulations will undoubtedly affect fishermen's landings and ultimately their profits. The National Oceanic and Atmospheric Administration declared the Chesapeake blue crab fishery a disaster in September 2008, which opened up the door for possible federal relief funds. On November 14<sup>th</sup>, 2008 \$20 million federal dollars were allocated to help Maryland and Virginia watermen affected by the emergency regulations (Dominguez, 2008). A large portion of these funds went to fishermen who lost substantial portions of their income or those that couldn't work at all such as the Virginia dredgers.

Rather than paying fishermen when their fishery collapses, a potential to help fishermen and the population is to pay fishermen not to fish (Rittschof pers. comm., 2009). By paying fishermen not to harvest crabs, the fishermen are able to retain their income and the crab population is protected. This plan does not require the government to pay fishermen to not fish for an entire season; instead, fishermen could be paid to take a month or two off when blue crab spawning is highest. This is a different approach to traditional seasonal closures because fishermen are compensated for the regulations rather than losing money by not fishing.

There are other possible programs that could help control the effort in the blue crab fishery such as an individual transfer quota system (ITQ). Due to the complex problems that have led to the collapse of east coast blue crab fisheries (i.e. pollution,

water quality, habitat loss) fishermen are not solely to blame for the lack of blue crabs. Rather than solely punishing crabbers, the crabbers can be paid not to fish so that they continue to have an income in spite of not being able to crab.

### **Conclusion**

Lotze et al. (2006) said it best, “Reduced exploitation, habitat protection, and improved water quality need to be considered together, and the cumulative effects of multiple human interventions must be included in both management and conservation strategies.” Human activities, whether it is over fishing, pollution or habitat destruction have put extreme pressures on blue crab populations. The coast wide harvest of blue crabs is down almost 14 million pounds in just one year. Not a single state is anywhere close to the maximum harvest levels that were once observed in the fishery and if we hope to preserve the species, let alone the fishery, drastic management changes need to occur.

Blue crab populations up and down the coast are connected and need to be managed as one population as opposed to separate stocks. A regional fishery management plan would help coordinate conservation efforts and change the downward trend observed recently in the landings data. The east coast blue crab population is recruitment limited and the obvious fix to this is to increase recruitment into the population. The debate continues on the exact mechanism that transport megalope larvae back into estuaries, but one way to increase the probability of settlement is to support the release of more larvae offshore. Protecting female crabs would promote the release of more larvae into the ecosystem and more recruits should settle. An aspect of protecting

females is eliminating dredging in every state. Winter dredge fisheries disproportionately target female crabs and if protecting females is the goal, then banning dredging is a required conservation measure. A final recommendation to save the blue crab is to improve the amount of available quality habitat. Our coastal ecosystems are severely degraded worldwide and even as hearty as the blue crab may be, habitat improvements are essential to their continued survival. Pollution controls need to be enforced and tightened, SAV beds need to be protected from further degradation and restored and daily sediment loads need to be reduced across the coast.

The future for the blue crab is bleak if management continues as is. My ideas to regionalize management, protect female blue crabs and improve habitat quality are the first steps to a lengthy recovery process. The iconic blue crab deserves protection not only as a valuable commercial fishery, but also as an organism that is a vital part of the Atlantic coastal estuarine ecosystem.

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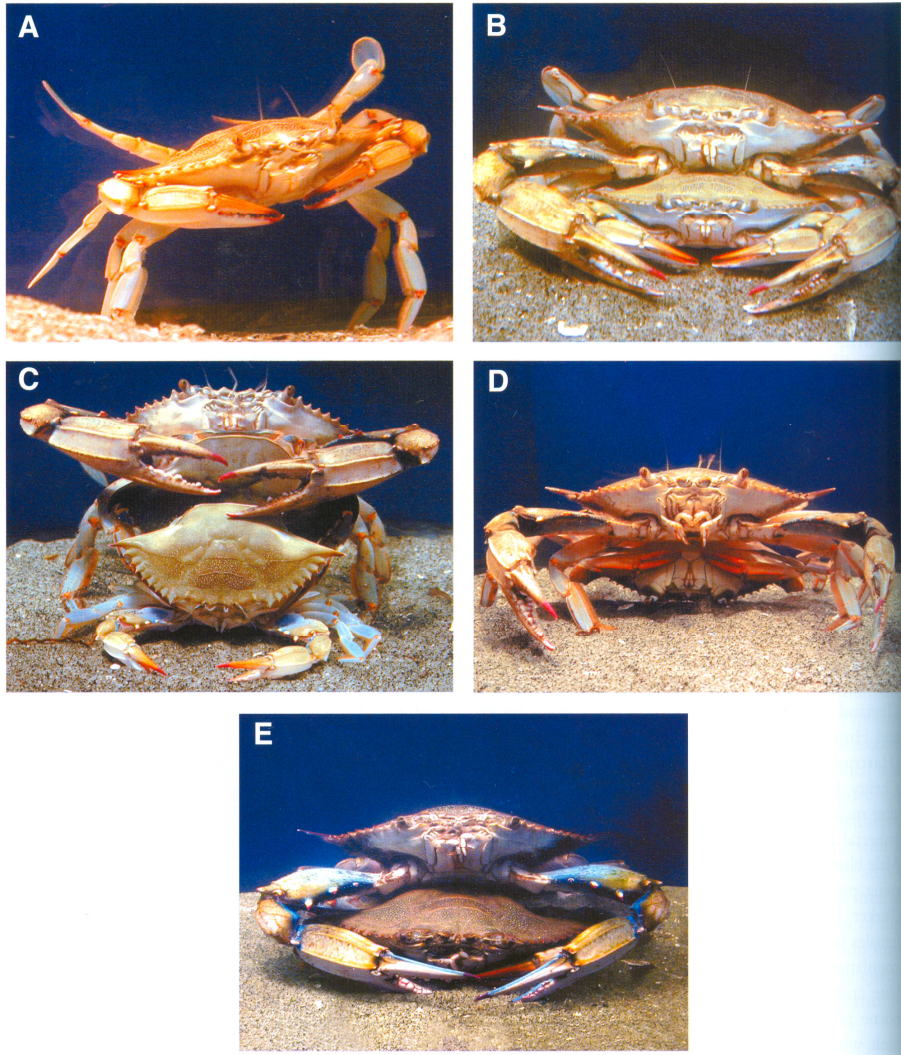
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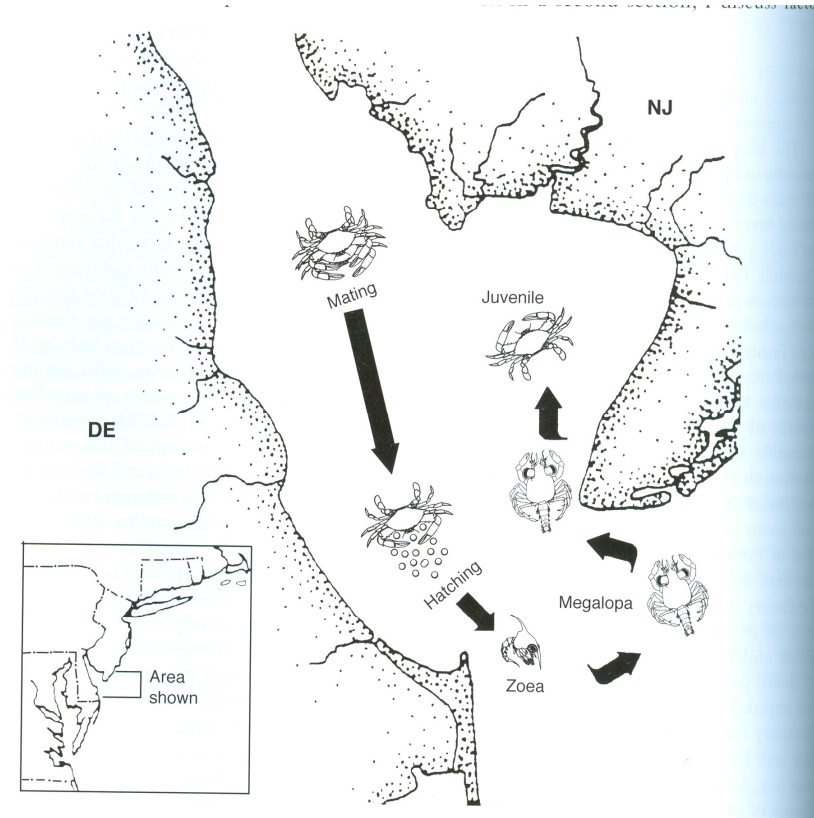
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## APPENDIX I



Graphic 1. Blue Crab mating sequence. A) Male mating display. B) Pre-copulatory mate guarding. C) Female undergoing terminal maturation molt. D) Copulation. E) Post-copulatory mate guarding. Photos by A. Young Williams.  
(Scanned from *The Blue Crab Callinectes sapidus*; Kennedy and Cronin ed., 2007)



Graphic 2. Generalized blue crab life cycle in a typical estuary (Delaware Bay, USA)  
 (Scanned from *The Blue Crab Callinectes sapidus*; Kennedy and Cronin ed., 2007)



<b>State</b>	<b>Season</b>	<b>Hard Crabs (in)</b>	<b>Peeler Crabs (in)</b>	<b>Dredge/Trawling</b>	<b>Sponge Crab Harvest</b>
New York	All Year	4.5	3	Yes	No
New Jersey	Gear Dependent	4.75 (m) 4.5 (f)	3	Yes	No
Delaware	Gear Dependent	5	3	Yes	No
Maryland	4/1 - 12/15	5 or 5.25 (after 7/15)	3.25 or 3.5 (after 7/15)	No	No
Virginia	4/1 - 11/30	5	3.25 or 3.5	No*	<b>Yes</b>
North Carolina	Gear Dependent	5	None	Yes	<b>Yes</b>
South Carolina	All Year	5	None	Yes	No
Georgia	All Year	5	3	No	No
Florida	All Year	5	None	No	No

Table 1. Summary of east coast blue crab regulations  
Hard Crabs and Peeler crab minimum sizes in inches.

\*Virginia banned dredging in 2007 and 2008, but it is only a temporary ban.

<b>State</b>	<b>2007 Landings</b>	<b>2007 vs 2006</b>	<b>'07 vs '00-'05 Average</b>
New York	591,308	<b>278,953</b>	<b>296,506</b>
New Jersey	4,821,452	<b>948,182</b>	<b>44,828</b>
Delaware	3,579,593	762,062	597,518
Maryland	21,386,087	<b>6,905,616</b>	<b>5,802,087</b>
Virginia	18,480,623	<b>3,340,705</b>	<b>5,766,267</b>
North Carolina	20,557,926	<b>3,851,011</b>	<b>13,291,849</b>
South Carolina	4,071,336	<b>82,985</b>	<b>676,465</b>
Georgia	3,897,880	<b>172,620</b>	1,116,424
Florida	4,037,663	933,971	865,556
<b>Total</b>	<b>81,423,868</b>	<b>13,884,039</b>	<b>23,298,504</b>

Table 2. Summary of blue crab landings data in pounds. Red numbers are decreases in landings and green are increases.

## APPENDIX II

All landings figures are in metric tons (1 metric ton = 2200 pounds). Overall trends in the data are most important.

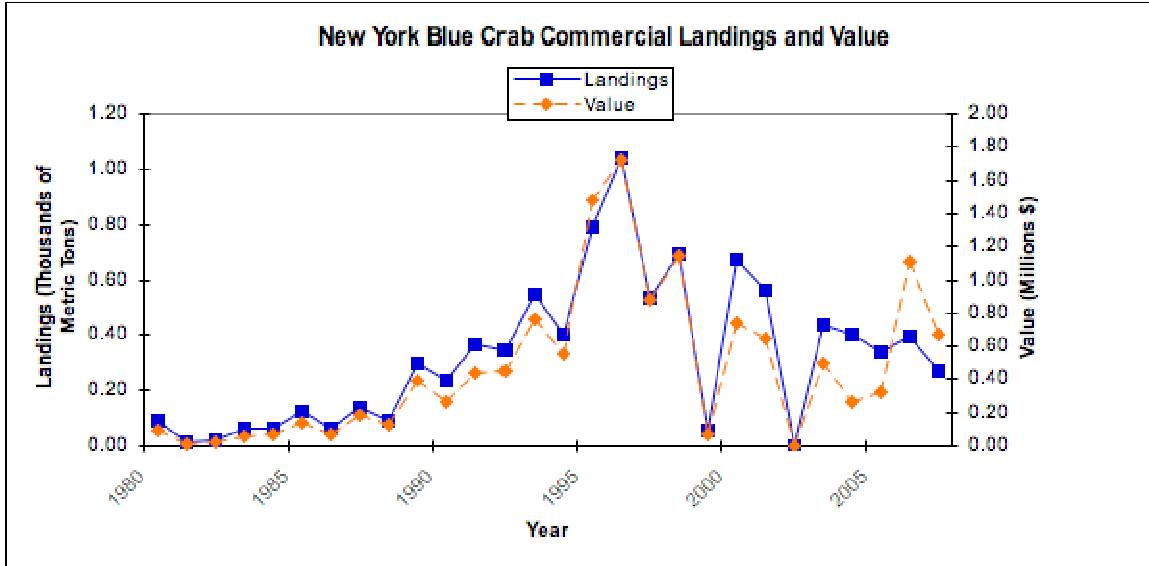


Figure 1. New York blue crab landings and value from 1980-2007.

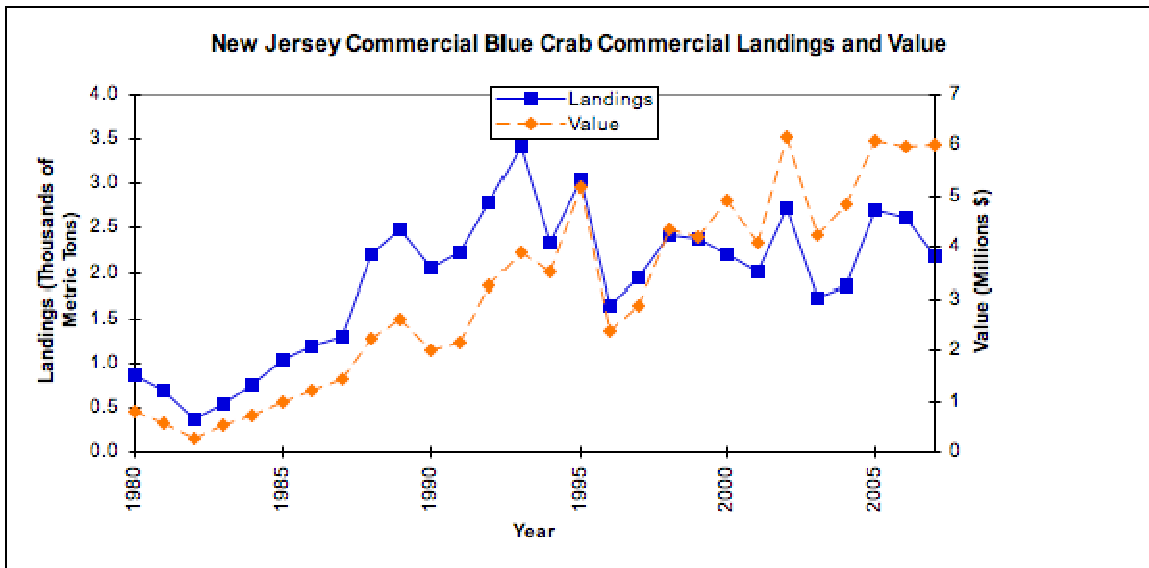


Figure 2. New Jersey blue crab landings and value from 1980-2007.

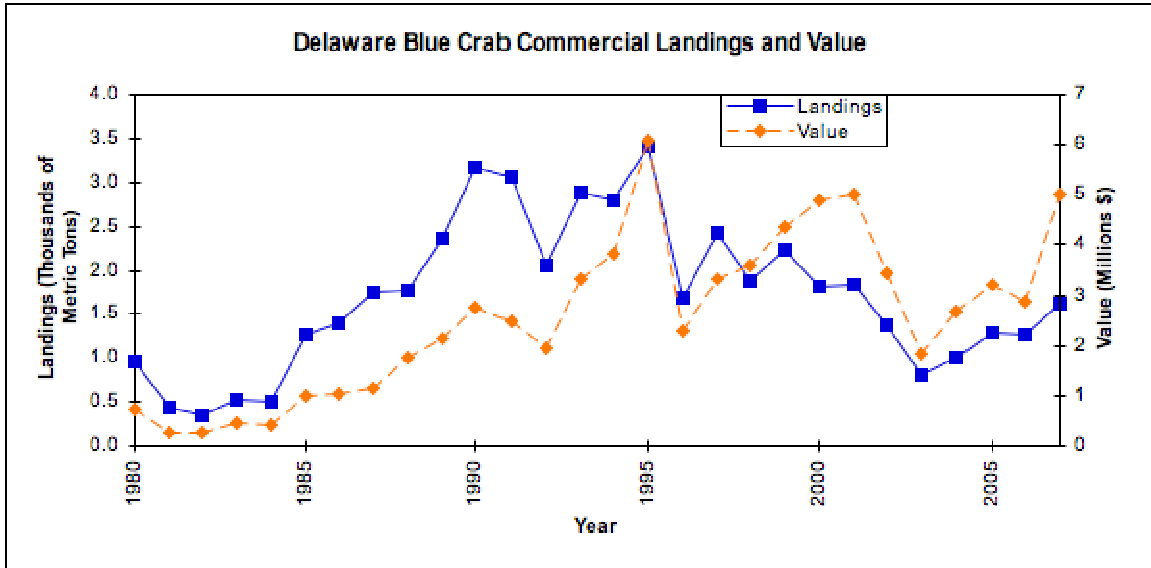


Figure 3. Delaware blue crab landings and value from 1980-2007.

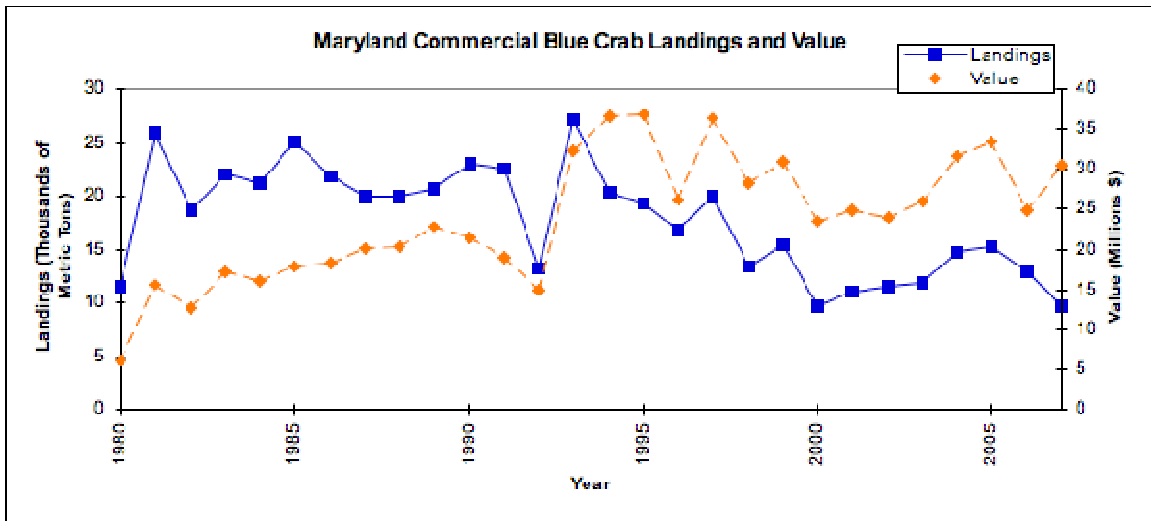


Figure 4. Maryland blue crab landings and value from 1980-2007.

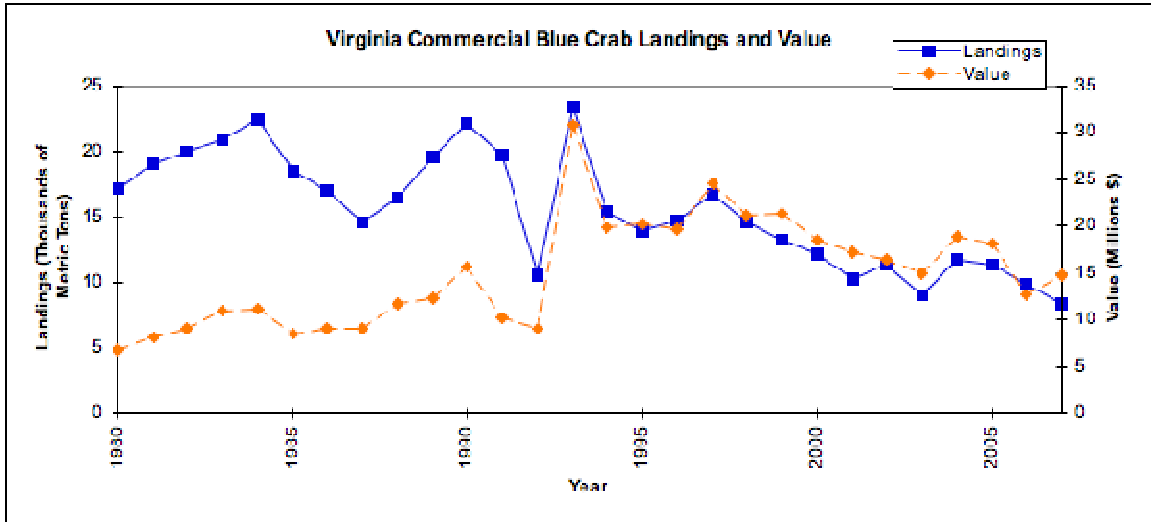


Figure 5. Virginia blue crab landings and value from 1980-2007.

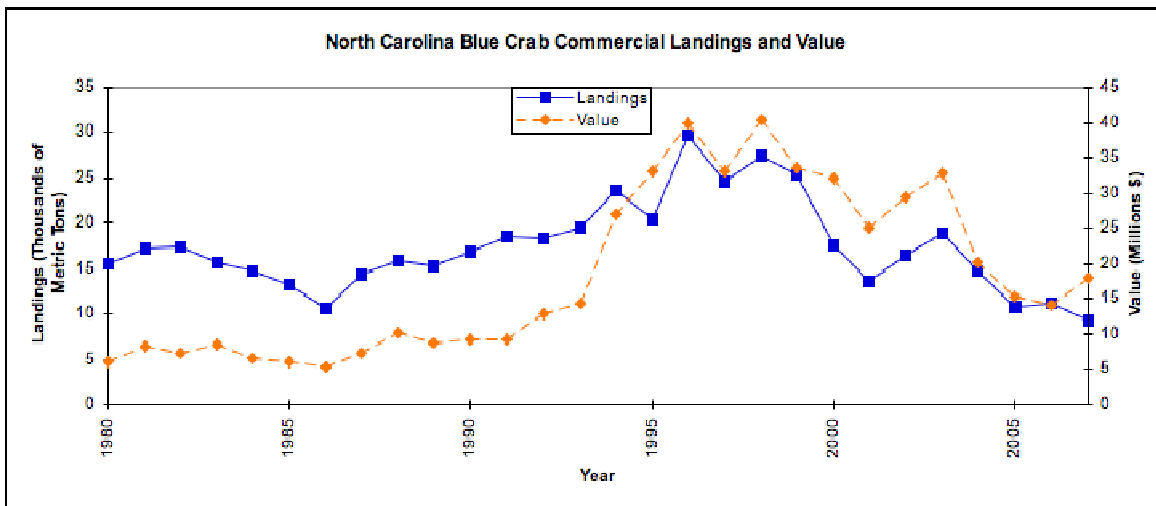


Figure 6. North Carolina blue crab landings and value from 1980-2007.

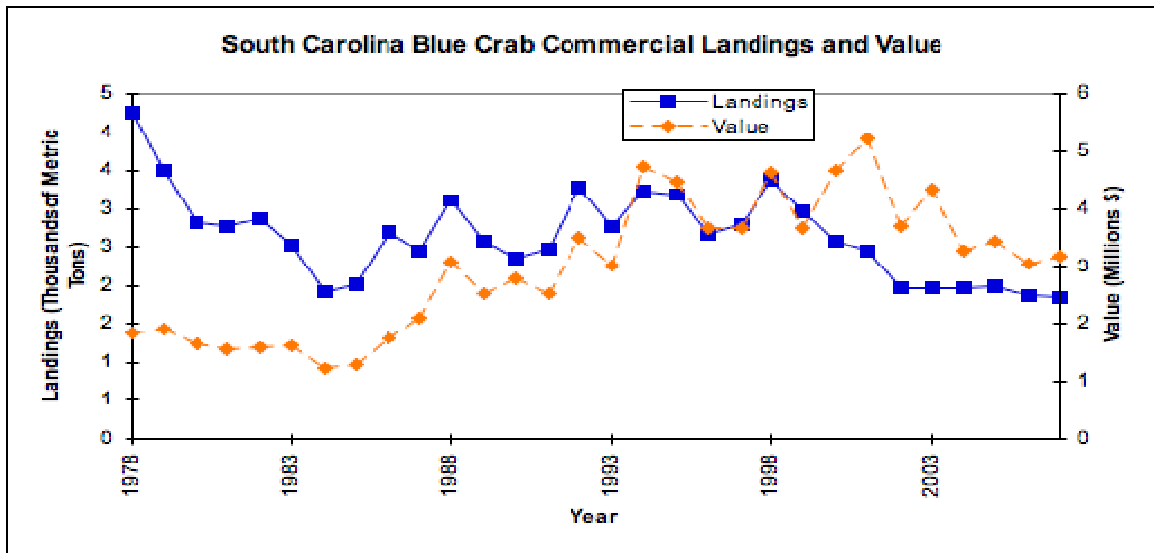


Figure 7. South Carolina blue crab landings and value from 1978-2007.

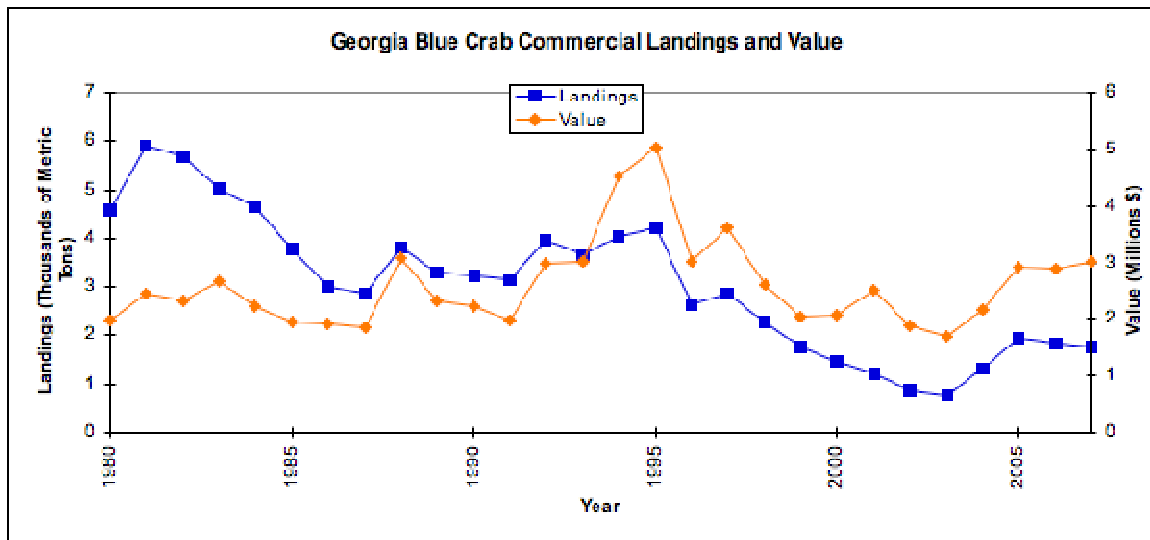


Figure 8. Georgia blue crab landings and value from 1980-2007.

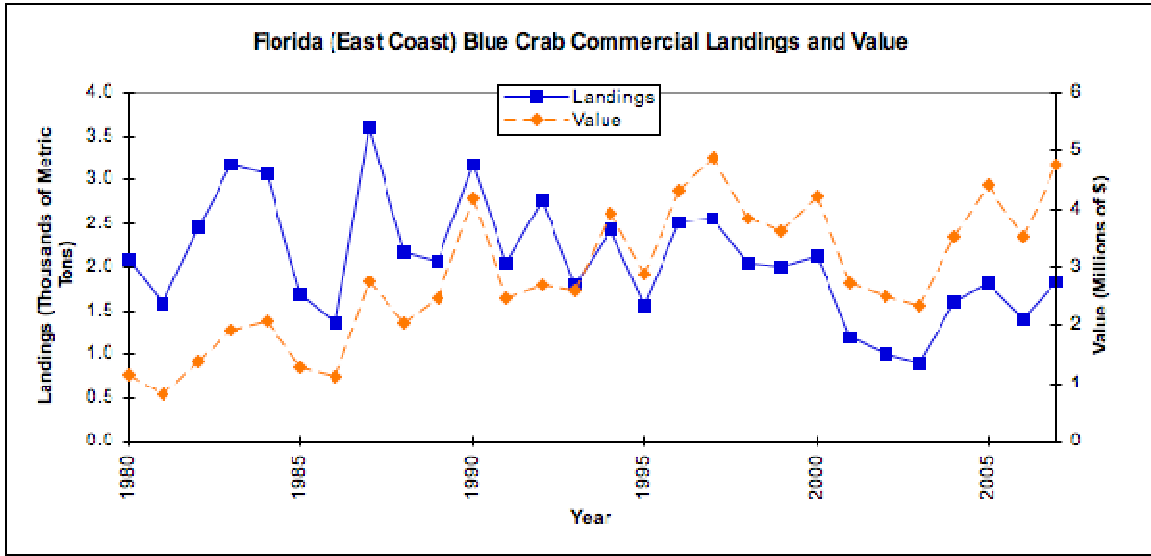


Figure 9. East coast of Florida blue crab landings and value from 1980-2007.