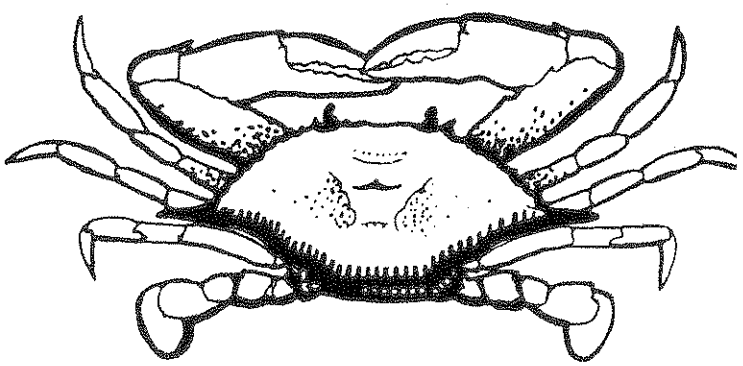
NorthCarolina
Fishery Management Plan

BLUE CRAB

North Carolina
MARINE
FISHERIES
Dept. of Environment and Natural Resources



December 1998

North Carolina
Fishery Management Plan

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by
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1. ACKNOWLEDGMENTS

The 1998 North Carolina Blue Crab Fishery Management Plan (FMP) was developed under the direction of the North Carolina Marine Fisheries Commission (MFC) with the advice of two MFC committees, the Blue Crab Advisory and Crustacean. The plan was prepared by the North Carolina Department of Environment and Natural Resources' Division of Marine Fisheries (DMF). Deserving special recognition are the members of the Blue Crab Advisory and Crustacean committees, the MFC, DMF Staff, and numerous other individuals who contributed their time and knowledge to this effort.

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3. EXECUTIVE SUMMARY

The goal of the 1998 North Carolina Blue Crab Fishery Management Plan (FMP) is to manage blue crabs in North Carolina in a manner which conserves the stock, protects its ecological value, and optimizes the long-term use of the resource. Plan objectives include: maintenance of the stock at a level that maximizes reproductive potential; distinguishing between conservation goals and allocation issues; providing resource utilization for all users and conflict minimization; promoting education; resource protection and waste minimization; habitat protection and restoration; identifying and promoting biological, social, and economic research; and maintaining the blue crab fisheries as a major source of income for commercial fishermen in the most efficient manner. The proposed management strategy for the blue crab fisheries in North Carolina is to 1) optimize resource utilization over the long-term, and 2) minimize waste. The first strategy will be accomplished by protecting the spawning stock, protection of critical habitats, and gear and area restrictions to protect the stock. Minimization of waste will be accomplished by gear modifications (trawl mesh size, crab pot escape rings, etc.), culling practices, and harvest restrictions. To achieve this management strategy, it will be necessary to prioritize management issues. Highest priority will be given to biological issues (habitat, water quality, stock protection, waste reduction, etc.), followed by social issues, and economic issues.

At this time, maximum sustainable yield (MSY) can not be determined for blue crabs in North Carolina. Necessary data are not available (accurate catch-effort data, bycatch estimates from other fisheries, recreational harvest data, and gaps in life history data). Until MSY can be estimated, the blue crab resource will be considered overfished when annual landings fall one standard deviation below mean landings for three consecutive years. Optimal yield for the blue crab in North Carolina is that amount of harvest of legal blue crabs which: prevents overfishing; provides for replenishment of the stock; reduces conflicts within the blue crab fisheries; reduces conflicts between the blue crab fisheries and other water-based activities; maintains the blue crab fisheries as a major source of income for commercial fishermen in coastal North Carolina in a proportion similar to that which exists at the present time in the most efficient manner; and provides reasonable opportunities for recreational harvest of blue crabs.

Issues addressed in formulating the management plan for North Carolina's blue crab fishery encompassed the following general categories: 1) environmental degradation; 2) wasteful or damaging fishing practices; 3) competition and conflict with other users; 4) increasing fishing effort; and 5) insufficient assessment data. Specific issues and recommendations are as follows:

1). Environmental issues

a). Habitat - Protect, enhance, and restore habitats utilized by the blue crab.

Habitat protection, conservation, and restoration are essential to accomplish the goal and objectives of this plan. When necessary, the N.C. Marine Fisheries Commission (MFC), North Carolina Coastal Resources Commission (CRC), and North Carolina Environmental

Management Commission (EMC) should adopt rules to protect blue crab critical habitats as outlined in the Coastal Habitat Protection Plans (CHPP) as those plans are prepared and approved. The MFC and N.C. Division of Marine Fisheries (DMF) should continue to comment on activities that may impact aquatic habitats and work with permitting agencies to minimize impacts and promote restoration. Research must be conducted to investigate the impacts of trawling on various habitats. This strategy would meet objectives 1, 4, and 7 of this plan.

b). Water quality - Protect, enhance, and restore estuarine water quality.

The MFC and DMF should continue to comment on activities that may impact estuarine water quality and work with permitting agencies to minimize negative impacts. Water quality standards should be based on the assimilative capacity of, and impacts to, the entire system. Several plans for water quality management have recommended strategies that need to be implemented to improve water quality. Water quality protection and restoration are essential to accomplish the goal and objectives of this plan. This strategy would meet objectives 1, 4, and 7 of this plan.

2). Wasteful or damaging fishing practices

a). Spawning stock management - Protect the reproductive potential of blue crabs.

Strengthening of spawning sanctuary rules should be accomplished by prohibiting all commercial gears except attended gill nets. Sanctuaries afford the greatest protection to spawners, contribute to optimum yield of this resource, and have minimal impact on the majority of fishermen. This strategy would meet objectives 1 and 5 of this plan.

b). Ghost pots - Reduce the bycatch and mortality of blue crabs and finfish in ghost (lost) pots.

Sinking lines should be required on all crab (hard and peeler) pots. This restriction would not only reduce the number of new ghost pots each year but should significantly reduce conflicts. In order to release entrapped crabs and finfish from ghost pots, biodegradable panels will be considered for all hard and peeler pots, once necessary research is completed. This strategy would meet objectives 1, 3, 5, 6, and 9 of this plan.

c). Crab pot escape ring - Minimize the catch of sublegal crabs in crab pots.

Data support the utility of escape rings as a viable management tool. The MFC should continue to require escape rings in hard crab pots. To maximize the biological and economic possibilities of escape rings, the following actions need to be taken by the MFC and DMF: develop criteria for proclamation authority to close or not require escape rings for mature female and peeler crab harvest; and investigate impact and optimum size of escape rings. This strategy would meet objectives 1, 5, and 6 of this plan.

d). Crab trawl bycatch - Minimize sublegal blue crab and flounder bycatch in the crab trawl fishery.

To minimize waste in this fishery, a 4 inch or 4.5 inch stretched mesh crab trawl should be considered in all coastal waters where crab trawling is allowed. Additionally, area restrictions need to be put in place during the summer months to prohibit trawling in areas that serve as critical habitat for the blue crab. Regional variations in fisheries will need to be taken into account when setting seasons or other restrictions. Definitions of peeler and hard crab trawls need to be established. The DMF should recommend a maximum allowable bycatch of crabs by shrimp trawls. Additional information on bycatch, peeler trawling, gear use, and social and economic impacts is needed to adequately evaluate the crab trawl fishery. This strategy would meet objectives 1, 5, 6, and 7 of this plan.

e). White line peeler harvest - Reduce mortality of "white line" peeler crabs.

Prohibiting the baiting of peeler pots, except with live, legal male blue crabs, would minimize the harvest of "green" and "white line" peelers in the peeler pot fishery, contribute to optimum yield of the resource, and have minimal impact on the majority of North Carolina's crab shedding operations. To address the problem in the hard crab pot fishery, peelers should be culled from the catch were taken, and the possession of male "white line" peelers should be prohibited during June through September. Additional information is needed on shedding practices, mortality rates, and economics of the peeler fishery, and related enforcement issues. This strategy would meet objectives 1, 5, and 6 of this plan.

f). Crab pot finfish bycatch - Evaluate finfish bycatch in crab pots.

No regulatory action should be taken at this time. Before this issue can be addressed, baseline information must be collected, including species composition, sizes, and differences among areas. This strategy would meet objectives 6 and 9 of this plan.

g). Small peeler/soft crab harvest - Evaluate the harvest of small peeler/ soft crabs.

Currently, there is not sufficient information to indicate that there is a need to curtail the harvest of small peeler/soft crabs in an effort to protect the blue crab spawning stock. A minimum size limit would have a severe economic impact on the existing fishery practices and markets; therefore, no rule change is recommended. In the absence of regulatory action, industry involvement, coupled with additional research, is necessary to minimize wasteful practices and optimize economic return from the fishery. This strategy would meet objectives 6 and 9 of this plan.

h). Diamondback terrapin bycatch and mortality in crab pots - Evaluate diamondback terrapin bycatch and mortality in crab pots.

Additional research on potential options is warranted before regulatory action is taken on this issue. This strategy would meet objectives 6 and 9 of this plan.

l). White belly crab harvest - Evaluate the harvest of white belly crabs.

No regulatory action should be taken on this issue at this time. The crab industry should voluntarily reduce the harvest of white belly crabs or reduce the incentive for harvesting this low quality product. Information on the economics of this product should be collected, summarized, and used in industry education efforts. This strategy would meet objectives 1, 6, and 9 of this plan.

3). Competition and conflict with other users

a). Conflict - Minimize conflict, theft, and gear damage and increase public trust utilization.

To minimize conflicts, theft, and gear damage, and increase public trust resource utilization the N.C. General Assembly needs to provide the Marine Patrol with statutory authority to deal with theft. The MFC needs to change the unattended pot rule from the existing 10-day period to seven days, modify existing crab pot areas using depth as the boundary instead of distance from shore, establish management areas, make it unlawful to use or set pots in any navigation channel marked by State or Federal agencies or identified by the MFC, consider gear licenses or permits, consider a pot tagging system, develop guidelines to mediate user conflicts, support the establishment of boating safety courses and boat operator licenses by the Wildlife Resources Commission (WRC), and re-examine the times when pots must be moved into designated crab pot areas. This strategy would meet objectives 3 and 5 of this plan.

b). Pots in inland waters - The use of crab pots in inland waters.

The MFC and Wildlife Resources Commission should work together to identify inland waters with historical crabbing activity and low recreational pressure. Commercial crab potting should continue to be allowed in these selected waters. Additionally, the commissions should work together to standardize rules for the crab fishery.

4). Increasing fishing effort

a). Effort Management - Address effort in the crab pot fishery.

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. No specific strategy for a continued open access or limited entry system to manage effort in the crab fishery is proposed at this time. The legislated time frame to develop the blue crab FMP did not allow for an effort management system to be fully developed for this fishery. Therefore, the crab licenses and license moratorium should be extended for one more year (until 1 July 2000) to allow for the development of an effort management system. Any option to reduce effort should provide an appropriate means to allow flexibility within the fishing community [future holders of the

limited Standard Commercial Fishing License (SCFL)]; minimize exclusive privileges and avoid monopolies; control or reduce effort in the crab fishery; and make management of the crab fishery more efficient and effective. Any strategy recommended should meet objectives 2, 3, 4, 5, 9, and 10 of this plan.

b). Recreational Commercial Gear License (RCGL) - Recommend blue crab gear and harvest limits for recreational fishermen using commercial gear.

The specific number of pots allowed for RCGL-holders will be five per person or vessel. Individuals (not possessing a RCGL) setting crab pots from privately owned shore or a pier will be limited to one pot per person and will be required to follow all gear marking requirements imposed on RCGL-holders. Crab trawls should not be considered as a gear for RCGL-holders. Buoys for all recreational pots shall be hot pink and engraved with the full name of the fisher. DMF shall select a buoy shape for recreational gear. Collapsible crab traps should be defined as non-commercial gear, and a RCGL would not be required. Existing non-commercial catch limits will apply to the recreational harvest of blue crabs. The current limit is 50 legal crabs per person per day, not to exceed 100 per vessel per day.

5). Insufficient assessment data

Insufficient assessment data - Necessary data needed to accurately assess the status of the blue crab stock are currently not available.

The MFC and DMF should prioritize research needs and implement actions to accomplish the identified research and data needs. Licenses and/or permits should be implemented to identify participants and quantify activities and gear usage in the blue crab fisheries.

4. INTRODUCTION

4.1 Legal authority for management

Fisheries management includes all activities associated with maintenance, improvement, and utilization of the fisheries resources of the coastal area, including research, development, regulation, enhancement, and enforcement.

Many different state laws (General Statutes - G.S.) provide the necessary authority for fishery management in North Carolina. General authority for stewardship of the marine and estuarine resources by the North Carolina Department of Environment and Natural Resources (NCDENR) is provided in G.S. 113-131. The Division of Marine Fisheries (DMF) is the arm of the Department which carries out this responsibility. Enforcement authority for DMF enforcement officers is provided by G.S. 113-136. General Statute 113-163 authorizes research and statistical programs. The North Carolina Marine Fisheries Commission (MFC) is charged to "manage, restore, develop, cultivate, conserve, protect, and regulate the marine and estuarine resources of the State of North Carolina" (G.S. 143B-289.51). The MFC can regulate fishing times, areas, fishing gear, seasons, size limits, and quantities of fish harvested and possessed (G.S. 113-182 and 143B-289.52). General Statute 143B-289.52 allows the MFC to delegate authority to implement its regulations for fisheries "which may be affected by variable conditions" to the Director of DMF by issuing public notices called "proclamations". Thus, North Carolina has a very powerful and flexible legal basis for coastal fisheries management. The General Assembly has retained for itself the authority to establish commercial fishing licenses, but has delegated to the MFC authority to set individual permit fees for various commercial fishing gears.

The Fisheries Reform Act of 1997 (FRA) establishes a process for preparation of coastal fisheries management plans in North Carolina. The FRA states that "the goal of the plans shall be to ensure the long-term viability of the State's commercially and recreationally significant species or fisheries. Each plan shall be designed to reflect fishing practices so that one plan may apply to a specific fishery, while other plans may be based on gear or geographic areas. Each plan shall:

a. Contain necessary information pertaining to the fishery or fisheries, including management goals and objectives, status of the relevant fish stocks, stock assessments for multi-year species, fishery habitat and water quality considerations consistent with Coastal Habitat Protection Plans adopted pursuant to G.S. 143B-279.8, social and economic impact of the fishery to the State, and user conflicts.

b. Recommend management actions pertaining to the fishery or fisheries.

c. Include conservation and management measures that prevent overfishing, while achieving, on a continuing basis, the optimal yield from each fishery."

Optimal yield is defined in the FRA as "The amount of fish that:

a. Will provide the greatest overall benefit to the State, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems;

b. Is prescribed on the basis of the maximum sustainable yield from the fishery, as reduced by any relevant economic, social, or ecological factor; and

c. In the case of an overfished fishery, provides for rebuilding to a level consistent with producing the maximum sustainable yield in the fishery."

Section 5.5 of the FRA specifically requires that the Marine Fisheries Commission "adopt a Fishery Management Plan (FMP) for the blue crab fishery" by January 1, 1999.

4.2 Recommended management program

4.2.1 Goals and objectives

The goal of the 1998 North Carolina Blue Crab FMP is to manage blue crabs in North Carolina in a manner which conserves the stock, protects its ecological value, and optimizes the long-term use of the resource. To achieve this goal, it is recommend that the following objectives be met:

1. Maintain the stock of mature adult males and females at a level that maximizes reproductive potential.

2. Maintain a clear distinction between conservation goals and allocation issues.

3. Minimize conflicts among user groups.

4. Promote a program of education and public information to help the public understand the causes and nature of problems in the blue crab stock, its habitats and fisheries, and the rationale for management efforts to solve these problems.

5. Develop a regulatory process that provides adequate resource protection, optimizes the harvest, provides sufficient opportunity for recreational crabbers, and considers the needs of other user groups.

6. Promote harvesting practices that minimize waste of the resource.

7. Restore and improve habitat and environmental quality to increase growth, survival and reproduction of blue crabs.

8. Identify and promote research to improve the understanding of blue crab biology, ecology and population dynamics.

9. Initiate, enhance, and/or continue studies to collect and analyze economic, social, and fisheries data needed to effectively monitor and manage the blue crab fishery.

10. Maintain the blue crab fisheries as a major source of income for commercial fishermen in coastal North Carolina in a proportion similar to that which exists at the present time in the most efficient manner.

Objectives one through nine were adapted from the Chesapeake Bay Blue Crab FMP (Chesapeake Bay Program 1997).

4.2.2 Optimum yield

At this time, maximum sustainable yield (MSY) can not be determined for blue crabs in North Carolina. Necessary data are not available (accurate catch-effort data, bycatch estimates from other fisheries, recreational harvest data, and gaps in life history data). Until MSY can be estimated, the blue crab resource will be considered overfished when annual landings fall one standard deviation below mean landings for three consecutive years.

Optimal yield for the blue crab in North Carolina is that amount of harvest of legal blue crabs which: prevents overfishing; provides for replenishment of the stock; reduces conflicts within the blue crab fisheries; reduces conflicts between the blue crab fisheries and other water-based activities; maintains the blue crab fisheries as a major source of income for commercial fishermen in coastal North Carolina in a proportion similar to that which exists at the present time in the most efficient manner; and provides reasonable opportunities for recreational harvest of blue crabs.

4.2.3 Management strategy

The proposed management strategy for the blue crab fisheries in North Carolina is to 1) optimize resource utilization over the long-term, and 2) minimize waste. The first strategy will be accomplished by protecting the spawning stock, protection of critical habitats, and gear and area restrictions to protect the stock. Minimization of waste will be accomplished by gear modifications (trawl mesh size, crab pot escape rings, etc.), culling practices, and harvest restrictions. To achieve this management strategy, it will be necessary to prioritize management issues. Highest priority will be given to biological issues (habitat, water quality, stock protection, waste reduction, etc.), followed by social issues, and economic issues. Additionally, the DMF must implement plans for evaluating rules adopted by the MFC (Are rules achieving desired results?).

In order to effectively accomplish these strategies, and to efficiently address the many issues outlined in this FMP, it is recommended that management areas be established. The formation of management areas would formalize existing DMF and MFC management strategies (Districts, proclamations, and Regional Advisory Committees) which recognize regional differences between areas. With the exception of the Outer Banks area, existing DMF District lines would be used to delineate management units (slight realignment of District boundaries might be needed). The area along the Outer Banks should be realigned with the Central District or made into its own District. The current advisory structure of the MFC, Regional Advisory Committees, and the Crustacean Committee should be adequate to manage these areas. This approach recognizes that too

much management imposed from without is just as bad as too little. The state of North Carolina should allow as much flexibility as possible for fishermen to operate as they see fit. However, government has a responsibility to all citizens of the state to protect public resources. Cooperative management at the local level would allow management to be more responsive to local situations. Many of the management options discussed in Section 10 would benefit from a regional-based management approach that would allow a given strategy (e.g., solving conflicts, effort management, escape rings, spawning stock management, and crab trawling) to be tailored to the needs of each area. Regional-based management was recommended by various fishermen during public meetings for the Blue Crab FMP Public Information Document (NCDENR 1998).

4.3 Definition of management unit

The management unit includes the blue crab (Callinectes sapidus) and its fisheries in all waters of coastal North Carolina.

4.4 General problem(s) statement

Issues that should be addressed in the management of North Carolina's blue crab fishery are: 1) environmental issues; 2) wasteful or damaging fishing practices; 3) competition and conflict with other users; 4) increasing fishing effort; and 5) insufficient assessment data (Henry and McKenna 1998).

4.4.1 Environmental issues

Blue crabs rely on adequate and sufficient habitat of various types during their different life cycle stages. Loss or degradation of spawning, nursery, and molting areas and reduced deep-water habitat and crowding in shallow habitats due to low dissolved oxygen levels may have long-term impacts on crab populations. Minor or short-term habitat disruptions, such as bottom-disturbing activities (i.e., trawling, dredging, etc.) may have significant, but hard-to-measure impacts on crab populations. Specific issues, options, and potential actions are outlined in Section 10.

4.4.2 Wasteful or damaging fishing practices

Wasteful and damaging fishing practices associated with the blue crab fishery have various and interrelated impacts on the resource and different segments of the fishery. Specific issues, options, and potential actions concerning current harvest practices are outlined in Section 10.

4.4.3 Competition and conflict with other users

The increase in hard and peeler crab pot numbers has resulted in more frequent and severe conflicts over fishing space between crab potters (full and part-time), other fisheries (trawlers, haul seiners, etc.), and recreational activities (swimming, fishing, boating). Conflicts may arise from damage to vessels encountering gear, and may result in fishing gear being moved, damaged, destroyed, or stolen. Also, theft of potted crabs is reputed to

have increased in some areas as effort and price of the commodity has increased. Specific issues, options, and potential actions are outlined in Section 10.

4.4.4 Increasing effort

The number of crab potters and pots used has increased dramatically, but catch-per unit-effort has declined. Information on blue crab pot use (number of pots per fisherman documented by National Marine Fisheries Service (NMFS) and DMF license information) and landings attributed to crab pots show an inverse relationship between the average number of pots fished and the overall landings per pot. Observations by the crabbing community indicate that the peeler/soft crab pot fishery is the most rapidly expanding segment of the fishery. Most of the expansion is occurring in the northeast portion of the state in Camden, Currituck, Dare, Hyde, Pasquotank, and Tyrrell counties. The increased sale of peelers to out-of-state buyers, new and expanding soft crab shedding operations, and increasing product demand are contributing to the increased effort and growth in the peeler/soft crab fishery. Specific issues, options, and potential actions are outlined in Section 10.

4.4.5 Insufficient assessment data

Before 1995, DMF did not have a stock assessment program specifically for blue crabs, although limited information (harvest statistics, juvenile abundance) was collected through other programs. Realizing the increasing importance of the blue crab fishery to the coastal economy, crabbers petitioned the North Carolina General Assembly in 1994 to allocate funding specifically for a crab assessment project. The resulting program is focusing on the establishment of fishery-dependent and -independent databases coastwide. Specific research needs are outlined in Section 10.

4.5 Existing plans, statutes, and rules

4.5.1 Plans

There are no federal, interstate, or state FMP's that apply specifically to the blue crab fishery in North Carolina. The Blue Crab FMP will be reviewed and updated at least every three years.

4.5.2 Statutes

All management authority for North Carolina's blue crab fishery is vested in the State of North Carolina. Statutes that have been applied to the crab fishery include:

- It is unlawful for any person without the authority of the owner of the equipment to take fish from said equipment. G.S. 113-268 (a)
- It is unlawful for any vessel in the navigable waters of the State to willfully, wantonly, and unnecessarily do injury to any seine, net or pot. G.S. 113-268 (b)
- It is unlawful for any person to willfully destroy or injure any buoys, markers, stakes, nets, pots, or other devices or property lawfully set out in the open waters

of the state in connection with any fishing or fishery. G.S. 113-268 (c)

- It is unlawful for an individual to take crabs from coastal fishing waters of North Carolina for commercial use by any means without having first procured a crab license. G.S. 113-153.1.

4.5.3 Marine Fisheries Commission Rules

Minimum Size: Hard crab minimum size limit of 5 inches measured from tip of spike to tip of spike, except that mature females, soft, and peeler crabs are exempt. All crabs less than the legal size except mature females, soft, and peelers shall immediately be returned to the water from which taken. Peeler crabs shall be separated from the entire catch in a separate container before reaching shore or dock. 15A NCAC 3L .0201 (a) (b) (MFC 1997)

Possession Tolerance: 10% by number in any container may be less than the minimum size limit. 15A NCAC 3L .0201 (a)

Spawning Sanctuaries: It is unlawful to use a trawl net or to take crabs with the use of commercial fishing equipment from crab spawning sanctuaries from March 1 through August 31. During the remainder of the year the Director may, by proclamation, close these areas and may impose any or all of the following restrictions: number of days, areas, means and methods which may be employed in the taking, time period, and limit the quantity. 15A NCAC 3L .0205 (a) (b) (1) (2) (3) (4) (5) and 3R .0110 (1) (2) (3) (4) (5)

Recreational Harvest Limit: Limit of 50 crabs per person per day not to exceed 100 crabs per vessel per day for non-commercial use. 15A NCAC 3K .0105 (a) (4)

Crab Trawls:

- It is unlawful to use trawl nets for the taking of finfish in internal waters, except that it shall be permissible to take or possess finfish incidental to crab or shrimp trawling in accordance with the following limitations: it is unlawful to possess more than 500 pounds of finfish from December 1 through February 28 or 1,000 pounds of finfish from March 1 through November 30. The Director may close by proclamation any area to trawling for specific time periods in order to comply with this rule. 15A NCAC 3J .0104 (a) (1)(2)
- It is unlawful to use trawl nets from December 1 through February 28 from one hour after sunset to one hour before sunrise in portions of the Pungo, Pamlico, Bay, Neuse, and New rivers. 15A NCAC 3J .0104 (b) (5) (A) (B) (C) (D) (E)
- It is unlawful to use trawls within one-half mile of the ocean beach between the Virginia line and Oregon Inlet. 15A NCAC 3J .0202 (2)
- From December 1 through March 31 it is unlawful to possess finfish caught incidental to shrimp and crab trawling in the Atlantic Ocean unless the weight of the combined catch of shrimp and crabs exceeds the weight of finfish; except that crab trawlers working south of Bogue Inlet may keep up to 300 pounds of kingfish, regardless of their shrimp or crab catch weight. 15A NCAC 3J .0202 (5) (Temporary rule effective 12/97)

- It is unlawful to trawl for crabs between one hour after sunset on any Friday and one hour before sunset on the following Sunday, except in the Atlantic Ocean. 15A NCAC 3L .0202 (d) and 3J .0104 (b) (1)
- It is unlawful to use trawl nets in Albemarle Sound and its tributaries. 15A NCAC 3J .0104 (b) (3)
- It is unlawful to use trawl nets in areas listed in 15A NCAC 3R .0106, except that certain areas may be opened to peeler trawling for single-rigged peeler trawls or double-rigged boats whose combined total headrope length does not exceed 25 feet. 15A NCAC 3R .0106
- It is unlawful to use any trawl net in any primary or secondary nursery area. 15A NCAC 3N .0104 and 3N .0105 (a)
- Special secondary nursery areas may be opened to shrimp and crab trawling from August 16 through May 14. 15A NCAC 3N .0105 (b)
- It is unlawful to take or possess crabs aboard a vessel in internal waters except in areas and during such times as the Fisheries Director may specify by proclamation. 15A NCAC 3L .0202 (a)
- It is unlawful to take crabs with crab trawls with a stretched mesh less than 3 inches, except that the Director may, by proclamation, increase the minimum mesh length to no more than 4 inches. 15A NCAC 3L .0202 (b)
- It is unlawful to use trawls with a mesh length less than 2 inches (stretched mesh) or with a corkline exceeding 25 feet in length for taking soft or peeler crabs. 15A NCAC 3L .0202 (c)
- The Director may by proclamation, require bycatch reduction devices or codend modifications in trawl nets to reduce the catch of finfish that do not meet size limits or are unmarketable as individual foodfish by reason of size. 15A NCAC 3J .0104 (d)

Crab pots:

- It is unlawful to leave pots in any coastal fishing waters for more than ten consecutive days, when such pots are not being employed in fishing operations, except upon a timely and sufficient showing of hardship. 15A NCAC 3I .0105 (b) (1) (2) (A) (B) (C)
- All pots shall be removed from internal waters from January 24 through February 7. Areas may be reopened, by proclamation, to the use of pots after January 28 if it is determined that such areas are free of pots. 15A NCAC 3J .0301 (a) (1)
- From May 1 through October 31 the use of crab pots is restricted in certain areas. Pots attached to shore or a pier are exempt from this regulation. 15A NCAC 3J .0301 (a) (2) and 3R .0107
- It is unlawful to use pots in any navigation channel maintained and marked by State or Federal agencies. 15A NCAC 3J .0301 (b) (1)
- It is unlawful to use pots in any turning basin maintained and marked by the North Carolina Ferry Division. 15A NCAC 3J .0301 (b) (2)
- Pots must be marked with a solid foam or other solid buoyant material no less than five inches in diameter and no less than five inches in length. Buoys may be any color except yellow. The pot owner's N.C. motorboat registration number, or U.S. vessel documentation name, or last name and initials shall be engraved in the buoy, or on a metal or plastic tag attached to the buoy. Pots attached to shore or a pier

are exempt from this regulation. 15A NCAC 3J .0301(c) (1) (2) (3)

- It is unlawful to use crab pots in coastal waters unless each pot contains 2 escape rings that are at least 2 5/16 inches inside diameter and located in opposite outside panels of the upper chamber of the pot. Peeler pots with a mesh size less than 1 ½ inches shall be exempt from the escape ring rule. 15A NCAC 3J .0301 (g)
- Vessels may be used to take blue crabs without a license if the following gears are used; seines less than 12 feet, a dip net having a handle not more than 8 feet in length and a hoop or frame to which the net is attached not exceeding 60 inches along the perimeter; or single bait-and-line equipment. 15A NCAC 3I .0101 (1) (A) (C) (D)
- It is unlawful to use more than 150 pots per vessel in the Newport River. 15A NCAC 3J .0301(h)
- It is unlawful to remove crab pots from the water or remove crabs from pots between one hour after sunset and one hour before sunrise. 15A NCAC 3J .0301(l)

Crab dredging:

- It is unlawful to use or have aboard a vessel any dredge weighing more than 100 lb. 15A NCAC 3J .0303 (a)
- It is unlawful to use more than one dredge per vessel to take crabs or to use any dredges between sunset and sunrise. 15A NCAC 3J .0303 (b)
- It is unlawful to take crabs with dredges except from January 1 through March 1 in portions of Pamlico Sound. 15A NCAC 3L .0203 (a) (1) and 3R .0109
- Crabs may be taken incidental to lawful oyster dredging provided the weight of the crabs shall not exceed 50% of the total weight of the combined oyster and crab catch; or 500 lb, whichever is less. 15A NCAC 3L .0203 (a) (2) (A) (B)
- It is unlawful to take crabs between sunset and sunrise and between sunset on any Saturday and sunrise on the following Monday, except in the Atlantic Ocean. 15A NCAC 3L .0203 (b)

Miscellaneous:

- It is unlawful to possess, sell, or purchase fish under four inches in length except for use as bait in the crab pot fishery in North Carolina. 15A NCAC 3M .0103 (1)

5. STATUS OF STOCK

5.1 General life history

The blue crab (Callinectes sapidus) ranges from Nova Scotia, Canada, southward throughout the Gulf of Mexico and along most of the Atlantic coast of South America. Blue crabs are most common in the United States from Long Island to Mexico. The preferred habitat of blue crabs is tidal marsh estuaries characterized by soft mud substrate and waters of moderate salinity. Blue crabs are harvested commercially and/or recreationally throughout their range.

Blue crabs mature at approximately 12 to 18 months of age. Mating takes place in brackish areas of the estuary, while spawning occurs in high-salinity waters in the vicinity

of ocean inlets. Spawning usually occurs within two months after mating in the spring or summer. However, females that mate in the fall usually delay spawning until the following spring. Peak spawning periods are April-June and August-September. The number of eggs per spawn ranges from 700,000 to 8,000,000. Females may spawn two or three times. Eggs hatch in approximately 15 days, and the first stage larvae (zoeae) are then carried offshore where they undergo seven to eight developmental stages (Costlow et al. 1959; Costlow and Bookhout 1959). Following the zoeal stages, a megalopal stage occurs which lasts from 6 to 20 days (Costlow and Bookhout 1959). The exact mechanism responsible for megalopae ingress in North Carolina is unclear, but is possibly the result of wind-driven onshore currents.

Year-class strength is initially determined by the number of postlarvae that enter the estuary and is greatly influenced by weather and current conditions encountered by planktonic crab larvae on the continental shelf. Tang (1985) and Ulanowicz et al. (1982) suggested that annual fluctuations in blue crab populations are the result of environmentally induced variations in recruitment.

Larval recruitment in North Carolina's inshore waters near the northern inlets have been correlated with the locations proximity to inlets, alongshore northerly winds, and hours of dark flood tide (Eggleston et al. 1998). Larval settlement peaks and magnitude at inshore locations of the Albemarle-Pamlico estuarine system were associated with the direction and magnitude of storm winds during a short period surrounding the passage of tropical cyclones (storms).

Juvenile blue crabs are widely distributed throughout estuaries. Although salinity influences distribution, factors such as bottom type and food availability also play a role in determining distributional patterns of juveniles. Adults show a differential distribution by sex and salinity, with mature females commonly found in higher-salinity waters (>10 ppt) and males preferring lower salinities (3 to 15 ppt). The size of mature females varies considerably (2.2-7.8 in). The average life span is about three years with a five to eight year maximum.

The blue crab has a role as both predator and prey in the ecosystem. Juvenile and larval crabs are found in the diet of many fishes, including striped bass (Manooch 1973), red drum (Bass and Avault 1975), Atlantic croaker (Overstreet and Heard 1978), and American eel (Wenner and Musick 1975). The blue crab is an important predator on oyster spat and juvenile hard clams (Williams 1984). The diet of blue crabs also includes fish (alive or dead), aquatic vegetation (Williams 1984), crustaceans, and annelid worms. Mansour and Lipcius (1993) suggested that during periods of high crab abundance or low alternative prey abundance, cannibalism may serve as a self-regulating population control.

5.2 Stock status

The stock status of the blue crab in North Carolina is unknown. Stock size may be influenced by a number of factors including habitat availability, natural events and cycles, harvest pressure, changes in stream flows, and water quality. Detailed analyses of the available databases are currently underway, however results will not be available until

1999. Preliminary examination of fishery-independent catch-per-unit-effort data (1978-1996) for juveniles (crabs less than 60 mm carapace width) suggest that, despite variability in abundance, there is no general downward or upward trend in population size (Figure 1).

6. STATUS OF FISHERIES

6.1 Commercial

The blue crab supports North Carolina's most valuable commercial fishery in terms of total landings, value, processing, participation, employment, and the amount of harvest gear used (Henry and McKenna 1998).

6.1.1 Hard crab fishery

Commercial hard crab landings have averaged 24 million pounds over the last 48 years, 1950 - 1997 (Figure 2). The major increases in landings noted during 1978 and 1994 were, in part, a function of improved data collection. The NMFS collected commercial landings statistics until 1978. The DMF initiated and augmented landings collection in 1978 under the NMFS/ North Carolina Cooperative Statistics Program. Both programs were based entirely on voluntary reporting. In 1994, DMF implemented a mandatory Trip Ticket Program which is a landings information record keeping system for each commercial harvest trip. During 1994, 131 seafood dealers, who had not previously reported hard blue crab landings under the voluntary collection programs, reported approximately 14 million pounds (26% of the total landings). Great caution must be used in comparing landings from the different periods because of the different collection methods and the precision of these methods. Additionally, landings data should be viewed as only a general indicator of fishing trends since they are influenced by market demand, price, fishing effort, weather, availability of alternate species, regulations, data collection techniques, and stock abundance.

Historically, many types of harvest gear have been utilized in North Carolina's commercial blue crab fishery. Trotlines, crab pots, and trawls have accounted for most of the landings. Definitive and varying trends in yield by harvest gear are evident from the annual blue crab landings compiled by NMFS and DMF (Figure 3).

The crab pot was developed in the Chesapeake Bay in 1928 (Van Engel 1962). The first reported landings from crab pots in North Carolina were in 1953 (Figure 3). Crab pots accounted for 30% of the hard blue crab landings from 1953 through 1962. During the remainder of the 1960's, the contribution of this gear to total hard crab landings ranged from 28% to 62% and averaged 46%. In the 1970's, crab pot harvest averaged 75% of the total hard crab landings and ranged from 63% to 85%. From 1980 to 1993, the contribution of pots to the total harvest ranged from 82% to 97% and averaged 91%. Since 1994, the crab pot has contributed, on average, 95% to the total hard crab harvest.

The peak months for crab pot landings are May through October [91% of the total landings (DMF Trip Ticket data, 1994-1997)]. Crab pot landings have been reported from all coastal waters of the state. The major waterbodies for pot-caught crabs from 1994 through 1997 were Pamlico Sound (26%), Albemarle Sound (25%), Pamlico River (13%), Neuse River (7%), and Bay River [5% (Table 1)].

Prior to 1964 blue crab landings by trawls were not separated by gear type (i.e., crab, shrimp, and fish trawl catches of crabs were lumped under one heading, "trawls"). From 1950 to 1963, the percent contribution of trawl-caught hard crabs to the total hard crab catch averaged 19% (Figure 3). During 1966 to 1969, the contribution of crab-trawl-caught hard crabs to the total harvest reached its peak (37%-50%). From 1970 to 1980, the percent of crab trawl landings ranged from 7% to 23%. The percent contribution of hard crabs landed by crab trawlers steadily declined from 16% in 1981 to 4% in 1993. Since 1994, the average contribution of this gear to the total hard crab landings has been 4%.

Peak crab landings in the crab trawl fishery occur during March - June, and November. Crab trawl landings have been reported from 19 waterbodies in the state (DMF Trip Ticket data, 1994-1997). Pamlico Sound accounts for 46% of all hard crabs landed by crab trawls. Other areas with significant crab trawl landings are: Pamlico River (17%); Neuse River (9%); Croatan Sound (7%); and Bay River [7% (Table 2)].

Yearly finfish landings by crab trawls have averaged 99,455 pounds (DMF Trip Ticket data, 1994-1997). The main species landed is southern flounder, averaging 81,725 lb per year and accounting for 82% of the total finfish weight landed by crab trawls (Table 2). Catfish are the next largest finfish component, averaging 9,590 lb per year and 10% of the total. This is followed by weakfish (gray trout) and kingfishes (sea mullet), which each contribute 1% to the total (1,128 and 1,108 lb). The remaining 6% of the finfish landed by crab trawls is divided among 29 different species. Pamlico Sound accounts for 58% of the flounder, 6% of the catfish, 91% of the sea mullet, and 34% of the weakfish landed by crab trawls (Table 2). The Pamlico River contributes, on average, 24% of the flounder, 89% of the catfish, 4% of the sea mullet, and 48% of the weakfish to the total crab trawl finfish landings. Flounder landings from the Neuse River contribute 3% to the crab trawl total, while catfish accounts for 1%, sea mullet 1%, and weakfish 2%. Pungo River accounts for 8% of the flounder and weakfish.

Other gears with reported commercial hard crab landings are gill nets (float, sink, drift, and runaround), pound nets, trotlines, shrimp trawls, skimmer trawls, eel pots, bull rakes, fish pots, channel nets, fyke nets, long haul seine, beach seine, hand tongs, hand rakes, crab dredge, oyster dredge, clam trawls, rod-n-reel, and by hand (DMF Trip Ticket data, 1994-1997). Combined, these gears contribute less than 1% to the total hard crab harvest.

6.1.2 Peeler and soft crab fishery

Peeler and soft crab landings have been reported in North Carolina since 1897. Recent developments in the peeler/soft crab fishery, notably on-shore shedding systems

and the peeler pot, have promoted steady growth in the landings and value (Table 3) over the last 15 years. Most peelers are caught with peeler pots (1 inch mesh) in peeler-specific operations or with hard crab pots (1 ½ inch mesh) during hard crabbing operations. Peelers are caught through directed peeler trawling or as bycatch associated with hard crab and shrimp trawling. Peelers are held in onshore shedding systems until the crabs complete the molting cycle. Soft crabs are shipped alive or cleaned and frozen.

Annual peeler crab landings have averaged 0.85 million lb since 1994 (DMF Trip Ticket data, 1994-1997). The peak month for peeler landings is May (51%), followed by June (15%), April (10%), and August (9%). Peeler and hard crab pots have accounted for 92% of the peeler landings.

The peak month for peeler crab landings from crab trawls is March (40%). April accounts for 21% of the landings, followed by June (17%) and May (11%). Overall this gear contributes 1.7% to the total peeler harvest. Shrimp trawls contribute, on average, 0.5% to the total peeler harvest. Thirty-six percent of the peelers landed by shrimp trawls are captured in August. July contributes 33% to the total shrimp trawl peeler harvest, while June and September account for 14% and 10%, respectively.

Other gears that reported landings of peeler crabs from 1994 to 1997 include pound nets, anchor gill nets, trotlines, rakes, runaround gill net, oyster tongs, long haul seines, crab dredge, hand, channel nets, cast nets, skimmer trawls, eel pots, turtle traps, and fyke nets. Combined, these gears contribute less than 1% to the total peeler harvest.

Pamlico Sound accounts for 28% of the total peeler harvest (DMF Trip Ticket data, 1994-1997). Other areas that show significant peeler landings are Croatan Sound (17%), Albemarle Sound (16%), Roanoke Sound (8%), Core Sound (5%), and the Pamlico River (5%).

Soft crab landings have averaged 0.6 million lb since 1994 (DMF Trip Ticket data, 1994-1997). May (66%) and June (22%) account for 88% of the total soft crab landings. Peeler and hard crab pots account for 95% of the total soft crab landings (DMF Trip Ticket data, 1994-1997). Sixty-six percent of the soft crabs captured in pots are landed in May, 23% in June, and 4% in April.

Crab trawls contribute less than 1% to the landings of soft crabs. May accounts for 37% of these landings, followed by April (24%) and June (21%). Soft crab landings by shrimp trawls are 0.3% of the total. Forty-two percent of those landings occur in July, 31% in August, 9% in September, and 8% in June.

Other gears with reported soft crab landings are float and sink gill nets, pound nets, runaround gill nets, hand tongs, long haul seines, hand, channel nets, hand rakes, cast nets, skimmer trawls, and turtle pots. These gears, combined, contribute less than 1% to the total soft crab harvest.

Albemarle Sound accounts for 31% of all soft crabs landed. Twenty-five percent of the landed soft crabs come from Roanoke Sound, 21% from Croatan Sound, 11% from

Pamlico Sound, and 4% from Currituck Sound.

6.2 Recreational

Blue crabs are harvested recreationally by a variety of means. These include crab pots (rigid and collapsible), trawls (crab and shrimp), hand lines, and dip nets. Currently, there is no license required to harvest crabs recreationally unless a vessel is used. The bag limit on recreationally caught crabs is 50 per person per day, not to exceed 100 per vessel. Estimates of the recreational harvest of blue crabs in North Carolina are not available but are thought to be significant. In 1990, it was estimated that 11.5 million pounds of blue crabs were landed by recreational crabbers in Maryland (Chesapeake Bay Program 1997). During the same year (1990) the commercial harvest in Maryland was approximately 30 million pounds.

7. ECONOMIC STATUS

7.1 Commercial fishery

7.1.1 Harvesting sector

7.1.1.1 Ex-vessel value and price

Hard blue crabs are the most important seafood product landed in North Carolina in terms of value. The percentage of total value of commercial fisheries landings attributable to hard blue crabs has risen substantially during 1972-1997. In 1972, hard blue crabs represented only 11% of the total value. By 1992, its share doubled the 1972 proportion: 22%. Hard blue crabs accounted for approximately 30% of the total value in 1997.

The value of North Carolina's hard blue crab landings increased from $1.3 million in 1972 to a peak of approximately $40 million in 1996 (Table 3). Most of the recent increase in value was due to increased landings. In 1997, value dropped to $33 million because of a decline in landings of over 11 million pounds from the previous year.

The price received by fishermen for hard blue crabs increased substantially between 1972 and 1995. In 1972, the average price was $0.10 per pound. By 1980, the price per pound increased to $0.17. Between 1985 and 1995, the price increased from $0.21 per pound to $0.73 per pound. When adjusted for inflation, the average price per pound increased by $0.25 between 1985 and 1995. In 1997, the real average price per pound was $0.34.

Prior to 1986, the peeler and soft crab fisheries could be characterized as relatively stable, averaging $121,800 for the 14-year period, 1972-1985 (Table 3). In 1990, the value of peeler and soft crab landings more than doubled the 1988 value:$1.45 million. The landed value averaged $1.3 million annually during 1991-1993 and ranged from $2.7 million in 1994 to $4.5 million in 1997.

Like most species, the price of peeler and soft crabs has fluctuated. In 1972, peeler and soft crabbers received $0.59 per pound. By 1978, the average price more than tripled

the 1972 price: $1.92 per pound. However, between 1982 and 1993, the price received by peeler and soft crabbers decreased from $2.00 per pound to $1.88 per pound. If the price is adjusted for inflation, crabbers received $1.50 per pound in 1997 in terms of 1982 value.

7.1.1.2 Fishing income

Gross fishing income derived from crabbing (all gears) was estimated using values of landings from the Trip Ticket Program and the endorsement to sell (ETS). Value data were derived from DMF surveys of ex-vessel prices received by fishermen at the point of initial sale to fish dealers. Gross income as indicated in Table 4 varied substantially among fishermen and among segments within the blue crab fisheries. Total average gross fishing income reported by individual fishermen and businesses participating in the blue crab fisheries was estimated at $27,069 and ranged from $222 to $102,485 in 1997 (Table 4). Income from hard blue crab fishing averaged $13,385, with a range of $157 to $40,920, while the average income from peeler and soft crabs was $1,820 and ranged from $25 to $6,266.

Sixty percent of the individual fishermen and businesses engaged in the blue crab fisheries reported a total average fishing income under $20,001 in 1997 (Table 4). The average percent contribution of blue crabs to total fishing income generally increased as the individual fishermen and businesses' total income increased. For individual fishermen and businesses with a total fishing income over $20,000, crabbing contributed at least 64% of gross fishing income. Crabbing sales contributed 56% (49% for hard crabs, and 7% for peeler and soft crabs) to the total fishing income of fishermen participating in the 1997 crab fisheries.

Cost data for the blue crab fisheries are not available. However, rising fuel costs and other factors suggest that profitability in the blue crab fisheries may be declining.

7.1.1.3 Employment

Employment in the blue crab harvesting sector can be only estimated because the basic unit licensed in North Carolina is the vessel rather than the individual fisherman. The number of vessel licenses issued for commercial fishing activities has exceeded 15,000 annually. One individual may have more than one license; thus, the number of licenses does not indicate the number of individuals engaged in commercial fishing.

Although the number of endorsement to sell (ETS) licenses is not necessarily indicative of the number of individuals involved in the industry, it does provide an indication of activity. In 1997, there were 3,115 ETS licensees reporting blue crab landings to the Trip Ticket Program. Using the following average total crew sizes for crab vessel ETS holders (1 per vessel of less than 18 feet, 2 per vessel of 19-38 feet, and 3 for a vessel greater than 38 feet) as recommended by the Blue Crab Advisory Committee, approximately 5,119 individuals were directly engaged in blue crab harvesting activities in 1997.

7.1.2 Distribution and processing sector

7.1.2.1 Unprocessed crab dealers

Blue crabs harvested in North Carolina are sold through licensed seafood dealers. This group includes fishermen reporting as dealers, wholesalers, processors, retailers, and restaurants. Figure 4 illustrates the flow of North Carolina blue crab products in 1997. Most of the harvest (80%) and value (83%), goes to local seafood dealers who sell directly to out-of-state dealers/processors, North Carolina dealers/processors, and retail markets. The other 20% of the harvest and 17% of the value goes directly to processors in North Carolina. However, the proportion of sales from other North Carolina dealers to processors is unknown.

The number of dealer licenses issued for unprocessed crabs generally increased in the early 1980s and then fluctuated between 150 and 200 during 1984-1992 (Figure 5). The number of licenses issued then plummeted to 122 in 1993. Since then, licenses issued have increased. In 1997, there were 347 dealer (unprocessed) licenses issued, of which 343 (99%) reported to the trip ticket program.

Employment by unprocessed crab dealers is unknown and cannot be estimated at this time.

7.1.2.2 Processing

Processing is an important component of the blue crab fisheries. The number of processor licenses issued by DMF and the number of processing plants certified by the Shellfish Sanitation Program (North Carolina Division of Environmental Health) have fluctuated yearly (Figure 5). The total number of crab processor licenses issued increased from 32 in 1980 to 42 in 1990 and then declined to 31 in 1993. The number of certified plants increased from 33 in 1980 to 43 in 1990 and then declined to 30 in 1997. The blue crab processing sector has faced increased problems. The declining trend in the number of processing plants can be attributed to three factors: (1) a shortage of local labor that has led to dependency on migrant workers to maintain an adequate work force; (2) a lack of steady supplies from local fishermen due to an apparent shift to the live "basket" market; and (3) competition from crabmeat imported from overseas. Steps to address these issues may be needed if the processing industry is to remain competitive in the long-run.

Data available from the NMFS indicate that the value of processed crab products averaged $27 million annually during 1980-1989 and ranged from $28 million in 1992 to over $45 million in 1994 (Table 5). A survey of blue crab processors by DMF estimates that 28 companies produced 4.7 million pounds of crab meat worth approximately $41 million and employed about 1,800 individuals in 1997 (DMF unpublished data).

7.1.3 Economic impacts of the commercial fishery

The commercial fishing industry in North Carolina produces ripple effects in the state's economy. Each dollar earned within the industry generates a more vigorous

economy by stimulating additional activity in the form of jobs, income, and output. In 1997, the commercial blue crab industry in North Carolina, contributed, directly and indirectly, an estimated $68 million in sales (output), $35 million in total income, and 7,440 full and part-time jobs to the state's economy[1]. As might be expected, most of the jobs were generated from harvesting and processing activities.

The estimates above are limited and must be viewed as conservative. These estimates do not include wholesale (seafood dealers), retail, and foodservice sectors because of a lack of economic data for those sectors.

7.2 Recreational fishery

No information exists concerning recreational crabbing because no license is required to fish recreationally in North Carolina. The Marine Recreational Fishery Statistics Survey (MRFSS) conducted by the Division does not collect data on recreational crabbing.

8. SOCIOECONOMIC CHARACTERISTICS

8.1 Commercial fishery

8.1.1 Fisherman's profile

Commercial fishermen who fish for blue crabs (Maiolo et al. 1985; Stroud 1996 and 1997), in general, have demographic characteristics similar to most commercial fishermen in North Carolina (Diaby 1998; Johnson and Orbach 1996).

Fishermen who harvest hard crabs tend to be younger than most of the commercial fishermen as a whole in North Carolina. Hard crabbers were between 14 and 74 years of age, with an average age of 36 years (Maiolo et al. 1985). In contrast, crab shedders averaged 49 years of age, with a range of 31 to 71 years (Diaby 1998). There are significant differences in average age between full and part-timers and across areas for North Carolina's fishermen. For example, the average age ranged from a low of 41.2 years for full-timers in the Albemarle Sound[2] area to a high of 55 years for part-timers in Dare County (Johnson and Orbach 1996).

With respect to years of experience in commercial fishing, hard crabbers were less experienced than other commercial fishermen in North Carolina. They averaged 14 years, compared to 22 years for crab shedders, ranging from a low of 13.7 years for full-timers in

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[1]Derived using IMPLAN (Impact Analysis for Planning) system.

[2]Includes Currituck, Camden, Pasquotank, Perquimans,Chowan, Bertie, Washington, and Tyrrell counties.

the inland (non-coastal) counties to a high of 30.7 years for part-timers in the western Pamlico Sound[3] area for commercial fishermen.

Sixty-five percent of hard crabbers had a high school education or more. Relative to crab shedders and commercial fishermen as a whole, 70% and 68% graduated from high school, respectively; thus, the education level attained by hard crabbers is comparable to those of shedders and commercial fishermen.

No significant differences in marital status and gender existed across fisheries. Ninety-nine percent of hard crabbers were male, and 77% were married. A total of 96% of commercial fishermem were male, with 81% being married, while 91% of shedders were male and 98% were married.

8.1.2 Economic dependence on fishing and related activities

Fishermen engaged in the blue crab fisheries are in general dependent on the fisheries. Hard blue crabs are the most important source of income within the blue crab fisheries. The degree of dependence on crabbing varies with status of the fisherman (full-time vs. part-time). In 1996, 70% of crab potters surveyed fished full-time, and the remaining 30%, part-timers, reported that some of their income came from non-fishing employment sources (Stroud 1997). Also, Maiolo et al. (1985) found that 58% of the full-time fishermen surveyed derived 100% of their total income from fishing activities, while fishing accounted for 40% of the part-timers's total income.

There is more economic dependence on fishing in rural areas than in urban areas. Johnson and Orbach (1996) showed that 75% of fishermen from the Albemarle Sound area, Dare County, and eastern Pamlico Sound area derived more than 50% of their income from commercial fishing, while in the southern coastal counties, commercial fishing accounted for less than 50% of commercial fishermen's income.

8.1.3 Employment opportunities and unemployment rates

Although commercial fishing is important to coastal local economies, all have some economic dependence on manufacturing, services, and retail, etc. These industries provide employment opportunities for many communities during the summer. Employment opportunities for commercial fishermen in these non-fishing sectors are heavily dependent on the individual fisherman's skills and level of education.

Data available from the Employment Security Commission indicates that coastal counties where blue crab fishing occurs are among those with high unemployment rates (Table 6). Unemployment rates are variable within a year as well as among coastal counties. For example, the annual unemployment rate for Tyrrell County in 1997 was 8.4%, with monthly ranges from 3.2% in August and September to 19.7% in January.

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[3]Includes Craven, Pamlico, Beaufort, and Hyde counties.

8.2 Recreational fishery

Data on socioeconomic characteristics of recreational crabbers are not available.

9. ENVIRONMENTAL FACTORS

9.1 Influences on Habitat and Water Quality

Habitat and water quality are critical elements linked in the ecology of estuarine systems. Degradation or improvement in one aspect of habitat or water quality may have a corresponding impact elsewhere. Maintenance and improvement of suitable estuarine habitat and water quality are probably the most important factors in providing a sustainable blue crab stock.

According to Lindall et al. (1979), the major man-induced activities that affect the estuarine environment are the following:

1. construction and maintenance of navigation channels;
2. discharges from wastewater plants and industries;
3. dredge and fill for land use development;
4. agricultural runoff;
5. ditching, draining, or impounding wetlands;
6. oil spills;
7. thermal discharges;
8. mining, particularly for phosphate and petroleum;
9. entrainment and impingement from electrical power plants;
10. dams;
11. marinas;
12. alteration of freshwater inflows to estuaries;
13. saltwater intrusion; and
14. non-point-source discharges of contaminants.

Other man-induced changes which may affect estuarine systems is the introduction of exotic species through ballast water discharges and excessive nutrient loading (eutrophication). In addition to man-induced changes, sea level rise, subsidence, storms, and erosion are natural processes responsible for loss of critical habitat (Steele and Perry 1990).

9.2 Habitat

Migration and movement of blue crabs among various habitats are seasonal, depending on life stage, sex, maturity, and associated salinity preferences. Many different habitats are used during migrations from high-salinity ocean waters to the lower-salinity and freshwaters of the coastal sounds, rivers and creeks. Functions provided by estuarine nursery areas, marshes, and sea grasses [i.e., eel grass (Zostera marina) and other submerged aquatic vegetation (SAV)] include shelter or refuge habitat, settlement site, mating, spawning, food, and foraging habitat.

Submerged aquatic vegetation and other shallow water habitats are used by blue crabs during postlarval settlement, juvenile development and overwintering, as well as for protection during molting and soft shell phases of all size classes. Several studies have documented that postlarval and juvenile blue crabs prefer SAV and macroalgae over unvegetated shallow-water habitats (Chesapeake Bay Program 1997). Lipcius et al. (1995) noted that data collected over many years indicates that seagrass beds in Chesapeake Bay are of vital importance as settlement and nursery habitat for blue crabs during early growth stages. Lipcius et al. (1995) suggested that the Chesapeake Bay owes much of its blue crab productivity to the presence of vegetated habitats, and without them, the blue crab population would almost certainly experience a dramatic decline. Much scientific evidence points to the importance of SAV in the blue crab life cycle. Growth of young crabs is faster in SAV; the survival of juvenile crabs is higher; the densities of crabs are substantially higher; and the abundance of juvenile crabs is higher in those years when SAV coverage is high (Chesapeake Bay Commission 1997). As juvenile crabs grow and disperse, they utilize other shallow-water habitats, as well as SAV (Chesapeake Bay Program 1997). In general, juvenile blue crabs have wide areal distributions, but they are most abundant in middle and upper estuarine waters of low to intermediate salinity (Perret et al. 1971; Swingle 1971; Adkins 1972; Daud 1979; Perry and Stuck 1982). The optimum sediment for small crabs is detritus, mud, or mud-shell bottom (Adkins 1972). Subtidal sand and mud bottoms have been documented as overwintering habitat for juvenile blue crabs (Thomas et al. 1990). Small creeks and rivers in and around salt marshes provide shallow-water habitats for larger juveniles and mature crabs for feeding and refuge during molting (Orth and van Montfrans 1987; Hines et al. 1987; Thomas et al. 1990). Ryer et al. (1990) suggested that pre-molt crabs aggregated in seagrass meadows, possibly to escape predators. Coarse woody debris (wood particles more than 2 centimeters or 0.8 inches in diameter) in shallow waters adjacent to forested riparian zones provides valuable shelter for large crabs, particularly during molting phases, when SAV is not present (Everett and Ruiz 1993; Wolcott and Hines 1989). Oyster reefs in high salinity waters are an important habitat for juvenile blue crabs (Wenner et al. 1996).

In North Carolina, shallow salt marshes are important nursery areas (Weinstein 1979). Within the Albemarle-Pamlico estuary, shallow detrital habitats and Eurasian watermilfoil (Myriophyllum spicatum) are important alternative nursery habitats (Etherington and Eggleston In press). Seasonal abundance of blue crabs for different habitat types in Core Sound, N.C. were documented by Dudley and Judy (1973). Juvenile blue crabs were most abundant from late fall through early spring in shallow soft-bottomed creeks bordered by marshlands. Peak juvenile abundance in shallow, sandy grass-bottomed areas at or near the mouths of small creeks occurred during the fall and again in spring. Samples from the ocean inlets during June, July, and August were composed mainly of mature females, most having either a sponge (egg mass on the abdomen) or remnant sponge (after the eggs have hatched).

Turner and Boesch (1987) noted evidence of a decrease in fishery production following wetland losses and stock increases following wetland gains. Steele and Perry (1990) suggested that habitat loss may be a significant factor in determining blue crab production.

Critical habitats may be impaired by freshwater drainage, land use changes, eutrophication (excessive nutrients), high organic loading, and physical destruction or disturbance by dredges, watercraft, and fishing practices. Changes in the amount and timing of freshwater inflow may have major effects on that segment of the blue crab life cycle taking place in the estuary (Steele and Perry 1990). Nursery areas are most threatened by nonpoint sources of pollution and development on nearby lands (Stanley 1992).

Essential fish habitat (EFH) is defined in the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act), U.S. Public Law 104-208, as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." EFH for the blue crab in North Carolina includes all oceanic near-shore, estuarine, and inland coastal waters and the substrates therein. Areas in North Carolina that meet the criteria for blue crab essential fish habitat-habitat areas of particular concern (EFH-HAPCs) as outlined in the Magnuson-Stevens Act (DOC 1997) include: all coastal inlets, SAV, shallow detrital habitats, salt marshes, and areas designated by the MFC as Crab Spawning Sanctuaries, Primary Nursery Areas, and Secondary Nursery Areas.

9.2.1 Habitat Protection

The North Carolina Division of Coastal Management (DCM) is responsible for development permits along the estuarine shoreline in 20 coastal counties. Wetland development activity throughout North Carolina is permitted through the United States Army Corps of Engineers (COE) and the North Carolina Division of Water Quality (DWQ; 401 certification program). Various federal and state environmental and resource agencies, including DMF, evaluate projects proposed for permitting and provide comments and recommendations to the DCM, DWQ, and COE on potential habitat and resource impacts. Habitat protection relies on enforcement, the efforts of commenting agencies to evaluate impacts, and the incorporation of recommendations into permitting decisions.

Various public agencies (state and federal) and private groups have established parks, refuges, reserves, sanctuaries, and natural areas that help to protect adjacent public trust estuarine habitats.

In an effort to protect SAV and other habitats from bottom-disturbing fishing gears, the MFC prohibits the use of rakes and dredges of a specific weight and type in internal coastal waters (MFC 1997; 15A NCAC 3J .0303, 3K .0102, and 3K .0503), dredges/mechanical methods to take shellfish and crabs (15A NCAC 3K .0204, 3R .0108, and 3I .0203) in certain areas, and trawl nets [15A NCAC 3J .0104 (b) (4) and 3R .0106(2)] in certain areas. Harvest methods for hard clams have been established in beds of submerged aquatic vegetation (15A NCAC 3K .0304), and the Fisheries Director has been granted proclamation authority to specify means and methods for mechanical harvest of shellfish by season and area (15A NCAC 3K .0302 and 3K .0501). The MFC has also provided habitat and fishery resource protection by prohibiting the use of various commercial gears in Primary Nursery Areas (PNA's) [15A NCAC 3N .0104 and 3R .0103], and prohibiting the use of trawl nets in Secondary Nursery Areas (15A NCAC 3N .0105, 3R .0104, and 3R .0105).

9.3 Water Quality

The most common causes of use support impairment of North Carolina's water quality classifications as documented in several coastal basinwide water quality management plans are oxygen-consuming wastes, nutrients, fecal coliform bacteria, metals/toxicants, sediment, and solids/turbidity (NCDEHNR 1997b). Nonpoint source pollution is identified as the major contributor to water quality impairment in the coastal river basins.

Several of North Carolina's major coastal river basins, including the Chowan, Tar-Pamlico, Neuse, and Cape Fear, are designated as "nutrient sensitive". Eutrophication, or excessive nutrient loading, can create an ecological imbalance resulting in nuisance and frequent algal blooms (EPA and NCDEHNR 1994). A decline of SAV species in Chesapeake Bay during the late 1960's and early 1970's was attributed to increasing amounts of nutrients and sediments (Chesapeake Bay Program 1997).

Respiration and decomposition of algal blooms and organic loading can cause hypoxic (low levels of dissolved oxygen) and/or anoxic (absence of oxygen) conditions. Temperature and salinity stratification contributes to the formation and severity of hypoxic and anoxic events. Direct or secondary effects of hypoxia and anoxia on crabs may include: reduced suitable habitat; impeding or promoting movement; reduced feeding (Das and Stickle 1991), growth, and molting rate (Das and Stickle 1993); increased (Nesterode 1998) or decreased nutrition (Noga et al. 1990) due to prey availability; deteriorating body condition; increased environmental stress; lower immunological competence (Noga et al. 1990) and increased susceptibility to disease; diminished reproductive capability; and mortality (Harper and Guillen 1989; Das and Stickle 1991 and 1993). Crab potters in the Albemarle - Pamlico sound complex indicate that hypoxic and anoxic (dead water) conditions can be frequent and widespread, resulting in significant trap mortalities and making vast areas unfishable. Anoxia and associated trap death has been reported in Mobile Bay (Tatum 1982), Chesapeake Bay (Carpenter and Cargo 1957; Van Engel 1982), Texas (More 1969), and Louisiana (Guillory et al. 1996). Low levels of dissolved oxygen may cause high local mortalities and influence the distribution or migration of blue crabs (Guillory et al. 1996). Crabbers in Chesapeake Bay have had to set traps progressively closer to shore because of hypoxic conditions in deeper water (Price et al. 1985). Conditions which suggest the presence of hypoxic and anoxic water conditions include crabs clinging to the top of crab pots attempting to get out of the low oxygen water; crabs swimming at or near the water's surface; weak crabs in pots; total mortality of potted crabs; and pots previously covered with aquatic organisms (marine fouling) suddenly appear clean.

Jordan et al. (1992; based on Funderburk et al. 1991) recommended a monthly average dissolved oxygen content of 5 mg/L for target species in Chesapeake Bay, including blue crabs. Blue crabs are tolerant of hypoxic (low oxygen) conditions (Lowery and Tate 1986); however, tolerance decreased with increasing temperature (deFur et al. 1990). Juvenile crabs may be less tolerant of hypoxia than adults (Stickle et al. 1989), and may require more oxygen than was recommended by Jordan et al. (1992).

A variety of pathogens can affect crustaceans, including viruses, bacteria, fungi, protozoans, and helminths. Some pathogens may cause significant mortalities, reduced fecundity, and unattractive necrotic lesions on the shell or black pigmentation in the meat, rendering affected crabs unmarketable.

Many infections are contagious to other crabs and may be an indication of stress in a population. The relationship between stress and disease is a well-documented phenomenon. Sindermann (1989) found that the occurrence of disease was higher in stressed populations. Various sources suggest a link between poor water quality conditions, immunocompetence, and disease in crustaceans. Areas of high organic load and poor water quality generally contribute to an increase in bacteria numbers (Sindermann 1974). Blue crabs in these areas may be more prone to bacterial infections (shell disease). Noga et al. (1990) suggested the environment and not the presence of bacteria, as responsible for the induction and development of shell disease.

Diseases that have been observed in blue crabs from North Carolina include bacterial infections (shell disease) and paramoebiasis (gray-crab disease). Gray-crab disease has not been a major problem, though there have been periodic outbreaks causing localized mortalities (Mahood et al. 1970). In 1987, an extreme outbreak of shell disease was observed in the Pamlico River (McKenna et al. 1990). The chronic presence of shell disease was suggested as a possible factor contributing to a significant, progressive decline in blue crab landings in the Pamlico River during 1985-1989 (Noga et al. 1990).

Diseases and infections in the blue crab population can bring about wide and varied effects, both actual and perceived, on the blue crab and its industry. Even the perception of diseases and pathogens, once shared with the public, can have considerable effects on the industry and on management (Chesapeake Bay Program 1997). A toxic dinoflagellate bloom in Maryland during the summer of 1997 focused attention on similar water quality issues in North Carolina, affecting blue crab markets along the east coast.

Blue crab kills following excessive freshwater runoff and subsequent oxygen depletion due to rapid decomposition of organic matter were reported by Van Engel (1982). Changes in the amount and timing of freshwater inflow may have a major effect on that segment of the blue crab life cycle taking place in the estuary (Steele and Perry 1990). Adkins (1972) concluded that domestic, agricultural, and industrial pollution, as well as dredge and fill operations, have adversely affected blue crab populations in Louisiana. Although the exact mechanisms through which environmental pollutants affect blue crab production are poorly understood, evidence suggests that chemical pollution may be responsible for crab mortalities (Steele and Perry 1990). Chemical and biological pollutants, sediment, temperature, salinity, and low dissolved oxygen have been associated with crab mortalities (Van Engel 1982). Various organic compounds and inorganic contaminants have been found to be toxic to different blue crab life history stages (Millikin and Williams 1984). Crab mortalities in North Carolina have been documented in relation to severe runoff events, low dissolved oxygen levels, fish kills of unknown cause, and detergent spills (NCDEHNR 1997a; NCDENR 1997). Algal blooms and *Pfiesteria*-like organisms have been identified in some areas where crab kills were observed (NCDENR 1997). Toxic algae have caused blue crab mortalities in controlled laboratory tests

(Burkholder et al. 1992).

9.3.1 Water Quality Protection

Federal and state laws mandate water quality protection activities through government commissions and agencies. Several divisions within the North Carolina Department of Environment and Natural Resources are responsible for providing technical and financial assistance, planning, permitting, certification, monitoring, and regulatory activities that have a direct or indirect impact on coastal water quality and habitat.

Various federal and state environmental and resource agencies, including DMF, evaluate proposed projects and provide comments and recommendations on potential water quality and resource impacts. Water quality protection relies on enforcement, the ability of commenting agencies to evaluate impacts, and whether recommendations are incorporated into permitting decisions.

An increase in population and land-based development, demands on water resources for various uses, and an inadequate understanding of impacts on estuaries have caused water quality degradation in spite of management efforts. The principal problems are a lack of strict pollutant standards, inadequate pollution abatement, and insufficient monitoring to protect water quality and the complex ecology of estuarine systems.

North Carolina has established a water quality classification and standards program for "best usage." Recent water quality classifications and standards have been implemented to promote protection of surface water supply watersheds, high quality waters, ecosystem functions, and the protection of unique and special pristine waters with outstanding resource values. Classifications, particularly for High Quality Waters (HQW), Outstanding Resource Waters (ORW), Nutrient Sensitive Waters (NSW) and Water Supply (WS) waters, outline protective management strategies aimed at controlling point and nonpoint source pollution. Many water quality standards are based on potential impacts in the immediate receiving waters and do not factor in the cumulative and long-term effects to the complex functions that characterize estuarine systems. Standards should be based on the assimilative capacity of, and impacts to, the entire system. The Comprehensive Conservation and Management Plan of the Albemarle-Pamlico Estuarine Study (EPA and NCDEHNR 1994) and other earlier plans for water quality management have recommended strategies that need to be implemented to improve water quality. Many of these recommendations have not been accomplished. Achievement of basinwide water quality management planning by the DWQ will hopefully improve coastal water quality.

Various public agencies (state and federal) and private groups have established parks, refuges, reserves, sanctuaries, and natural areas that help to protect adjacent public trust estuarine water quality.

10. PRINCIPAL ISSUES AND MANAGEMENT OPTIONS

A summary of the major issues and management options identified during the development of the FMP are contained in this section. Each issue is briefly described along with potential management options, recommended strategies, and actions to be taken by the MFC, DMF, and others. An in-depth discussion of each issue is contained in Section 13 (Appendices).

10.1 ENVIRONMENTAL ISSUES

10.1.1 HABITAT

10.1.1.1 Issue/ Purpose Protect, enhance, and restore habitats utilized by the blue crab.

Suitable and adequate habitat is a critical element in the ecology and productivity of estuarine systems. Degradation or improvement in one aspect of habitat may have a corresponding impact on water quality. Maintenance and improvement of suitable estuarine habitat and water quality are probably the most important factors in providing a sustainable blue crab stock.

10.1.1.2 Management Options

1. No regulatory action.
2. MFC rule changes to protect additional blue crab critical habitats.
3. Rule changes by other agencies (North Carolina Coastal Resources Commission, North Carolina Environmental Management Commission, and others) to protect blue crab critical habitats and water quality.

Option two would require rule changes by the MFC.

10.1.1.3 Recommended Management Strategy

Habitat protection, conservation, and restoration are essential to accomplish the goal and objectives of this plan. The MFC, North Carolina Coastal Resources Commission (CRC), and North Carolina Environmental Management Commission (EMC) should adopt rules to protect blue crab critical habitats as outlined in the Coastal Habitat Protection Plans (CHPP), as those plans are prepared and approved. The MFC and DMF should continue to comment on activities that may impact aquatic habitats and work with permitting agencies to minimize impacts and promote restoration. Research must be conducted to investigate the impacts of trawling on various habitats. This strategy would meet objectives 1, 4, and 7 of this plan.

10.1.1.4 Actions

Actions 1,2,3,4,5, and 6 would need to be implemented through the cooperate efforts of the N.C. General Assembly and several divisions within the Department of

Environment and Natural Resources. The involvement of federal agencies and funding (state and federal) may be necessary to accomplish these actions.

Action 1: The identification, maintenance, and enhancement of habitats critical to the life cycle of the blue crab should be a priority of efforts by the DENR and the MFC and its committees, in developing Coastal Habitat Protection Plans as outlined in the Fisheries Reform Act of 1997.

Action 2: Management Actions as outlined in the Vital Habitats Plan (Appendix 1: page 74) of the Albemarle - Pamlico Estuarine Study Comprehensive Conservation and Management Plan (EPA and DEHNR 1994) should receive priority for funding and be completed in a timely manner.

Action 3: Management Actions as outlined in the Vital Habitats Plan (Appendix 1) of the Albemarle - Pamlico Estuarine Study Comprehensive Conservation and Management Plan (EPA and DEHNR 1994) should be expanded to all river basins that drain to North Carolina's coastal region.

Action 4: Work with the permitting and commenting agencies to enhance protection of wetlands and estuarine habitats. The MFC should fully utilize its permit commenting authority as outlined in G.S. 143B-289.52.

Action 5: Request funding to document the impact of land use changes on estuarine habit and resources.

Action 6: Identification of areas by the MFC and protection by the CRC of critical habitats where watercraft usage might be detrimental.

Action 7: Investigate the impacts of trawling on various habitats.

10.1.2 WATER QUALITY

10.1.2.1 Issue/ Purpose Protect, enhance, and restore estuarine water quality.

Suitable water quality is a critical element in the ecology and productivity of estuarine systems. Degradation or improvement in one aspect of water quality may have a corresponding impact on habitat. Maintenance and improvement of suitable estuarine water quality and habitat are probably the most important factors in providing a sustainable blue crab stock.

10.1.2.2 Management Options

The MFC has no regulatory authority over water quality impacts. The MFC should highlight problem areas and advise other regulatory agencies on preferred options and potential solutions.

10.1.2.3 Recommended Management Strategy

The MFC and DMF should continue to comment on activities that may impact estuarine water quality and work with permitting agencies to minimize impacts. Water quality standards should be based on the assimilative capacity of, and impacts to, the entire system. Several plans for water quality management have recommended strategies that need to be implemented to improve water quality. Water quality protection and

restoration are essential to accomplish the goal and objectives of this plan. This strategy would meet objectives 1, 4, and 7 of this plan.

10.1.2.4 Actions

Actions would need to be implemented through the cooperate efforts of the N.C. General Assembly and several divisions within the Department of Environment and Natural Resources. The involvement of federal agencies and funding (state and federal) may be necessary to accomplish these actions.

Action 1: The identification, maintenance, and enhancement of water quality critical to the life cycle of the blue crab should be a priority of efforts by the NCDENR and the MFC and its committees, in developing Coastal Habitat Protection Plans as outlined in the Fisheries Reform Act of 1997.

Action 2: Management Actions as outlined in the Water Quality Plan (Appendix 1: page 74) of the Albemarle - Pamlico Estuarine Study Comprehensive Conservation and Management Plan (EPA and DEHNR 1994) should receive priority for funding and be completed in a timely manner.

Action 3: Management Actions as outlined in the Water Quality Plan (Appendix 1) of the Albemarle - Pamlico Estuarine Study Comprehensive Conservation and Management Plan (EPA and DEHNR 1994) should be expanded to all river basins that drain to North Carolina's coastal region.

Action 4: Work with the permitting and commenting agencies to enhance protection of water quality. The MFC should fully utilize it's permit commenting authority as outlined in G.S. 143B-289.52.

Action 5: Additional research is needed on the extent, causes, and impacts of hypoxia and anoxia on blue crab behavior and population abundance in North Carolina's estuarine waters.

Action 6: The MFC should strive for accomplishment of the management strategies as outlined in the coastal basinwide water quality management plans and water quality recommendations of the Fisheries Moratorium Steering Committee.

Action 7: Request that the North Carolina Environmental Management Commission review "Nutrient Sensitive Waters", "High Quality Waters", and "Outstanding Resource Waters" designations for the coastal river basins and implement additional strategies as needed.

Action 8: Conduct research on the water quality impacts of crab pot zincs, bait discard, and alternative crab baits in the pot fishery.

Action 9: Conduct education efforts on problems associated with the use of chlorine pot antifoulants (HTH®) and the surface water discharge of these solutions, which is prohibited by federal and state laws.

10.2 WASTEFUL or DAMAGING FISHING PRACTICES

10.2.1 SPAWNING STOCK MANAGEMENT

10.2.1.1 Issue/ Purpose

Protect the reproductive potential of blue crabs.

Harvesting egg-bearing females (sponge crabs) continues to be a controversial issue among both harvesters and resource managers. It is important for managers to consider not only the impact of harvesting mature female crabs, but, also, the influence of male harvest on the population (Chesapeake Bay Program 1997). Conflicting views exist regarding the existence (Lipcius and Van Engle 1990) or absence (Pearson 1948; Sulkin et al.1983; Van Engel 1987) of a spawning stock-recruitment relationship for the blue crab.

10.2.1.2 Management Options

1. No action.
2. Establish spawning sanctuaries around inlets in the southern coastal area.
3. Expand existing spawning sanctuaries (boundaries and/or time).
4. Reduce existing spawning sanctuaries (boundaries and/or time).
5. Establish a tolerance limit for certain sponge stages (e.g., brown or black sponge).
6. Reduce harvest of sponge crabs.
7. Prohibit the use of commercial fishing gear in spawning sanctuaries during March 1 - August 31, excluding gill nets.
8. Prohibit the use of commercial fishing gear in spawning sanctuaries during March 1 - August 31, excluding attended gill nets.
9. Prohibit the use of commercial fishing gear in spawning sanctuaries during March 1 - August 31.

Options two through nine would require rule changes by the MFC.

10.2.1.3 Recommended Management Strategy

Strengthening of spawning sanctuary rules should be accomplished by prohibiting all commercial gears, except attended gill nets. Sanctuaries afford the greatest protection to spawners, contribute to optimum yield of this resource, and have minimal impact on the majority of fishermen. This strategy would meet objectives 1 and 5 of this plan. If this management strategy is adopted by the MFC, the actions in Section 10.2.1.4 need to be implemented.

10.2.1.4 Actions

Action 1: Keep current rules on spawning sanctuaries in place.
Action 2: Conduct a survey of existing and potential sanctuary areas to determine population levels and to see if these areas function as spawning grounds.
Action 3: Areas determined to function as spawning grounds should be designated as spawning sanctuaries by the MFC.
Action 4: Modify current crab spawning sanctuary rules to prohibit commercial fishing gear (excluding attended gill nets) in sanctuaries during March 1 - August 31.

See Appendix 2 (page 77) for an in-depth discussion of the issue and management options.

10.2.2 GHOST POTS

10.2.2.1 Issue/ Purpose Reduce the bycatch and mortality of blue crabs and finfish in ghost (lost) pots.

Concern stems from the significant increase in the numbers of crab pots, the long life of vinyl coated pots, the pot's ability to continue to trap blue crabs and finfish, and mortality associated with prolonged entrapment.

10.2.2.2 Management Options

A. Options to minimize pot loss:

1. No action.
2. Harvest seasons by gear type (pot and trawl).
3. Area restrictions by gear type (pot and trawl).
4. Require weighted or sinking lines on all crab pot buoys.
5. Require reflective tape on all crab pot buoys.
6. Require the use of "full size" buoys (5 inches X 11 inches vs. 5 inches X 5 inches) on all crab pots.

Options two through six would require rule changes by the MFC.

B. Options to minimize ghost pot fishing mortality:

1. No action.
2. Require biodegradable panels in crab pots.

Option two would require a rule change by the MFC.

10.2.2.3 Recommended Management Strategy

Sinking lines should be required on all crab (hard and peeler) pots. This restriction would not only reduce the number of new ghost pots each year but should significantly reduce conflicts. Biodegradable panels will be considered for all hard and peeler crab pots, once necessary research is completed. This strategy would meet objectives 1, 3, 5, 6 and 9 of this plan. If this management strategy is adopted by the MFC, the actions in Section 10.2.2.4 need to be implemented.

10.2.2.4 Actions

Action 1: Require sinking lines on all crab pot buoys.
Action 2: Require reflective tape on all crab pot buoys, if research supports the practicality.
Action 3: Conduct research on biodegradable panels:

a. Test galvanic time release devices, natural twine, and non-coated steel (24 gauge or less) across a wide range of salinities.
b. Determine the optimal panel location for finfish and crab escapement.
c. Determine minimum panel size for blue crab and finfish escapement.
d. Determine desired release time for blue crabs and finfish.

See Appendix 3 (page 91) for an indepth discusion of the issue and management options.

10.2.3 CRAB POT ESCAPE RING

10.2.3.1 Issue/ Purpose Minimize the catch of sublegal crabs in crab pots.

The use of escape rings in crab pots has a number of important benefits: a possible increase in legal crab catch, reduction in sublegal harvest, reduction in ghost pot fishing mortality, reduced culling time for fishermen, and reduced injuries, mortality, and/or physiological stress for sublegal crabs. Conversely, some negative factors are possibly associated with escape rings, such as loss of small mature females, loss of peeler crabs, and (as suggested by some fishermen) an overall reduction in the size of crabs (escape rings let small mature females out, and they may pass on their small size to their offspring). Preliminary analysis of available data does not support the hypothesis that crabs are getting smaller due to escape rings (see Appendix 4 : page 97). Escape rings were required in all pots with a mesh size greater than 1.5 inches on February 1, 1989 (MFC 1997). Effective March 1, 1994, The Fisheries Director was granted proclamation authority to exempt the escape ring requirement in order to allow the harvest of peeler crabs or mature female crabs and may impose any or all of the following restrictions: (1) specify areas, and (2) specify time (MFC 1997).

10.2.3.2 Management Options

1. No rule change (retain two 2 5/16 inch cull rings and proclamation authority for peeler and mature female harvest).
2. Repeal proclamation authority to close escape rings for peeler crab harvest.
3. Repeal existing rule.
4. Refine escape ring size by area to optimize biological and economic efficiency.
5. Set up guidelines for using proclamation authority to close or not require escape rings.

Options two through four would require rule changes by the MFC.

10.2.3.3 Recommended Management Strategy

Data support the utility of escape rings as a viable management tool. The MFC should continue to require escape rings in hard crab pots. To maximize the biological and economic possibilities of escape rings, the actions listed in section 10.2.3.4 need to be taken by the MFC and DMF. This strategy would meet objectives 1, 5, and 6 of this plan.

10.2.3.4 Actions

Action 1: Develop criteria for using proclamation authority to close or not require escape rings for mature female and peeler crab harvest.

Action 2: Further investigate the impact or potential impact of escape rings on crab size.

Action 3: Determine optimum escape ring size for various geographic areas.

See Appendix 4 (page 97) for an in-depth discussion of the issue and management options.

10.2.4 CRAB TRAWL BYCATCH

10.2.4.1 Issue/ Purpose Minimize sublegal blue crab and flounder bycatch in the crab trawl fishery.

The crab trawl fishery has received a large amount of attention due to concerns over the bycatch and potential mortality of finfish and sublegal crabs.

10.2.4.2 Management Options

1. No rule change.
2. Increase crab trawl tailbag mesh size (4 inch or 4.5 inch stretched mesh).
3. Increase crab trawl stretched mesh size to 4 inches throughout the net in the Pamlico-Pungo, Bay, and Neuse rivers.
4. Harvest seasons.
5. Areas restrictions.
6. Ban crab trawling.

Options two through four and six would require rule changes by the MFC.

10.2.4.3 Recommended Management Strategy

To minimize waste in this fishery, a 4 inch or 4.5 inch stretched mesh crab trawl should be considered in all coastal waters where crab trawling is allowed. Additionally, area restrictions need to be put in place during the summer months to prohibit trawling in areas that serve as critical habitat for the blue crab. Regional variations in fisheries will need to be taken into account when setting seasons or other restrictions. This strategy would meet objectives 1, 5, 6, and 7 of this plan. If this management strategy is adopted by the MFC, the actions in Section 10.2.4.4 need to be implemented.

10.2.4.4 Actions

Action 1: Suggest a 4 inch or 4.5 inch stretched mesh for crab trawls in all coastal waters where crab trawling is allowed.
Action 2: Identify and protect blue crab critical habitat.
Action 3: Collect fishery-dependent data from the peeler crab and shrimp trawl fisheries.
Action 4: Conduct tailbag mesh size studies in Pamlico Sound (work to be conducted during 1998 and 1999 through a grant funded by the Fisheries Resource Grant Program).
Action 5: Investigate the economic and social impacts of the crab trawl fishery.
Action 6: Separate hard and peeler crab trawl landings on trip tickets.
Action 7: Establish definitions for peeler and hard crab trawls and allow only these gears to direct for blue crab harvest.

Action 8: DMF should recommend a maximum allowable bycatch of crabs for shrimp trawls.

See Appendix 5 (page 109) for an in-depth discussion of the issue and management options.

10.2.5 WHITE LINE PEELER HARVEST

10.2.5.1 Issue/ Purpose Reduce mortality of "white line" peeler crabs.

"White line" peelers held in shedding operations may experience relatively high mortality (over 50%) because of the length of time held until they molt. Some peeler and hard crab pot fishermen retain "green crabs" calling them "white line" peelers and, thereby use the peeler crab exemption to circumvent the minimum size limit and culling tolerance for hard crabs.

10.2.5.2 Management Options

1. No rule change.
2. Prohibit the possession of "white line" peelers.
3. Establish a season for the possession of "white line" peelers.
4. Prohibit the baiting of peeler pots, except with live, legal-sized male blue crabs.
5. Peelers should be culled from the catch where taken in the hard crab pot fishery.
6. Establish a season for the possession of male "white line" peelers.

Options two through six would require rule changes by the MFC.

10.2.5.3 Recommended Management Strategy

Prohibiting the baiting of peeler pots, except with live, legal male blue crabs would minimize the harvest of "green" and "white line" peelers in the peeler pot fishery, contribute to optimum yield of the resource, and have minimal impact on the majority of North Carolina's crab shedding operations. To address the problem in the hard crab pot fishery, peelers should be culled from the catch were taken, and the possession of male "white line" peelers should be prohibited during June through September. This strategy would meet objectives 1, 5, and 6 of this plan. If this management strategy is adopted by the MFC, the actions in Section 10.2.5.4 need to be implemented.

10.2.5.4 Actions

Action 1: Prohibit the baiting of peeler pots, except with live legal male blue crabs.
Action 2: Repeal the exemption for culling peelers before reaching shore or dock in the hard crab fishery.
Action 3: Prohibit the possession of male "white line" peelers from June - September.
Action 4: Determine shedding mortality rates by peeler stage, area, and season.

Action 5: Determine the importance of "white line" peelers to the economics of the fishery and examine related enforcement issues.
Action 6: Develop and implement more effective shedding practices to minimize mortality.

See Appendix 6 (page 117) for an in-depth discussion of the issue and management options.

10.2.6 CRAB POT FINFISH BYCATCH

10.2.6.1 Issue/ Purpose

Evaluate finfish bycatch in crab pots.

No data exist on the species composition, quantity, or fate of unmarketable finfish bycatch in the crab pot fishery.

10.2.6.2 Management Options

1. No regulatory action.
2. Require finfish excluders in hard and peeler crab pots.

Option two would require a rule change by the MFC.

10.2.6.3 Recommended Management Strategy

No regulatory action should be taken at this time. Before this issue can be addressed, baseline information as outlined in Section 10.2.6.4 must be collected. This strategy would meet objectives 6 and 9 of this plan.

10.2.6.4 Actions

Action 1: Collect baseline data on the composition, quantity, and fate of unmarketable finfish bycatch in the crab pot (hard and peeler) fishery, by season and area.
Action 2: If needed, develop a finfish bycatch reduction device for hard and peeler crab pots.

See Appendix 7 (page 121) for an in-depth discussion of the issue and management options.

10.2.7 SMALL PEELER/ SOFT CRAB HARVEST

10.2.7.1 Issue/ Purpose

Evaluate the harvest of small peeler/soft crabs.

Establishing a peeler size limit could potentially provide an increase in spawning stock biomass by allowing more females to enter the spawning population, thereby reducing the potential for broodstock overfishing (Uphoff et al. 1993). Raising the size limit could also increase yield to the fishery (Uphoff et al. 1993). A peeler/soft crab size limit could allow more effective, efficient, and consistent enforcement of size limits. In contrast, small peelers and soft crabs, especially at the beginning of the spring season,

often bring extremely high prices to the fisherman.

10.2.7.2 Management Options

1. No rule change.
2. Establish a minimum size limit for peelers and/or soft crabs.

Option two would require a rule change by the MFC.

10.2.7.3 Recommended Management Strategy

Currently, there is not sufficient information to indicate that there is a need to curtail the harvest of small peeler/soft crabs in an effort to protect the spawning stock. A minimum size limit would have a severe economic impact on the existing fishery practices and markets; therefore, no rule change is recommended. In the absence of regulatory action, industry involvement coupled with additional research (see Section 10.2.7.4) is necessary to minimize wasteful practices and maximize economic return from the fishery. This strategy would meet objectives 6 and 9 of this plan.

10.2.7.4 Actions

Action 1: Keep current rules in place.
Action 2: Develop more effective shedding practices to minimize mortality.
Action 3: Examine the economic and biological issues involved and quantify the results.

See Appendix 8 (page 122) for an in-depth discussion of the issue and management options.

10.2.8 DIAMONDBACK TERRAPIN BYCATCH and MORTALITY in CRAB POTS

10.2.8.1 Issue/ Purpose Evaluate diamondback terrapin bycatch and mortality in blue crab pots.

Populations of diamondback terrapins have declined throughout their range from Cape Cod, Massachusetts to southern Texas (Palmer and Cordes 1988; Seigal and Gibbons 1995). The diamondback terrapin is included on the North Carolina listing of "Endangered and Threatened Species" as a "Species of Special Concern"(North Carolina Endangered Species Act - G.S. 113-331 to 113-337). Blue crab pots may account for more adult diamondback terrapin mortalities than any other single factor (Bishop 1983).

10.2.8.2 Management Options

1. No regulatory action.
2. Require terrapin excluders and/or modifications to crab pots fished within a specified distance of shore during the spring, within specified areas.

Option two would require rule changes by the MFC.

10.2.8.3 Recommended Management Strategy

Additional research on potential options is warranted before regulatory action is taken on this issue. This strategy would meet objectives 6 and 9 of this plan.

10.2.8.4 Actions

Action 1: Collect information on diamondback terrapin distribution.
Action 2: Conduct an assessment of crab pot bycatch and terrapin mortality by season and area, including fishermen observations.
Action 3: Assess excluder devices and/ or potential pot modifications.
Action 4: Educate crab potters on the problem and potential solutions.

See Appendix 9 (page 125) for an in-depth discussion of the issue and management options.

10.2.9 WHITE BELLY CRAB HARVEST

10.2.9.1 Issue/ Purpose

Evaluate the harvest of white belly crabs.

White belly crabs are light in weight, and meat yield and quality is reduced. It is widely recognized by the industry that these crabs, if not harvested would provide a greater meat yield at a later date (usually within 2 – 3 weeks post molt).

10.2.9.2 Management Options

1. No regulatory action.
2. Prohibit harvest of white belly crabs.
3. Reduce harvest of white belly crabs.

Options two and three would require rule changes by the MFC.

10.2.9.3 Recommended Management Strategy

No regulatory action should be taken on this issue at this time. The crab industry should voluntarily reduce the harvest of white belly crabs or reduce the incentive for harvesting this low quality product. Information on the economics of this product should be collected and summarized and used in industry education efforts (see Section 10.2.9.4). This strategy would meet objectives 1, 6, and 9 of this plan.

10.2.9.4 Actions

Action 1: Collect economic information on the harvest of poor quality white belly crabs.

See Appendix 10 (page 130) for an in-depth discussion of the issue and management

options.

10.3 COMPETITION and CONFLICT WITH OTHER USERS

10.3.1 CONFLICT

10.3.1.1 Issue/ Purpose Minimize conflict, theft, and gear damage and increase public trust utilization.

The increase in hard crab and peeler pot numbers has resulted in more frequent and severe conflicts over fishing space between crab potters (full and part-time), other commercial fisheries (trawlers, long haul seiners, etc.) and recreational activities (swimming, fishing, boating). Conflicts may arise from damage to vessels encountering gear, and may result in fishing gear being moved, damaged, destroyed or stolen. Also, theft of potted crabs has increased in some areas, as effort for and price of the commodity has increased.

10.3.1.2 Management options

1) Management areas;
2) Harvest seasons;
3) Gear restrictions/ reductions;
4) Time restrictions;
5) Catch limits;
6) Delayed entry;
7) Licenses;
8) Permits;
9) Area restrictions; and
10) Limited entry.

All options would require rule changes by the MFC. Options six, seven, and ten would require legislative action.

10.3.1.3 Recommended Management Strategy

To minimize conflicts, theft, and gear damage, and increase public trust utilization, the N.C. General Assembly needs to provide the Marine Patrol with statutory authority to deal with theft. The MFC needs to change the unattended pot rule from the existing 10 day period to seven days, modify existing crab pot areas using depth as the boundary instead of distance from shore, establish management areas, make it unlawful to use or set pots in any navigation channel marked by State or Federal agencies and in areas identified by the MFC, consider gear licenses or permits, consider a pot tagging system, develop guidelines to mediate user conflicts, support the establishment of boating safety courses and boat operator licenses by the Wildlife Resources Commission (WRC), and re-examine the times when pots must be moved into designated crab pot areas. Continual and sometimes significant modifications to these recommended actions will be needed, if steps are not taken to control the growth of the pot (hard and peeler) fisheries. If this

management strategy is adopted by the MFC, the actions in section 10.3.1.4 need to be implemented. This strategy would meet objectives 3 and 5 of this plan.

10.3.1.4 Actions

Action 1: Provide Marine Patrol with statutory authority to deal with theft.
Action 2: Change the unattended pot rule from the existing 10 day period to 7 days.
Action 3: Make it unlawful for pots (hard and/or peeler) to be used or set in any navigation channel marked by State or Federal agencies and in areas identified by the MFC.
Action 4: Modify existing crab pot area regulations using depth as the boundary instead of distance from shore.
Action 5: Develop guidelines for the DMF and MFC to mediate user conflicts.
Action 6: Establish management areas to address user conflicts.
Action 7: Consider gear licenses or permits for identification and inventory.
Action 8: Consider a pot tagging system for identification and inventory.
Action 9: The MFC should support the establishment of boating safety courses and/or a boat operators license by the WRC for individuals operating any watercraft.
Action 10: Re-examine the times when pots must be moved into designated crab pot areas.

See Appendix 11 (page 131) for an in-depth discussion of the issue and management options.

10.3.2 POTS IN INLAND WATERS

10.3.2.1 Issue/ Purpose The use of crab pots in inland waters.

On March 4, 1998, the WRC tabled a proposal to ban commercial crab pots in inland waters. This was done at the request of the MFC, so that the issue could be addressed in the Blue Crab FMP. The WRC had proposed the ban due to conflicts with sport fishermen.

10.3.2.2 Management Options

1. Maintain existing WRC rules which allow the use of traps (crab pots) in inland waters through special device licenses.
2. Prohibit the use of crab pots in inland waters, except that two may be set from private property.
3. Maintain existing WRC rules, only in inland waters with historical crabbing activity and low recreational pressure.
4. Identify specific waters, with historical crabbing activity and low recreational pressure, that can be reclassified as joint waters.

10.3.2.3 Recommended Management Strategy

The MFC and WRC should work together to identify inland waters with historical crabbing activity and low recreational pressure. Commercial crab potting should continue to be allowed in these selected waters. Additionally, the commissions should work

together to standardize rules for the crab fishery.

10.3.2.4 Actions

Action 1: The joint committee of the MFC and WRC should meet to discuss crab pots and other issues pertaining to the crab fishery and plan a cooperative course of action.
Action 2: DMF and WRC should document the number of crab pots in inland waters weekly (March-November) for one full crabbing season.
Action 3: The WRC should adopt rules for management of the crab fishery in inland waters that are compatible with MFC rules.

See Appendix 12 (page 163) for an in-depth discussion of the issue and management options.

10.4 INCREASING FISHING EFFORT

10.4.1 EFFORT MANAGEMENT

10.4.1.1 Issue/ Purpose Address effort in the crab pot fishery

The general consensus is that although the crab catch fluctuates with environmental conditions, the total number of crab pots and fishermen in the crab pot fishery has been increasing at a rate much greater than the increase in the crab catch itself (Figure 6). The degree of increase varies from one part of the state to another, but some degree of economic inefficiency, social conflict, and possible biological and ecological impact appears to be present in the crab pot fishery throughout the state. Concerns exist about the possible escalation of effort in the crab trawl fishery (hard crab and peeler trawl).

The Blue Crab FMP Advisory Committee (BCAC) endorsed the following statement: Within the currently legislated cap on the new Standard Commercial Fishing License, none of the traditional open-access management alternatives listed below (for example seasons, time, and area restrictions) hold great promise for significantly controlling or reducing the overall effort in the crab pot fishery without severely restricting landings or traditional fishing patterns. The BCAC also agreed that there are too many pots to support economic stability. Therefore, some type of limited entry system has been suggested as an option to control or reduce effort in the fishery (Johnson and Orbach 1996; discussions of the BCAC; crabber organizations).

10.4.1.2 Management Options

10.4.1.2.1 Open Access

1) Management areas;
2) Harvest seasons;
3) Gear restrictions/ reductions (i.e., uniform pot limits);

4) Time restrictions;
5) Catch limits;
6) Delayed entry;
7) Licenses;
8) Permits; and
9) Area restrictions.

10.4.1.2.2 Limited entry

The license cap on Standard Commercial Fishing Licenses (SCFL), as enacted by the FRA (1997), established a limited entry system for North Carolina's commercial fishing industry (effective 1 July 1999). The MFC has no authority to limit entry in the blue crab fishery. The North Carolina General Assembly would have to enact legislation approving any further limited entry in the fisheries or delegate this authority to the MFC.

The following analysis of limited entry options, including a comparison with selected open access options, is taken from Johnson and Orbach (1996) and discussions of the BCAC. The BCAC approved and utilized a list of objectives and criteria (see Appendix 11; Attachment 1) by which to judge the merits of any potential limited entry option. Limited and non-limited entry options are indicated in parentheses.

1. Marketable Crab License Limitation (Limited Entry) -- Under this alternative, licenses to participate in the crab fishery would be issued at the beginning of the system to a number of "initial qualifiers". Initial qualifiers might be those fishermen who had a valid ETS over a qualifying period, probably four years (1994-97, for example), and had landed more than a certain amount of crab, say 500 pounds, in at least two of those four years. After the initial issuance of licenses, the total number of licenses would remain the same; that is, they would not increase above the total number originally issued. Each licensee would be limited to 450 pots. These licenses would be marketable; that is, bought and sold among the fishermen themselves.

   Evaluation: This alternative would control the total number of pots in the fishery, most probably at approximately the level they are now. In terms of fishermen flexibility and social and economic impact, the effects would be generally positive for those with licenses and negative for those without them, and clearly negative for those who currently fish over 450 pots. There would be significant enforcement costs associated with the pot limit, and negative effects from displacement of fishermen into other fisheries (because of the threshold requirements for obtaining initial licenses) and the inability of fishermen to move freely among fisheries.

2. Transferable Two-Stage License Limitation (Limited Entry) -- Under this system, the original distribution of licenses would be done through a one-time opportunity to purchase one of two kinds of licenses. The first, or "full-time transferable" license, would be available for one-time purchase by any fisherman who either: a) had landed more than 7,000 pounds of crab in two of the four years 1994-97, or b) could demonstrate by tax records that he/she had made over 75% of his/her earned income from commercial fishing in the years 1994-97. These licenses would be

transferable either: a) with the sale of a boat; b) to the immediate family of the license holder; or c) by sale to the state separate from the boat. Holders of this license would be limited to 300 pots per licensee or 500 pots per licensee with an apprentice onboard.

The second, or "part-time" license, would be available to any ETS holder who had landed at least 500 pounds in any two of the four years, 1994-97. These licenses would be non-transferable; that is, when the holders of this license gave up fishing, the license would disappear. Thus, this system would eventually eliminate all of this type of license. Holders of this license would be limited to 125 pots per licensee.

New entrants would either have to purchase a boat and license from a licensed fisherman, or serve a two-year apprenticeship with a licensed fisherman. After this apprenticeship, the apprentice would be eligible to purchase a license from the state if any were available.

Evaluation: This alternative would provide a cap on the number of pots at approximately the current level. It would have some displacement effect because of the relatively high level of initial qualifying criteria, and would have a positive impact on those who qualified for the initial licenses in terms of flexibility and social and economic impact, but a negative impact on those who did not. It would be difficult to enforce because of the two different pot limits, and more costly to administer because of continued state involvement in license allocation.

3. License Shares (Limited Entry) -- Under this system each current Crab License holder would be issued license shares in quarter-share increments of 150 pots. A full license (four quarter-shares) would be limited to 600 pots, hard crab and peeler pots combined, in the water at any given time. The initial shares would be issued based on the landings of each fishermen in a qualifying period (1994-97), with quarter, half, three-quarter, and full shares being issued to fishermen based on their historic catch level. Thereafter, licenses would be marketable among the fishermen in quarter-share increments.

Evaluation: This alternative yielded the greatest reduction in the total number of potential pots in the water of the alternatives considered, and would allow fishermen the flexibility to adjust the amount of pots they fished compared to the other limited entry alternatives. It would have some negative effects in terms of fisherman flexibility and social and economic impact because of qualifying thresholds, and the same enforcement and administrative difficulties associated with a pot limit and the need for the state to track the license share sales.

4. Gear Certificates (Limited Entry) -- Under this alternative, each fisherman would be issued certificates for the amount of gear they had used in the fishery under the qualifying period (1994-97, for example). Thus, a fisherman who has used 400 crab pots would be issued gear certificates in those amounts. An appropriate method would be worked out to allow fishermen to transfer these certificates.

Evaluation: On the one hand, this is one option that would actually cap the total number of pots in the fishery. However, it would be extremely difficult to determine how to distribute the original gear certificates to reflect the number of pots each fisherman actually has in use, and would be a costly and complex system to set up, administer, and enforce. It would, however, allow fishermen maximum flexibility in adjusting their fishing operations and allow new entrants to enter the fishery at relatively low cost.

5. The Status Quo (Non-Limited Entry) -- This is the "no change" alternative, meaning that the management systems currently in place for the crab pot fishery would remain in effect with no changes, with one important note: *The moratorium, and the crab license, would no longer be in place*. At some point we either have to let the moratorium expire and go back to the open access situation (within the new limitations of the cap on SCFLs), or design a new system which might more directly control access and effort.

Evaluation: This option was evaluated negatively across all criteria. It was assumed that the number of pots, and perhaps fishermen, in the pot fishery would increase, increasing conflict, enforcement problems, reducing efficiency in the fishery, and creating potential negative environmental effects.

6. One-time Purchase Without Transfer (Limited Entry) -- Under this system all fishermen with a current Endorsement to Sell would be given the opportunity, during one 30-day period, to purchase a Crab or Crab Vessel License. After that 30-day period, the number of licenses that had been sold would be the capped number. Each licensee would be allowed to fish 300 pots, or up to 900 pots with three licensees onboard. These licenses would not be transferable; when the fisherman gave up the license, it would revert to the state. Licenses would be re-issued only to those who had served a two-year apprenticeship with a licensed crab fisherman.

Evaluation: This alternative would allow a potentially significant increase in the number of authorized pots, and would have the same difficulties in enforcement and administration associated with both a pot limit and the continued involvement of the state in license allocation. There would be some displacement of fishers into other fisheries, and negative impact on those fishermen who currently fish over 300 pots. Fishermen flexibility would be reduced because of the non-transferability of the license.

7. License Choice (Non-Limited Entry) -- Under this system, fishermen would have to choose between two basic licenses: A Standard Commercial Fishing License, which would be good for anything except crab pots; and a Crab License, which would be good for only crab pots, and which would be available to only those fishermen who had made ETS landings on 120 days of the previous year.

Holders of either the SCFL or the Crab License, however, would be allowed to purchase a temporary license to fish in the other fishery (SCFL in crab, or crab in other fisheries) for up to 60 days each year.

Crab License holders, or Temporary Crab License holders, would be allowed to fish up to 400 pots per licensee.

Evaluation: This alternative would not control or reduce the number of pots potentially in the water and allow flexibility for fishermen. It would be difficult to administer and have the same enforcement and administration costs associated with a pot cap and the continued involvement of the state in issuing licenses.

8. Time Slot Tag Purchase (Non-Limited Entry) -- Under this system any fisherman possessing a SCFL would be allowed to purchase a crab pot endorsement and an unlimited number of pot tags, but only during the period July 1-July 31 of each year.

Evaluation: This alternative would not control or reduce effort in the pot fishery, and would have the same administrative and enforcement difficulties associated with a pot limit.

9. Uniform Two-Stage Limit on the Number of Pots per Fisherman (SCFL) (Non-Limited Entry) -- Under this alternative, each owner/operator (the owner is on the boat at all times when it is crab fishing) fishing crab pots would be limited to a total of 600 pots in the water at any one time, while a non-owner/operator would be limited to 300 pots in the water at any one time.

Evaluation: This alternative would not control or reduce effort in the pot fishery and would have the same administrative and enforcement difficulties associated with a pot limit.

10. Gear Certificates Based on Historical Landings (Restricted Entry) -- Under this alternative, each commercial license holder would be issued pot certificates in increments based on individual overall commercial Trip Ticket landings (all species combined) or blue crab landings during a specific qualifying period (4 years). The license holder would decide on the method of qualification (overall or crab landings). An appropriate and equitable method of allocation could be based on an average daily catch-per-pot for the fishery statewide. To recognize those licensees with a history of participation in the crab fishery, crab landings could qualify a license holder at a higher level than overall landings. Certificates would not be transferable among licensees. A maximum level could be placed on the units of gear used statewide and/or per license to address biological, social, and economic issues. A licensee could advance to a higher level based on an average of the previous 4-years crab landings, unless an overall gear cap is established. An entry level allocation would need to be addressed for new licensees.

Evaluation: This option was not evaluated by the BCAC. This option may or may not cap the total gear units within the fishery depending on the specific strategy adopted. However, it could reduce pot numbers through an equitable means of distribution of gear certificates based on an average catch-per-pot in relation to the number of pots that would be necessary to achieve a specific historical landing

level. It would be complex to set up, administer, and enforce. This system would allow all license holders to participate at some level in the crab pot fishery through an equitable landings based distribution of gear units.

Different combinations of these alternatives would also be possible. For example, a license limitation system could be combined with a trap certificate system.

10.4.1.3 Recommended Management Strategy

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. No specific strategy for a continued open access or limited entry system to manage effort in the crab fishery is proposed at this time. The legislated time frame to develop the blue crab FMP did not allow for an effort management system to be fully developed for this fishery. Therefore, the crab licenses and license moratorium should be extended for one more year (until 1 July 2000) to allow for the development of an effort management system. Any option to reduce effort should provide an appropriate means to allow flexibility within the fishing community (future holders of the limited SCFL); minimize exclusive privileges and avoid monopolies; control or reduce effort in the crab fishery; and make management of the crab fishery more efficient and effective. Any strategy recommended should meet objectives 2, 3, 4, 5, 9, and 10 of this plan.

10.4.1.4 Actions

Action 1: Extension of the crab licenses and license moratorium until 1 July 2000.
Action 2: Ongoing discussion of options.
Action 3: The MFC Crustacean Committee and Blue Crab Advisory Committee are charged with continuing the discussion of effort management options for the blue crab fishery and making a final recommendation to the MFC by 1 May 1999. The MFC will make a final recommendation to the N.C. General Assembly on effort management as an amendment to the Blue Crab FMP on or before 1 July 1999.

See Appendix 11 (page 131) for an in-depth discussion of the issue and management options.

10.4.2 RECREATIONAL COMMERCIAL GEAR LICENSE (RCGL) and EXEMPTION

10.4.2.1 Issue/ Purpose Determine blue crab gear limits for recreational fishermen using commercial gear.

On July 1, 1999, a new license for recreational fishermen using commercial gear will go into effect [Recreational Commercial Gear License (RCGL)]. Prior to the implementation of this license, the MFC is required by the FRA (1997) to adopt rules authorizing the use of limited amounts of commercial equipment by RCGL-holders. These limits may be imposed on a uniform basis for all coastal fishing waters or may vary for

various geographical areas. Additionally, gear used by RCGL-holders shall be identified by colored tags or other means to distinguish between commercial and recreational users of commercial gear. The FRA also states that recreational creel limits will apply to species harvested with the RCGL.

10.4.2.2 Management Options

Specific recommendations and questions that need to be addressed for harvesting blue crabs with the RCGL are:

1. Number of pots.
    - 1a) Should there be a pot limit for crab pots attached to privately owned shoreline or pier?
    - 1b) How many pots should be allowed under a RCGL license?
2. Crab trawl.
    - 2a) Should RCGL-holders be allowed to use a crab trawl?
    - 2b) Allow only single-rigged boats? Double-rigged? Is headrope length the limit per trawl, or total combined length for double-rigged boats? Should mechanical retrieval methods be allowed?
3. Tag or buoy color.
4. Recreational catch limit?
5. Definitions of commercial and non-commercial gear?

10.4.2.3 Recommended Management Strategy

The specific number of pots allowed for RCGL-holders will be five per person or vessel. Individuals (not possessing a RCGL) setting crab pots from privately owned shore or a pier will be limited to one pot per person and will be required to follow all gear marking requirements imposed on RCGL-holders. Crab trawls should not be considered as a gear for RCGL-holders. Buoys for all recreational pots shall be hot pink and engraved with the full name of the fisher. DMF shall select a buoy shape for recreational gear. Define collapsible crab traps as non-commercial gear, and a RCGL would not be required. Existing non-commercial catch limits will apply to the recreational harvest of blue crabs. The current limit is 50 legal crabs per person per day, not to exceed 100 per vessel per day.

10.4.2.4 Actions

Action 1: Limit RCGL-holders to five pots per person or vessel.
Action 2: Individuals setting pots from privately owned shoreline or piers will be limited to one pot per person.
Action 3: Require engraved (full name), hot pink buoys on recreational pots.
Action 4: Select a buoy shape for recreational pots.
Action 4: Prohibit the use of crab trawls by RCGL-holders.
Action 5: Define collapsible traps as non-commercial gear; no license required.

See Appendix 13 (page 167) for an in-depth discussion of the issue and management options.

10.5 INSUFFICIENT ASSESSMENT DATA

10.5.1 Issue/ Purpose

Data needed to accurately assess the blue crab stock and fishery.

Before 1995, DMF did not have a stock assessment program specifically for blue crabs, although limited information was collected through other programs. Realizing the increasing importance of the blue crab fishery to the coastal economy, crabbers petitioned the North Carolina General Assembly in 1994 to allocate funding specifically for a crab assessment project. The resulting program is focusing on the establishment of fishery-dependent and -independent databases coastwide.

10.5.2 Research needs

1. Catch/effort data from the commercial fisheries.
2. Catch/effort data from the recreational fishery.
3. Annual estimates of spawning stock biomass.
4. Blue crab distribution and abundance patterns.
5. Recruit-stock and stock-recruitment relationships.
6. Crab mortality rates.
7. The relationship between crab abundance and commercial harvest.
8. Develop bycatch (blue crab) reduction devices for the shrimp trawl fishery.
9. Blue crab bycatch estimates from other fisheries.
10. Bycatch reduction of non-target species in the blue crab fisheries.
11. Collect necessary social and economic data.

10.5.3 Data needs

1. Collect information on the expanding crab shedding industry. Establish a license or permit to identify individual shedding operations.
2. Establish harvesting and/or gear licenses or permits to collect information on participation.
3. Obtain blue crab recreational harvest data.

10.5.4 Recommended Management Strategy

The MFC and DMF should prioritize research needs and implement actions to accomplish the identified research and data needs. Licenses and/or permits should be implemented to identify participants and quantify activities and gear usage in the blue crab fisheries.

10.5.5 Actions

Action 1: Prioritize research needs and implement actions to secure funding and accomplish research.

Action 2: Implement licenses (N.C. General Assembly) and/or permits (MFC) for shedding

operations, harvest, and/or gears associated with the blue crab fisheries.

10.6 SUMMARY OF MANAGEMENT ACTIONS

10.6.1 Rules (new, modifications, or technical changes)

1. Modify current crab spawning sanctuary rules to prohibit commercial fishing gear (excluding attended gill nets) in sanctuaries during March 1 - August 31.

2. Require sinking lines on all crab pot buoys.

3. Prohibit the baiting of peeler pots, except with live legal male blue crabs.

4. Repeal the exemption for culling peelers before reaching shore or dock in the hard crab fishery.

5. Prohibit the possession of male "white line" peelers from June - September.

6. Change the unattended pot rule from the existing 10 day period to 7 days.

7. Make it unlawful for pots (hard and/or peeler) to be used or set in any navigation channel marked by State or Federal agencies and in areas identified by the MFC.

8. Modify existing crab pot area regulations using depth as the boundary instead of distance from shore.

9. Implement requirements for recreational pots (number, buoy color, shape, and marking).

10. Define collapsible traps as non-commercial gear; no license required.

11. The MFC, CRC, and EMC should adopt rules to protect blue crab critical habitats as outlined in the Coastal Habitat Protection Plans.

12. Establish a permit (MFC) to identify individual shedding operations.

13. Establish gear permits (MFC) for identification and inventory.

10.6.2 Legislative Action

1. Extend the crab licenses (G.S.113-153.1) and license moratorium for one year (until July 1, 2000).

2. Provide Marine Patrol with statutory authority to deal with theft.

3. Establish a license to identify individual shedding operations.

4. Establish gear licenses for identification and inventory.

10.6.3 Processes

1. Develop criteria for using proclamation authority to close or not require escape rings for mature female and peeler crab harvest.

2. Suggest a 4 inch or 4.5 inch stretched mesh for crab trawls in all coastal waters where crab trawling is allowed.

3. Establish definitions for peeler and hard crab trawls.

4. DMF should recommend a maximum allowable bycatch of crabs for shrimp trawls.

5. Develop guidelines for the DMF and MFC to mediate user conflicts.

6. Consider a pot tagging system for identification and inventory.

7. Re-examine the times when pots must be moved into designated crab pot areas.

8. The joint committee of the MFC and WRC should meet to discuss crab pots and other issues pertaining to the crab fishery and plan a cooperative course of action.

9. The MFC should support the establishment of boating safety courses and/or a boat operators license by the WRC for individuals operating any watercraft.

10. Establish a process to develop management areas to address biological issues and user conflicts.

11. The MFC Crustacean Committee and Blue Crab Advisory Committee are charged with continuing the discussion of effort management options for the blue crab fishery and making a final recommendation to the MFC by 1 May 1999. The MFC will make a final recommendation to the N.C. General Assembly on effort management as an amendment to the Blue Crab FMP on or before 1 July 1999.

12. Identify and protect blue crab critical habitat.

13. Request that the EMC review "Nutrient Sensitive Waters", "High Quality Waters", and "Outstanding Resource Waters" designations for the coastal river basins and implement additional strategies as needed.

14. Work with the permitting and commenting agencies to enhance protection of water quality, wetlands, and estuarine habitats.

15. Management Actions as outlined in the Water Quality Plan (Appendix 1) of the Albemarle - Pamlico Estuarine Study Comprehensive Conservation and

Management Plan (EPA and DEHNR 1994) should be expanded to all river basins that drain to North Carolina's coastal region.

16. Management Actions as outlined in the Vital Habitats Plan (Appendix 1) of the Albemarle - Pamlico Estuarine Study Comprehensive Conservation and Management Plan (EPA and DEHNR 1994) should be expanded to all river basins that drain to North Carolina's coastal region.

17. Select a buoy shape for recreational pots.

10.6.4 Management Related Research (ranked in order of priority)

1. Investigate the impacts of trawling on various habitats.

2. Develop bycatch reduction devices for blue crabs in the shrimp trawl fishery.

3. Conduct a survey of existing and potential sanctuary areas to determine population levels and to see if these areas function as spawning grounds.

4. Conduct research on biodegradable panels:
    a. Test galvanic time release devices, natural twine, and non-coated steel (24 gauge or less) across a wide range of salinities.
    b. Determine the optimal panel location for finfish and crab escapement.
    c. Determine minimum panel size for blue crab and finfish escapement.
    d. Determine desired release time for blue crabs and finfish.

5. Determine optimum escape ring size for various geographic areas.

6. Determine blue crab bycatch estimates from other fisheries.

7. Determine bycatch and evaluate reduction of non-target species in the blue crab fisheries.

8. Conduct tailbag mesh size studies in Pamlico Sound (work being conducted during 1998 and 1999 through a grant funded by the Fisheries Resource Grant Program).

9. DMF and WRC should document the number of crab pots in inland waters weekly (March-November) for one full crabbing season.

10. Investigate the use of reflective tape on crab pot buoys.

11. Collect fishery-dependent data from the peeler crab and shrimp trawl fishery.

12. Collect baseline data on the composition, quantity, and fate of unmarketable finfish bycatch in the crab pot (hard and peeler) fishery, by season and area.

13. If needed, develop a finfish bycatch reduction device for hard and peeler crab pots.

14. Conduct an assessment of crab pot bycatch and diamondback terrapin mortality by season and area, including fishermen observations.

15. Assess diamondback terrapin excluder devices and/ or potential pot modifications.

16. Determine shedding mortality rates by peeler stage, area, and season.

17. Develop and implement practices for more effective shedding practices to minimize mortality.

18. Examine the biological issues of small peeler/soft crab harvest and quantify the results.

10.6.5 Biological Research Needs (ranked in order of priority)

1. Determine annual estimates of spawning stock biomass.

2. Determine blue crab distribution and abundance patterns.

3. Determine blue crab mortality rates.

4. Determine the extent, causes, and impacts of hypoxia and anoxia on blue crab behavior and population abundance in North Carolina's estuarine waters.

5. Determine recruit-stock and stock-recruitment relationships.

6. Determine catch/effort data from the recreational fishery.

7. Determine catch/effort data from the commercial fisheries.

8. Determine the relationship between crab abundance and commercial harvest.

9. Conduct research on the water quality impacts of crab pot zincs, bait discard, and alternative crab baits in the pot fishery.

10. Further investigate the impact or potential impact of escape rings on crab size.

11. Collect information on diamondback terrapin distribution

10.6.6 Social and Economic Research Needs (ranked in order of priority)

1. Costs and earnings data collection for the harvesting sector.

2. Demographic data of harvesters (e.g., household size, income, experience, etc.).

3. Processing and wholesaling data collection.

4. Socio-economic data collection of recreational fishing.

5. Investigate the economic and social impacts of the crab trawl fishery.

6. Determine the importance of "white line" peelers to the economics of the fishery and examine related enforcement issues.

7. Examine the economic and biological issues involved in small peeler/soft crab harvest and quantify the results.

8. Collect economic information on the harvest of poor quality white belly crabs.

10.6.7 Data Needs

1. Separate hard and peeler crab trawl landings on trip tickets.

2. Collect information on the expanding crab shedding industry.

3. Obtain estimates of the recreational harvest of blue crabs.

4. Enumerate the number of crab fishermen, commercial and recreational.

10.6.8 Education

1. Educate crab potters on diamondback terrapin bycatch and potential solutions.

2. Conduct education efforts on problems associated with the use of chlorine pot antifoulants (HTH®) and the surface water discharge of these solutions, which is prohibited by federal and state laws.

10.6.9 Rule Changes other agencies

1. The WRC should adopt rules for management of the crab fishery in inland waters that are compatible with MFC rules.

10.6.10 Secure funding

1. Management Actions as outlined in the Vital Habitats and Water Quality Plans (Appendix 1) of the Albemarle - Pamlico Estuarine Study Comprehensive Conservation and Management Plan (EPA and DEHNR 1994) should receive priority for funding and be completed in a timely manner.

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12. TABLES AND FIGURES

Table 1. Reported North Carolina hard crab landings by crab pot, 1994 - 1997*.

Water	Total landings for water	Percent of total landings
Pamlico Sound	52,619,477	25.51
Albemarle Sound	52,542,225	25.47
Pamlico River	27,320,880	13.24
Neuse River	14,972,944	7.26
Bay River	11,146,494	5.40
Currituck Sound	9,750,267	4.73
Croatan Sound	7,400,993	3.59
Core Sound	6,518,981	3.16
Alligator River	5,607,567	2.72
Pungo River	4,697,178	2.28
Roanoke Sound	3,722,062	1.80
Cape Fear River	2,509,768	1.22
Newport River	1,379,117	0.67
Inland Waterway	1,265,005	0.61
Bouge Sound	902,747	0.44
New River	867,477	0.42
Pasquotank River	569,368	0.28
Stump Sound	543,785	0.26
Masonboro Sound	483,321	0.23
Topsail Sound	471,223	0.23
White Oak River	390,330	0.19
North River	241,265	0.12
Perquimans River	109,390	0.05
Lockwood Folly	65,176	0.03
Shallotte River	64,010	0.03
Chowan River	63,807	0.03
Ocean < 3 mi	28,969	0.01
Back Bay (VA)	26,132	0.01
Roanoke River	1,187	0.00
Ocean > 3 mi	728	0.00
Ocean < 3 mi, S Cape Hatteras	717	0.00
Unknown	118	0.00

* NCDMF Trip Ticket Data.

Table 2. Average crab trawl landings (pounds) by waterbody for selected species and groups, North Carolina, 1994 - 1997.

	Blue crab									Total	Total	Total
	Hard	Peeler	Soft	Catfish	Croaker	Flounder	Sea mullet	Spot	Weakfish	finfish	Inverts.	catch
Albemarle Sound												
Average	2,897	17	1	0	2	49	0	7	1	60	2,915	2,975
% of total species	0.13	0.11	0.03	0.00	0.16	0.06	0.02	0.77	0.11	0.06	0.12	0.12
Bay River												
Average	170,704	28	15	1	11	1,234	3	10	33	1,309	170,752	172,060
% of total species	7.38	0.18	0.31	0.01	1.11	1.51	0.29	1.19	2.90	1.32	7.26	7.02
Bogue Sound												
Average	56	100	0	0	0	24	0	0	0	24	156	180
% of total species	0.00	0.64	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.02	0.01	0.01
Chowan River												
Average	43	0	0	0	0	0	0	0	0	0	48	48
% of total species	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Core Sound												
Average	85,488	9,200	990	0	10	756	14	0	0	1,089	107,415	108,504
% of total species	3.70	58.60	20.79	0.00	1.08	0.92	1.25	0.00	0.02	1.09	4.57	4.43
Croatan Sound												
Average	168,208	1,994	302	82	137	2,967	26	400	44	3,755	170,538	174,293
% of total species	7.27	12.70	6.34	0.85	14.39	3.63	2.32	47.18	3.94	3.78	7.25	7.11
Lockwood Folly												
Average	410	0	0	0	0	0	0	0	0	0	410	410
% of total species	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02
Ocean < 3 mi, N of Cape Hatteras												
Average	19	0	0	0	0	0	0	0	0	0	19	19
% of total species	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ocean < 3 mi, S of Cape Hatteras												
Average	12	0	0	0	0	0	0	0	0	0	12	12
% of total species	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ocean < 3 miles												
Average	351	3	0	0	0	0	0	0	0	97	386	483
% of total species	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.02	0.02
Ocean > 3 miles												
Average	623	3	0	0	0	283	6	0	0	289	637	926
% of total species	0.03	0.02	0.00	0.00	0.00	0.35	0.52	0.00	0.00	0.29	0.03	0.04
Neuse River												
Average	222,838	2,139	1,290	81	5	2,771	10	28	23	2,944	226,360	229,304
% of total species	9.63	13.62	27.08	0.84	0.53	3.39	0.92	3.29	2.07	2.96	9.62	9.35
New River												
Average	21,486	31	9	0	0	564	0	42	0	611	22,697	23,308
% of total species	0.93	0.20	0.18	0.00	0.00	0.69	0.00	4.93	0.00	0.61	0.96	0.95
Newport River												
Average	1,669	0	0	0	0	13	0	0	0	13	1,679	1,692
% of total species	0.07	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.01	0.07	0.07
Pamlico River												
Average	413,094	452	905	8,570	54	19,309	45	63	543	30,068	414,475	444,543
% of total species	17.86	2.88	19.01	89.36	5.68	23.63	4.08	7.38	48.14	30.23	17.62	18.13
Pamlico Sound												
Average	1,059,257	736	316	562	617	47,126	1,004	242	384	51,880	1,066,100	1,117,980
% of total species	45.79	4.69	6.64	5.86	64.93	57.66	90.56	28.58	34.04	52.16	45.32	45.59

Table 2. Continued

	Blue crab									Total	Total	Total
	Hard	Peeler	Soft	Catfish	Croaker	Flounder	Sea mullet	Spot	Weakfish	finfish	Inverts.	catch
Topsail Sound												
Average	15	0	0	0	0	0	0	0	0	0	15	15
% of total species	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
White Oak River												
Average	22	0	0	0	0	1	0	0	0	1	22	23
% of total species	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
North River												
Average	296	2	0	0	0	0	0	0	0	0	298	298
% of total species	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Roanoke Sound												
Average	21,013	984	930	5	4	351	0	51	8	443	22,927	23,369
% of total species	0.91	6.27	19.54	0.05	0.39	0.43	0.02	6.00	0.71	0.45	0.97	0.95
Inland waterway												
Average	225	0	0	0	0	0	0	0	0	0	225	225
% of total species	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Pungo River												
Average	144,452	13	4	290	112	6,278	0	6	91	6,874	144,469	151,343
% of total species	6.24	0.08	0.08	3.02	11.74	7.68	0.00	0.69	8.06	6.91	6.14	6.17
Total												
Overall average	2,313,174	15,700	4,763	9,590	950	81,725	1,108	847	1,128	99,455	2,352,553	2,452,008
% of total catch	94.34	0.64	0.19	0.39	0.04	3.33	0.05	0.03	0.05	4.06	95.94	
% of total finfish catch				9.64	0.96	82.17	1.11	0.85	1.13			

* 1994 - 1997 NCDMF Trip Ticket Program

Table 3. Commercial value (dollars) of hard, peeler and soft blue crabs landings, North Carolina, 1972-1997.

Year	Hard blue crabs				Peeler and soft crabs			
	Current value	Real value*	Current price/lb	Real price/lb*	Current value	Real value*	Current price/lb	Real price/lb*
1972	1,345,159	3,558,622	0.10	0.26	29,186	77,212	0.59	1.55
1973	1,536,873	3,400,162	0.13	0.28	27,762	61,420	0.61	1.36
1974	1,373,499	2,837,808	0.10	0.22	23,130	47,789	0.69	1.43
1975	1,454,456	2,807,830	0.13	0.25	16,996	32,811	0.84	1.62
1976	2,405,635	3,729,667	0.21	0.32	26,549	41,161	1.32	2.05
1977	2,148,346	3,082,275	0.18	0.25	17,000	24,390	1.06	1.53
1978	4,326,084	5,838,170	0.18	0.25	89,718	121,077	1.92	2.59
1979	4,622,539	5,085,301	0.17	0.19	129,908	142,913	1.62	1.78
1980	5,975,221	6,805,491	0.17	0.20	132,448	150,852	1.51	1.72
1981	8,172,428	9,141,418	0.22	0.24	100,860	112,819	1.30	1.45
1982	7,184,748	7,184,748	0.19	0.19	296,838	296,838	2.00	2.00
1983	8,444,863	8,012,204	0.24	0.23	188,223	178,580	2.15	2.04
1984	6,664,731	5,913,692	0.21	0.18	276,302	245,166	1.38	1.23
1985	6,089,982	5,314,120	0.21	0.18	350,373	305,736	1.07	0.94
1986	5,429,534	4,347,105	0.23	0.19	684,822	548,296	1.15	0.92
1987	7,345,210	5,246,579	0.23	0.17	2,263,437	902,455	1.91	1.36
1988	10,211,661	6,867,291	0.29	0.20	921,403	619,639	1.97	1.32
1989	8,790,304	6,151,367	0.26	0.18	1,567,298	1,096,780	1.99	1.39
1990	9,156,390	6,220,374	0.25	0.17	2,136,942	1,451,727	1.97	1.34
1991	9,154,358	6,123,316	0.22	0.15	1,389,140	929,191	1.84	1.23
1992	12,836,836	8,223,470	0.23	0.20	996,904	638,632	1.78	1.14
1993	14,262,152	9,113,196	0.33	0.21	1,515,569	968,415	1.88	1.20
1994	26,896,282	16,664,363	0.51	0.32	2,703,997	1,675,339	2.16	1.34
1995	33,053,805	19,352,345	0.73	0.43	3,372,149	1,974,326	2.19	1.28
1996	39,873,692	24,034,775	0.61	0.37	3,168,873	1,910,110	2.27	1.37
1997	33,236,425	18,661,665	0.61	0.34	4,520,219	2,538,023	2.60	1.50

* Base year 1982 = 100.

Source: DMF Trip Ticket Program.

Table 4. Reported income by North Carolina's individual commercial fishermen[1] and commercial fishing businesses in 1997.

Dockside sales ($)	All fishing sales ($) including crabbing		Average sales ($) by fishery		
	Percent	Average	Hard blue crabs	Peeler & soft crabs	Others species
Under $500	12	222	157	25	40
500-1,000	5	730	416	61	253
1,001-2,000	6	1,463	752	80	631
2,001-3,000	4	2,464	1,039	167	1,258
3,001-4,000	3	3,456	1,396	211	1,850
4,001-5,000	2	4,516	2,420	245	1,851
5,001-10,000	12	7,292	3,422	592	3,279
10,001-20,000	16	14,831	8,560	1,114	5,157
20,001-30,000	11	24,688	14,910	1,624	8,154
30,001-40,000	8	34,511	23,173	3,054	8,285
40,001-50,000	6	45,064	29,128	3,125	12,811
50,001 and up	15	102,485	40,920	6,266	55,299
Average	100	27,069	13,385	1,820	11,863

[1] Individual commercial fisherman with multiple ETS was considered as one entity.

Source: DMF Trip Ticket Program.

Table 5. Production and employment for crab processing in North Carolina, 1980-1996.

		Employment			
Year	# Plants	Average	Seasonal	Production (lb)	Value ($)
1980	32	896	983	8,727,429	18,102,153
1981	33	1,098	1,167	9,160,252	21,944,290
1982	34	1,063	1,176	10,259,198	24,268,060
1983	33	1,276	1,359	10,808,337	29,704,413
1984	37	1,162	1,260	10,828,797	28,647,864
1985	39	1,402	1,506	11,899,089	36,414,169
1986	39	1,304	1,397	10,083,441	27,785,930
1987	37	1,133	1,190	11,216,287	32,499,354
1988	37	1,176	1,237	9,511,037	27,532,189
1989	35	998	1,095	8,900,778	23,203,338
1990	35	1,001	1,128	9,428,868	29,149,734
1991	37	1,104	1,227	10,818,353	29,903,637
1992	37	1,082	1,170	9,400,788	28,207,831
1993	35	1,091	1,279	10,087,800	39,377,950
1994	36	1,040	1,221	9,992,450	45,368,550
1995	30	864	908	8,001,545	35,431,381
1996	28	884	919	9,970,389	40,663,461

Source: National Marine Fisheries Service.

Table 6. Unemployment rates in selected coastal counties, North Carolina, 1994-1997.

County	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Beaufort	1994	7.2	7.7	7.4	6.0	7.6	8.4	5.9	5.5	5.7	5.6	5.7	6.3	6.6
	1995	8.8	8.6	8.1	7.8	7.7	7.7	6.8	13.9	6.5	6.8	7.8	8.6	8.3
	1996	9.7	13.2	9.6	11.5	7.7	7.3	7.3	6.3	5.8	5.8	6.4	5.8	8.0
	1997	6.9	6.4	5.7	7.3	7.4	7.7	7.7	7.6	7.0	7.0	7.5	8.2	7.2
Carteret	1994	9.4	9.3	7.6	5.4	4.3	4.0	3.7	4.4	4.2	4.5	5.6	6.8	5.8
	1995	9.9	8.9	7.1	5.6	4.5	3.9	3.5	4.1	3.9	4.2	6.2	7.1	5.7
	1996	8.1	8.1	6.2	3.9	3.1	3.2	3.5	3.4	3.7	3.8	5.8	6.0	4.9
	1997	7.7	6.2	4.6	3.4	3.0	3.2	2.6	3.4	3.2	4.2	5.5	6.9	4.5
Dare	1994	17.3	15.8	10.6	3.8	2.8	2.5	1.9	1.9	2.0	2.7	4.3	10.1	5.8
	1995	17.6	15.0	9.5	4.3	2.5	2.5	1.5	1.5	1.8	2.7	6.1	12.6	5.9
	1996	18.1	17.1	10.5	3.9	2.5	2.0	1.5	1.5	1.6	2.3	5.4	10.7	5.8
	1997	17.9	14.4	8.5	3.1	2.3	2.1	1.4	1.5	1.6	2.4	5.7	12.9	5.7
Hyde	1994	21.2	21.9	16.7	9.1	7.0	5.6	5.0	5.1	5.4	5.5	8.3	15.4	9.9
	1995	21.5	23.9	15.9	10.1	6.0	5.8	4.1	4.5	3.9	3.9	10.1	18.4	10.0
	1996	20.3	21.8	16.4	9.8	7.3	5.2	4.0	3.8	4.2	4.2	8.8	13.0	9.2
	1997	18.9	15.8	11.2	6.4	4.6	3.7	2.9	3.9	2.6	2.3	7.6	12.7	7.2
Pamlico	1994	8.7	9.1	7.8	4.8	3.9	4.4	4.3	4.5	4.8	5.2	5.8	4.7	5.6
	1995	10.9	11.2	10.7	9.3	4.6	4.5	3.0	3.9	3.3	4.4	3.5	3.5	6.1
	1996	8.0	8.9	8.9	8.9	3.9	3.8	2.7	3.1	3.0	3.0	4.6	2.8	5.2
	1997	5.5	5.7	3.0	4.3	3.3	4.6	3.0	3.6	3.5	3.7	5.5	3.8	4.2
Tyrrell	1994	15.9	16.0	11.7	9.5	7.5	4.0	4.6	2.4	3.6	7.9	10.5	15.1	8.4
	1995	20.1	19.3	13.2	7.3	6.7	5.4	6.0	5.7	6.3	6.4	14.9	17.7	10.2
	1996	21.9	18.4	13.7	9.0	7.5	6.7	4.1	3.3	3.7	5.2	12.1	13.6	9.5
	1997	19.7	15.8	9.2	7.1	5.5	4.4	4.2	3.2	3.2	4.6	14.5	14.5	8.4
Statewide	1994	5.0	5.0	4.5	4.0	4.2	4.6	4.6	4.5	4.1	4.2	4.1	3.6	4.4
	1995	4.5	4.7	4.2	4.0	4.3	4.7	4.7	4.4	4.0	4.1	4.3	4.2	4.3
	1996	5.6	5.0	4.5	4.3	4.3	4.7	4.5	4.1	3.8	3.9	3.9	3.5	4.3
	1997	4.3	4.1	3.5	3.2	3.5	4.0	3.9	3.6	3.2	3.3	3.5	3.3	3.6

Source: Labor Market Information, Employment Security Commission of North Carolina.

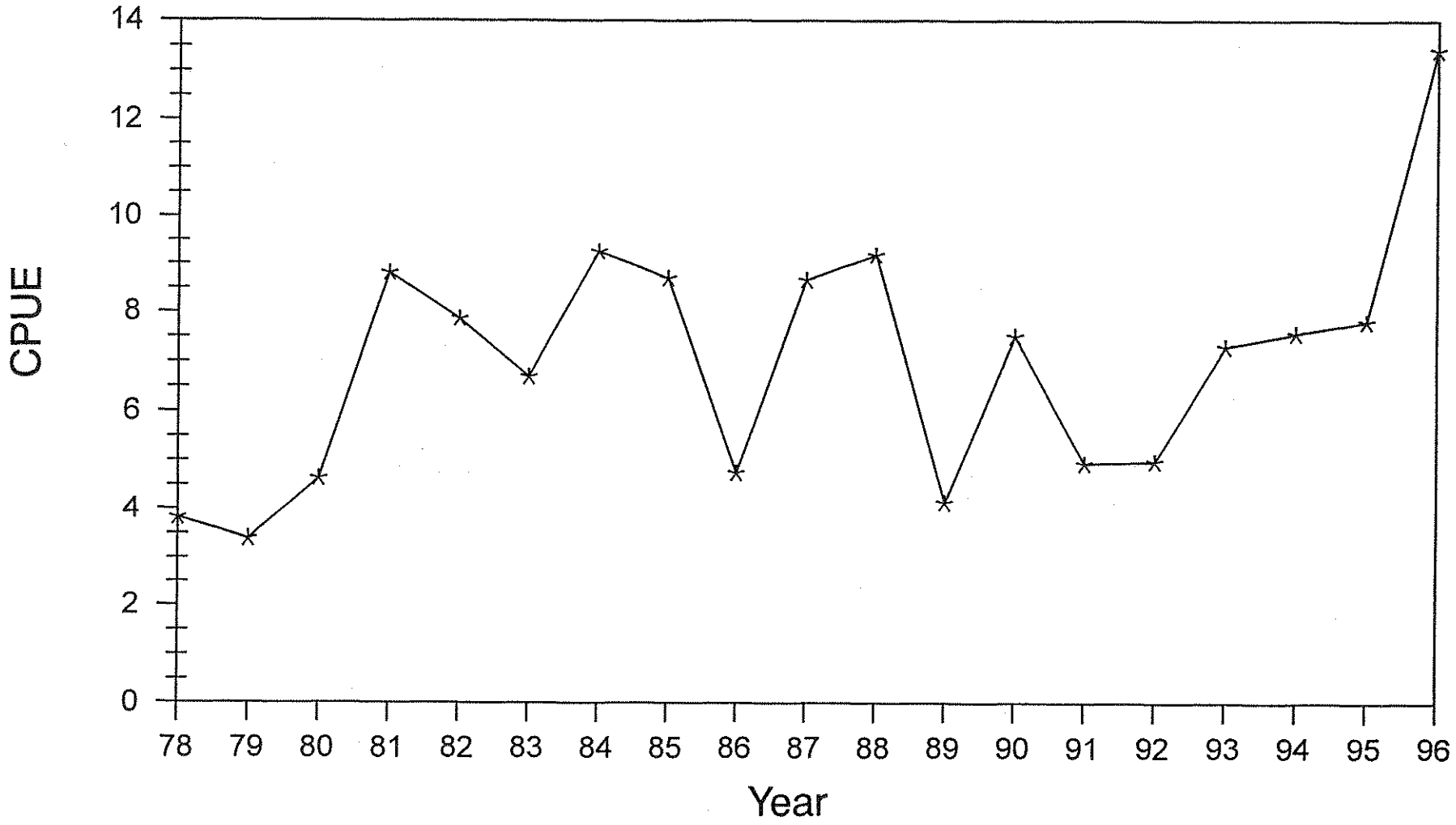

Figure 1. North Carolina juvenile blue crab (<60 mm) indices of abundance, 1978-1996.

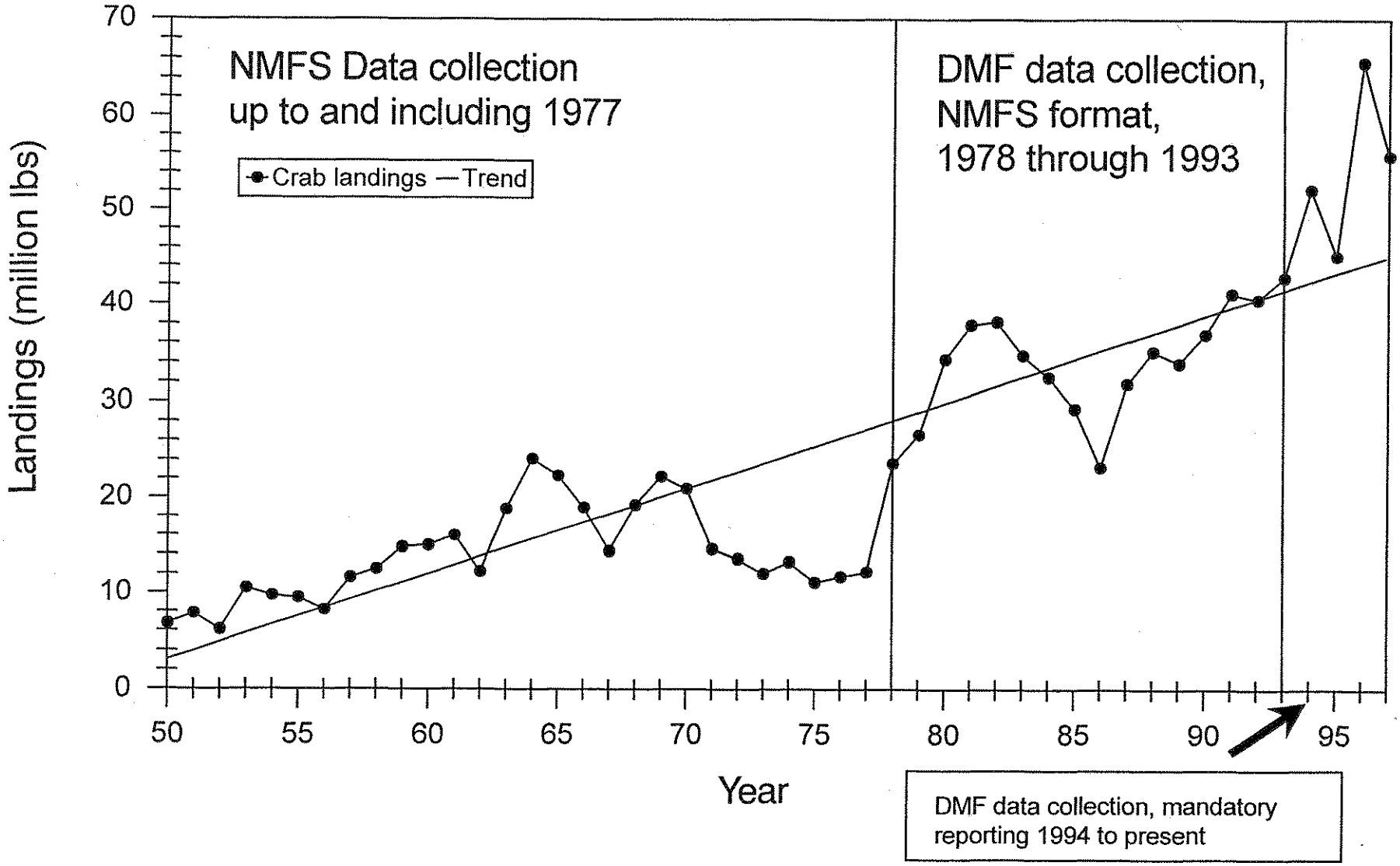

Figure 2. North Carolina hard blue crab landings, 1950-1997.

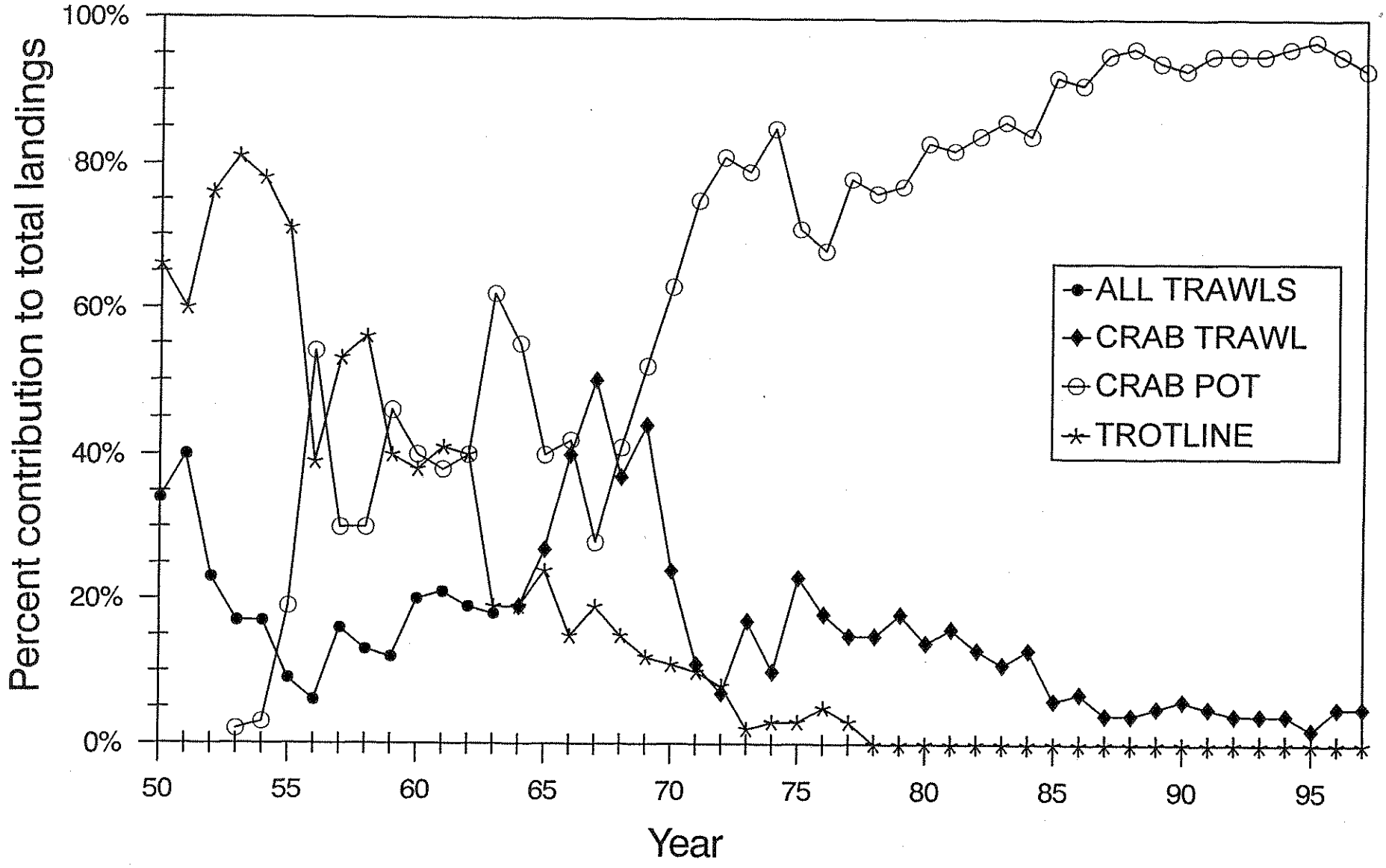

Figure 3. North Carolina hard blue crab landings by gear, 1950-1997.

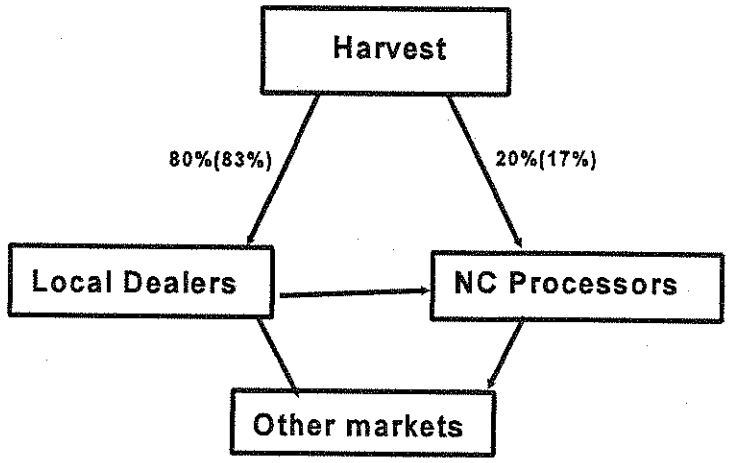

Figure 4. Flow of North Carolina blue crab harvest (value) in 1997.

Source: NC DMF Trip Ticket Program.

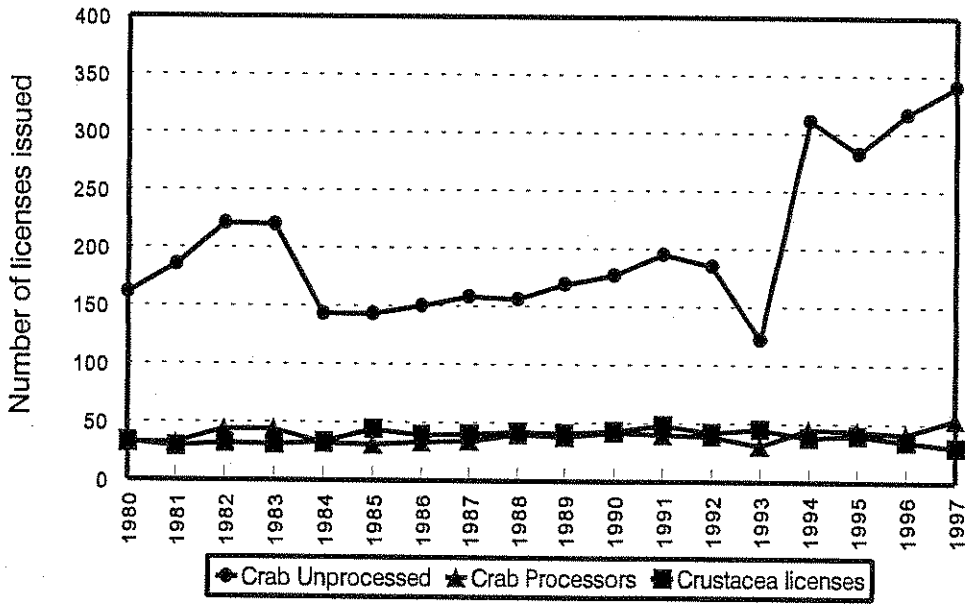

Figure 5. Unprocessed and processed DMF crab licenses, and Shellfish Sanitation crustacea licenses issued, NorthCarolina, 1980-1997.

Source: DMF and Shellfish Sanitation license data

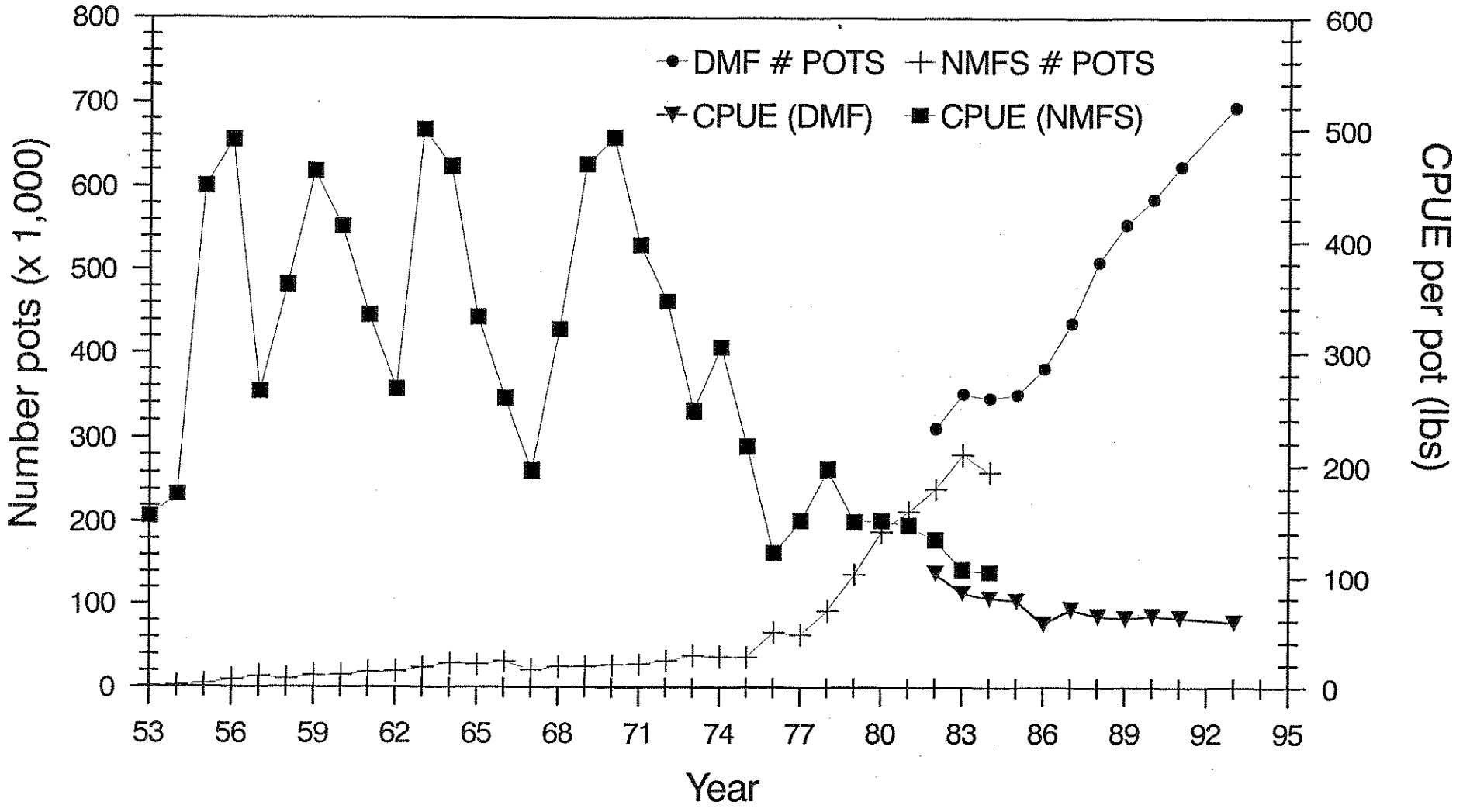

Figure 6. Number of Operating Units and CPUE for the North Carolina Blue Crab Pot Fishery.

13. APPENDICES

Appendix 1. Summary of Vital Habitats and Water Quality Plans in the Albemarle-Pamlico Estuarine Study (APES) Comprehensive Conservation and Management Plan (EPA and DEHNR 1994)

Vital Habitats Plan

Goal: Conserve and protect vital fish and wildlife habitats and maintain the natural heritage of the Albemarle-Pamlico region.

Objective A: Promote regional planning to protect and restore the natural heritage of the APES region.

Management Actions:

1. Develop ecosystem protection and restoration plans (basinwide ecosystem plans) for each river basin in the region. Individual basinwide ecosystem plans will be completed and implemented according to the schedule established for basinwide water quality management plans. (See Objective A in the Water Quality Plan.) Plans should establish coordinated priorities for protecting habitats and critical areas in each basin, and should target areas most vital to the survival of wildlife and fisheries and the protection of natural heritage.
2. Develop and maintain accurate maps and records of wetlands, fisheries habitats, federal and state endangered species and their habitats, natural areas, and natural communities.
3. Expand programs to identify wetlands on a regional scale and to evaluate and rank wetland function.

Objective B: Promote the responsible stewardship, protection, and conservation of valuable natural areas in the APES region.

Management Actions:

1. Bring areas identified as having the highest priority for protection into public ownership and/or management. Expand funding for public acquisition of park lands, gamelands, coastal reserves, and other natural areas.
2. Provide incentives and technical assistance for the protection of privately owned vital habitats.

Objective C: Maintain, restore, and enhance vital habitat functions to ensure the survival of wildlife and fisheries.

Management Actions:

1. Enhance the ability of state and federal agencies to enforce existing wetlands regulations by 1995.
2. Strengthen regulatory programs to protect vital fisheries habitats, which include submerged aquatic vegetation, shellfish beds, and spawning areas by 1995.
3. Enhance existing efforts to restore the functions and values of degraded wetlands and vital fisheries habitats. Develop and begin implementing an expanded program to restore wetlands.
4. Establish by 1995 a consistent and effective mitigation program to compensate for

unavoidable permitted wetlands losses.

Water Quality Plan

Goal: Restore, maintain or enhance water quality in the Albemarle-Pamlico region so that it is fit for fish, wildlife and recreation.

Objective A: Implement a comprehensive basinwide approach to water quality management.

Management Actions:

1. Develop and begin implementing basinwide plans to protect and restore water quality in each basin according to the schedule established by the Division of Environmental Management's Water Quality Section. The plans would include provisions for basinwide wetland protection and restoration.
2. Establish total maximum daily loads (TMDLs) and associated control strategies for all impaired streams in the Albemarle-Pamlico region by 1999.
3. Renew all discharge permits in a river basin simultaneously by 1999.
4. Consider the potential for long-term growth and its impacts when determining how a basin's assimilative capacity will be used.
5. Improve the scientific models for understanding the estuarine system, the effects of human activities on the system, and the viability of alternative management strategies.
6. Continue long-term, comprehensive monitoring of water quality in the APES system, collecting data to assess general system health and target regional problems.

Objective B: Reduce sediments, nutrients and toxicants from nonpoint sources.

Management Actions:

1. For each river basin, develop and implement a plan to control non-point source pollution as part of the basinwide management plans.
2. Expand funding to implement nonpoint source pollution controls, particularly agricultural best management practices through the N.C. Agriculture Cost Share Program, and also to develop a broader Water Quality Cost Share Program. Expand the cost share programs to include wetlands restoration. Increase cost share funds to problem areas.
3. Continue to research and develop alternative septic systems and new best management practices to reduce nonpoint source pollution.
4. Strengthen current enforcement to detect and correct ground and surface water quality violations from non-point sources.
5. Strengthen implementation of forestry best management practices through training, education, technical assistance and enforcement.
6. Enhance stormwater runoff control by strengthening existing regulations and developing new ones, if needed, by 1995. Improve enforcement to ensure that stormwater management systems are properly installed and regularly maintained.
7. Implement an inter-agency state policy that addresses marina siting and integrates best management practices through permitting and better public education by 1995.

Objective C: Reduce pollution from point sources, such as wastewater treatment facilities and industry.

Management Actions:

1. Promote pollution prevention planning and alternatives to discharge, where feasible, for all point sources to reduce the volume and toxicity of discharges.
2. Expand and strengthen enforcement of National Pollutant Discharge Elimination System permits. Increase site inspections and review of self-monitoring data to improve facility compliance by 1995.

Objective D: Reduce the risk of toxic contamination to aquatic life and human health.

Management Actions:

1. Increase efforts to assess and monitor the extent of estuarine sediment contamination, fish and shellfish tissue contamination, and water quality violations, and to identify the causes and sources of these problems.
2. Continue to issue fish advisories as necessary to protect public health. Improve communication and education about the risks associated with eating contaminated fish and shellfish.
3. Remediate toxic contamination where necessary and feasible.

Objective E: Evaluate indicators of environmental stress in the estuary and develop new techniques to better assess water quality degradation.

Management Actions:

1. Continue to track and evaluate indicators of environmental stress, including algal blooms, fish kills, and fish and shellfish diseases.
2. Improve the techniques for evaluating the overall environmental health of estuarine waters.
3. Develop and adopt better indicators of shellfish contamination as soon as possible.

APPENDIX 2. SPAWNING STOCK MANAGEMENT

I. Issue:

Management measures needed to protect the reproductive potential of blue crabs.

II. Background:

With increasing concerns over fluctuating blue crab landings and increasing fishing effort, there have been numerous requests to protect sponge crabs in North Carolina. Blue crab recruits in any given year rely, in part, on the size of the spawning stock from which the young originated (Chesapeake Bay Program 1997). The spawning stock includes all female crabs that survive natural and fishing mortality to reproduce.

The protection of the spawning stocks of various organisms is achieved through the establishment of minimum/maximum size limits and/or the protection of eggbearing females. These methods are most effective when dealing with species that take a number of years to reach sexual maturity (i.e., lobster and striped bass). The protection of spawners has often been utilized by fisheries managers to protect declining stocks and/or stocks that are showing signs of growth or recruitment overfishing. Growth overfishing occurs when fish are harvested at sizes below those which produce the maximum weight. Hence, there is a net loss of biomass from one year to the next (NMFS 1993) which is characterized by a decreasing proportion of older and larger individuals in the catch. Growth overfishing may continue without any visible effect on the number of individuals in a stock (i.e., reproduction remains high enough to replace individuals removed by the fishery).

Recruitment overfishing is the rate of fishing above which recruitment to the exploitable stock is reduced. It is characterized by a reduced spawning stock and generally very low production of young, year after year (NMFS 1993). Excessive fishing pressure can result in recruitment overfishing. A decline in the Chesapeake Bay blue crab population in the early 1990's, along with increased fishing effort and decreased CPUE in the commercial fishery, were believed to be symptomatic of a stock in the process of being recruitment-overfished. Abundance of juvenile crabs during this same time period has been increasing, indicating that recruitment overfishing is not occurring (Chesapeake Bay Program 1997). No overall decline in recruitment patterns has been observed in North Carolina's juvenile blue crab indices (DMF unpublished data, Program 120, Estuarine Trawl Survey).

Concerns with protecting egg-bearing female blue crabs (sponge crabs) are complex, consisting of economic factors (fewer pounds of meat can be picked from a given weight of sponge crabs than from the same weight of non-sponge crabs), biological considerations (recruitment overfishing), and personal opinions regarding "motherhood". Conflicting views exist regarding the existence (Lipcius and Van Engle 1990) or absence (Pearson 1948; Sulkin et al.1983; Van Engel 1987) of a spawning stock-recruitment relationship for the

blue crab. Most investigators state that annual fluctuations in blue crab populations are the result of environmentally-induced variations in recruitment. Although a definitive stock-recruitment relationship has not been identified for blue crabs, this does not mean that recruitment is independent of the size of the spawning stock. To manage a fishery based on the assumption that recruitment is independent of spawning stock size when this is not the case could lead to the decline of the population. In cases like this, the most appropriate management approach would be to protect some spawners until the dynamics of the population are better understood.

Currently, there are a number of states which prohibit the sale or possession of egg-bearing females (Table 1). Without exception, these states experience the same fluctuations in blue crab landings as seen in states that do not protect egg bearing females. From the early 1920's until 1964, it was unlawful to harvest sponge crabs in North Carolina. When the sponge crab law was repealed in 1964, it was replaced with the establishment of Crab Spawning Sanctuaries (MFC rules 15A NCAC 3L .0205 and 3R .0110). During the time frame that the sponge crab law was in effect in North Carolina, reported hard crab landings showed the same patterns in fluctuations as observed after its repeal (Figure 1).

Table 1. Summary of blue crab sponge and spawning sanctuary regulations (New Jersey to Texas).

State	Prohibit the sale or possession of sponge crabs	Have established crab spawning sanctuaries
Texas	Yes	No
Mississippi	Yes	No
Louisiana	Yes	No
Alabama	No	No
Florida	Yes	No
Georgia	No	No
South Carolina	Yes	No
North Carolina	No	Yes
Virginia	No[1]	Yes
Maryland	Yes	No
Delaware	Yes	No
New Jersey	Yes	No

[1] Minimum tolerance for brown and black sponge crabs

Two states use the spawning sanctuary concept to protect the spawning stock in certain areas and during specific seasons when sponge crabs may be abundant (Table 1). In addition to sponge crab protection, these areas also protect all crabs from harvest. North Carolina has five locations designated as Crab Spawning Sanctuaries (see attached maps) through MFC Rule 15A NCAC 3L .0205 (see below IV. Current Regulations) and 3R .0110 (sanctuary boundary description). Approximate surface acreage for each of the

sanctuaries is contained in Table 2.

Table 2. North Carolina blue crab spawning sanctuaries.

Location	Acreage
Oregon Inlet	5,787.5
Hatteras Inlet	4,444.0
Ocracoke Inlet	8,745.0
Drum Inlet	5,388.0
Bardens Inlet	4,610.0

Male reproductive capacity can have a significant effect on the lifetime reproductive success of females. Insemination rates of female crabs and the amount of sperm they receive from male crabs during mating may be dependent on the abundance and size of male crabs in the population. A small male may not be able to transfer enough sperm for the female to fertilize all of the eggs she is capable of producing. Consequently, it is important for managers to consider not only the impact of harvesting mature female crabs, but, also, the influence on males in the population (Chesapeake Bay Program 1997).

III. Discussion:

The underlying hypothesis of a rule to prohibit sponge crab harvest is that by protecting the spawning stock (defined here as egg-bearing females), the fishery would benefit with more recruits to the fishery. Assuming a direct relationship between spawning stock and future recruits, reducing sponge crab harvest could result in less protection to spawners than currently is afforded through the sanctuary system. The spawning stock of blue crabs is composed of all mature females, not just egg-bearing females. Hence, the current system (sanctuaries) affords protection to all spawners within the sanctuary, while prohibiting sponge crab harvest would protect spawners only during the short time eggs are visible (approximately 14 days). Since the proportion of egg-bearing females to mature females at any given time is relatively low, the net results of a change in current regulations (from sanctuaries to prohibiting sponge crab harvest) would be a reduction in protection afforded to spawners (mature females).

If it's decided to prohibit the sale or possession of sponge crabs, there are a number of questions that need to be considered: 1) Will there be a tolerance?; 2) Where will culling have to take place?; 3) What are the effects of stress on the viability of the eggs?; and 4) Should the ban include all mature females? The first two questions are easily answered. Question three would require investigations on how stress affects the production of eggs, as well as how physical damage from culling and capture may affect egg viability. If these factors did affect egg viability, then the usefulness of this regulation would be reduced.

The fourth question involves the protection of all mature females. Studies conducted in South Carolina showed that over 98% of all mature females were fertile [carried a sperm plug (Dr. Elizabeth Wenner, personal communication). These individuals should be protected along with sponge crabs in order to reap the maximum benefits of spawner protection. Following mating, mature females migrate to high salinity water to spawn. Mature females are the largest component of the commercial catch in these areas. A regulation banning the sale or possession of all mature females would have a significant economic impact on the crab fisheries in these areas. Prohibiting the harvest of sponge crabs would have a significant economic impact on the crab fisheries in some areas during certain periods (e.g., Outer Banks during spring).

No spawning sanctuaries have been established south of Cape Lookout, N.C. Local crabbers suggest that the deep fast flowing waters of the lower Cape Fear River "ship channel" provides a natural barrier to some crab harvesting practices and thus might serve as a sanctuary area for all crabs. Designating spawning sanctuaries or prohibiting sponge crab harvest, as has been suggested by crabbers in the southern coastal area, would be viable options to protect a portion of the spawning stock. Spawning sanctuaries around the southern coastal inlets would prohibit commercial gears currently in use, forcing commercial harvesters into other areas, thereby increasing conflicts among all user groups.

IV. Current Regulations:

15A NCAC 3L .0205

(a) It is unlawful to use a trawl net or take crabs with the use of commercial fishing equipment from the crab spawning sanctuaries described in 15A NCAC 3R .0110 from March 1 through August 31.

(b) From September 1 through February 28, the Fisheries Director may, by proclamation, close the crab spawning sanctuaries and may impose any or all of the following restrictions:
- (1) Specify number of days;
- (2) Specify areas;
- (3) Specify means and methods which may be employed in the taking;
- (4) Specify time period;
- (5) Limit the quantity.

V. Management Options

(+ potential positive impact of action)
(- potential negative impact of action)

1. No action
   - \+ No rule changes
   - \+ Some level of protection for spawning stock
   - \- No protection in southern part of state
   - \- Utilization of current areas unknown

2. Establish spawning sanctuaries around inlets in the southern coastal area.
   + Spawning stock protection
   + Reduce user conflict (navigation)
   + Minimal economic impact as compared with prohibited harvest
   - Increase in user conflict (forcing commercial harvesters into other areas)
   - Close existing harvest areas
   - Decrease in harvest

3. Expand existing spawning sanctuaries (boundaries and/or time).
   + Increase spawning stock protection
   + Reduce user conflict (navigation and other fishing activity)
   + Minimal economic impact as compared with prohibited harvest
   - Increase in user conflict (forcing commercial harvesters into other areas)
   - Close existing harvest areas
   - Decrease in harvest

4. Reduce existing spawning sanctuaries (boundaries and/or time).
   + Open additional harvest areas
   + Increase in harvest
   - Increase in user conflict (navigation)
   - Increased potential for recruitment failure

5. Establish a tolerance limit for certain sponge stages (e.g., brown or black sponge).
   + Spawning stock protection
   + Increase in harvest (if sanctuaries rule is repealed)
   - Increased potential for recruitment failure
   - Possible impact on egg viability
   - Enforcement problems

6. Reduce harvest of sponge crabs.
   + Spawning stock protection
   - Decrease in harvest
   - Increased management related activity (seasons, harvest allocation, opening/ closing areas)

7. Prohibit the use of commercial fishing gear in spawning sanctuaries during March 1 - August 31, excluding gill nets.
   + Allow traditional finfish harvest in spawning sanctuaries
   - Harvest and post harvest mortality of captured blue crabs

8. Prohibit the use of commercial fishing gear in spawning sanctuaries during March 1 - August 31, excluding attended gill nets.
   + Allow traditional finfish harvest in spawning sanctuaries
   + Minimize harvest and post harvest crab mortality
   - Harvest and post harvest mortality of captured blue crabs

9. Prohibit the use of commercial fishing gear in spawning sanctuaries during March 1 - August 31.
   + Complete protection of blue crabs on sanctuaries
   - Loss of traditional fishing areas

10. Repeal existing spawning sanctuary rules.
   + Open additional harvest areas
   + Increase in harvest
   - Increase in user conflict (navigation)
   - Increased potential for recruitment failure

11. Prohibit harvest of all mature females.
   + Increase spawning stock protection (year round)
   - Decrease in harvest (significant)
   - Increase pressure on other harvest segments (males, immature females, peelers)

12. Prohibit harvest of all sponge crabs.
   + Some spawning stock protection (seasonal and by area)
   + Increase in harvest area (if sanctuaries rule is repealed)
   - Decrease in harvest (seasonal and by area)

13. Reduce harvest of mature females.
   + Spawning stock protection
   - Decrease in harvest
   - Increased management related activity (seasons, harvest allocation, opening/ closing areas)
   - Increased pressure on other harvest segments (males, immature females, peelers)

14. Reduce harvest of male crabs.
   + Spawning stock protection
   - Decrease in harvest
   - Increased management related activity (seasons, harvest allocation, opening/ closing areas)
   - Increased pressure on other harvest segments (females, immature females, peelers)

15. Establish mating sanctuaries in the upper estuaries.
   + Spawning stock protection
   - Decrease in harvest
   - Increased management related activity (sanctuary delineation)

Options two through fifteen would require rule changes by the MFC.

The Blue Crab FMP Advisory Committee (BCAC) supported including options 1- 6 in the FMP for consideration. Option 7 was added by DMF after the BCAC vote. Options 8

and 9 were added by the MFC.

VI. Research Needs:

1) Conduct a survey of existing and proposed sanctuary areas to determine population levels and to determine if these areas function as spawning grounds.
2) Conduct tagging studies to determine exploitation rates of different life history stages, movement on and off the spawning grounds, and other life history parameters of female blue crabs.

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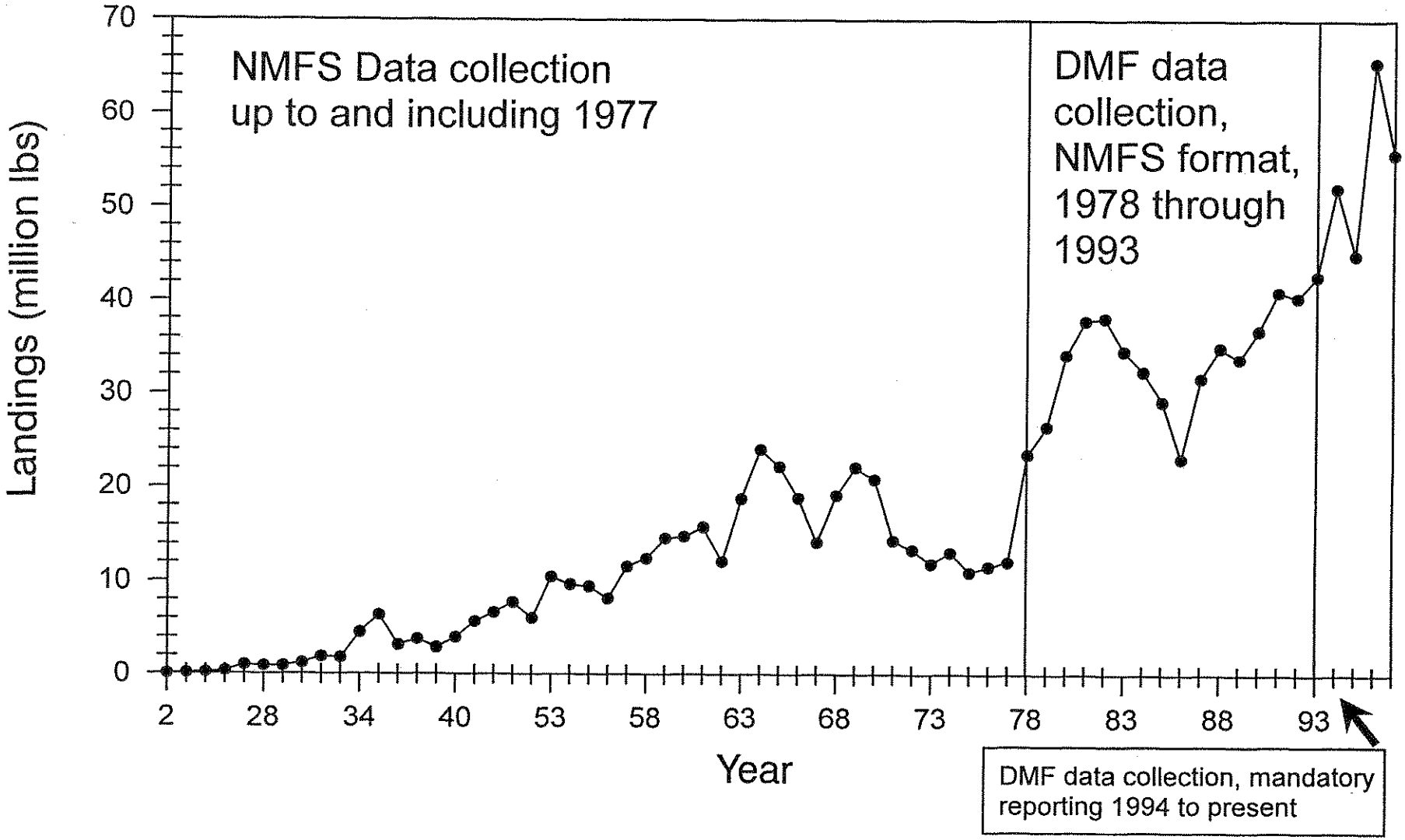
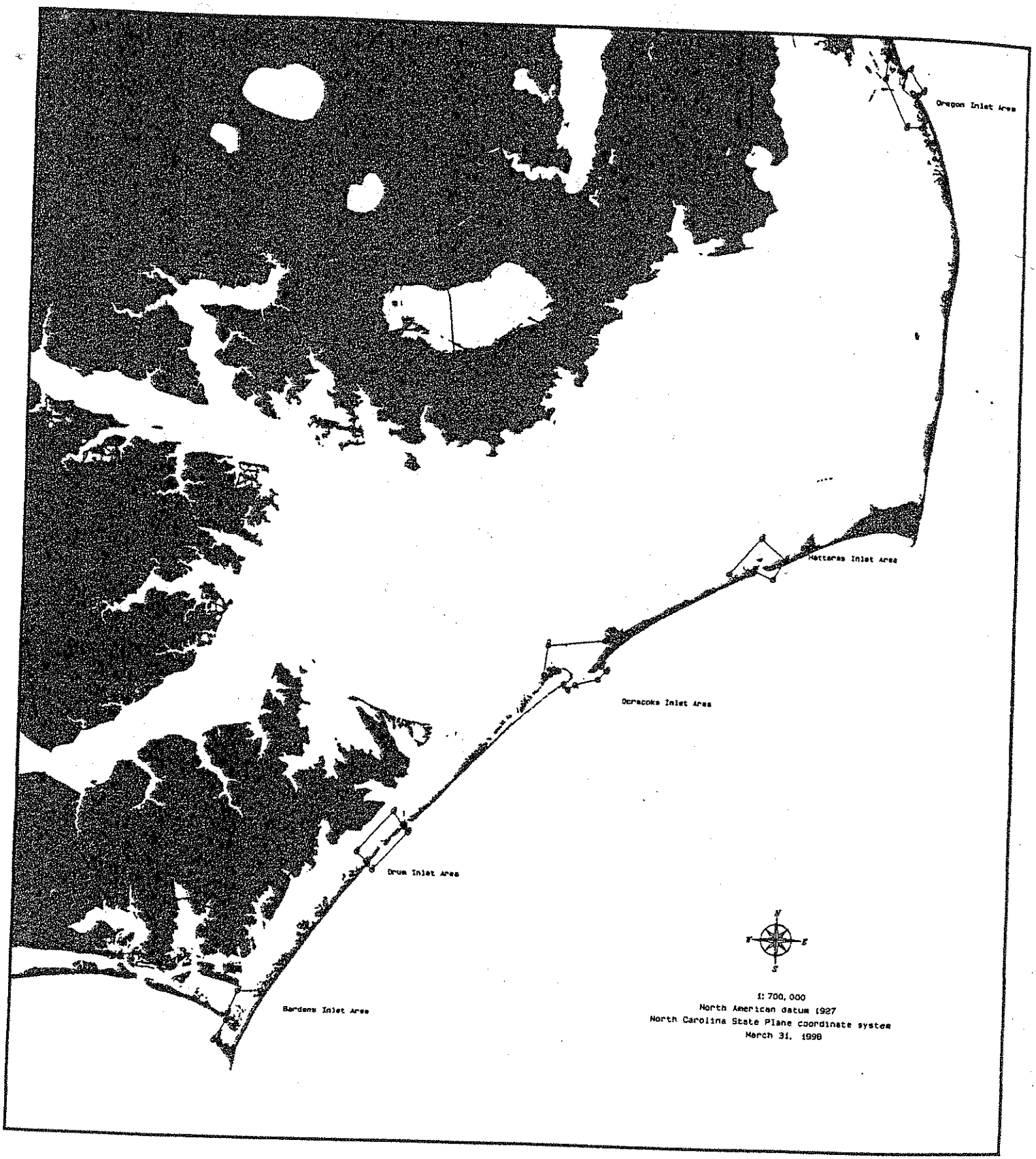
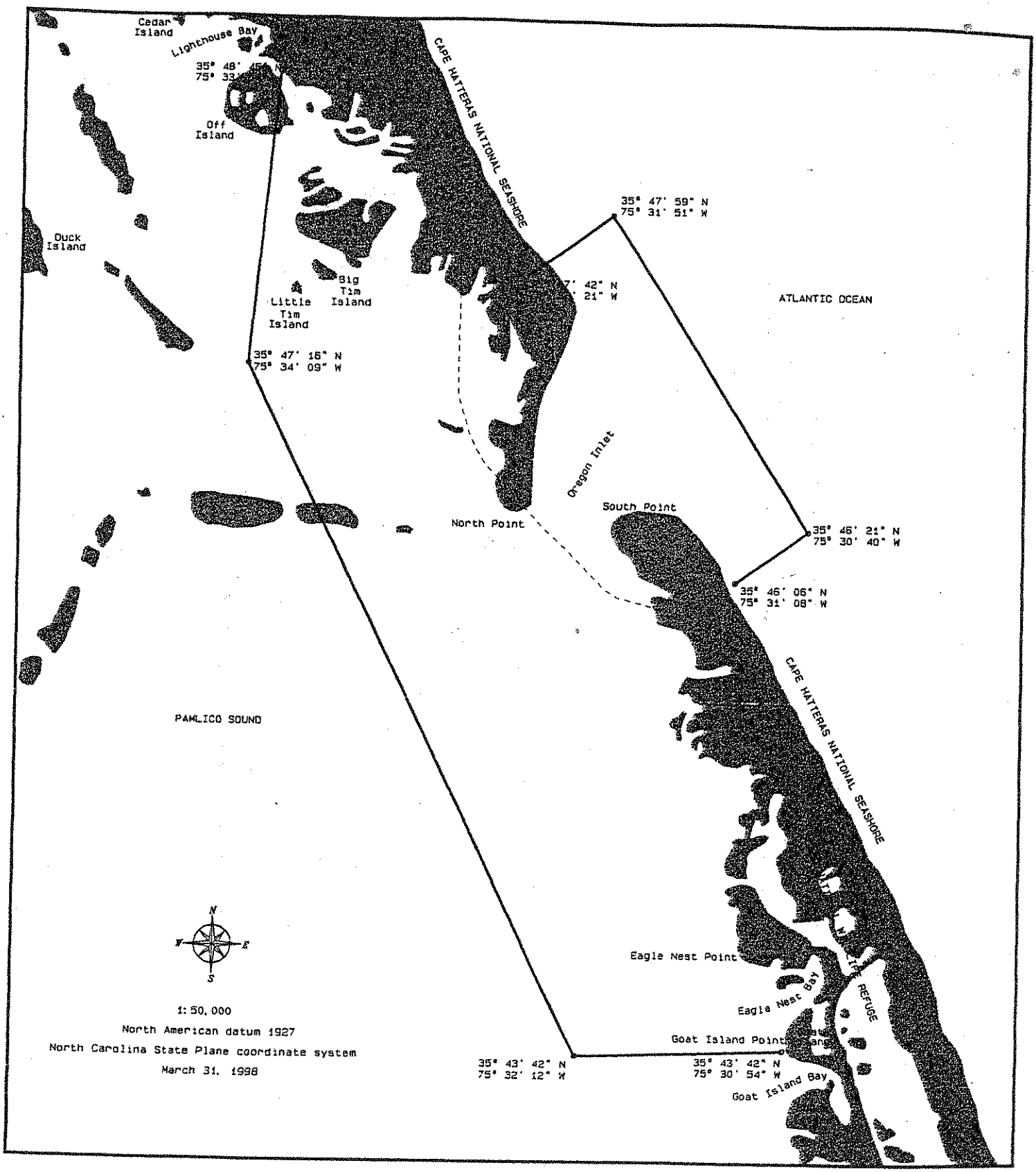


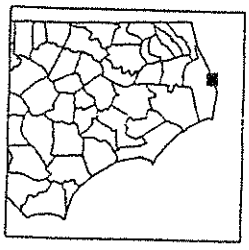
Figure 1. North Carolina hard blue crab landings, 1902-1997.



North Carolina Crab Spawning Sanctuaries

North Carolina MARINE FISHERIES

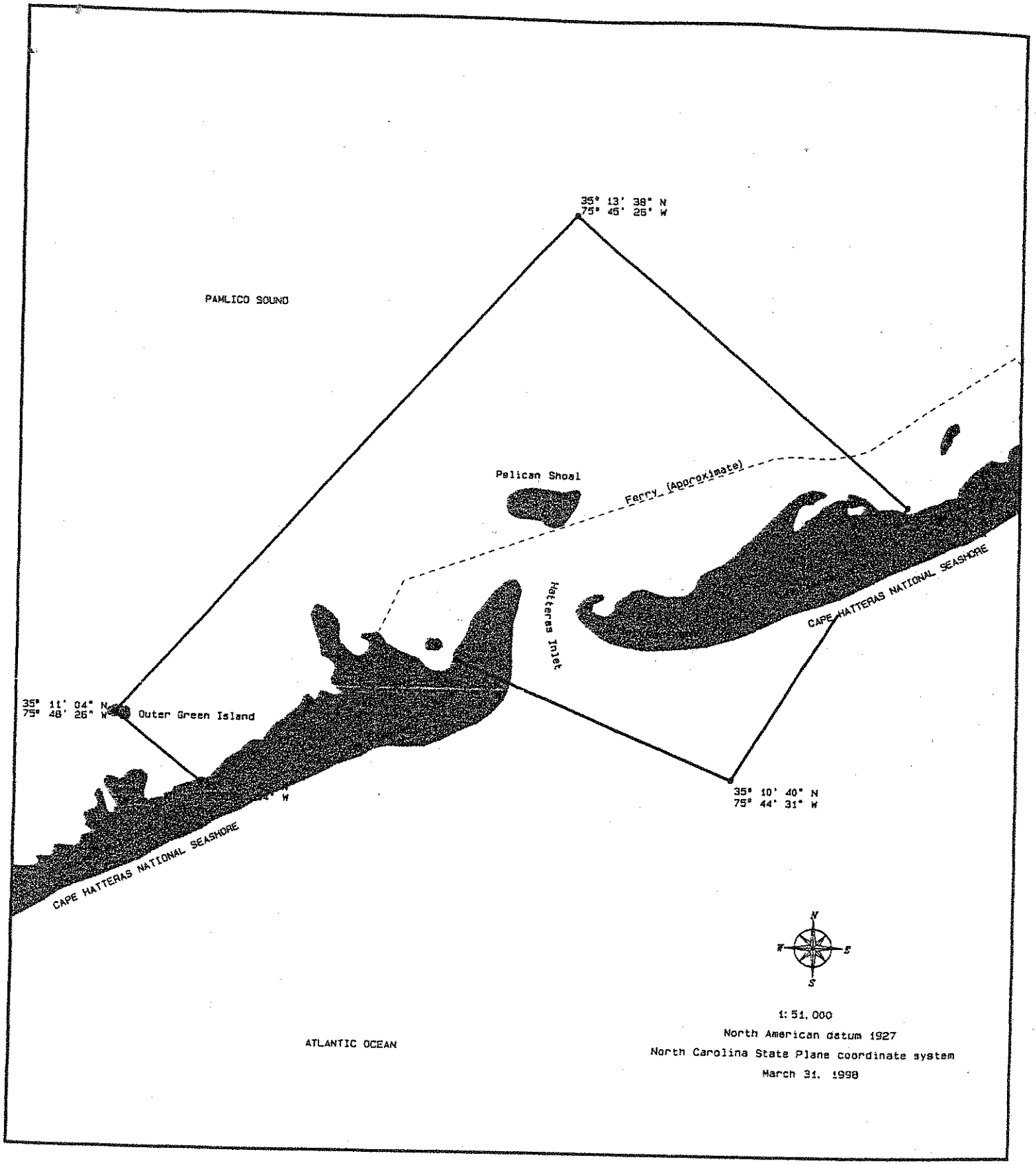


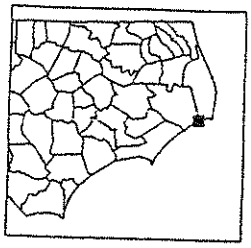


North Carolina Crab Spawning Sanctuaries

(1) Oregon Inlet

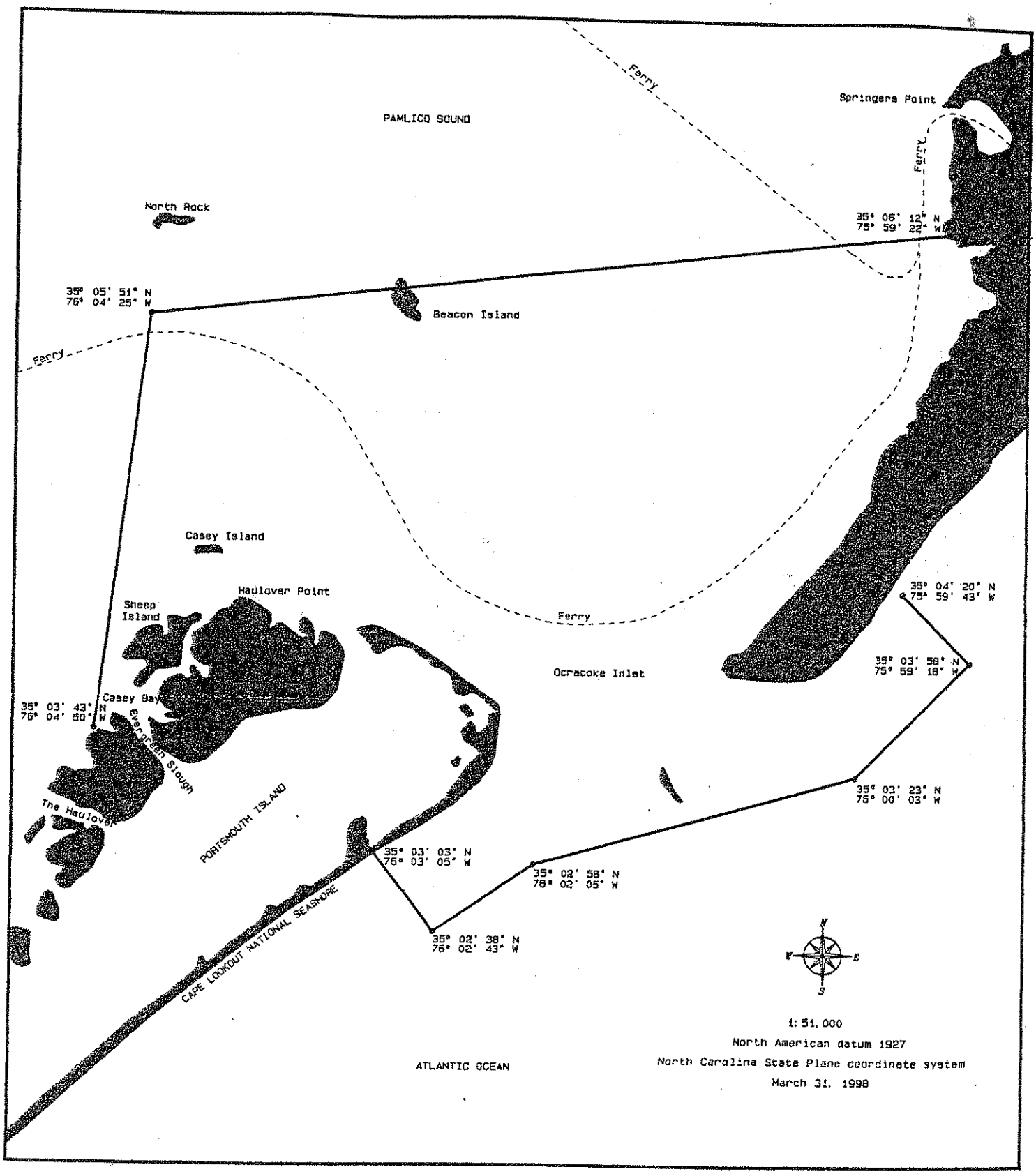
North Carolina MARINE FISHERIES

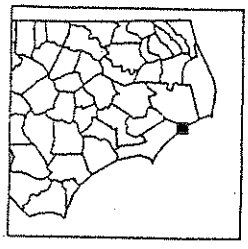




North Carolina Crab Spawning Sanctuaries

(2) Hatteras Inlet

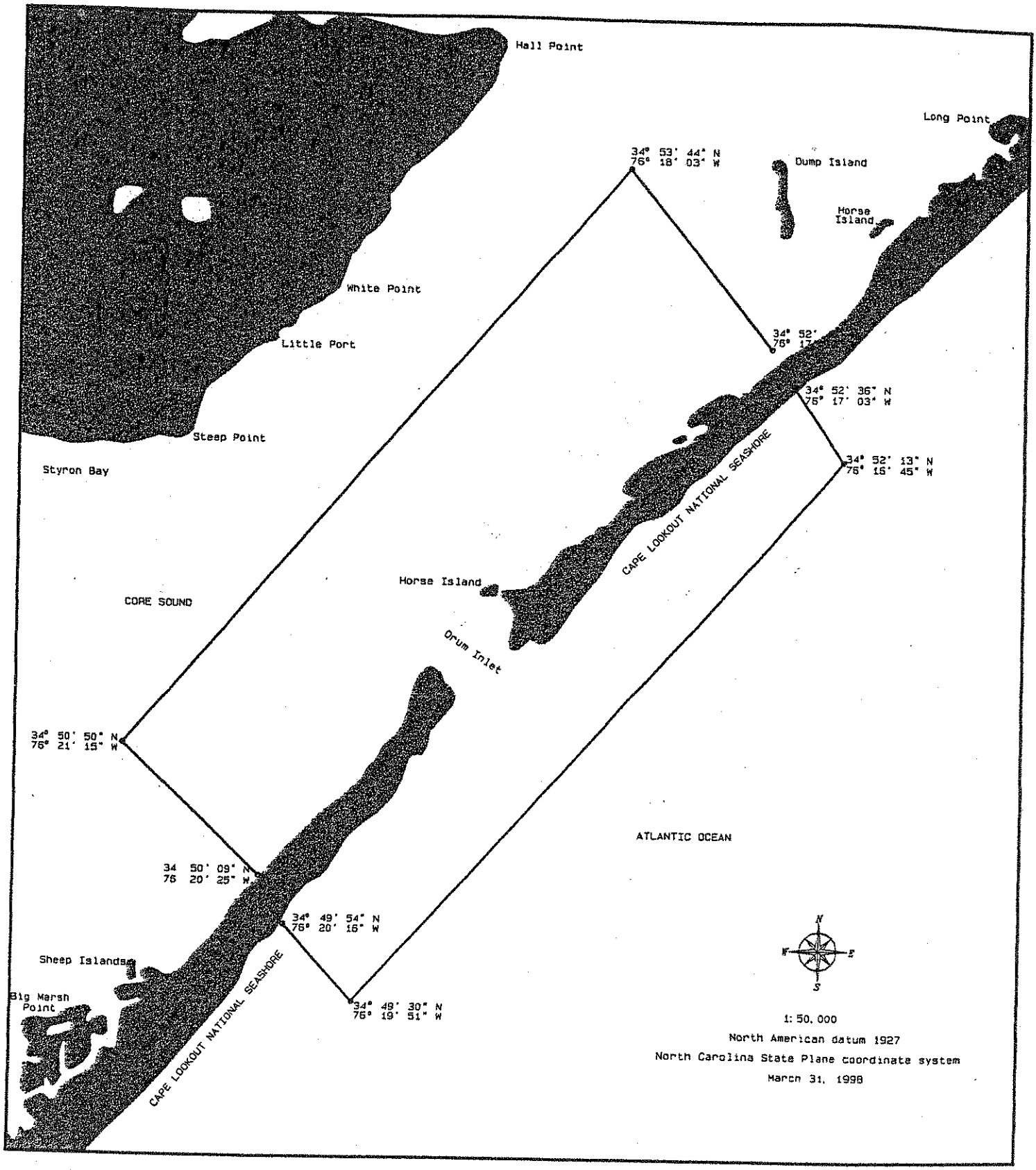


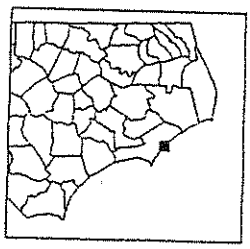


North Carolina Crab Spawning Sanctuaries

(3) Ocracoke Inlet

North Carolina MARINE FISHERIES

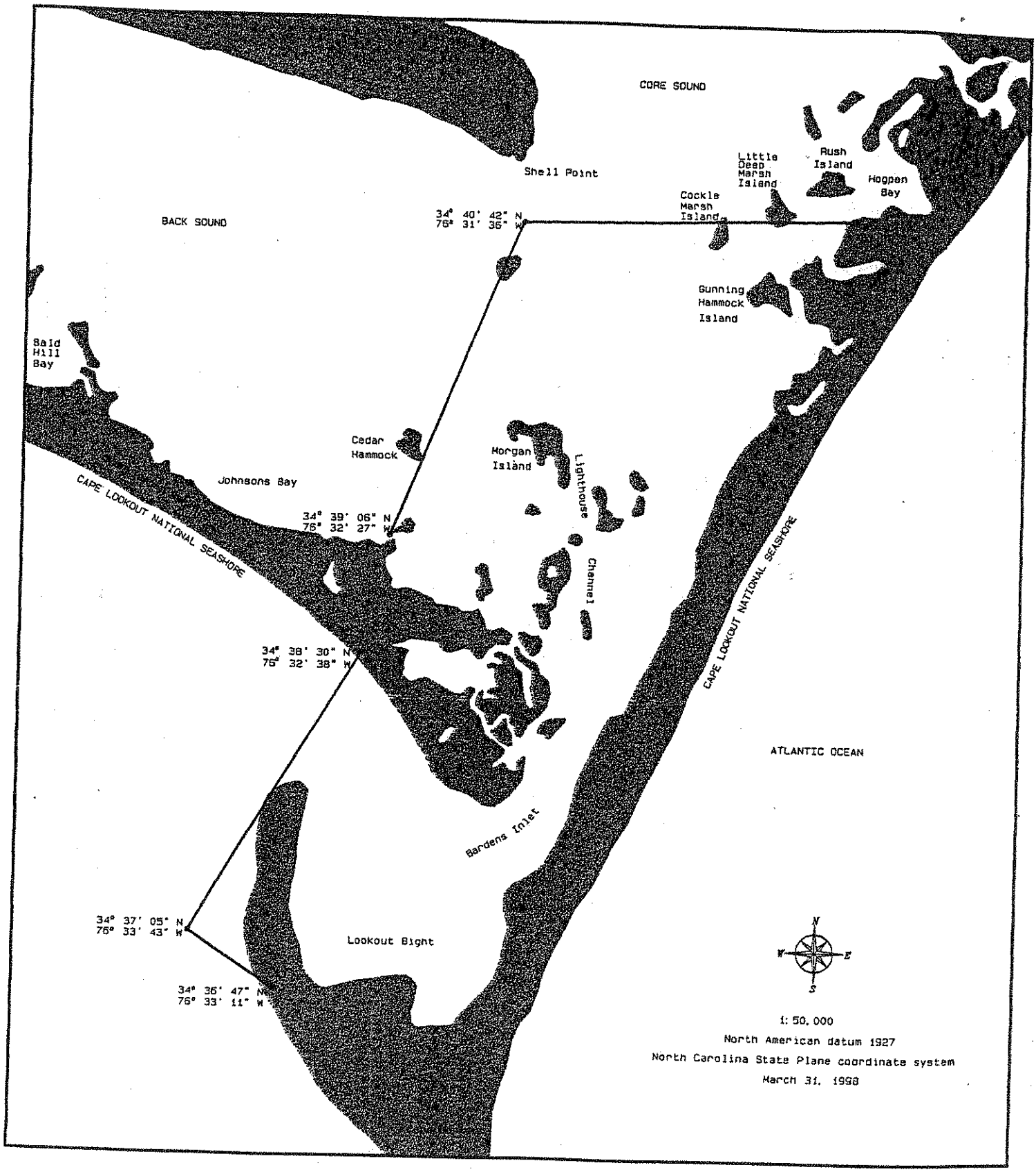


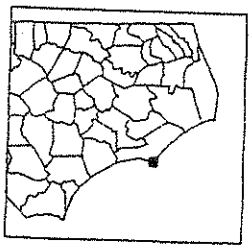


North Carolina Crab Spawning Sanctuaries

(4) Drum Inlet

North Carolina MARINE FISHERIES





North Carolina Crab Spawning Sanctuaries

(5) Bardens Inlet

North Carolina MARINE FISHERIES

APPENDIX 3. GHOST POTS

I. Issue:

The bycatch and mortality of blue crabs and finfish in ghost (lost) pots.

II. Background:

A major issue specific to the crab pot fishery is "ghost pots". These are pots that either through abandonment or loss (float lines cut by props, storm events, etc.), continue to catch crabs and finfish. Concern stems from the significant increase in the numbers of crab pots, the long life of vinyl coated pots, and the pot's ability to continue to trap crabs and finfish. McKenna and Camp (1992) reported annual estimates of 14% crab pot loss for Pamlico and Pungo rivers, N.C. Included in these estimates were pots lost to theft and trawlers. Guillory (1993) estimated annual blue crab mortality at 25 crabs per ghost pot for Louisiana waters. In a study conducted in the Pamlico River in 1993, it was estimated that the annual mortality of legal blue crabs in ghost pots was 11.5 crabs per pot (DMF unpublished data, 1993). The difference in mortality estimates are due largely to the different escapement rates seen in the two studies, 45% in Louisiana and 64% in North Carolina. Research conducted by High and Worlund (1978), suggests that the level of delayed mortality for crustaceans escaping from ghost pots may be high. In the Louisiana ghost pot study, eleven species of finfish were captured, totaling 8.6 fish per trap-year (Guillory 1993). Three species, southern flounder ($n=11$), Atlantic croaker ($n=1$), and white catfish ($n=1$) were captured in the North Carolina study (DMF unpublished data, 1993). In North Carolina, all the captured fish were quickly consumed by blue crabs.

The issue of ghost pots is a major concern in other pot fisheries: Caribbean spiny lobster (Seaman and Aska 1974); Dungeness crab (Breen 1987); American lobster (Sheldon and Dow 1975); snow crab (Gagnon and Boudreau 1991); and sablefish (Scarsbrook et al. 1988). For the most part, these fisheries now require that some sort of escape mechanism be incorporated into the various pot designs. In 1976, the state of Alaska passed legislation which required all pots (crab and fish) to have a biodegradable termination device which in time breaks down and allows crabs and fish to escape (Paul et al. 1993). The state of Florida is the only blue crab-producing state that requires biodegradable panels in blue crab pots. However, several other states are looking at this issue: Louisiana, Maryland, and Virginia.

III. Discussion:

Factors affecting ghost fishing include number of pots lost, pot type, location where lost, and target-species behavior (Smolowitz 1978). The first two factors are controllable.

Large areas of North Carolina waters are fished by both trawlers and potters. Sometimes trawlers inadvertently tow across areas containing pots and either sever the

buoys, or drag the pot away from the line. Pots that are caught by trawlers are usually returned to the water. However, the new location of the pot is unknown to the owner and, unless notified by law enforcement or another fishermen, the pot is seldom retrieved. Large numbers of pot buoy lines are severed by the propellers of boats. Other sources of pot loss include abandonment (fishermen simply cut the buoys off older pots), spacial conflicts (competing potters cutting lines), storms events, water currents (pots become partially buried by sand or mud), and theft. Although the theft of crab pots is a serious problem, it does not contribute to ghost fishing since stolen pots are usually put into production or are sold by the thief.

The mortality caused by ghost pots is directly related to the durability of the pot and its retention capability. The use of vinyl coated wire in crab pot construction has increased the life of crab pots. When lost, these pots do not degrade quickly, thereby increasing the potential for ghost fishing. The use of escape rings in hard crab pots significantly reduces ghost fishing mortality in sublegal blue crabs (Arcement and Guillory 1994). Since peeler pots are exempt from the escape ring requirement in North Carolina, this gear has a much greater potential for ghost fishing mortality than hard crab pots.

By minimizing pot loss and by incorporating design features into pots to prevent or reduce ghost fishing, significant reductions in ghost fishing mortality in blue crab pots could be achieved.

Harvest seasons for crab trawling and potting would eliminate crab pot loss by crab trawls. However, negative interactions would still occur between shrimp trawlers and potters. This problem could be solved by a combination of seasonal and area restrictions.

The willful destruction of fishing gear is currently prohibited by General Statute [G.S. 113-268 (b) and (c)]. The problem with this statute is that evidence has to be provided that the violator "willfully, wantonly, and unnecessarily" did injury or "willfully destroyed" fishing gear legally set. With regard to trawler/potter interactions, this problem could be addressed by seasonal and area restrictions. Problems with other crab potters damaging gear would still be difficult to enforce under this statute for the aforementioned reasons.

Many crabbers rig their pots with buoy lines that match the deepest water fished. When pots are moved inshore to follow the crabs or to meet regulatory requirements, no change is made in the length of the buoy line. This extra line causes the buoy to float for a considerable area around the pot. Boaters unaware of the extra line just below the surface may end up cutting lines inadvertently. A requirement for weighted or sinking lines on pot buoys would address the problem of buoy lines being cut by recreational and commercial boaters.

Biodegradable panels and galvanic time release (GTR) devices are used in many pot fisheries to minimize ghost pot fishing mortality. Biodegradable material can easily be incorporated into trap designs to provide an exit port for animals captured in ghost pots. Examples of these devices include: untreated wooden slats in lobster traps; escape panels constructed of natural twine; the use of untreated wire in certain sections of the pot;

corrodible pot-lid hooks; and pot-lid hooks held in place by untreated wire or natural twine. GTR devices are composed of an active metal cylinder functioning as an anode, joining together two stable metal eyelets which function as cathodes. When immersed in salt water, conductivity produces galvanic corrosion of the anode. When the anode disintegrates, the eyelets separate and release. These devices can be constructed to meet predetermined release times (i.e., 50 days, 100 days, etc.). Tests conducted in Alaska and Canada have shown that these devices are very predictable [+ or - a couple of days (Paul et al. 1993; Boudreau 1991)]. However, GTR devices are usually constructed to specific salinity ranges, and a device designed for high salinity sites would take longer to degrade in lower salinity areas. With many fishermen moving their pots to different areas and salinity ranges, the major advantage of GTR devices, their predictability, would be negated. Depending on the desired release time, the cost of GTR's for fishermen could be high. For example, a device that would release after 30 days would have to be replaced seven times a year in North Carolina (assuming 200 fishing days per year). At approximately $1.60 per device the cost per pot per year would be $11.20. This would cost a person fishing 300 pots an extra $3,360 per year.

Two natural twines (heavy duty jute and sisal) tested on exit ports in North Carolina broke, on average, in 47 and 53 days, respectively, at a low salinity site and 49 and 50 days in high salinity waters (DMF unpublished data, 1993). These twines were not as consistent in breaking time as GTRs. The range in breaking times for sisal was 35 to 77 days, and jute ranged from 28 to 63 days. The cost of this material is minimal, a 300 foot roll of sisal is about $1.50 and would be enough to rig about 600 pots. Hence, the cost for materials to a fishermen fishing 300 pots and making three or four changes per year would be approximately $2.25 to $3.00 per year.

Escapement mechanisms were evaluated by the DMF in 1993 and tested under commercial conditions in 1995 (Hooker 1996). These devices included the lid closure strap, an escapement panel, and an escape ring, all of which were held in place by natural twine. The lid closure strap was attached to a piece of natural twine located on top of the pot. In pots without a lip wire, the release of the strap would allow the top of the pot to open and all crabs to escape. The ability of crabs to escape through this opening was examined in 1993. In this study, all legal blue crabs (n=59) placed in test pots escaped in 48 hours (DMF unpublished data, 1993). No data were collected on finfish escapement. Under commercial evaluation, fishermen reported that this device was cumbersome to work with and could be expensive to maintain since the strap was lost when the device degraded.

The escape ring was held in place with a two hog rings on the bottom and a piece of natural twine at the top. An extra mesh had to be cut to allow legal crabs to escape. The ability of crabs to escape through this opening was examined in 1993. In this study, all legal blue crabs (n=70) placed in test pots escaped in 72 hours (DMF unpublished data, 1993). Commercial fishermen testing this device felt that the hog rings interfered with the escapement of sublegal crabs through the escape ring (Hooker 1996). Additionally, fishermen were concerned with the inability of flounder and larger crabs to escape from this small panel when abandoned. Fishermen noted that blue crabs cut the string causing premature failure of the device.

The escapement panels were 4 ½ inches by 3 inches made from ½ inch by 1 inch wire and were attached to the back of the pots. The bottom of the panel was held in place by three hog rings, while the top was secured at both corners and in the middle by twine. This larger device was preferred by fishermen, since it would allow larger crabs and flounder to escape from ghost pots (Hooker 1996).

IV. Current Rules: None

V. Management Options/Impacts:
(+ potential positive impact of action)
(- potential negative impact of action)

A. Options to minimize pot loss:

1. No action.
   + No new regulations
   - Continued problems with ghost pots (pot loss, mortality, spacial conflict)

2. Harvest seasons by gear type (pot and trawl).
   + Minimize interactions between crab trawlers and potters, thereby;
      a. Reducing pots lost to crab trawlers, and
      b. Reducing user conflicts
   + More efficient law enforcement (able to concentrate on fewer fisheries at a time)
   - Lost revenue for fishermen
   - Reduced flexibility for trawlers and potters

3. Area restrictions by gear type (pot and trawl).
   + Minimize interactions between crab trawlers and potters, thereby;
      a. Reducing pots lost to crab trawlers, and
      b. Reducing user conflicts
   + More efficient law enforcement (able to concentrate on fewer fisheries at a time)
   - Lost revenue for fishermen
   - Reduced flexibility for trawlers and potters

4. Require weighted or sinking lines on all crab pot buoys (hard and peeler pots).
   + Reduce ghost pots
   + Reduce user conflicts between boaters and potters
   - Increased economic burden on pot fishermen (might be offset by having to replace fewer pots)

5. Require reflective tape or paint on crab pot buoys.
   + Reduce ghost pots
   + Reduce user conflicts between boaters and potters
   - Increased economic burden on pot fishermen (might be offset by having to replace fewer pots)

6. Require the use of full size (5 inch X 11 inch vs. 5 inch x 5 inch) buoys on crab pots.
   + Reduce ghost pots
   + Reduce user conflicts between boaters and potters
   - Increased economic burden on fishermen (might be offset by having to replace fewer pots)

Options two through six would require rule changes by the MFC. The BCAC's preferred options were 4 and 6.

B. Options to minimize ghost pot fishing mortality:

1. No action.
   + No new regulations
   - Continued problem with ghost pot fishing mortality

2. Require biodegradable panels in crab pots.
   + Reduce waste of the blue crab resource
   + Increase harvest of blue crabs
   + Reduce finfish bycatch in ghost pots
   - Possible loss of legal catch due to premature failure of panel

Option two would require a rule change by the MFC.

VI. Research Needs:

1. Test galvanic time release devices, natural twine, and non-coated steel (24 gauge or less) across a wide range of salinities.
2. Determine the optimal panel location for finfish and crab escapement.
3. Determine minimum panel size for blue crab and finfish escapement.
4. Determine desired release time for blue crabs and finfish.

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APPENDIX 4. CRAB POT ESCAPE RING

I. Issue:

Crab pot escape rings as a management tool to minimize the catch of sublegal crabs.

II. Background:

Rule 15A NCAC 3J .0301(g) (effective March 1, 1994) states that: "The Fisheries Director may, by proclamation, exempt the escape ring requirement in order to allow the harvest of peeler crabs or mature female crabs and may impose any or all of the following restrictions: (1) Specify areas, and (2) Specify time." Since this regulation became effective, there have been numerous requests to exempt areas from the escape ring requirement. To date no exemptions have been granted for peeler harvest (biological and enforcement concerns), and only one for mature females (M-6-94 effective 3/8/94; still in effect as of 3/31/98). Staff discussed this issue and the need to develop criteria for exemptions with the Blue Crab Committee (BCC) of the former Marine Fisheries Commission (MFC). The consensus of the BCC was that closing escape rings for peeler harvest was not a good idea. Some members felt that people only wanted to harvest sublegal crabs during times of low adult abundance and high price under the guise of harvesting peelers. Additionally, there are alternate gears available for peeler harvest: peeler pots, peeler trawls, and peeler pounds. Various fishermen have suggested that different sized escape rings be used in different areas in order to maximize reduction capabilities (2 7/16 inches in rivers, 2 5/16 inches in sounds, and 2 inches along the Outer Banks). Still others have suggested that we do away with the escape ring rule altogether.

The use of escape rings in crab pots has a number of important benefits: possible increase in legal crab catch, reduction in sublegal harvest, reduction in ghost pot fishing mortality, reduced culling time for fishermen, and reduced injuries, mortality, and/or physiological stress for sublegal crabs. Conversely, some negative factors are possibly associated with escape rings, such as: loss of small mature females, loss of peeler crabs, and (as has been suggested by some fishermen) an overall reduction in the size of crabs (escape rings let small mature females out, and they may pass on their small size to their offspring).

Guillory and Merrell (1993) suggested that there may be an immediate increase in the catch rates of legal crabs due to trap saturation effects associated with retention of sublegal crabs. In traps equipped with escape rings most sublegal crabs escape through the escape rings while legal crabs continue to enter, because traps take longer to reach saturation levels or never reach those levels. Studies conducted in South Carolina (Eldridge et al. 1979; Whitaker 1980) and Louisiana (Guillory and Merrell 1993) have shown higher legal catches in blue crab traps equipped with escape rings.

While sublegal crab catches might not be reduced to legal tolerance levels, studies

have shown that reduction rates of sublegal crabs in pots equipped with escape rings was significant. Reduction rates varies with the size, number, and placement of rings in the pots. Studies conducted in North Carolina showed a 69% reduction in the catch of sublegal crabs in pots equipped with two 2-5/16 inch escape rings (DMF unpublished data, 1982).

Studies conducted in Louisiana (Guillory 1993; Arcement and Guillory 1994) on ghost pots with and without escape rings showed that mortality of blue crabs was significantly less in ghost pots with escape rings (5.3 crabs per pot) than in ghost pots without escape rings (17.3 crabs per pot).

Eldridge et al. (1979) and Guillory and Merrell (1993) suggested that culling time for fishermen will be reduced because culling/sorting time is directly related to the number of sublegal crabs.

A future increase in the catch rates of legal crabs may occur due to decreased fishing and handling mortalities of captured sublegal crabs. Escape rings may reduce the rate of cannibalism of sublegal crabs. Cannibalism by blue crabs was observed in ghost trap studies in North Carolina (DMF unpublished data, 1993) and Louisiana (Guillory 1993). Factors affecting the level of delayed mortality in crustaceans are temperature, onboard exposure time, amount and level of physical injury, and total catch biomass (Smith and Howell 1987; Wassenberg and Hill 1989). Estimates of physical injuries for pot-caught blue crabs were 57% for South Carolina (Eldridge et al. 1979), and 25% for North Carolina (McKenna and Camp 1992). Van Engel (1958) suggested that blue crab injuries may reduce the growth increment at molting from 25-33% to 5-10%, or possibly no increase at all. Smith (1990) showed that multiple limb loss in blue crabs significantly reduced molt increment and percent weight gain in blue crabs. Thirty-one percent of the injured pot-caught crabs examined in North Carolina showed multiple limb loss (McKenna and Camp 1992). The only estimates of delayed mortality for pot-caught blue crabs are from North Carolina (McKenna and Camp 1992). This study showed a 7% delayed mortality rate for sublegal blue crabs culled by fishermen. Estimates of delayed mortality for other crustaceans range from 3-5% for red king crab to 11% for tanner crab (Guillory and Hein 1998).

III. Discussion:

When the escape ring regulation was first proposed in 1988, two major problems were identified: escapement of mature females and peeler crab loss. Available data suggested that the use of 2 5/16 inch escape rings could potentially cause a 31% reduction in mature females and a 33% reduction in peeler crabs [DMF unpublished data (study conducted April through September, 1982)]. Of these two problems, it was felt that the loss of mature females had the greatest potential to cause an economic burden to fishermen. The ability of a crab to pass through an escape ring is a function of the length of the crab (crabs pass through the escape ring sideways). Mature females tend to have longer lateral spines than males of the same size, and therefore proportionally smaller carapace lengths. In some areas (Outer Banks and Core Sound), over 90% of the catch is

composed of mature females, while the peeler crab catch in hard crab pots varies seasonally by area, and ranges from 5 to 27%. For example, a catch of 100 crabs in Core Sound would be composed of 90 mature females of which 34 crabs could escape through the escape rings. A catch of 100 crabs in western Pamlico Sound would contain between 5 and 27 peelers, of which between 1.7 and 8.9 could escape. Various data show that most of the peelers caught in hard crab pots are white line [over 70% in North Carolina (DMF unpublished data, 1982), 90% in Georgia (Christian et al. 1987), and 67% in Louisiana (Guillory 1990)]. Comments provided by various crab potters, during the drafting of the escape ring regulation in 1988, indicated that the majority of hard crabbers only keep "rank" peelers (pink or red line). When using this information, the catch rates would be between 1.5 and 8.1 "rank" peelers per 100 crabs, of which between 0.5 and 2.7 could escape.

Since escape rings were required (February 1, 1989), some fishermen have suggested that by letting the smaller mature females out the pots we were altering the genetic structure of the natural population and selecting for smaller size crabs. This was based on fishermen's personal observations of seeing more smaller mature females than in years past. For this assumption to be valid, we must assume that the ultimate size of the female is genetically controlled. Males continue to grow during their entire life, although molt increment lengthens as the size of the crab increases. After their terminal molt (from immature female to mature female), mature females generally do not shed again (there have been a few reports of mature females shedding). While there are no data available on the genetic control of size for blue crabs, data do exist for the effects of temperature and salinity on crab growth. Generally, most investigations have noticed that females spending their entire life in high salinity water tend to be significantly smaller than females from lower salinity waters. Additionally, an increase in abundance of smaller mature females could be an indicator of growth overfishing. In stressed populations animals tend to reproduce at smaller sizes than in healthy populations. Another possible explanation for the reported increase in small mature females could be species misidentification. The lesser blue crab (Callinectes similis) is found in high salinity sites in North Carolina. This animal is very similar in appearance to the blue crab, with accurate identification only possible through counting the frontal teeth (ridges on the carapace between the eyes). One other possible explanation is that since mature females live for a couple of years after becoming mature, and the smaller ones are no longer being removed from the population, their overall percent contribution to the total mature female population would increase yearly.

To examine this problem, we looked at carapace width data from the DMF Pamlico Sound Survey (Tables 1 and 2). The data from Table 1 are shown in Figure 1 as a trend line. These data suggest that the trend in mean length for females (immature and mature) is increasing, while males are stable. Data for areas east of Bluff Shoal in waters less than 12 feet are shown in Figure 2. Here we see an upward trend in length for immature females and males and a downward trend for mature females. In Figure 3, data are presented for females (immature and mature) for this area from 1989 through 1993. This time period represents the time that escape rings were required along the Outer Banks. Here we see an upward trend in immature female length and a downward trend for mature females. On March 8, 1994, the area from the western shore of the Outer Banks out to four miles from Oregon inlet to Wainwright Island was exempted from the escape ring

requirement. This exemption has never been lifted. Figure 4 shows data for areas east of Bluff Shoal during this time period. The trends in female lengths for this time are relatively stable. Interpretation of these data suggests that the use of escape rings is not breeding a smaller crab, as shown by an overall increase in immature and mature female lengths (Figure 1). The observed reduction in the size of mature females by fishermen along the Outer Banks is supported (Figure 2). This decline in mature female size is most likely the result of their overall percent contribution to the total mature female population (Figure 3; reduced harvest, and Figure 4; harvest of smaller mature females).

IV. Current Regulations:

Rule 15A NCAC 3J .0301

(g) It is unlawful to use crab pots in coastal waters unless each pot contains no less than two unobstructed escape rings that are at least 2 5/16 inches inside diameter and located in the opposite outside panels of the upper chamber of the pot. Peeler pots with a mesh size less than 1 ½ inches shall be exempt from the escape ring requirement. The Fisheries Director may, by proclamation, exempt the escape ring requirement in order to allow the harvest of peeler crabs or mature female crabs and may impose any or all of the following restrictions:
(1) Specify areas, and
(2) Specify time.

V. Management Options:

(+ potential positive impact of action)
(- potential negative impact of action)

1. No rule change (two 2 5/16 inch cull rings and proclamation authority for peeler and mature female harvest).
   - \+ Allow flexibility for harvest of peelers
   - \+ Allow flexibility for harvest of mature females
   - \- Potentially increase immediate and delayed mortality of sublegal crabs
   - \- Potential reduction in yield to the hard crab fishery
   - \- Poor yield from small crabs would be detrimental to the markets
   - \- Problems with pending and future court cases for closed escape rings
   - \- Potentially increased problems with crabbers circumventing the size limit and culling tolerance

2. Repel proclamation authority to close escape rings for peeler crab harvest.
   - \+ Potential increased hard crab harvest for fishermen
   - \+ Decreased mortality of sublegal crabs
   - \+ Less administrative burden on DMF
   - \+ DMF will need criteria (% catch peelers) to determine when exemption should be used
   - \- Increased pot numbers (more peeler pots)

3. Repeal existing regulation. (Rule 15A NCAC 3J. 0301)
   + Less burden on enforcement (checking cull rings)
   - Increased burden on enforcement (culling crabs)
   - Increased mortalities of sublegal crabs
   - Possible reduction in legal harvest
   - Increased culling burden on pot fishermen

4. Refine regulation to optimize biological and economic efficiency by area.
   + Maximize escapement
   + Minimize onboard culling
   - Increased administrative burden
   - Increased enforcement burden

5. Set up guidelines for using Proclamation authority to close or not require escape rings.
   + Uniform standard for granting or denying requests for exemptions
   - Increased administrative burden
   - Increased enforcement burden
   - DMF will need criteria (% catch mature females or peelers) to determine when exemption should be used

Options two through four would require rule changes by the MFC.

VI. Research Needs:

1. Determine optimum size escape ring for various geographic areas.
2. Further investigate the impact or potential impact of escape rings on crab size.

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Table 1. Mean length and total number of blue crabs from the Pamlico Sound Survey, 1987-1997, for the months of June and September.

Year	Immature females		Mature females		Mature sponge		Males	
	Mean length (mm)	Number	Mean length (mm)	Number	Mean length (mm)	Number	Mean length (mm)	Number
1987	69.5	1,908	134.4	822	141.8	28	80.6	2,615
1988	69.8	703	134.1	341	136.5	32	85.0	844
1989	60.6	1,163	141.8	439	135.6	73	80.0	1,542
1990	73.2	5,672	139.3	1,720			93.4	7,197
1991	69.5	4,818	126.0	2,591			91.5	6,011
1992	75.1	2,189	140.5	738			89.9	2,817
1993	71.5	1,889	134.7	671	178.0	1	82.9	3,028
1994	82.3	1,542	140.0	729	121.0	5	100.0	2,046
1995	69.6	939	127.5	526			86.5	1,312
1996	76.1	2,058	145.3	1,439			90.8	2,671
1997	65.6	4,250	149.5	2,235			75.1	5,018
Overall	71.1	27,131	138.0	12,251	136.8	139	87.5	35,101

Table 2. Mean length and total number of blue crabs from the Pamlico Sound Survey, 1987-1997, for the months of June and September from stations less than 12 feet deep east of Bluff Shoal.

Year	Immature females		Mature females		Mature sponge		Males	
	Mean length (mm)	Number	Mean length (mm)	Number	Mean length (mm)	Number	Mean length (mm)	Number
1987	68.4	385	137.6	205	141.0	10	79.6	458
1988	78.9	124	138.5	155	136.8	4	88.2	194
1989	62.6	249	139.8	97	144.6	16	77.8	260
1990	72.7	1,409	137.4	262			83.0	1,267
1991	72.0	775	122.3	540			95.5	1,483
1992	75.4	314	141.0	196			86.3	573
1993	73.8	323	127.2	290			87.4	462
1994	73.6	271	137.5	126	121.0	5	84.5	274
1995	70.0	125	122.2	162			88.3	159
1996	73.8	145	142.5	362			99.7	259
1997	74.7	291	130.1	180			85.5	326
Overall	72.2	4,411	132.8	2,575	139.3	35	87.7	5,715

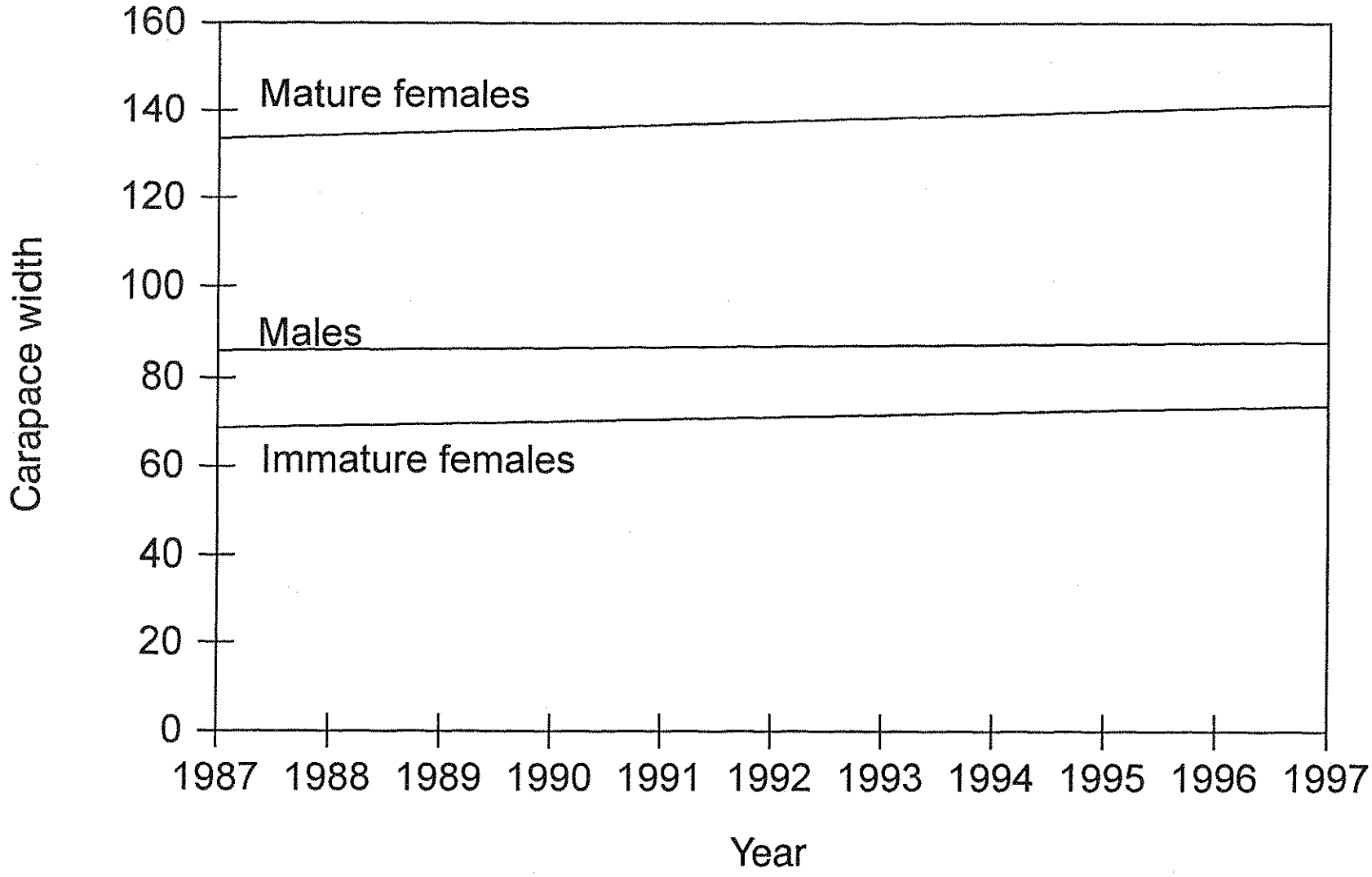

Figure 1. Trends in carapace width for blue crabs captured during the Pamlico Sound Survey, 1987-1997.

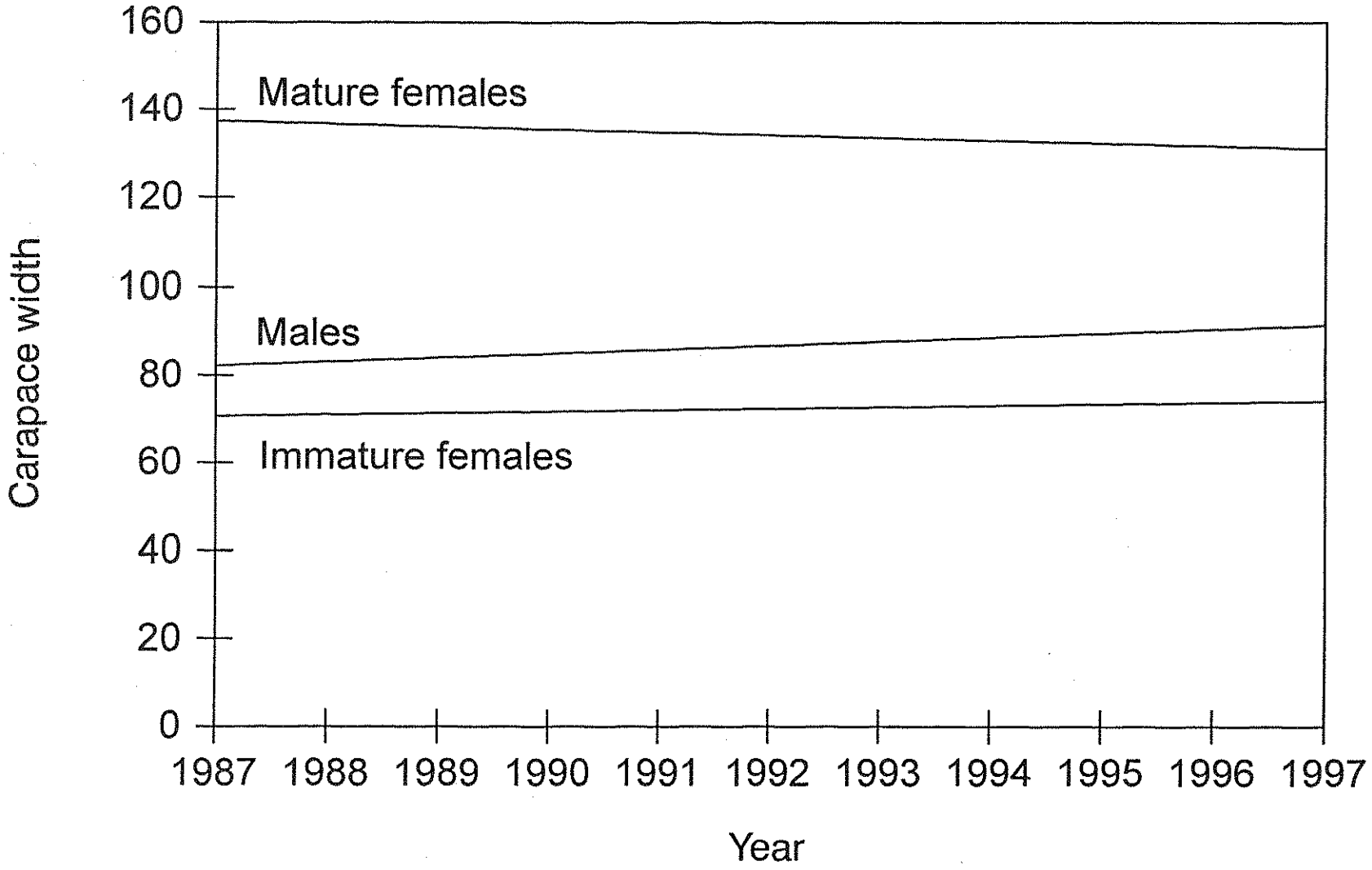

Figure 2. Trends in carapace width for blue crabs captured during the Pamlico Sound Survey in water less than 12 feet deep east of Bluff Shoal, North Carolina, 1987-1997.

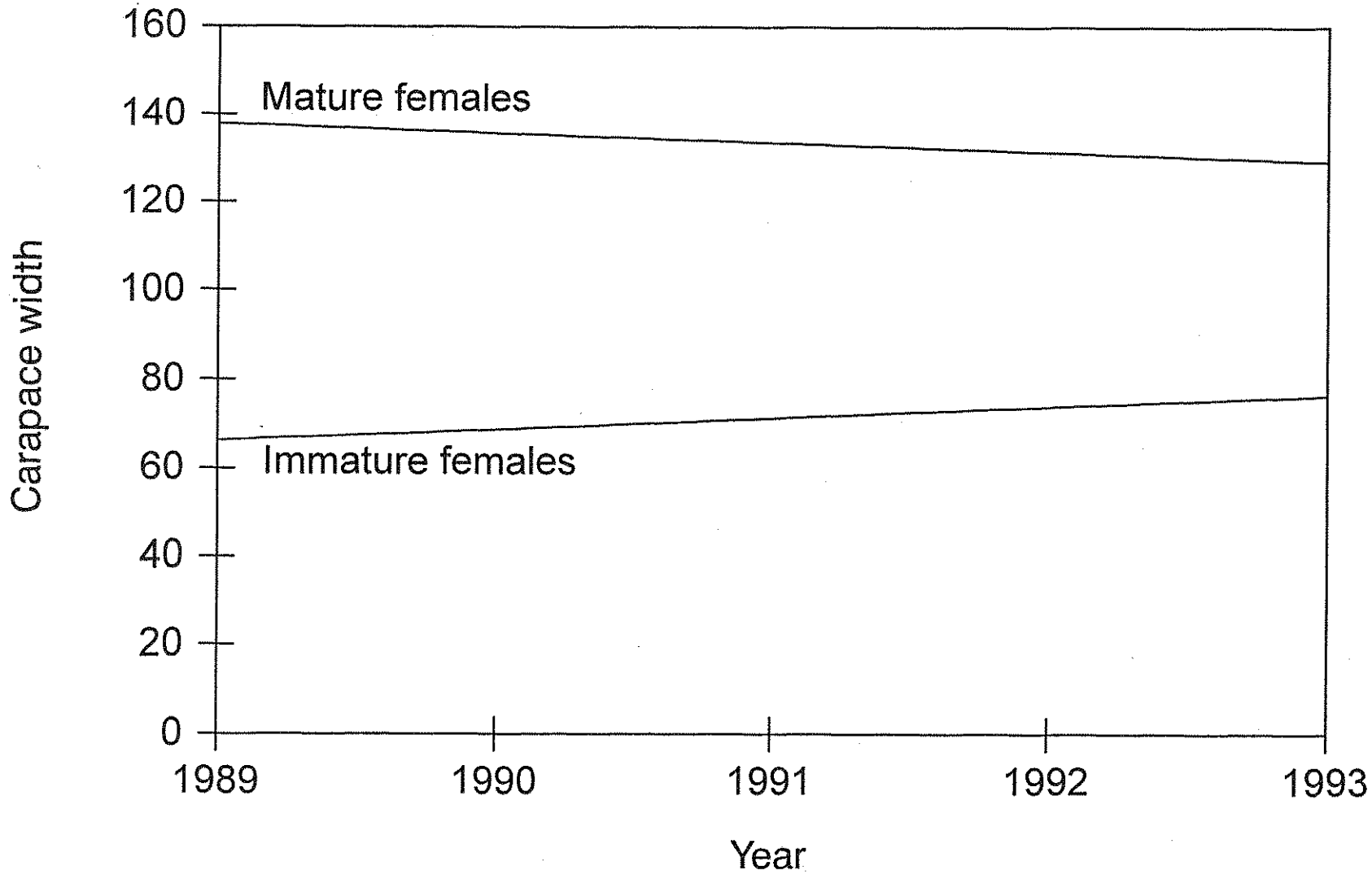

Figure 3. Trends in carapace width for female blue crabs captured during the Pamlico Sound Survey in water less than 12 feet deep east of Bluff Shoal, North Carolina, 1989-1993 (escape ring required).

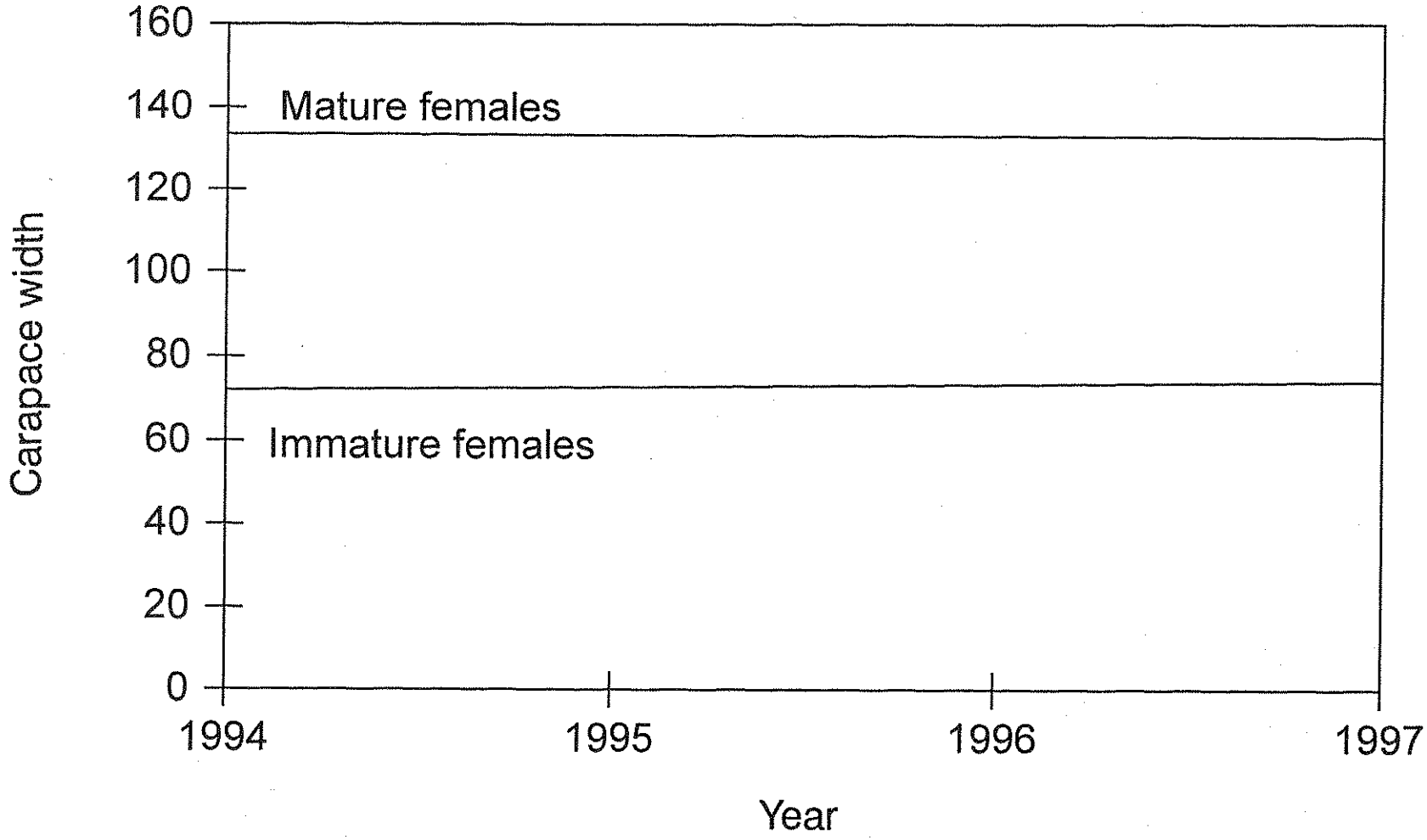

Figure 4. Trends in carapace width for female blue crabs captured during the Pamlico Sound Survey in water less than 12 feet deep east of Bluff Shoal, North Carolina, 1994-1997 (escape ring exemption for the Outer Banks area).

APPENDIX 5. CRAB TRAWL BYCATCH

I. Issue:

Sublegal blue crab and flounder bycatch in the crab trawl fishery.

II. Background:

In North Carolina's internal coastal waters, there are very few (less than 25) trawlers that harvest blue crabs exclusively. Trawling activity is generally directed toward species that will generate the greatest economic yield per unit effort. During the spring, summer, and fall, trawl effort is directed toward shrimp, and in the winter months activity shifts to crabs and flounder. Crab trawl headrope lengths for double-rigged vessels range from 30 to 45 feet, while twin-rigged vessels usually pull four nets in the 30-foot range. Tow times vary depending on the amount of biomass encountered. Tow times generally decrease as biomass increases. Reduced tow time not only saves time in culling catches, but also ensures a quality (live crab) product is delivered to the packing house.

Crab Trawl Landings

Peak crab landings in the crab trawl fishery occur during March - June, and November. Crab trawl landings have been reported from 19 waterbodies in the state (DMF Trip Ticket data 1994-1997). Pamlico Sound accounts for 46% of all hard crabs landed by crab trawls. Other areas with significant crab trawl landings are Pamlico River (17%), Neuse River (9%), Croatan Sound (7%), and Bay River (7%).

Yearly finfish landings by crab trawls have averaged 99,455 pounds (DMF Trip Ticket data 1994-1997). The main species landed is southern flounder, averaging 81,724 lb per year and accounting for 82% of the total finfish landed by crab trawls. Catfish are the next largest finfish component, averaging 9,590 lb per year and 10% of the total. This is followed by weakfish (gray trout) and kingfishes (sea mullet), which each contribute 1% to the total (1,128 and 1,108 lb). The remaining 6% of the finfish landed by crab trawls is divided among 29 different species. Pamlico Sound accounts for 58% of the flounder, 6% of the catfish, 91% of the sea mullet, and 34% of the weakfish landed by crab trawls. The Pamlico River contributes, on average, 24% of the flounder, 89% catfish, 4% sea mullet, and 48% weakfish to the total crab trawl finfish landings. Flounder landings from the Neuse River contribute 3% to the crab trawl total, while catfish accounts for 1%, sea mullet 1%, and weakfish 2%. Pungo River accounts for 8% of the flounder and weakfish.

Summary of Crab Trawl Studies

The crab trawl fishery has received a large amount of attention due to concerns over the bycatch of finfish and sublegal crabs. In 1990 - 1991, a study was conducted by DMF in the Pamlico-Pungo river complex to examine this problem (McKenna and Camp 1992). During this study, 15 trips were made aboard commercial crab trawlers. The mean number of tows made during a trip was 3.3, and ranged from 1 to 5. Tow times ranged from 1 to 4 hours and averaged 2.87 hours. An average trip consisted of 9.46 hours of

towing. On average, 181.55 lb of blue crabs (124.49 lb culls and 57.06 lb of basket crabs), and 131.15 lb of flounder were landed per trip.

Finfish and Invertebrate Bycatch

Species compositions were available for 14 of the 15 trips in the 1990-1991 study (McKenna and Camp 1992). Twenty-seven species of fish and eight invertebrate species were captured. Southern flounder were caught during every trip (15). Spot and Atlantic menhaden were caught in 10 of the 14 trips where species composition was recorded. Hogchokers occurred in eight of the trips, followed by Atlantic croaker (7), oyster toadfish (4), harvestfish (3), striped mullet (3), clearnose skates (2), pinfish (2), gizzard shad (2), bay whiff (2), and spotted seatrout (2). The remaining 14 species of finfish were observed only once. Blue crabs were the most frequently observed invertebrate per trip (15), followed by jellyfish (10), pink shrimp (7), lesser blue crab (5), mantis shrimp (3), iridescent swimming crab (2), horseshoe crab (1), and squid (1).

Of the 26 species of fish (excluding flounder) captured during the study, nine were of commercial importance (spot, Atlantic croaker, Atlantic menhaden, weakfish, harvestfish, striped mullet, sheepshead, spotted seatrout, and white catfish), and 11 are sought by recreational fishermen (pinfish, pigfish, brown bullhead, and all of the above except Atlantic menhaden). With the exception of spot, Atlantic croaker, Atlantic menhaden, harvestfish, and white catfish, the total weight of each species caught during the study (50 tows) was less than 1.1 lb. Due to the nonselective nature of trawls and the inherent variability of fish assemblages, bycatch in the crab trawl fishery will vary temporally and spatially. This variability was evident throughout this study with significant temporal and spatial differences being observed.

Southern flounder was the most abundant fish species by weight, accounting for 95% of the total fish weight and 47% of the total catch weight. Blue crabs accounted for 96% of the invertebrate weight and 33% of the total catch weight. The remaining percentage of the total catch weight was composed of miscellaneous material (16%), fish (3%), and invertebrates (1%).

On average, 13.2 lb of finfish (excluding flounder) were caught (3.9 lb per tow). Spot was the most abundant species by weight, accounting for 35% of the total finfish bycatch (excluding flounder). Atlantic croaker was the second most abundant species (26%), followed by clearnose skates (20%), harvestfish (4%), oyster toadfish (3%), white catfish (2%), Atlantic menhaden (2%), hogchoker (1%), and weakfish (1%). The remaining 6% of the bycatch weight was made up of 16 different species. More than 71% of the spot and 92% of the Atlantic croaker were caught on a single trip on November 14, 1990. This trip and the June 12, 1991 trip accounted for 78% of the total finfish bycatch, 49% and 29% respectively.

Finfish Bycatch and Trawl Tailbag Mesh Size

Over 97% of the finfish bycatch (excluding flounder) was caught during trips in which a three-inch tailbag was used. However, as was the case above, 80% of this bycatch was caught during two trips (11/14/90 and 6/12/91). Twenty-two species of fish were caught in the three-inch tailbag, and eight species occurred in the four-inch tailbag.

Spot and Atlantic croaker occurred in all of the three-inch tailbag trips for which data were available (7 of 8 trips), and accounted for 98% and 100% of the total catch weights for these species, respectively. Atlantic menhaden was the most frequently observed species in the four-inch tailbag, occurring in five of the seven trips, and accounting for 8% of the finfish bycatch for this gear. Redhorse suckers were the dominant species by weight (36%), but they only occurred in one trip. Spot was the second most abundant species in terms of frequency of occurrence and weight, 43% and 25%, respectively. The average catch of finfish bycatch in the three-inch tailbag was 24.16 lb (7.14 lb per tow) and 0.71 lb in the four-inch tailbag (0.21 lb per tow); this difference was significant at the $p=0.001$ level.

Flounder Bycatch and Mortality

Fifty-one percent of the southern flounder caught during this study were sublegal. For every pound of legal flounder landed, 1.04 lb of sublegal flounder (less than 13 inches) were culled from the catch. Mortality estimates for these sublegal fish were not determined. However, studies conducted by the DMF in January and February of 1991 showed that the survival rate of sublegal flounder held for 48 hours was greater than 95%. Tow times for these studies were two hours and the gears used were 30-foot crab trawls. The sample size for these studies was small (29 fish), and exact exposure times and scale loss estimates were not recorded (DMF unpublished data, 1991). In a crab trawl tailbag study conducted in Bay River during 1995 - 1996, Lupton (1996) found that nearly all of the sublegal southern flounder caught during the summer months were dead when returned to the water, while in the spring and winter little immediate mortality was observed.

Studies conducted in Long Island Sound, N.Y., estimated the survival of sublegal winter flounder caught in otter trawls at 60% for two hour tows and 75% for one hour tows (Simpson 1990). Critical factors affecting the survival of fish from trawl catches are tow duration, scale loss, total biomass, handling and sorting time, temperature and maximum depth fished (Jean 1963; Neilson et al. 1989; Wassenberg and Hill 1989; Simpson 1990).

Sublegal Blue Crab Bycatch

The overall percentage of sublegal crabs in the crab trawl catch (54%) was well above the legal tolerance (McKenna and Camp 1992). There was an apparent difference in the percentage of sublegal crabs retained in the two tailbag sizes sampled, 57% and 38% for the three- and four-inch, respectively.

Blue Crab Bycatch Mortality

The incidence of physical injury to trawl and pot-caught crabs was similar in that the appendages were the most frequently damaged area (McKenna and Camp 1992). The chelipeds (pincher appendages) were the most frequently damaged appendage for both gear types; pot-caught crabs showed a greater loss than did trawl-caught crabs, 52% and 33%, respectfully. There were no differences between the survival rates of damaged crabs and undamaged crabs. These findings are in agreement with those of Smith and Howell (1987), who found the appendages were the most frequently damaged structure in pot and trawl-caught American lobsters in Long Island Sound, N.Y. Additionally, Wassenberg and Hill (1989) found that 99% of the trawl-induced damage to sand crabs was restricted to

the appendages.

The only observed cases of immediate mortality in crab-trawl-caught crabs occurred in June (McKenna and Camp 1992). During this trip, a large number of paper shell and soft crabs were killed in the trawling process. These findings agree with those of other investigators who found that immediate mortality in trawl-caught crustaceans was almost entirely limited to soft or paper stage individuals (Smith and Howell 1987; Wassenberg and Hill 1989).

Factors affecting the level of delayed mortality in crustaceans are temperature, exposure time, amount and level of physical injury, and total catch biomass (Smith and Howell 1987; Wassenberg and Hill 1989). Overall survival rates for trawl-caught crabs was 64%, while 93% of the crab pot crabs survived (McKenna and Camp 1992). The effects of temperature were readily apparent; survival rates for trawl-caught crabs during the winter months were 74%, while the individuals caught in June had a 20% survival rate.

III. DISCUSSION:

Sublegal Blue Crab Bycatch and Trawl Tailbag Mesh Size

Requiring a larger mesh size in the tailbag of crab trawls could have biological and economic impacts similar to those of increasing minimum size limits, such as a short-term reduction in the marketable catch and a long-term positive effect on total landings. The number of sublegal blue crabs in commercial catches from the Pamlico River, in which a 3 inch tailbag was used, ranged from 33 to 77% and averaged 54% (McKenna and Camp, 1992). In 1992, the DMF (McKenna and Clark, 1993) conducted a study to examine the culling ability of two larger tailbag sizes (4 inch and 4.5 inch stretched mesh). During this study, the number of sublegal blue crabs was reduced by 13% in the 4 inch tailbag and by 53% in the 4.5 inch tailbag, as compared to catches in a 3 inch tailbag. Also, the number of legal crabs was reduced by 7% in the 4 inch tailbag and by 17% in the 4.5 inch tailbag. Given the high percentage of sublegal blue crabs currently being harvested by the crab trawl fishery, an increase in the minimum tailbag mesh size should be implemented to reduce fishing mortality on this species. Increasing the mesh size to 4.5 inch would significantly reduce the harvest of sublegal crabs. Even though this tailbag might also reduce the harvest of legal crabs by 17%, these individuals would not necessarily be lost to the fishery. Except for the fall migration of mature females to the Outer Banks area, blue crabs exhibit very little long-range movement, and therefore should not be lost to future harvest. Additionally, the reduction of fishing mortality on sublegal crabs should make more individuals available for harvest at a future date.

Flounder Bycatch and Trawl Tailbag Mesh Size

Southern flounder are the most common finfish species landed by crab trawls (85%), averaging 82,474 lb per year (DMF trip ticket data 1994-1996). Over half of the southern flounder caught by commercial crab trawlers in the Pamlico River complex in 1990-1991 were sublegal (McKenna and Camp 1992). The two experimental tailbags tested in 1992 significantly reduced the harvest of sublegal southern flounder (less than 13

inches), 40% in the 4 inch tailbag and 76% in the 4.5 inch tailbag (McKenna and Clark 1993). Reduction rates in the 4 inch tailbag appear to be proportional throughout the sampled size range, whereas, the 4.5 inch tailbag almost totally eliminated the harvest of southern flounder below 9.8 inches.

Finfish Bycatch and Trawl Tailbag Mesh Size

Overall, finfish bycatch (excluding southern flounder) in the 3 inch tailbag averaged 3.90 lb per tow (McKenna and Clark 1993). This number compares favorably with estimates obtained from commercial samples of crab trawlers working the Pamlico River complex during the 1990-91 fishing season, 2.75 lb per tow (McKenna and Camp 1992). Additionally, DMF tailbag studies have shown that the 3 inch tailbag reduces finfish bycatch by over 70% when compared to a 1.5 inch mesh tailbag (DMF unpublished data, 1985 and 1988). The 4 inch tailbag averaged 1.94 lb of finfish per tow, while 0.57 lb of finfish were caught, on average, in the 4.5 inch tailbag. Since the biomass of finfish (excluding southern flounder) caught in crab trawls is relatively small, the selection of a tailbag for its ability to cull finfish should be secondary to its culling ability for crabs and flounder.

Lupton (1996) recommended that a 4 inch tailbag be required in crab trawls. The 4.5 inch tailbag would put too much of an economic burden on crab trawlers, through the reduction of legal crab catch (Lupton 1996). Lupton (1996) suggested that water temperature determines estuarine crab trawl catch (i.e., with surface water temperatures below 50° F crabs go into the mud and are unavailable to trawl gears, and an increase in sublegal crab catch was observed at surface temperatures above 70° F).

IV. Current Regulations:

- It is unlawful to use trawl nets for the taking of finfish in internal waters, except that it shall be permissible to take or possess finfish incidental to crab or shrimp trawling in accordance with the following limitations: it is unlawful to possess more than 500 pounds of finfish from December 1 through February 28 and 1,000 pounds of finfish from March 1 through November 30. 15A NCAC 3J .0104 (a) (1)
- It is unlawful to use trawl nets from December 1 through February 28 from one hour after sunset to one before sunrise in portions of the Pungo, Pamlico, Bay, Neuse, and New rivers. 15A NCAC 3J .0104 (b) (5) (A) (B) (C) (D) (E)
- It is unlawful to use trawls within one-half mile of the ocean beach between the Virginia line and Oregon Inlet. 15A NCAC 3J .0202 (2)
- From December 1 through March 31 it is unlawful to possess finfish caught incidental to crab or shrimp trawling in the Atlantic Ocean unless the weight of the combined catch of shrimp and crabs exceeds the weight of finfish; except that crab trawlers working south of Bogue Inlet may keep up to 300 pounds of kingfish, regardless of their finfish or crab catch weight. 15A NCAC 3J .0202 (5) Temporary rule effective 12/97
- It is unlawful to trawl for crabs between one hour after sunset on any Friday and one hour before sunset on the following Sunday, except in the Atlantic Ocean. 15A NCAC 3L .0202 (d) and 3J .0104 (b) (1)

- It is unlawful to use trawl nets in Albemarle Sound and its tributaries: 15A NCAC 3J .0104 (b) (3)
- It is unlawful to use trawl nets in areas listed in 15A NCAC 3R .0106, except that certain areas may be opened to peeler trawling for single-rigged peeler trawls or double-rigged boats whose combined total headrope length does not exceed 25 feet. 15A NCAC 3R .0106
- It is unlawful to use any trawl net in any primary or secondary nursery area. 15A NCAC 3N .0104 and 3N .0105 (a)
- Special secondary nursery areas may be opened to shrimp and crab trawling from August 16 through May 14. 15A NCAC 3N .0105 (b)
- It is unlawful to take or possess crabs aboard a vessel in internal waters except in areas and during such times as the fisheries Director may specify by proclamation. 15A NCAC 3L .0202 (a)
- It is unlawful to take crabs with crab trawls with a stretched mesh less than 3 inches, except that the Director may, by proclamation, increase the minimum mesh length to no more than 4 inches. 15A NCAC 3L .0202 (b)
- It is unlawful to use trawls with a mesh length less than 2 inches (stretched mesh) or with a corkline exceeding 25 feet in length for taking soft or peeler crabs. 15A NCAC 3L .0202 (c)
- The Director may by proclamation, require finfish excluder [bycatch reduction (new wording effective August 1, 1998)] devices or codend modifications in trawl nets to reduce the catch of finfish that do not meet size limits or are unmarketable as individual foodfish by reason of size. 15A NCAC 3J .0104 (d)

V. **Management Options/Impacts:**
(+ potential positive impact of action)
(- potential negative impact of action)

1. No rule change.
   + No new regulations
   - Continued biological concerns with finfish and sublegal crab bycatch
   - Continued spacial conflicts

2. Increase tailbag mesh size (4 inch or 4.5 inch stretched mesh).
   + Reduce bycatch
   + Possibly increase numbers of legal crabs and southern flounder by delaying age at entry into the fishery
   - Potential economic burden on fishermen
   - Additional regulations will be required to prevent fishermen from using shrimp trawls to target crabs

3. Increase crab trawl stretched mesh size to 4 inches throughout the net in the Pamlico-Pungo, Bay, and Neuse rivers.
   + Reduce bycatch
   + Possibly increase numbers of legal crabs and southern flounder by delaying age at entry into the fishery

- Maximum reduction benefits will not be achieved (area and gear)

4. Harvest seasons.
   + Reduce bycatch mortality
   + Potential decrease in effort
   + Reduce/eliminate conflicts (crab trawl and crab potters)
   + More efficient law enforcement
   - Potential economic burden on fishermen

5. Area restrictions.
   + Reduce bycatch mortality
   + Protect critical habitats
   + Reduce effort
   + Reduce/eliminate user conflicts (shrimp and crab trawler vs. crab potters)
   - Potential economic burden on fishermen (reduction in catch)
   - Increased law enforcement duties

6. Ban crab trawling.
   + Eliminate trawl bycatch mortality
   + Reduce user conflicts (potters vs crab trawlers)
   + Increased crab pot catches
   - Economic hardship for trawlers

Options two through four and six would require rule changes by the MFC. The BCAC's preferred option was 3. Option 6 was added by DMF after the BCAC's approval of the draft plan and was supported by the MFC.

VI. Research Needs:

1) Collect fishery-dependent data from the peeler crab and shrimp trawl fisheries.
2) Conduct tailbag mesh size studies in Pamlico Sound (work to be conducted during 1998 and 1999, through a grant funded by the Fisheries Resource Grant Program).

VII. References:

Jean, Y. 1963. Discards of fish at sea by northern New Brunswick draggers. J. Fish. Res. Board Can. 20:497-524.

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McKenna, S., and J. T. Camp. 1992. An examination of the blue crab fishery in the Pamlico River estuary. Albemarle-Pamlico Estuarine Study Rep. No. 92-08. 101p.

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APPENDIX 6. HARVEST OF WHITE LINE PEELER BLUE CRABS

I. Issue:

Mortality of "white line" peeler crabs.

II. Background:

Peeler crabs are exempt from the 5 inch minimum size limit (Rule 15A NCAC 3L .0201). Peeler crabs (crabs that exhibit signs of impending shedding or molting) are defined by Rule 15A NCAC 3I .0101 (b) (16) (see page 118).

Law enforcement officers have found in certain cases fishermen retain "white line" peelers and use the peeler crab exemption to circumvent the minimum size limit and culling tolerance for hard crabs. The "white line" stage is harder to distinguish (same crab may be staged differently by different people) than the other peeler stages, making the rule harder to enforce. Most states with a peeler definition include "white line" in their definition.

Molting (or shedding) is the process by which blue crabs discard their old shells and grow. Before molting, a new shell is formed beneath the outer shell of the crab. Fishermen use color changes (signs) in the last two sections of the swimming legs to determine the time to next molt. "White line" peeler crabs are within two weeks of molt, "pink line" crabs are within one week, and "red line" crabs are within 1 - 3 days of shedding. During their lifetime, a crab may molt 18 - 22 times. Within 12 hours after the molt, the shell is like parchment and will fully harden within 2 - 3 days. Crab shedding operations collect "peelers" and hold them in tanks until they molt to "soft" crabs.

Natural mortality of sublegal crabs (less than five inches) is in the range of 26 to 32% per year in Chesapeake Bay (Casey et al. 1992). Uphoff et al. (1993) reported the following observations from a survey of Maryland crab shedding operations (June-Sept. 1990):

- 5% to 80% peeler mortality (peeler stage was not reported),
- 80% of responders reported between 10% and 50% peeler mortality, and
- 38% mean mortality (weighted by number of shedding units and production).

"White line" peelers held in shedding operations may experience relatively high mortality (over 50%) because of the length of time held until they molt. Some shedders contend that this high shedding mortality is due to the inexperience of new people entering the shedding business.

Based on this survey of Maryland crab shedding operations, Uphoff et al. (1993) concluded that current industry practices are not sufficiently minimizing shedding mortality. Options outlined to address mortality in shedding operations were:

1) Develop and enforce standards for shedding operations as part of licensing requirements.
2) Prohibit the harvest of white line peelers. (These crabs experience higher

mortality due to more handling).

3) Conduct research to evaluate the conclusions reached in the shedding operation survey and develop more effective practices to minimize mortality.

Observations of North Carolina peeler crabbers indicate that peeler pots baited only with live male "jimmie" crabs catch fewer "white line" peelers and small hard crabs than unbaited or fish and shrimp-baited pots. A requirement that peeler pots be baited only with live male crabs would potentially reduce the harvest of "white line" peelers. Virginia, South Carolina, Georgia, and Florida have varying rules which either: (1) define peeler pots as those pots baited with live male crabs, or (2) provide that peeler pots be baited only with live male crabs, or (3) exempt pots baited only with live male crabs from the escape ring requirement.

III. Discussion:

The DMF's continued concern with this issue is based on two main points: (1) the high shedding mortality of "white line" peelers, and (2) law enforcement concerns with distinguishing the "white line" peeler stage.

The total prohibition of "white line" peeler harvest was addressed by the MFC in 1994, with the MFC voting not to adopt a rule. Seasonal prohibition of "white line" peeler harvest, from June 15 through December 31, was considered by the MFC in 1996; the proposed rule was not adopted.

An alternative to prohibiting the harvest of "white line" peelers would be a rule to require that peeler pots be baited only with live, legal-size male "jimmie" crabs. This option would potentially reduce the harvest of "white line" peelers and have a minimal affect on current fishing practices employed by the crabbing industry.

IV. Current Regulation:

15A NCAC 3I .0101 DEFINITIONS

(a) All definitions set out in G.S. 113, Subchapter IV apply to this Chapter.

(b) The following additional terms are hereby defined:

(16) Peeler Crab. A blue crab that has a soft shell developing under a hard shell and having a definite pink, white, or red line or rim on the outer edge of the back fin or flipper.

V. **Management Options/ Impacts:**
(+ potential positive impact of action)
(- potential negative impact of action)

1. No rule change.
   - \+ Crab shedders have existing "peelers", as defined, to hold for producing soft crabs
   - \+ Current definition is what fishermen coastwide mean when they refer to a peeler
   - \- Fishermen may use definition to exceed size tolerance
   - \- Wasteful, if "white line" peelers die before shedding

2. Prohibit the possession of "white line" peelers.
   - \+ Allow more effective size limit enforcement
   - \+ Prevent a wasteful harvesting practice
   - \- Penalizes experienced shedders that can successfully shed "white line" peelers
   - \- May make the term "peeler" ambiguous

3. Establish a season for the possession of "white line" peelers.
   - \+ Allow more effective size limit enforcement
   - \+ Prevent a wasteful harvesting practice
   - \- Penalizes experienced shedders that can successfully shed "white line" peelers

4. Prohibit the baiting of peeler pots, except with live legal-sized male blue crabs.
   - \+ Reduce catches of "white line" peelers
   - \+ Reduce a wasteful harvesting practice
   - \- Increased enforcement burden

5. Peelers should be culled from the catch where taken in the hard crab pot fishery.
   - \+ Reduce the mortality of undersized crabs
   - \+ Compatibility of regulations (hard crabs must be culled where taken)
   - \+ Decreased burden on law enforcement
   - \+ Increase the survival of peeler crabs
   - \- Increased work for crabbers

6. Establish a season for the possession of male "white line" peelers.
   - \+ Allow more effective size limit enforcement
   - \+ Prevent wasteful harvesting practice
   - \+ Decreased burden on law enforcement
   - \- Increased work for crabbers

Options two through six would require rule changes by the MFC. The BCAC's preferred option was 4.

VI. Research Needs:

1) Shedding mortality rates by peeler stage, area, and season.
2) Importance of "white line" peelers to the economics of the fishery.
3) Peeler pot catch rates by peeler stage with various baiting methods.
4) Develop more effective shedding practices to minimize mortality.

VII. References:

Casey, J.F., B. Daugherty, G. Davis, and J.H. Uphoff. 1992. Stock assessment of the blue crab in Chesapeake Bay, 1 July 1990 – 30 September 1991. Maryland Department of Natural Resources, Annapolis, Maryland.

Uphoff, J., J.F. Casey, B. Daugherty, and G. Davis. 1993. Maryland's blue crab peeler and soft crab fishery: problems, concerns, and solutions. Tidal Fisheries Technical Report Series, No. 9. Maryland Department of Natural Resources, Annapolis, Maryland.

APPENDIX 7. CRAB POT FINFISH BYCATCH

I. **Issue:**

Finfish bycatch in crab pots.

II. Background:

Yearly finfish landings by crab pots have averaged 84,626 pounds (DMF Trip Ticket Program, 1994-1997). In 1997, 33 species of finfish were landed by crab pots. Catfish accounted for 66%, and flounder accounted for 20% of the crab pot finfish landings. Landings of finfish bycatch from crab pots are most common in the following waterbodies: Albemarle Sound (36%), Currituck Sound (24%), Pamlico Sound (8%), and the Pamlico River [8% (DMF Trip Ticket Progam, 1997)].

III. **Discussion:**

No data exist on the composition (species), quantity, or fate of unmarketable finfish bycatch in the crab pot fishery. Before this issue can be addressed, this baseline information must be collected.

IV. **Current Rules:** None

V. **Management Options/Impacts:**
(+ potential positive impact of action)
(- potential negative impact of action)

1. No regulatory action.
   + No new regulations
   - Potential waste of finfish resource

2. Require finfish excluders in hard and peeler crab pots.
   + Reduce unmarketable finfish bycatch
   - Reduction in marketable finfish bycatch
   - Possible loss of legal crabs

Option two would require a rule change by the MFC. The BCAC supported Option 1.

VI. **Research Needs:**

1. Collect baseline data on the composition, quantity, and fate of unmarketable finfish bycatch in the crab pot (hard and peeler) fishery, by season and area.
2. Develop a bycatch reduction device for hard and peeler crab pots.

APPENDIX 8. SMALL PEELER/SOFT CRAB HARVEST

I. Issue:

The harvest of small peeler/soft crabs.

II. Background:

Peeler and soft crabs are exempt from the 5 inch minimum size limit (Rule 15A NCAC 3L .0201). Peeler crabs (immature hard crabs that exhibit signs of impending shedding or molting) are defined by Rule 15A NCAC 3I .0101 (b) (16).

Molting (or shedding) is the process by which blue crabs shed their shells and grow. Before molting, a new shell is formed beneath the outer shell of the crab. Fishermen use color changes (signs) in the last two sections of the swimming legs to determine the time to next molt. "White line" peeler crabs are within two weeks of molt, "pink line" crabs are within one week and "red line" crabs are within 1 - 3 days of shedding. During their lifetime, a crab may molt 18 - 22 times. Within 12 hours after the molt, the shell is like parchment and will fully harden within 2 - 3 days. Crab shedding operations collect "peelers" and hold them in tanks until they molt to "soft" crabs.

Natural mortality of sublegal crabs (less than five inches) is in the range of 26 to 32% per year in Chesapeake Bay (Casey et al. 1992). Uphoff et al. (1993) reported the following observations and conclusions from a survey of Maryland crab shedding operations (June-Sept. 1990):

- 5% to 80% peeler mortality (peeler stage was not reported),
- 80% of responders reported between 10% and 50% peeler mortality, and
- 38% mean mortality (weighted by number of shedding units and production).

Some shedders contend that this high shedding mortality is due to the inexperience of new people entering the shedding business. Generally, mortality is less for the smaller peelers.

Raising the peeler size limit would potentially provide an increase in spawning stock biomass by allowing more females to enter the spawning population, thereby reducing the potential for recruitment overfishing (Uphoff et al. 1993). The percent of mature females (assuming a 30% increase in size after the peeler sheds) rises rapidly with an increase in peeler minimum size from 3.0 inches (0%) to 3.5 inches (30-40%) or from 3.0 inches to 4.0 inches (80-90%; Rothschild et al. 1992). With a minimum size limit between 3.5 and 4.0 inches, female soft crabs must molt one or two more times to reach maturity. Approximately, 10% would be mature at 4.5 inches and nearly 90% would be mature at 5.0 inches (Rothschild et al. 1992).

Raising the size limit should also increase yield to the fishery (Uphoff et al. 1993). An increase of 0.5 inches to the minimum 3.0 inch peeler size, increases the after-shedding weight of an individual crab by an additional 60% and an increase of 1.0 inches increases individual weight by 120%. The time interval between sheds of 3.0 or 3.5 inch crabs will

generally be one to three months (Rothschild et al. 1992). The increase in yield from an increased peeler size limit would not be totally lost to natural mortality. Increasing the peeler size limit 0.5 inches would result in a 9% drop in numbers and a 25% increase in yield by weight at 3.5 inches. Increasing from 3.0 to 4.0 inches decreases numbers by 18% and increases yield at the new minimum size by 49%. As the time between sheds increases with increasing size, the probability of capture of larger crabs at the peeler stage decreases.

Law enforcement officers have found, in certain cases, that fishermen use the peeler crab exemption to circumvent the minimum size limit and culling tolerance. A peeler/soft crab size limit could allow more effective and efficient enforcement of size limits.

III. Discussion:

Several of the Atlantic and Gulf Coast States have minimum size limit restrictions on peeler and/or soft crab harvest. Minimum size limits (3 inches for peelers and 3.5 inches for soft crabs) in Maryland date back to 1929, and like many size limits of the time, probably reflected perceived marketability by seafood dealers (Uphoff et al. 1993). Adopting a minimum size limit of 3 inches for peelers and/or 3.5 inches for soft crabs would address regulatory consistency among the Atlantic Coast States and foster interstate trade.

The overall value of the peeler/soft crab fishery might be enhanced by a size limit as larger soft crabs generally bring a higher price. A potential adverse impact on the soft crab fishery would be a decrease in market flexibility, particularly during the early spring when product availability is low and small peeler/soft crabs are in demand, bringing very high prices to fishermen. A size limit might increase handling mortality and waste in the fishery.

IV. Current Rule:

15A NCAC 3L .0101 SIZE LIMIT AND CULLING TOLERANCE

(a) It is unlawful to possess blue crabs less than five inches from tip of spike to tip of spike except mature females, soft and peeler crabs. A tolerance of not more than 10 percent by number in any container shall be allowed.

(b) All crabs less than legal size, except mature female and soft crabs shall be immediately returned to the waters from which taken. Peeler crabs shall be separated from the entire catch and placed in a separate container before reaching shore or dock. Those peeler crabs not separated before reaching shore or dock shall be deemed hard crabs and are not exempt from the size restrictions specified in Paragraph (a) of this Rule.

V. Management Options/ Impacts:

(+ potential positive impact of action)
(- potential negative impact of action)

1. No rule change.
   + Crab shedders have existing "peelers", as defined, to hold for producing soft crabs
   + Allows for market flexibility
   + Reduced handling mortality and waste
   - Fishermen may use peeler/soft crab exemption to exceed size tolerance
   - No protection for small peeler/soft crabs
   - Potential for increased harvest pressure on small peeler/soft crabs

2. Establish a minimum size limit for peelers and/or soft crabs.
   + Enable better enforcement of size limit
   + Protect small peeler/soft crabs
   + Reduce harvest of small peeler/soft crabs
   + Increase regulatory consistency among states
   + Potential increase in spawning stock biomass
   + Increased yield
   - Increased enforcement burden
   - Eliminate early high price market for small peeler/soft crabs
   - Potentially increase handling mortality and waste
   - Reduce existing peeler availability

Option two would require a rule change by the MFC. Option one was the BCAC's preferred option.

VI. Research Needs:

1) Shedding mortality rates by size, area, and season.
2) Develop more effective shedding practices to minimize mortality.
3) Economic impact of implementing minimum size limit.

VII. References:

Casey, J.F., B. Daugherty, G. Davis, and J.H. Uphoff. 1992. Stock assessment of the blue crab in Chesapeake Bay, 1 July 1990 – 30 September 1991. Maryland Department of Natural Resources, Annapolis, Maryland.

Rothschild, B.J., J.S. Ault, E.V. Patrick, S.G. Smith, H. Li, T. Maurer, B. Daugherty, G. Davis, C.H. Zhang, and R.N. McGarvey. 1992. Assessment of the Chesapeake Bay blue crab stock. University of Maryland, Chesapeake Biological Laboratory, CB92-003-036, CEES 07-4-30307, Solomans, Maryland.

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APPENDIX 9. DIAMONDBACK TERRAPIN BYCATCH IN CRAB POTS

I. Issue:

Diamondback terrapin (Malaclemys terrapin) bycatch and mortality in blue crab pots.

II. Background:

Diamondback terrapins are found throughout North Carolina's high salinity coastal marshes. In a South Carolina study (Bishop 1983), terrapins were captured in salinities ranging from 4.3 to 22 parts per thousand (ppt), with most captures in 10.1 to 15 ppt. Preferred habitats are the waters immediately adjacent to the marsh, small creeks, and mosquito control ditches. Terrapins are a long-lived species, probably surviving in excess of forty years. Females mature in 7 to 9 years, and fecundity is relatively low (Hildebrand 1932).

Populations of diamondback terrapins have declined throughout their range from Cape Cod, Massachusetts to southern Texas (Palmer and Cordes 1988, Seigal and Gibbons 1995). Possible reasons for this decline (Grant 1997) are (1) degradation and loss of habitat, (2) mortality on roads (Wood 1995), (3) raccoon predation (Seigel 1980), and (4) incidental drowning in trawls, nets, and crab pots (Bishop 1983, Wood 1995). Blue crab pots may account for more adult diamondback terrapin mortalities than any other single factor (Bishop 1983). The diamondback terrapin is included on the North Carolina listing of "Endangered and Threatened Species" as a "Species of Special Concern." The status of "Special Concern" does not provide any special protection under the federal Endangered Species Act. The status may be upgraded to "Threatened" or deleted from the list as more information is collected on the species.

Various studies in New Jersey (Wood 1995), Maryland (Roosenburg et al. 1997), North Carolina [Grant 1997; NC Wildlife Resources Commission (WRC) unpublished; Tom Henson (WRC), pers. comm.], and South Carolina (Bishop 1983) have documented diamondback terrapin bycatch and mortality in crab pots. Few captured terrapins were drowned when crab pots were checked daily, and estimated capture mortality amounted to 10% (Bishop 1983). Bishop (1983) noted that the occurance of ghost pots is perhaps far more detrimental to terrapin populations than actively fished pots. Some observations suggest that once a terrapin is captured others may be attracted, particularly males to a female.

Limiting factors affecting the catchability of terrapins in crab pots are:
(1) the abundance of terrapins,
(2) terrapin size (depth of shell),
(3) vertical height of the crab pot funnel,
(4) distance of the crab pot from shore, and
(5) season.

Each of these limiting factors and its relationship to crab pot catchability are discussed

below.

Population size will influence catchability. Estimates of capture rates and population size by Roosenburg et al. (1997), suggest that 15-78% of a local population may be captured annually. However, all coastal areas do not contain suitable terrapin habitat as outlined by Palmer and Cordes (1988).

Male terrapins do not grow as large (shell depth and length) as females, and may remain vulnerable to entrapment throughout their life. Female terrapins become too large to enter crab pots by the time they reach age eight (Roosenburg 1997). However, small terrapins of either sex are vulnerable to capture.

Rectangular wire excluders, which restrict the vertical and horizontal dimensions of crab pot funnels, have been used to reduce or eliminate terrapin bycatch. A 90% reduction in terrapin captures and an increase in crab captures was reported by Wood (1995) in New Jersey for pots equipped with 2 X 4 inch excluders. Grant (1997) conducted a study of the impacts of crab pots with and without excluder devices in North Carolina's estuarine waters near Ocracoke, Sneads Ferry, and Wrightsville Beach. Each area contained small populations of terrapins and active commercial crab pot fisheries. The 2 X 4 inch excluder, tested in 1995-96, showed a 75.7% reduction in terrapin bycatch and a 19% reduction in legal-size crabs (Grant 1997). In an effort to further reduce small terrapin bycatch, Grant (1997) tested a more restrictive vertical dimension (1 5/8 X 4 3/4 inch) excluder in 1997. The 1 5/8 X 4 3/4 inch excluder eliminated all terrapin bycatch and reduced legal crab harvest by about 29%. An alternative to excluders, a modified crab pot that maintains permanent access to air and prevents the drowning of terrapins, has been tested by Roosenburg et al. (1997) in Chesapeake Bay. Roosenburg et al. (1997) reported that the modified crab pot caught more crabs than standard pots.

Grant (1997) showed a significant reduction in terrapin captures as distance from shore increased. The majority of the terrapins (84.5%) were captured less than 27 yards from shore and 15.5% were taken between 28 and 55 yards offshore. No terrapins were captured in pots more than 55 yards from shore. He noted that few commercial crab pots are fished near-shore where most terrapins occur. Generally the water is too shallow near-shore for commercial crabbing operations, except in the deeper tidal creeks and along the Intracoastal Waterway (ICW). Most of the near-shore pots observed by Grant (1997) were along the edges of the ICW and within 22 yards of shore. No diamondback terrapins were observed in the surveyed area of the ICW, Stump Sound, N.C.

Crab pot catch of terrapins was distinctly seasonal in South Carolina, with the majority of captures occurring during April and May. The elevated catches in April and May were probably associated with post hibernation feeding and reproduction activity (Bishop 1983). Pots may be concentrated in shallow near-shore waters, near terrapin habitat, during the spring to catch peeler crabs. Pots in these areas decline during June through August (Tom Henson, WRC, pers. comm.).

III. Discussion

New Jersey is the only state that requires the use of terrapin excluders in crab pots. Other states may be considering terrapin excluders in the future.

New Jersey's original rule (effective January 1, 1998) required that all commercial crab pots set in any body of water, less than 150 feet wide from shore to shore or any man-made lagoon, contain terrapin excluder devices attached to the inside of all pot entrance funnels which met the following criteria:

1) The terrapin excluder device shall be rectangular and no larger than four inches wide and two inches high;
2) The terrapin excluder device shall be securely fastened inside each funnel to effectively reduce the size of the funnel opening to no larger than four inches wide and two inches high; and
3) Any similar device may be approved by the Division after consultation at a regularly scheduled meeting of the Marine Fisheries Council.

In May 1998, New Jersey modified the rule to allow rectangular and diamond shaped excluder devices no larger than six inches wide and two inches high.

Based on the study done by Grant (1997) in North Carolina, an excluder that restricts the funnel opening to 1 5/8 inches in height would be the most efficient size to eliminate terrapin bycatch. Grant (1997) also noted that the combination of excluders and pot distance from shore effectively eliminated terrapin mortality in crab pots.

IV. Current Rule: None

V. Management Options/ Impacts:

(+ potential positive impact of action)
(- potential negative impact of action)

1. No regulatory action.
   + No additional pot regulations on fishery
   + No increased costs for crabbers to modify pots
   + No reduction in crab catch
   - Continued uncontrolled terrapin bycatch and mortality

2. Require terrapin excluders and/or modifications to crab pots fished within a specified distance of shore during the spring, within specified areas.
   + Reduce terrapin bycatch and mortality
   - Additional pot regulations on fishery
   - Increased costs for crabbers to modify pots
   - Reduction in crab catch
   - Increased enforcement burden

Option 2 would require rule changes by the MFC. The Blue Crab FMP Advisory Committee (BCAC) supported including options 1 and 2 in the FMP for consideration and supported additional research prior to any action.

VI. Research Needs:

1) Diamondback terrapin distribution.
2) Problem assessment of crab pot bycatch and mortality by season and area, including fishermen observations.
3) Assessment of excluder devices and/or potential pot modifications.

VII. Literature Cited:

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APPENDIX 10. WHITE BELLY CRAB HARVEST

I. Issue:

The harvest of white belly crabs.

II. Background:

White belly crabs are blue crabs that have recently completed the molting process (shedding the exoskeleton in the process of growth). The shells of white belly crabs have not fully hardened and the crab has not yet filled out or grown into its new shell. These crabs are light in weight and meat yield and quality is reduced. It is widely recognized by the industry that these crabs, if not harvested would provide a greater meat yield at a later date (usually within 2 – 3 weeks post-molt). When crabs are plentiful, white belly crabs do not have meat yields suitable for the live basket market and are generally sold to the picking houses. However, when crabs are in short supply and demand and price is high, these crabs do enter the live basket market (as a grade number 4).

III. Discussion:

Current markets and the continuing harvest of white belly crabs reduces yield from the fishery and promotes waste of a potentially more valuable resource. Due to the complexity of markets and defining a white belly crab for enforcement purposes, no regulatory action has been taken to reduce this wasteful harvesting practice. In the absence of regulatory measures, the industry could provide the greatest protection to this segment of the resource by not purchasing these poor quality crabs. It is perceived that yield and the fishery in general would ultimately benefit from a concerted effort by all crab buyers and harvesters to provide a higher quality product.

IV. Current Rule: None

V. Management Options/ Impacts:

(+ Potential positive impact of action)
(- Potential negative impact of action)

1. No regulatory action.
   - \+ No new rules
   - \+ Allows for market flexibility
   - \- Continuation of a wasteful harvest practice
   - \- Reduced yields for the fishery

2. Prohibit harvest of white belly crabs.
   + Prohibits a wasteful harvest practice
   + Increased yields for the fishery
   - Difficulty in defining white belly crab stage for enforcement purposes
   - Increased enforcement burden
   - Increase work for crabbers
   - Loss of short-term income for crabbers

3. Reduce harvest of white belly crabs.
   + Reduces a wasteful harvest practice
   + Potential increased yield for the fishery
   - Difficulty to define white belly crab stage for enforcement purposes
   - Increased enforcement burden
   - Increase work for crabbers
   - Loss of short-term income for crabbers

Options 2 and 3 would require rule changes by the MFC. The BCAC supported Option one and industry education efforts to reduce white belly harvest.

VI. Research Needs:

1) Information on meat yields of post molt crabs by week and distinguishing characteristics of white belly crabs.
2) Economics of the existing or reduced harvest of poor quality white belly crabs.

APPENDIX 11. CONFLICT AND EFFORT MANAGEMENT

Issue:

Effort management deals with the biological, social, and economic aspects of the blue crab fishery. This discussion will focus on the social and economic issues. The number one problem with regard to effort management is the increase in the number of crab pots in the fishery.

Background:

A. Social Issues:
A1. Spacial conflicts

Vessel license data provides information on the type and amount of gear owned. These data do not indicate what is actively used, only what an individual says they own. However, over the long-term, these data are useful for examining gear trends.

The number of reported crab pots possessed by all user groups (full-time, part-time, and recreational) in North Carolina increased 96% from 350,379 in 1983 to 687,968 in 1993 (1983 - 1993 DMF vessel licenses data). Reported pot numbers for full-time commercial fishermen increased by 151% (198,226 to 498,179).

Due to concerns over the increase in pot numbers and the threat of crab pot limits, a group of crabbers met in March of 1993 and recommended to the state the formation of a separate crab license and a blue crab advisory panel. The crab license was passed by the General Assembly in July 1993, and went on sale on January 1, 1994. On January 29, 1994, a group of crabbers met in Manteo to discuss the concept of a two-year moratorium on crab license sales. The concern of crabbers attending this meeting was the rapid increase in the number of crabbers and the subsequent build-up of pots. State officials expanded this concept to cover all commercial fishing licenses. With support from the majority of the commercial fishing community the North Carolina General Assembly put a freeze on new licences, effective July 1, 1994. An Appeals Panel was established at this time to allow new entrants into the fishery. From July 1994 through October 14, 1997, there were 1,565 petitions for new commercial licenses received [does not include 15 emergency (30 day) and 81 issued to family members due to death in the family or a family member surrendering his/her license]. A total of 579 new licenses was approved (37%). Of the 1,565 petitions received, 444 were for crab licenses (28.4%). One hundred and eighty new crab licenses were approved (40.5%). The breakdown by crab license category is 282 individual crab, of which 100 (35.5%) were approved; 162 vessel crab, of which 80 (49.4%) were approved.

The license moratorium is scheduled to expire on June 30, 1999. At this time, there will be an overall cap (approx. 8,785) on the number of commercial fishing licenses available. Additionally, the crab license will no longer exist, and all fishermen holding a Standard Commercial Fishing License (SCFL) could fish for crabs.

The drastic increase in pot numbers has resulted in more frequent and severe conflicts over fishing space and competition for the resource.
Conflict over space occurs between:

1) Trawlers and potters;
2) Other commercial fishermen and potters;
3) Recreational users and potters; and
4) Potter and potter (part-time, full-time, and recreational).

Competition for the blue crab resource occurs among:

1) Trawlers and potters;
2) Potter and potter (part-time, full-time, and recreational);
3) Nonresident crabbers and resident crabbers; and
4) Trawler and trawler.

Conflicts may result in gear being moved, damaged, destroyed, or stolen. Theft of potted crabs has increased in some areas as effort and price of the resource has increased. Fishermen are setting more pots then can actively be fished. Pots may be set in several locations to hold fishing sites, while crabbing more productive areas. Additionally, pots may be left during unproductive times to pursue other activities (gill netting, trawling, hunting, etc.). Unattended pots continue to capture crabs and contribute to unnecessary mortality and waste of the fishery resource. These unattended pots cause conflicts with other water users, commercial and recreational.

In a series of in-depth interviews with fishermen throughout North Carolina, Johnson and Orbach (1996) found that 58% of the full-time fishermen interviewed in the Albemarle area had conflicts over space. Forty-three percent of the full-time fishermen from the Pamlico area reported spacial conflicts, 35% in the Dare area, 34% from the Carteret area, and 33% from the Southern area (Johnson and Orbach 1996). Except in the Carteret area, crab pots were the major gear involved in spacial conflicts among full-time fishermen; 82% Albemarle, 60% Pamlico, 50% Southern, and 43% Dare (Johnson and Orbach 1996). Spacial conflicts in the Carteret area were with trawls and pots (38% each) and channel nets (25%). In a survey sent to crabbers landing over 6,000 lbs of crabs, Stroud (1997 and 1998) found that 25% of the respondents reported conflicts with other crab potters in 1996 compared to 44% in 1997. In 1996, 16% of the respondents reported conflicts with recreational water users and 14% of the fishermen reported conflicts with other commercial fishermen (Stroud 1997). These numbers increased to 25% for both groups in 1997 (Stroud 1998). A social/economic study conducted in 1984 by Maiolo et al. (1985) in North Carolina indicated that 62% of the full-time crab fishermen and 35% of the part-time crab fishermen had problems with recreational fishermen. Space and gear conflicts were the main problem, with 41% of the crabbers stating that sports fishermen fish their pots (Maiolo et al. 1985). Seventy-five percent of the crab trawlers interviewed said that the presence of crab pots presented a problem (Maiolo et al. 1985). The main problem reported by crab trawlers (67%) was limited trawling area due to space conflicts with potters, while 33% complained that pots were drifting offshore and getting tangled in their nets (Maiolo et al. 1985). Only 42% of the crab potters interviewed said the presence of crab trawlers presented a problem (Maiolo et al. 1985). The major complaint by full (76%) and part-time (75%) crab potters was destruction of pots by trawls (Maiolo et al. 1985). The recent proposal by Goose Creek State Park to close waters off the park's boundaries

to commercial fishing and the Wildlife Resources Commission's proposal to close inland waters to commercial crab pots, exemplifies the conflicts between recreational water users and commercial fishermen.

To date the Marine Fisheries Commission (MFC) and the Division of Marine Fisheries (DMF) have dealt with spacial conflicts by:

1) Meeting with the various user groups to work out compromises;
2) Designating pot areas;
3) Restricting crab pot fishing times; and
4) Increasing law enforcement.

Possible solutions to spacial conflicts include:

1) Management areas;
2) Harvest seasons;
3) Gear restrictions/ reductions;
4) Time restrictions;
5) Catch limits;
6) Delayed entry;
7) Licenses (individual, fishery, and/or gear specific);
8) Permits (individual, fishery, and/or gear specific); and
9) Area restrictions;
10) Limited entry.

All options would require rule changes by the MFC. Options six, seven, and ten would require legislative action. The BCAC did not specifically endorse any management strategy or action on this issue. However, the BCAC agreed that there are too many pots resulting in social conflicts.

(Refer to section **C. Discussion of Management Options** (page 137) for discussion of solutions.)

B. Economic Issues:

B1. Increasing Effort and Declining Catch-Per-Unit-Effort (CPUE)

The blue crab is a finite resource, and landings do not increase proportionally with effort. The number of crab potters and pots have increased dramatically, but CPUE has declined. Information on blue crab pot use, number of fishermen, and harvest are available from landings and operating unit surveys conducted by the National Marine Fisheries Service [NMFS (early 1900's to 1977)] and the DMF (1978 to present). Although data (number of pots and fishermen, trips, and landings) are available for 1994 through 1997, a new data collection technique (mandatory trip tickets) and a license moratorium were imposed in 1994, thereby hindering comparisons with older data. Therefore, only data from 1952 through 1993 are used. These data are useful for showing long term trends in landings and CPUE's. From 1952 through 1968 CPUE varied from year to year. Since 1969, there has been an inverse relationship between the average number of crab pots fished and the overall landings per pot (Figure 1). The average number of crab pots per fishermen in 1969 was 67, while the average CPUE was 469 pounds. In 1985, the

average number of crab pots being fished was 167, and the CPUE had dropped to 77 pounds.

The reported number of crab pots used by all user groups (full-time, part-time, and recreational) in North Carolina increased 96% from 350,379 in 1983 to 687,968 in 1993 (1983 - 1993 DMF vessel licenses data; Table 1). Reported pot numbers for full-time commercial fishermen increased by 151% (198,226 to 498,179). Commercial landings by pots for this period increased by 39%, while the catch per pot declined by 29% (1983 - 1993 DMF landings data). Data from other major blue crab producing states has shown the same trends as North Carolina with regard to increasing effort (pots and fishermen) and decreasing CPUE [Texas (Cody et al. 1991), Louisiana (Guillory et al. 1994), Alabama and the West Coast of Florida (Steele and Perry 1990), Georgia (Evans 1997), and Virginia and Maryland (Rugolo et al. 1997)].

Many fishermen have shifted their effort to the crab pot fishery in recent years. This shift is due to declines in several of North Carolina's historically significant fisheries (oyster, river herring, shad, striped bass, etc.) and the resulting gear and harvest quota restrictions that accompanied these declines. From 1983 through 1993, the total number of vessel license respondents who checked crab pots has declined by 1.5%, while those who checked full-time commercial fishermen increased by 80% [1,278 in 1983 and 2,295 in 1993 (1983 - 1993 DMF vessel license data)]. These data show that overall participation in the crab fishery has remained steady from 1983 through 1993, while the number of full-time commercial fishermen using pots has increased significantly.

Observations by the crabbing community indicate that the peeler/soft crab fishery is the most rapidly expanding segment of the fishery. Most of the expansion is occurring in the northeast portion of the state in Camden, Currituck, Dare, Hyde, Pasquotank, and Tyrrell counties. The increased sale of peelers to out of state buyers, new and expanding soft crab shedding operations, and increasing product demand are contributing to the increased effort and growth in the peeler/soft crab fishery. Due to the data collection and recording methods, DMF has insufficient trip level effort data on this fishery to quantify this trend of increasing effort. Although, peeler pots were added to the Trip Tickets in 1996, trips with this gear are generally combined with hard crab pot trips. Also, hard crab and peeler trawl trips are likely lumped together.

The reported number of trips and catch-per-trip for crab pots and crab trawls are shown below (DMF trip ticket program, 1994-1997).

Gear	1994	1995	1996	1997
Crab trawl trips	3,888	2,221	4,344	5,060
Catch-per-trip	480 lb.	471 lb.	707 lb.	581 lb.
Hard crab pot trips	114,063	119,998	115,995	121,476
Catch-per-trip	433 lb.	361 lb.	533 lb.	431 lb.
Peeler pot trips	No data	No data	135	457
Catch-per-trip			535 lb.	275 lb.

This database is not of sufficient length to make any interpretations concerning effort trends. However, the number of reported trips does indicate that in terms of effort reduction or stabilization the crab pot fishery should be the number one priority.

If crab abundance is controlled primarily by environmental factors, then there is little that management can do biologically to control declining CPUE, except to minimize waste and assure adequate brood stock for future production. Possible non-biological solutions include:

1) Management areas;
2) Harvest seasons;
3) Gear restrictions/ reductions;
4) Time restrictions;
5) Catch limits;
6) Delayed entry;
7) Licenses (individual, fishery, and/or gear specific);
8) Permits (individual, fishery, and/or gear specific; and
9) Limited entry.

(Refer to section **C. Discussion of Management Options** (page137) for discussion of solutions.)

B2. Access to the Fishery:
B2.1. Commercial

It has long been advocated that in any fishery in which access is open to all, overfishing and serious economic problems will eventually occur (Kirkley et al. 1995; Waters 1991; Buck 1995a). Increases in fishing effort reduces future catch rates by reducing the size of next year's population via increased fishing mortality and decreased spawning potential. At high levels of effort, a slight increase in effort can cause a stock to decline drastically, and populations will take longer to recover. The major economic problem often encountered in open access fisheries is a decline in profit, production, and revenues per individual; while cost per unit of production increases. As effort (number of fishermen) increases from A (low effort) to C (high effort); profit becomes smaller (Figure 2). Eventually, the number of fishermen increases to such a level that overall profit for the

fishery becomes zero (Kirkley et al. 1995; Waters 1991). When total cost and total revenue are equal, there are more fishermen and gear than are necessary to harvest a given level of crabs. Harvesting becomes inefficient, when effort is unnecessarily high. So excess capital and labor could be used elsewhere in a more cost effective manner and the same quantity of fish could be produced at lower overall cost (Waters 1991).

B2.1.2 Open Access

Hardin (1968) felt that natural resources held in "common" are doomed to over-exploitation. Users of a common resource do not have exclusive rights to the resource and cannot prevent others from sharing in their exploitation. Hence, natural resources are inevitably overexploited because each user places self-interest above community interests.

Open access methods of fisheries management attempt to reduce fishing mortality directly (gear restrictions or prohibitions) or indirectly (trip limits, quotas, size limits, seasonal and area closures, and individual, fishery, and/or gear-specific licenses). Most of these methods create economic inefficiencies by forcing fishermen to adopt less productive harvesting techniques and/or incur higher cost to comply with or react to the regulations (Waters 1991; Buck 1995a). Additionally, these types of regulations typically require expensive enforcement and monitoring programs. If regulations (gear restrictions, quotas, size limits, trip limits, etc.) were successful in enhancing stock biomass; catch rates and profits would be expected to increase along with effort. An increase in effort would nullify the short-term biological gains that had been achieved, and would require additional regulations to further control fishing mortality. The usual result of open access fisheries is more and increasingly restrictive regulations as competition for dwindling fishery resources increases (Waters 1991; Buck 1995a). Fishermen tend to perceive the introduction of new, more restrictive, costly, and complex regulations as a source of instability in the fishery and see the management agency as part of the problem. The likely outcomes of open access are higher fishing costs, less productive fishermen, additional regulations to control fishing effort in the long term, and an adversarial relationship between fishermen and fishery managers (Waters 1991). The striped bass and summer flounder fisheries exemplify these problems.

B2.1.2 Limited entry

Limited entry methods of management restrict access to a fishery. Capping and/or reducing fishing effort can protect the biological viability of a species and the economic integrity of the fishery. The species is protected by preventing recruitment overfishing and depletion of the stocks. The fishery is enhanced by reducing costs and increasing earnings; effectively increasing efficiency. Other benefits of limited entry programs include an incentive to conserve, more efficient management, bycatch minimization, and habitat protection. However, piecemeal implementation of limited entry programs can easily displace fishing effort from one fishery to create new problems in other areas and fisheries (Buck 1995a).

Johnson and Orbach (1996) reported that 78% of the fishermen interviewed agreed with the statement that "Limited entry may be appropriate to some of North Carolina's

fisheries." In a survey of crab potters landing over 6,000 pounds, Stroud (1996 and 1997) reported that 29% of the potters responding in 1995 felt that there should be no limits on entry compared to 18% in 1996. Additionally, the Fisheries Moratorium Steering Committee's License Subcommittee recommended that;

> "vesting general authority in the Marine Fisheries Commission (MFC) to appropriately limit entry into North Carolina fisheries on a case-by-case basis and as a part of a relevant Fishery Management Plan will best serve the State's long-term management needs" (Fisheries Moratorium Steering Committee 1996).

This recommendation was not formally included in the 1997 Fisheries Reform Act (FRA 1997). However, the General Assembly may consider the option of limited entry during the 1998 Legislative session (see page 145).
[Refer to section **C. Discussion of Management Options** (page137) and **Attachment 1** (page 156) for a discussion of Limited Entry Options and Open Access.]

C. Discussion of Management Options:
C1. Management areas:

Griffith (1996) found that the flexibility to move among and between fisheries is a hallmark of North Carolina fishermen. This movement is driven by regional/ecological factors, proximity to metropolitan areas, and by relationships to the marketing and processing sectors (Griffith 1996). Based on these findings Griffith (1996) recommended that North Carolina consider creating management areas to allow for community-based fisheries management. Regional-based management was recommended by various fishermen during public meetings for the Blue Crab FMP Public Information Document [PID(NCDENR 1998)].

This approach recognizes that too much management imposed from without is just as bad as too little. The state of North Carolina should allow as much flexibility as possible for fishermen to operate as they see fit. However, government has a responsibility to all citizens of the state to protect public resources. Cooperative management at the local level would allow management to be more responsive to local situations. The various management options discussed below would benefit from a regional-based management approach that would allow a given management strategy to be tailored to the needs of each area.

PROS:

1) Flexibility of management options.
2) More public involvement.
3) Establish advisory committees to mediate user conflicts.
4) Fishermen get a felling of ownership and believe in the management system.

CONS:

1) Increased administrative cost?
2) Increased enforcement cost?
3) Might need to redraw enforcement lines to allow better enforcement.
4) Might need to redraw District lines to fully encompass management areas.

There are a number of considerations that need to be addressed:

1) How will areas be delineated?
    a) DMF district lines?
    b) DMF enforcement lines?
    c) Regional Advisory Committee lines?
    d) Some other criteria?

2) Will fishermen be allowed to move between areas?

C2. Harvest Seasons:

The blue crab dredge fishery is currently the only blue crab fishery under seasonal restrictions (January 1 through March 1). Harvest seasons could potentially reduce conflicts between trawlers (shrimp and crab) and crab potters.

Questions that need to be addressed when considering harvest seasons include:

1) How will seasons be determined?
    a) Overall?
    b) Area?
    c) Gear and species?
        c1) Crab trawl vs. shrimp trawl (fall and spring crab trawl; spring pink shrimp, summer brown shrimp, etc.)?

2) What criteria will be used to set seasons?
    a) Base on historic average landings?

3) Will allowances be made for variable conditions?
    a) Water temperature?
    b) Salinity?

C3. Gear restrictions/ reductions:
C3.A. Pots:

Pot limits have been suggested as one way of reducing spacial conflicts, and improving economic efficiency in the crab pot fishery. Pot limits have been gaining support in the industry over the last 10 years. A social/economic study conducted in 1984 by Maiolo et al. (1985) in North Carolina showed that 47% of all fishermen (52% full-time, and 38% part-time) supported a 250 pot limit. In a survey sent to crabbers landing more than 6,000 lbs of crabs, Stroud (1996 and 1997) found that 82% of the respondents supported pot limits in 1995, while in 1996 pot limits were supported by 71% of the fishermen. Suggested limits for both years are shown in Table 2.

Table 2. Suggested crab pot limits by category and year.

Category	1995	1996
Full-time crab potter	426	443
Part-time crab potter, full-time commercial fishermen	332	403
Part-time crab potter, other major source of income	381	342
Overall average	403	424

During public meetings for the PID, numerous comments were received concerning suggested pot limits. Suggested pot limits for the entire state ranged from a low of 300 to a high of 1,000. Most of the proposed limits were for 400 pots. Some suggested 400 per person and up to 800 per vessel with a crew member. There was one suggestion for a 300 pot limit for full-time fishermen and 100 for part-time. Suggested limits for various waterbodies were: Pamlico Sound, 600; rivers 300; 500 for one person, 1,000 per vessel,; Outer Banks and Core Sound, 250, and 400; and one person suggested that only trotlines and collapsible traps be allowed in the rivers.

Many questions need to be addressed when considering a crab pot limit.

1) How will it be enforced?
    a) Gear tags?
    b) Fee for tags?
        1) Suggested fees by fishermen range from $0.50 to $1.00.
    c) Exemption for pots attached to shore or a pier?
    d) Where to attach tag?
        1) Buoy?
        2) Pot?
        3) Bait well?
    e) Replacement tags for lost pots?
        1) One industry suggestion was for 5%.
    f) How long are tags good for?
        1) One fisherman suggested that old tags be turned in every four years.

2) Uniform limits statewide?
    a) Pot limits by area?
    b) Limits by crew size?
    c) Hard crab vs. peeler pot limits?

3) Limit by level of dependence?
    a) "X" number of pots for full-time potters.
    b) "X" number of pots for full-time fisherman, part-time crabber.

c) "X" number of pots for part-time fishermen.

4) How should the level of dependence on the fishery be determined? What criteria should be used to qualify for license or fishing privilege?

a) Income?

a1) Full-time crab potter, greater than "X%" of fishing income from crabs.

a2) Full-time fisherman, part-time crabber, greater than "X%" (suggested limits from public include 50%, 80% and 85%) of income from fishing and less than "X%" of income from crabbing.

a3) Part-time fishermen, less than "X%" of income from commercial fishing.

b) Historic landings?

b1) Full-time crab potter, greater than "X" pounds of crabs landed over a qualifying period.

b2) Full-time fisherman, part-time crabber, less than "X "pounds of crabs landed over a qualifying period.

b3) Part-time fishermen, less than "X" pounds of crabs landed over a qualifying period.

b4) Any licensed fisherman, based on overall and/or crab landings over a qualifying period.

c) Combination of both income and landings?

c1) Separate full- and part-time fishermen based on an income requirement, then separate full-time fishermen into two categories based on historic landings.

5) Penalties

a) Loss of license

Other public comments concerning gear restrictions for the pot fishery include;

1) Prohibiting peeler potting (user conflicts).
2) Not allowing partitions in crab pots attached to shore or a pier (bycatch concerns).
3) Only allowing one fisherman in a vessel in the rivers (reducing efficiency).
4) Prohibiting pot pullers (reducing efficiency).
5) Setting multiple pots on one line (limiting buoys).
6) Mandatory use of weighted or sinking lines (help with ghost pots).
7) Require "full size" buoys (5 inches by 11 inches) on all pots (user conflicts).
8) Require full names on buoys (user conflicts).
9) Have trawlers return pots to owners if they have tags and buoys on them.

C3.B. Trawls:

Headrope length limits could potentially allocate resources more equitably to alleviate conflicts between recreational and commercial trawlers, fixed gear and trawlers, and small commercial trawlers. In the smaller bodies of water, smaller headropes could

potentially allow the traditional small-medium trawl boats to operate more equally with the larger vessels. Headrope limits would allow any size vessel to work in an area, but would limit its fishing power.

Questions that need to be addressed regarding headrope length limits are;

a) How to determine minimum size?
    1) Vessel license data?
    2) Surveys with crab trawlers?

b) Limits by area?
    1) By geographic area?
    2) By management area?

Other gear restrictions for crab trawls that have been suggested;

1). Allow only single- or doubled-rigged crab trawlers in the rivers.
2). Prohibiting crab trawling in the rivers, or in all inside waters.

C4. Time Restrictions:
C4.A. Pots:

Three time restrictions currently pertain to the crab pot fishery (time limits on potting areas are considered in the area restrictions section). All crab pots must be removed from the water during a pot clean-up period between January 24 and February 7. Potting is prohibited from one hour after sunset to one hour before sunrise. There is also a 10 day abandoned-gear rule.

The pot clean-up period and the abandoned gear rule were implemented to reduce ghost pots. The prohibition on fishing time was an attempt to deal with the theft of crabs and pots.

Suggestions from fishermen concerning time restrictions and crab pots include:

1) Change the period for when gears are considered abandoned from 10 days to either three or four days (effort reduction and resource protection).

2) Pots can only be fished from one hour before sunrise to 3:00 P.M. (effort reduction).

3) No crabbing on Sunday (protect the resource).

When considering time restrictions there are a number of things that need to be considered:

1) Set for the entire state or for management areas?

2) Allow for variation in environmental conditions?

1) Water temperature?
2) Tides (current nighttime prohibition on fishing pots negatively affecting fishermen in some areas)?

C4.B. Trawls:

Two regulations restrict fishing times in the crab trawl fishery. The first regulation closes trawling one hour after sunset on Friday to one hour before sunset on Sunday. The rivers (Pamlico, Pungo, Bay, and Neuse) are closed to nighttime trawling, one-hour after sunset to one hour before sunrise, from December 1 through February 28.

Restrictions on weekend trawling were implemented to minimize conflicts with recreational fishermen, and to reduce fishing effort. The nighttime closure was driven by resource and policy concerns, flounder bycatch, and retaining finfish caught in trawls.

C5. Catch Limits:

Catch limits attempt to reduce effort, and/or fishing mortality by limiting the daily allowable catch of fishermen.

C6. Delayed Entry:

A delayed entry program attempts to stabilize a fishery by limiting fishermen from entering during periods of high resource abundance. If any type of crab license is considered, then delayed entry provisions should be examined. Suggestions from fishermen are generally for a one-year waiting period.

C7. Area restrictions:

Crab pot areas, no trawl areas, and the crab dredge area are examples of area restrictions. These areas were set up to reduce user conflicts (crab pot areas), reduce environmental impacts (trawl and dredge areas), and to achieve biological objectives (trawl areas).

Public comments received on this subject were:

1) Six foot depth contour for pots in all rivers and creeks (reduce user conflicts);

2) Ten foot depth contour for pots in Pamlico Sound from July 1 through November 30 (reduce user conflicts);

3) No pots set in any channel in the rivers, creeks, sound, or boat basins (reduce user conflicts); and

4) Regional variations need to be taken into account.

C8. Licenses and/or Permits (individual, fishery, and/or gear):

Licenses/Permits may be used in an attempt to reduce effort, but any reduction in effort will depend mainly on cost in relation to potential return. Principally, licenses/permits are used to identify participants in the fishery and gears (quantity, type and specifications) employed in the harvest. Social and economic impacts of proposed regulatory measures are easier to address, when the participants, type and level of participation can be identified.

C9. Limited Entry Options:

License limitations, individual transferable quotas (ITQs), individual transferable effort (ITE), individual transferable gear (ITG), and community development quotas (CDQs) are types of limited entry systems. These approaches offer possible ways to manage the blue crab resource. See Attachment 1 for limited entry options discussed by the Blue Crab Advisory Committee (BCAC).

License Limitations:

Under license limitations (individual, fishery, and/or gear specific), a limited number of licenses are issued for participation in the fishery. Depending on the type, cost, or qualifying criteria, licenses may be used to restrict access to a fishery. License limitations are usually implemented when the number of fishermen is the management issue. This type of system will not automatically translate into a limitation on effort unless additional provisions are included to limit the amount of gear. Biological objectives of management are addressed using traditional catch or effort restrictions (catch quotas). Since fishermen are the unit-of-effort controlled in license limitation systems, economic incentives of individual fishermen are unchanged from the open access fisheries ("race to fish"). License limitations are currently in place in the New Jersey, Delaware, Maryland, Virginia, Georgia, and Florida blue crab fisheries (Table 3). With the exception of Florida, all of these states also have pot limits in addition to limited entry. A moratorium on new crab licenses is in place in North Carolina (effective through June 30, 1999), and Louisiana (expires the end 1998). Crab pot license limitations were supported by 71% of survey respondents in 1995 and 53% in 1996 (Stroud 1996; 1997). Additional harvest restrictions for the major blue crab harvesting states are contained in Table 4.

Individual Transferable Quotas (ITQs):

An ITQ is an allocated privilege of landing a portion of the total annual fish catch in the form of quota shares (pounds or percentage) to individual operators. ITQs divide the total allowable catch (TAC) quota into smaller individual transferable portions. ITQ programs are intended to reduce overcapitalization, promote conservation of stocks, improve market conditions, and leave the ultimate decision regarding whether to participate in the fishery and at what level to the individual fishermen. ITQ shares are usually marketable among fishermen, with upper limits on holdings imposed to prevent monopolies. This system is used when the major management issue is the amount of fish that may be taken. In the United States, ITQ programs are in place for the wreckfish fishery along the

South Atlantic coast, the surf clam and ocean quahog fishery in the Mid-Atlantic and New England fishery, and for halibut and sablefish off Alaska.

ITQ's were first implemented in some of New Zealand's fisheries in 1986 and the halibut fishery in British Columbia in 1991. Dewees (1988) interviewed fishermen before and after the ITQ programs were implemented and concluded that ITQ's ended the "race for fish" since each quota owner is assured access to a portion of the total allowable catch (TAC). This "race to fish" is characteristic of many fully or overexploited fisheries. Additionally, industry participants sought to maximize the return from their quota holdings. This takes the form of value added products, innovative marketing, quality improvements, market timing, and in some cases highgrading [discard of lower value catch (Dewees 1988)]. As with any limited entry systems, pre-industry structure and the design details strongly influence outcome (Buck 1995b; Dewees 1988).

Individual Transferable Effort (ITEs):

An ITE program limits the total amount of fishing effort in the fishery. Fishermen would be allocated a fixed number of fishing days or pot days. After the initial allocation fishermen would be free to buy, sell, barter, trade, or rent their ITEs to other fishermen. An ITE program allows total effort to be limited while giving opportunities to improve economic efficiency and returns to fishermen (Kirkley et al. 1995).

Implementing an ITE program for the blue crab fishery would be problematic. Limited data exist for fishing effort. There is not an apparent relationship between fishing mortality and fishing effort. Variation in fishing operations would make it difficult to determine the level of fishing effort needed to achieve optimum yield (OY). The compliance, monitoring, and enforcement cost could be high.

Individual Transferable Gear (ITG):

An ITG program limits the amount of gear in the fishery (e.g., number of pots or trawls). This type of system would allow maximum flexibility for fishermen to adjust their fishing effort and allow new entrants into the fishery at a relatively low cost (Johnson and Orbach 1996). This system would also reduce overcapitalization and promote conservation of the stocks. ITG shares are usually marketable among fishermen, with upper limits imposed to prevent monopolies. Typically there is an upper cap on the total number of gear certificates available. In some fisheries there is a trap reduction plan tied to an ITG program. This type of program is currently being used in the Florida spiny lobster fishery. Two variations of this program were included in a survey sent out by Stroud (1996 and 1997). The license by share program (Attachment 1; page 156) was supported by 13.5% of the respondents in 1996 (not included in 1995 survey). A pot ticket program was supported by 12% of the respondents in 1995 and 16% in 1996.

Community Development Quotas (CDQ):

A CDQ program allocates a portion of the total allowable catch (TAC) to eligible communities (Fujita et al. 1998). The primary purpose of this program is to foster economic development in communities. Proponents of this system claim that fishermen working under this system tend to have a greater conservation ethic than fishermen in other fisheries. A modification to the CDQ program is currently being used in Chile for invertebrate management. This program, Management and Exploitation Areas (MEA), assigns exclusive fishing rights, defined areas of inshore ocean bottom, to registered organizations or communities of fishermen (Castilla and Fernandez 1998). This type of system, CDQ or MEA, transfers ownership and management of resources over to the community.

D. Goals, objectives, standards, and procedures for limited entry programs:

In general, the principal goals of limited entry are to raise or maintain the net incomes of fishermen, to reduce conflicts, and to give fishermen more of a stake in conservation efforts by giving them specific fishing privileges (Johnson and Orbach 1996).

According to Johnson and Orbach (1996), there are six objectives toward which any potential limited entry or access system should be directed:

"1) To control, or reduce, the effort in the fisheries under consideration so that the effort more closely matches the available fishery resource;

2) To increase stability in the fisheries, and promote maximum net incomes for fishermen;

3) To promote flexibility for fishermen in their fishing operations;

4) To avoid conflicts among fishermen and between fishermen and other marine users;

5) To ensure that fishermen who have traditionally fished in the fisheries under consideration be able to continue to do so, as much as possible in their traditional fishing patterns; and

6) To make management of the fisheries more efficient and effective."

Proposed language for a limited entry option being considered by the North Carolina General Assembly is:

" (g) To achieve optimal yield under a Fishery Management Plan, the Marine Fisheries Commission may include in the Plan a recommendation that the General Assembly limit the number of fishermen authorized to participate in the fishery. The Commission may recommend that the General Assembly limit participation in a fishery only if the Commission determines that optimal yield cannot other wise be achieved. In determining whether to recommend that the General Assembly limit participation in a fishery, the

Commission shall consider all of the following factors:

1) Current participation in and dependence on the fishery.
2) Past fishing practices in the fishery.
3) Economics of the fishery.
4) Capability of fishing vessels used in the fishery to engage in other fisheries.
5) Cultural and social factors relevant to the fishery and any affected fishing communities.
6) Capacity of the fishery to support biological parameters.
7) Equitable resolution of competing social and economic interests.
8) Any other relevant considerations."

Questions that need to be considered when designing a limited entry program:

License Limitations:

1) How are licenses initially distributed?
    a) By random drawing?
    b) Historic participation in the fishery?
    c) By auction?
    d) All fishing families?

2) Could the holder of a license;
    a) Transfer the license?
    b) Rent the license?
    c) Sell the license?
        1) How long before allowed to sell (5 years has been suggested by one fisherman)?
    d) If, no sale provision, how will new fishermen get into the fishery?
        1) Apprenticeship program?
            1) How to setup and monitor?
            2) Provisions for school programs?
        2) Transfer within family?

3) Unit of effort to license;
    a) Fishery (crab license)?
    b) Gear license (pot and/or trawl)?
    c) License for geographic areas?

4) Use it or lose it provisions?
    a) How long (one fisherman suggested 6-8 months of no landings)?

5) Will provision be made for other fisheries (without crab license) to land crabs caught as a bycatch in their fishing operations?

ITQs, ITEs, and ITGs:

1) Initial allocation.
    a) By product form?
    b) By gear?
    c) By area?
    d) What criteria or documentation will be used to distribute shares to fishermen?
        1) Based on historic landings over a qualifying period?
        2) Vessel size?
        3) Historic use?

2) Denomination of tradeable units.
    a) What will units be?
    b) What will be the minimum size of a unit?
    c) What is the maximum number of units that an individual can own?

3) Will provision be made for other fisheries to land crabs caught as a bycatch in their fishing operations (for ITQs)?

Johnson and Orbach (1996:132-133) listed eight criteria for considering the impact of various management alternatives:

> "1) Effort Control or Reduction -- Would the alternative control or reduce fishing effort?
>
> 2) Fishermen Flexibility -- Would the alternative give the fishermen flexibility to adjust their fishing operations?
>
> 3) Biological Impact -- Would the alternative have a noticeable effect on the fish population or habitat?
>
> 4) Economic Impact -- What would the economic impact of the alternative be on the individual fishermen and the industry as a whole (prices, net profits, marketability, etc.)?
>
> 5) Social Impact -- Would the alternative alter fishing patterns? Would it affect the fishermen's families or communities? Would it be fair and equitable to different groups of fishermen?
>
> 6) Enforcement and Administration -- Would the alternative be easy or difficult to put into place? Would it make regulations easier to enforce? Would it be difficult for the fishermen to comply with?
>
> 7) Impact on Other Fisheries -- How would the alternative for each fishery affect other fisheries or fishermen, especially fishermen who fish in several fisheries throughout the year?

8) Other Criteria -- Are there other things we should consider in terms of the potential impact of these alternatives?"

E. Goal of Fishery Management Plans:

The 1997 Fisheries Reform Act (FRA) states that "The goal of the plans (Fishery Management Plan) shall be to ensure the long-term viability of the State's commercially and recreationally significant species or fisheries." To accomplish this goal each plan shall "Include conservation and management measures that prevent overfishing, while achieving, on a continuing basis, the optimal yield from each fishery."

Optimal yield is defined in the FRA as "The amount of fish that:

a. Will provide the greatest overall benefit to the State, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems;

b. Is prescribed on the basis of the maximum sustainable yield from the fishery, as reduced by any relevant economic, social, or ecological factor; and

c. In the case of an overfished fishery, provides for rebuilding to a level consistent with producing the maximum sustainable yield in the fishery."

F. Recommendations:

An open access strategy will not allow the citizens of the state to receive maximum economic benefits from the blue crab resource. This type of system will offer maximum employment opportunities in the short-run. However, over time an open access system could likely cause some type of biological overfishing, loss of profit, and zero or near-zero growth opportunities (Kirkley et al. 1995). Although the blue crab stock appears healthy now, fishing effort has been increasing and most likely will continue to increase after the crab license and moratorium is lifted on July 1, 1999. Blue crab stocks should be protected before there is a crisis. A judicious policy approach would be to cap or restrict effort increases until the uncertainty surrounding the status of the crab stock is known. The most efficient way to accomplish this goal is through the formation of management areas.

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Table 1. Reported number of crab pots in North Carolina, from vessel license data.

	Number of fishermen				Total number of reported pots				Average number of pots				Rate of increase in reported pot numbers			
Year	Full time	Part time	Recreational	Total	Full time	Part time	Recreational	Total	Full time	Part time	Recreational	Total	Full time	Part time	Recreational	Total
1983	1,278	2,233	3,707	7,218	198,226	105,604	46,549	350,379	155.11	47.29	12.56	48.54				
1984	1,247	2,152	3,100	6,499	207,273	101,239	36,777	345,289	166.22	47.04	11.86	53.13	4.56	-4.13	-20.99	-1.45
1985	1,350	1,989	3,203	6,542	216,907	83,092	49,558	349,557	160.67	41.78	15.47	53.43	4.65	-17.92	34.75	1.24
1986	1,327	1,981	3,346	6,654	229,861	99,729	51,422	381,012	173.22	50.34	15.37	57.26	5.97	20.02	3.76	9.00
1987	1,485	2,114	3,345	6,944	264,984	108,743	62,816	436,543	178.44	51.44	18.78	62.87	15.28	9.04	22.16	14.57
1988	1,676	2,020	3,096	6,792	328,091	107,846	72,935	508,872	195.76	53.39	23.56	74.92	23.82	-0.82	16.11	16.57
1989	1,918	2,296	3,606	7,820	357,007	119,864	77,384	554,255	186.14	52.21	21.46	70.88	8.81	11.14	6.10	8.92
1990	2,010	2,134	3,361	7,505	382,061	119,467	82,854	584,382	190.08	55.98	24.65	77.87	7.02	-0.33	7.07	5.44
1991	2,123	2,255	3,222	7,600	401,796	137,507	83,945	623,248	189.26	60.98	26.05	82.01	5.17	15.10	1.32	6.65
1993	2,295	2,012	2,800	7,107	498,179	120,829	68,960	687,968	217.07	60.05	24.63	96.80				
1994	2,992	2,413	3,113	8,518	697,276	154,861	99,571	951,708	233.05	64.18	31.99	111.73	39.96	28.17	44.39	38.34
1995	2,717	1,863	2,418	6,998	1,928,182	350,443	135,996	2,414,621	709.67	188.11	56.24	345.04	176.53	126.30	36.58	153.71
1996	2,691	1,548	1,924	6,163	2,989,731	410,875	181,497	3,582,103	1111.01	265.42	94.33	581.23	55.05	17.24	33.46	48.35
1997	2,347	1,458	1,754	5,559	870,199	135,344	57,788	1,063,331	370.77	92.83	32.95	191.28	-70.89	-67.06	-68.16	-70.32
1998	1,798	1,365	1,400	4,563	601,441	120,759	34,700	756,900	334.51	88.47	24.79	165.88	-30.88	-10.78	-39.95	-28.82

Table 3. State comparisons of blue crab effort management actions for the commercial pot fishery.

State	Commercial License Required	Crew License	Crab License: Individual License	Crab License: License Cap	Crab License: Trap Permit	Crab License: Pot Limit (maximum)	Crab License: Transferable	Crab License: Use or Lose Provision	Soft-shell Dealer License	Soft-shell Shedding License	Apprenticeship Program
NEW JERSEY	Yes	None	Yes	Yes (312)	None	600 Delaware Bay 400 Other waters	Yes Only Family	None	None	None	None
DELAWARE	Yes	None	Yes 50 pot increments	Yes Previous licensee (219)	None	200	Yes Family or Designee	None	None	None	None
MARYLAND (effective 6/98)	Yes Limited Entry	Fee for Crew	Yes	Yes Tied to Comm. Lic.	None	300 up to 900/ vessel with 2 crew	Yes with criteria	None	None	None	Yes with criteria
VIRGINIA	Yes 2 year delay	None	Yes 100, 300 or 500 pots	Yes Hardship criteria	Peeler and Hard	400 peeler 500 hard/ 300 tributaries 500 bay	Yes	None	None	Yes	None
NORTH CAROLINA	Yes	None	Yes or Vessel License	Moritorium on new license 1994	None	150 only in Newport River	Yes	None	None	None	None
SOUTH CAROLINA	Yes	None	Yes $25/50 pots $1/pot over 50 pots	None	None	None	No	None	None	Yes	None
GEORGIA	Yes	Yes	Yes 50 pot increments	Yes 1998/99 licenses	$2/ pot	200/ includes peeler pots	Yes	2 years	Yes	None	None
FLORIDA	Yes	Endorsement to cover crew	Yes Income criteria	Yes 1997/98 licenses	None	None	Yes Only Family	None	None	None	None
ALABAMA	Yes	None	Yes	None	None	None	No	None	None	None	None
MISSISSIPPI	Yes	None	Vessel	None	None	None	Yes	None	None	None	None
LOUISIANA	Yes	None	Yes	Moratorium on new lic. 1996-98	None	None	Yes Comm. Lic. holders	None	None	Yes	None
TEXAS (effective 9/98)	No	None	Yes	Yes Eligibility criteria	None	200	Yes Heir or Devisee Open in 3 years	None	None	None	None

Table 4. State comparisons of blue crab management actions for the commercial pot fishery.

State	Harvest restrictions				Gear restrictions			Size limits (inches)				Sponge crab protection	Effort management
	Season	Catch limits	Time	Days	Pots (max.)	Escape rings	Buoys	Hard	Soft	Peeler	Tolerance		
NEW JERSEY	Apr. 16-Dec. 14 Delaware Bay Mar. 15-Nov. 30 Other waters	None	4:00am-9:00pm Bay, 24-hrs other waters	None	600 Delaware Bay 400 Other waters	None Terrapin excluder some areas Degradable panel	Reflective I.D. Sink line	4.75*	3.5	3	Zero	A	Yes
DELAWARE	Mar.1-Nov. 30	None	1 hr before sunrise-sunset	None	200 500/vessel	None	I.D. Color coded	5	3.5	3	5% by number	A	Yes
MARYLAND	Apr. 1-Nov. 30	None	4:30am-5:00pm	Prohibited either Sun. or Mon.	300 up to 900/ vessel w/ 2 crew	1 (2-3/16 in) 1 (2-5/16 in) may close for peelers	I.D.	5	3.5	3 separate from catch	10 hard crabs/ bushel	A and D	Yes effective 6/98
VIRGINIA	Apr. 1-Nov. 30	Apr. 1-May 31 51 bushels or 17 barrels/ vessel	3 hrs before sunrise-sunset	Mon.-Sat. except peeler pots	400 peeler 500 hard crab/ 300 tributaries 500 bay	1 (2-3/16 in) 1 (2-5/16 in)/ may close in some areas	I.D.	5	3.5	None	10 hard crabs/ bushel or 35/ barrel	B and C	Yes
NORTH CAROLINA	None	None	1 hr before sunrise-1 hr after sunset	None	150 Newport River only	2 (2-5/16 in) may close in one area	I.D.	5	None	None separate from catch	10% by number/ container	C	None
SOUTH CAROLINA	None	None	5am-9pm 4/1-9/15 6am-7pm 9/16-3/31	None	None	2 (2-3/8 in) Jun. 1-Mar. 14	I.D. with colors	5*	5*	None with peeler permit	Zero	A	None
GEORGIA	None	None	None	None	200/ includes peeler pots	2 (2-3/8 in)	Color coded	5	5	3	Zero	None	Yes
FLORIDA	None	None	1 hr before sunrise-1 hr after sunset	None	None	3 (2-3/8 in) Degradable panel	I.D.	5*	5	None separate from catch	5% by number/ container except bait	A	Yes
ALABAMA	None	None	1 hr before sunrise-sunset	None	None	None	½ white	5*	None	5	Zero except bait	None	None
MISSISSIPPI	None	None	None	None	None	None	I.D. or color code	5*	None	None	Zero	A	None
LOUISIANA	None	None	½ hr before sunrise- ½ hr after sunset	None	None	2 (2-5/16 in)	I.D. on trap tag	5*	None	None separate from catch	10%by number in a 50 crab random sample	A 2% by number tolerance in work box only	Yes
TEXAS	None	None	½ hr before sunrise-½ hr after sunset	None	200	2 (2-3/8 in) Degradable panel	White gear tag - I.D. & date set	5*	5	5	5% by number in separate container for bait only	A	Yes effective 9/98

* Includes mature female

A = Unlawful to take, sell or possess sponge crabs; B = Prohibit brown/ black sponge with tolerance; C = Crab sanctuary to protect females; D = May sell or possess sponge crabs, if taken legally in another state.

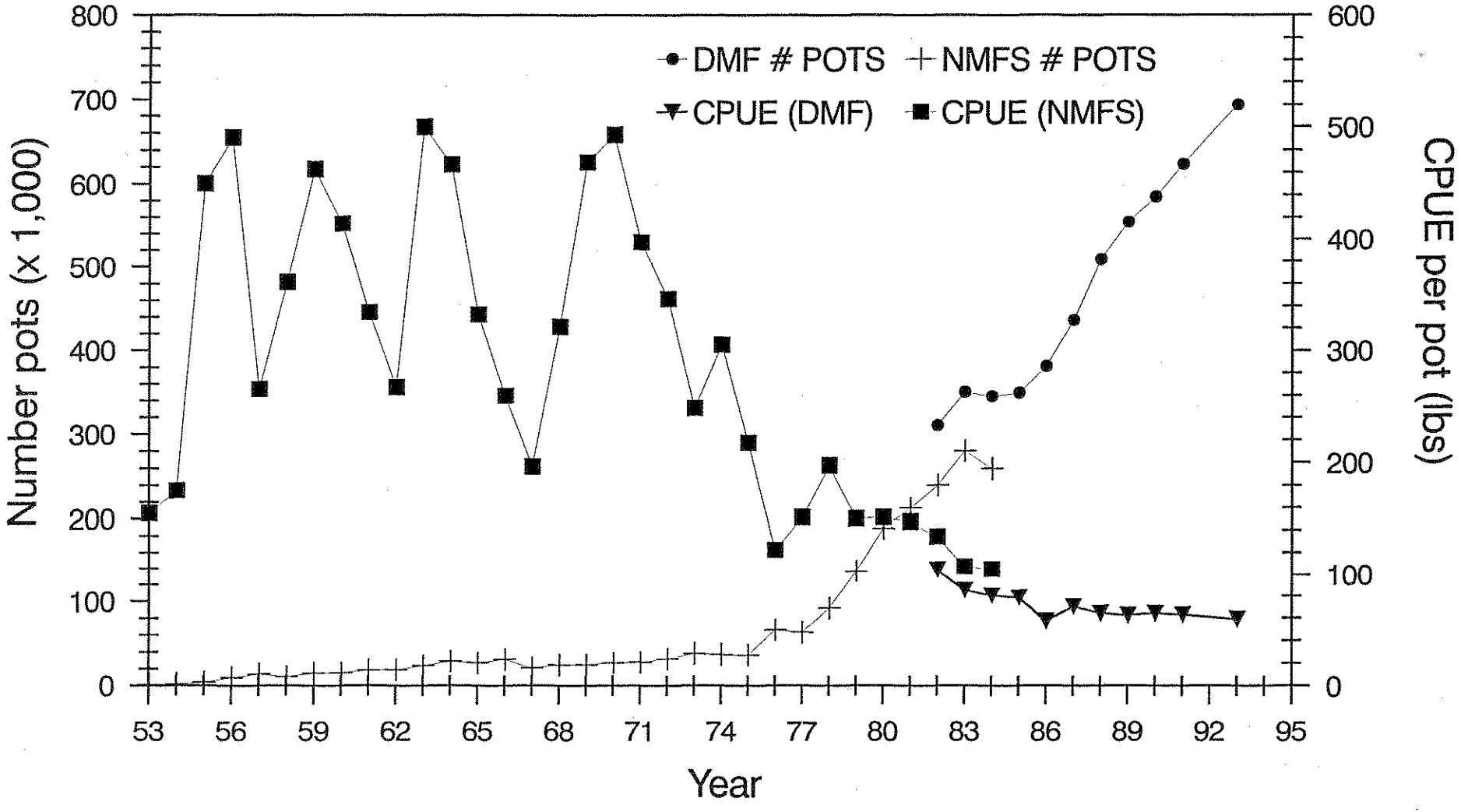
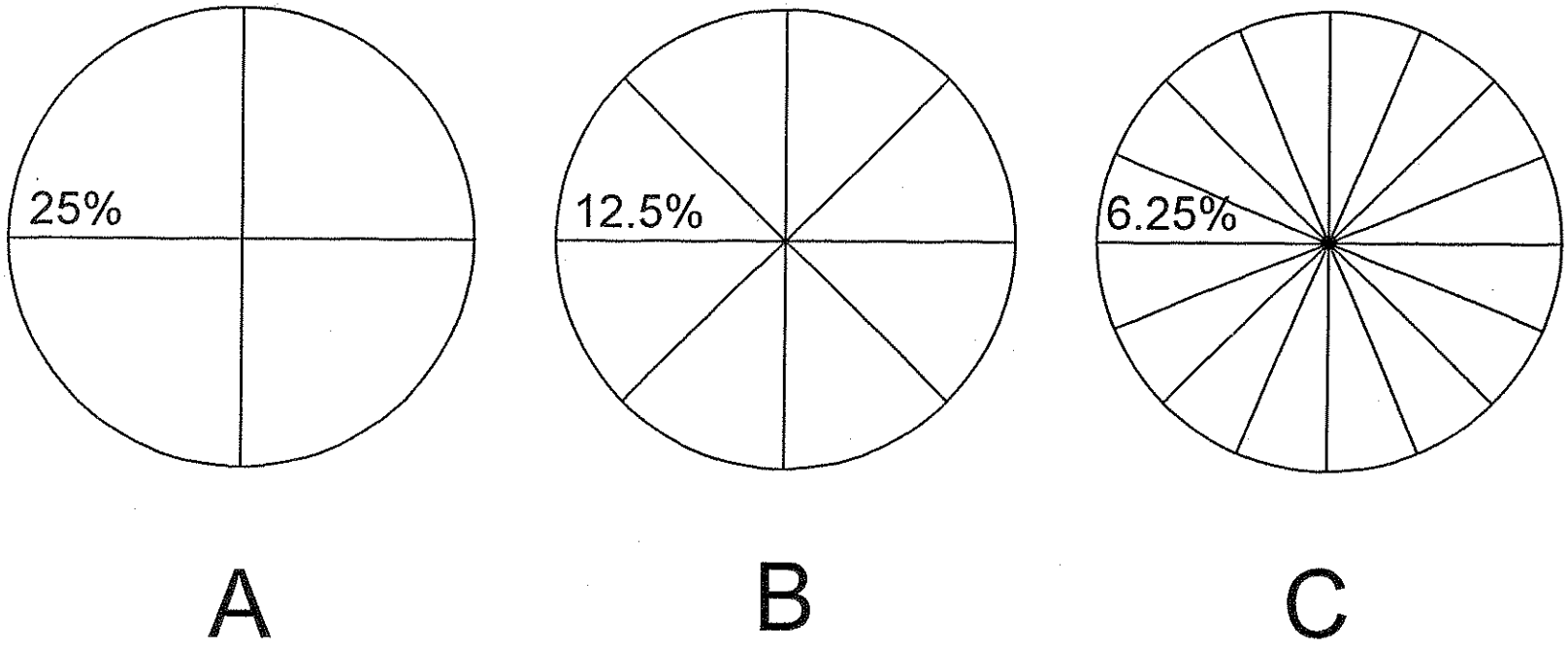


Figure 1. Number of Operating Units and CPUE for the North Carolina Blue Crab Pot Fishery.

Figure 2. Effects of increasing effort (A to C) on profit in the blue crab fishery.



Attachment 1. Effort Control and Limited Entry Options

Objectives

The objectives of any potential limited entry system in the blue crab pot fishery would be:

1) To control, or reduce, the effort in the crab pot fishery so that the effort more closely matches the available fishery resource;

2) To increase stability in the crab pot fishery, and promote maximum net incomes for fishermen;

3) To promote flexibility for fishermen in their fishing operations;

4) To avoid conflict among fishermen and between fishermen and other marine users;

5) To ensure that fishermen who have traditionally fished in the crab pot fishery be able to continue to due so, as much as possible in their traditional fishing patterns;

6) To make management of the crab pot fishery more efficient and effective.

General Condition of the Crab Pot Fishery with Respect to Pot Effort

The general consensus seems to be that although the crab catch fluctuates with environmental conditions, the total number of crab pots and fishermen in the crab fishery has been increasing at a rate much greater than the increase in the crab catch itself (see Figure 1). The degree of increase varies from one part of the state to another, but some degree of economic inefficiency, social conflict, and possible biological and ecological impact appears to be present in the fishery throughout the state.

The Management Alternatives

Within the currently legislated cap on the new Standard Commercial Fishing License, none of the traditional open-access management alternatives (for example seasons, time and area restrictions) hold great promise for significantly controlling or reducing the overall effort in the crab pot fishery without severely restricting landings or traditional fishing patterns. The following analysis of limited entry options, including a comparison with selected open access options, is taken from Johnson and Orbach (1996) and discussions of the Blue Crab Advisory Committee (BCAC).

1) The Status Quo -- This is the "no change" alternative, meaning that the management systems currently in place for the crab pot fishery would remain in effect with no changes, with one important note: *The moratorium, and the crab license, would no longer be in place*. At some point we either have to let the moratorium expire and go back to the open access situation (within the new limitations of the cap on SCFLs), or design a new system which might more directly control access and effort.

2) Marketable Crab License Limitation -- Under this alternative, licenses to participate in the crab fishery would be issued at the beginning of the system to a number of "initial qualifiers". Initial qualifiers might be those fishermen who had a valid ETS over a qualifying period, probably three years (1994-97, for example), and had landed more than a certain amount of crab, say 500 pounds, in at least two of those three years. After the initial issuance of licenses, the total number of licenses would remain the same; that is, they would not increase above the total number originally issued. Each licensee would be limited to 450 pots. These licenses would be marketable; that is, bought and sold among the fishermen themselves.

3) Transferable Two-Stage License Limitation -- Under this system the original distribution of licenses would be done through a one-time opportunity to purchase one of two kinds of license. The first, or "full time transferable" license, would be available for one-time purchase by any fisherman who either a) had landed more than 7,000 pounds of crab in two of the three years 1994-97, or b) could demonstrate by tax records that they had made over 75% of their earned income from commercial fishing in the years 1994-97. These licenses would be transferable either a) with the sale of a boat; b) to the immediate family of the license holder; or c) by sale to the state separate from the boat. Holders of this license would be limited to 300 pots per licensee.

The second, or "part time" license, would be available to any ETS holder who had landed at least 500 pounds in any two of the three years 1994-97. These licenses would be non-transferable; that is, when the holders of this license gave up fishing the license would disappear. Thus, this system would eventually eliminate all of this type of license. Holders of this license would be limited to 125 pots per licensee.

New entrants would either have to purchase a boat and license from a licensed fisherman, or serve a two-year apprenticeship with a licensed fisherman. After this apprenticeship, the apprentice would be eligible to purchase a license from the state if any were available.

4) One-time Purchase without Transfer -- Under this system all fishermen with a current Endorsement to Sell would be given the opportunity, during one 30-day period, to purchase a Crab or Crab Vessel License. After that 30-day period, the number of licenses that had been sold would be the capped number. Each licensee would be allowed to fish 300 pots. These licenses would not be transferable; when the fisherman gave up the license, it would revert to the state. Licenses would be re-issued only to those who had served a two-year apprenticeship with a licensed crab fisherman.

5) License Choice -- Under this system, fishermen would have to choose between two basic licenses: A Standard Commercial Fishing License, which would be good for anything except crab pots; and a Crab License, which would be good for only crab pots, and which would be available to only those fishermen who had made ETS landings on 120 days of the previous year.

Holders of either the SCFL or the Crab License, however, would be allowed to purchase a temporary license to fish in the other fishery (SCFL in crab, or crab in other fisheries) for up to 60 days each year.

Crab License holders, or Temporary Crab License holders, would be allowed to fish up to 400 pots per licensee.

6) License Shares -- Under this system each current Crab License holder would be issued licenses share in quarter-share increments of 150 pots. A full license (four quarter shares) would be limited to 600 pots, hard crab and peeler pots combined, in the water at any given time. The initial shares would be issued based on the landings of each fishermen in a qualifying period (1994-97), with quarter, half, three-quarter and full shares being issued to fishermen based on their historic catch level. Thereafter, licenses would be marketable among the fishermen in quarter-share increments.

7) Time Slot Tag Purchase -- Under this system any fisherman possessing a SCFL would be allowed to purchase a crab pot endorsement and an unlimited number of pot tags, but only during the period July 1-July 31 of each year.

8) A Uniform Two-Stage Limit on the Number of Pots per Fisherman (SCFL) -- Under this alternative, each owner/operator (the owner is on the boat at all time when it is crab fishing) fishing crab pots would be limited to a total of 600 pots in the water at any one time, while a non-owner/operator would be limited to 300 pots in the water at any one time.

9) Gear Certificates -- Under this alternative, each fisherman might be issued certificates for the amount of gear they had used in the fishery under the qualifying period (1994-97, for example). Thus, a fisherman who has used 400 crab pots would be issued gear certificates in those amounts. An appropriate method would be worked out to allow fishermen to transfer these certificates.

Different combinations of these alternatives would also be possible. For example, a license limitation system could be combined with a trap certificate system. It was not possible to evaluate all possible combinations in this draft of the plan, but comments would be welcome on possible or desirable combinations.

Criteria for Evaluating the Alternatives

Several criteria could be used for considering the impact of each of the alternatives for the blue crab fishery (Johnson and Orbach 1996):

1) Effort Control or Reduction -- Would the alternative control or reduce fishing effort?

2) Fishermen Flexibility -- Would the alternative give the fisherman flexibility to adjust their fishing operations?

3) Biological Impact -- Would the alternative have a noticeable effect on the crab population or habitat?

4) Socio-economic Impact -- What would the economic impact of the alternative be on the individual fisherman and the industry as a whole (prices, net profits, marketability, etc.)?

Would the alternative alter fishing patterns? Would it effect the fishermen's families or communities? Would it be fair and equitable to different groups of fishermen?

5) Enforcement and Administration -- Would the alternative be easy or difficult to put into place? Would it make regulations easier to enforce? Would it be difficult for the fishermen to comply with?

6) Impact on Other Fisheries -- How would the alternative for the crab pot fishery affect other fisheries or fishermen, especially fishermen who fish in several fisheries throughout the year?

Evaluation of the Alternatives

1) Status Quo -- This option was evaluated negatively across all criteria. It was assumed that the number of pots, and perhaps fishermen, in the pot fishery would increase, increasing conflict, enforcement problems, reducing efficiency in the fishery and creating potential negative environmental effects.

2) Marketable License with a uniform 450 pot limit per license -- This alternative would control the total number of pots in the fishery, most probably at approximately the level they are now. In terms of fishermen flexibility and social and economic impact, the effects would be generally positive for those with licenses and negative for those without them, and clearly negative for those who current fish over 450 pots. There would be significant enforcement costs associated with the pot limit, and negative effects from displacement of fishermen into other fisheries (because of the threshold requirements for obtaining initial licenses) and the inability of fishermen to move freely among fisheries.

3) Transferable two-stage license limitation -- This alternative would provide a cap on the number of pots at approximately the current level. It would have some displacement effect because of the relatively high level of initial qualifying criteria, and would have a positive impact on those who qualified for the initial licenses in terms of flexibility and social and economic impact but a negative impact on those who did not. It would be difficult to enforce because of the two different pot limits, and more costly to administer because of continued state involvement in license allocation.

4) One-time purchase without transfer -- This alternative would allow a potentially significant increase in the number of authorized pots, and would have the same difficulties in enforcement and administration associated with both a pot limit and the continued involvement of the state in license allocation. There would be some displacement of fishers into other fisheries, and negative impact on those fishermen who currently fish over 300 pots. Fishermen flexibility would be reduced because of the non-transferability of the license.

5) License choice -- This alternative would not control or reduce the number of pots potentially in the water and allow flexibility for fishermen, but would be difficult to administer and have the same enforcement and administration costs associated with a pot cap and the continued involvement of the state in issuing licenses.

6) License shares -- This alternative yielded the greatest reduction in the total number of potential pots in the water of the alternative considered, and would allow fishermen the flexibility to adjust the amount of pots they fished compared to the other limited entry alternatives. It would have some negative effects in terms of fisherman flexibility and social and economic impact because of qualifying thresholds, and the same enforcement and administration difficulties associated with a pot limit and the need for the state to track the license share sales.

7) Time slot tag purchase -- This alternative would not control or reduce effort in the pot fishery, and would have the same administrative and enforcement difficulties associated with a pot limit.

8) Uniform two stage pot limit -- This alternative would not control or reduce effort in the pot fishery and would have the same administrative and enforcement difficulties associated with a pot limit.

9) Gear Certificates -- On the one hand, this is one option that would actually cap the total number of pots in the fishery. However, it would be extremely difficult to determine how to distribute the original gear certificates to reflect the number of pots each fisherman actually has in use, and would be a costly and complex system to set up, administer and enforce. It would, however, allow fishermen maximum flexibility in adjusting their fishing operations and allow new entrants to enter the fishery at relatively low cost.

The BCAC determined that options 2,3,6, and 9 would, to different degrees, achieve the objectives of this FMP. No single preferred option, however, has been identified at this time.

Other Issues

Several issues are important with respect to any potential limited entry system for crab pots:

1) Consideration should be given to regional differences in the fishery.

2) The issue of peeler pots must be addressed.

3) The possibility of different limitations for full- and part-time fishermen could be considered.

4) The possibility of some form of "owner/operator" provision could be considered; that the owner or licensee would have to be present for the boat to fish.

6) The potential for an increase in crab trawl effort, after the total number of crab pots in the fishery has been limited, must be considered. This would have the potential to shift a higher proportion of the crab catch to the trawl fishery, and would have to be addressed in a crab fishery management plan.

7) Depending on the outcome of decisions with respect to the policy towards recreational crab pot users, the potential exists for an expansion in recreational crab pot effort.

Questions with Respect to Limited Entry Systems

If the blue crab pot fishery were to be considered for some form of limited entry, the following questions must be addressed:

1) What is the problem that needs to be solved?

2) What is the appropriate unit of effort to consider limiting?

3) If a limited entry or access system were set up, how would the initial fishing privileges be assigned?

4) How would fishermen get in or out of the fishery, or adjust their fishing operations?

5) How would the system be administered, and how would it be paid for?

6) Are there special conditions in the fishery that would have to be taken into account?

Table 1 contains a series of such questions, as examples of the kinds of details that would have to be considered to further design limited entry or access systems for the blue crab pot fishery. The purpose of this table is not to advocate the adoption of any of these systems, but to further explore the potential effects of such systems.

Table 1: Details of a Potential Limited Entry System for the Blue Crab Pot Fishery

1) The problem -- Too many pots, and to some extent too many fishermen, in the fishery.
2) The appropriate unit of effort to limit -- Number of fishermen, and number of pots.
3) How would initial privileges be assigned?
    A) Number of fishermen -- Issue original licenses to:
        1) All holders of crab licenses?
        2) All holders of crab licenses with minimum landings?
            a) Any landings?
            b) Minimum landings (1,000 lbs; 6,000 lbs)?
            c) Minimum landings in two of three years?
    B) Licenses available in fractions, or "shares"?
    C) Number of pots -- Limit each licensee to
        1) 300/400/500/600? pots per license
        2) Gradually declining limit (600 first year; 500 second year; 400 third year)?
        3) Total limit per boat/operation?
4) How would licenses be transferred?
    A) Marketable licenses?
        1) With "apprenticeship" requirement?
        2) With anti-monopoly cap (no person could hold more than a certain number of licenses)?
    B) Non-marketable licenses?
        1) Must surrender to state for reissue
            a) By lottery?
            b) To waiting list?
        2) Transfer within immediate family?
5) How would the system be administered and paid for?
    A) Annual license fee?
    B) Annual fee for pot tags?
    C) If marketable licenses, license transfer fee?
6) Special conditions?
    A) Owner/operator requirement?
    B) 50% earned income requirement?

APPENDIX 12. POTS IN INLAND WATERS

I. Issue:

The use of crab pots in inland waters.

II. Background:

The Wildlife Resources Commission (WRC) requires a "Special Fishing Device License" for taking nongame fish in inland fishing waters. The blue crab is considered a nongame fish by the WRC. Special fishing devices, which may be licensed for the taking of nongame fishes include fish pots, eel pots, and traps. Crab pots are not specified as a special device gear in the WRC Regulations Digest, but are considered to be traps. Traps must be marked with the license holder's name and address. A noncommercial special device license is required when no more than three special devices are used. A commercial special device license is required when four or more special devices are used. When taking nongame fish for the purpose of sale by means other than hook and line or by grabbling, a special fishing device license is required. Persons owning property adjacent to inland fishing waters of coastal rivers and their tributaries may set two crab pots attached to their property, and a special device license is not required.

III. Discussion:

On March 4, 1998, the WRC tabled a proposal to ban commercial crab pots in inland waters. This was done at the request of the MFC, so that the issue could be addressed in the Blue Crab Fishery Management Plan (FMP). The WRC had proposed the ban due to conflicts with sport fishermen; "Crab pots interfere substantially with sport fishing techniques employed by fishers in inland waters and sport fishers are not supportive of expansion of crab pots into inland waters." The proposed ban by the WRC does not affect people setting two pots attached to their property. In 1997, only 34 Commercial Special Device Fishing Licenses were issued for crab pots, and the WRC estimates that fewer than 1,000 pots were set. Table 1 lists the inland waters open to crab potting, and DMF and WRC law enforcement officer's estimates of pot use in each area.

IV. Management Options:

(+ potential positive impact of action)
(- potential negative impact of action)

1. Maintain existing WRC rules which allow the use of traps (crab pots) in inland waters.
   - \+ Fishermen flexibility
   - \- Continued conflicts with recreational users

2. Prohibit the use of crab pots in inland waters, except that two may be set from private property.
    + Reduce (eliminate) conflicts with recreational users in inland waters
    + Provide a refuge for male crabs
    - Lost income for commercial fishermen

3. Maintain existing WRC rules, only in inland waters with historical crabbing activity and low recreational pressure.
    + Minimize conflicts with recreational users in inland waters
    + Provide a refuge for male crabs
    + Fishermen flexibility
    - Continued conflicts with recreational users
    - Lost income for commercial fishermen

4. Identify select waters, with historical crabbing activity and low recreational pressure, that can be reclassified as joint waters.
    + Minimize conflicts with recreational users
    + Provide a refuge for male crabs
    + Fishermen flexibility
    - Continued conflicts with recreational users
    - Lost income for commercial fishermen
    - Additional waters for DMF enforcement to patrol

Table 1. Seasons and inland waters where special fishing devices, classified as traps, may be used by area and county, with estimated crab pot effort (see footnotes).

Tributaries of the Albemarle, Currituck and Croatan sounds:			
Bertie County*	July 1	June 30,	Broad Creek (tributary of Roanoke River)
Camden County	July 1	June 30,	all inland public waters (listed below)
			Pasquotank River above US 158 bridge at Elizabeth City
			Raymond Creek
			Portohonk Creek
			Areneuse Creek
			North River above a line from Long Creek to Green Island Creek
			Wading Gut
			Little Broad Creek
			Broad Creek (WRC-slight)
			Hunting Creek
			Abel Creek
			Back Landing Creek
			Public Creek
			Cow Creek
			Great Creek
			Indiantown Creek (DMF-200; WRC-slight)
Chowan County	July 1	June 30,	all inland public waters (listed below), excluding impounded waters
			Queen Anne Creek
			Pollock Swamp (Pembroke Creek)
			Rocky Hock Creek
			Dillard (Indian) Creek
			Stumpy Creek
			Catherine (Warwick) Creek
Currituck County	July 1	June 30,	Tulls Creek (WRC-slight)
			Northwest River (DMF-200; WRC-slight)
Dare County	July 1	June 30,	Mashoes Creek
			Milltail Creek (WRC-slight)
			East Lake (DMF-75; WRC-moderate)
			South Lake (WRC-moderate)
Hertford County*	July 1	June 30,	Wiccacon River (tributary of Chowan River)
Pasquotank County	July 1	June 30,	all inland waters (listed below)
			Little River above a line from Manston Creek to Davis Creek
			Symonds Creek
			Manston Creek
			Big Flatty Creek above a line from Long Point to Folly Creek (WRC-moderate)
			Marsh Landing
			Folly Creek
			Pasquotank River above US 158 bridge at Elizabeth City (WRC-moderate)
			Little Flatty Creek (WRC-slight)
			New Begun Creek above a line from the mouth of Paling Creek to the mouth of James Creek (WRC-moderate)
			Paling Creek
			James Creek
			Charles Creek

Table 1. Continued.

Perquimans County	July 1	June 30, all inland waters (listed below) Yeopim River above Norcum Point (DMF-25) Yeopim Creek (WRC-moderate) Perquimans River above old US 17 bridge at Hertford (DMF-25) Walter s Creek Mill Pond Creek Suttons Creek Jackson (Cove) Creek Muddy Creek Little River above a line from Manston Creek to Davis Creek (WRC-slight) Deep Creek Davis Creek
Tyrrell County	July 1	June 30, Scuppernong River Alligator Creek/ Little Alligator River (DMF-300; WRC-moderate/heavy)
<u>Tributaries to Pamlico Sound, Pungo and Tar-Pamlico rivers</u>:		
Beaufort County	July 1	June 30, Pungo River (see Hyde County below) and Tar-Pamlico River above Norfolk and Southern Railroad bridge
Hyde County	July 1	June 30, all inland waters (listed below) Pungo River above US 264 bridge at Leechville (DMF-25; WRC-slight/heavy) Rutman Creek Wilkerson Creek (DMF-5) Horse Island Creek Tarkiln Creek (DMF-5) Scranton Creek above US 264 bridge Smith Creek (DMF-25) Fishing Creek (DMF-15) Juniper Bay Creek Canal Lake Mattamuskeet Outfall Canal above US 264 bridge (DMF-10; WRC-moderate) Lake Landing Canal above US 264 bridge (DMF-20; WRC-moderate) Waupopin Canal above SR 1311 bridge All other Manmade Tributaries to Lake Mattamuskeet Long Shoal River above US 264 bridge Flag Creek Cumberland Creek Alligator River above Cherry Ridge Landing (DMF-225) Swan Creek and Lake Alligator Creek
<u>Neuse, Trent and White Oak rivers</u>:		
Craven County	July 1	June 30, main run of the Trent and Neuse rivers
Jones County	July 1	June 30, Trent and White Oak rivers below US 17 bridge
Onslow County	July 1	June 30, White Oak River below US 17 bridge

*Crab pots are not likely to be used in these areas.
DMF- Div. of Marine Fisheries (Marine Patrol) estimates of the average number of crab pots used in inland waters (2/98).
WRC- Wildlife Resources Commission s (Enforcement Division) indication of crab pot use in inland waters (2/98).

APPENDIX 13. RECREATIONAL COMMERCIAL GEAR LICENSE

I. Issue:

Gear limits for recreational fishermen using commercial gear.

II. Background:

On July 1, 1999, a new license for recreational fishermen using commercial gear will go into effect [Recreational Commercial Gear License (RCGL)]. Prior to the implementation of this license the MFC has to adopt rules authorizing the use of a limited amount of commercial equipment for RCGL holders. These limits may be imposed on a uniform basis for all coastal fishing waters or may vary for various geographical areas. Additionally, gear used by RCGL users shall be identified by colored tags or other means to distinguish between commercial and recreational users of commercial gear. The Fishery Reform Act of 1997 (FRA) also states that recreational creel limits will apply to species harvested with the RCGL.

III. Discussion:

The only data available for commercial gear use by recreational crabbers in North Carolina is from the vessel license data. While this data is useful for showing long-term trends in gear use patterns, caution must be taken when using this data at finer levels. Table 1 shows the reported number of crab pots used by recreational crabbers from 1983-1997. Table 2 summarizes the restrictions and rules for recreational crabbers from other states. The DMF will be conducting a survey of potential RCGL holders during the summer of 1998 to obtain data on participation, effort, gear used, and other aspects of this fishery.

Specific recommendations and questions that need to be addressed for harvesting blue crabs with the RCGL are:

1) Number of pots.
    - 1a) Should there be a pot limit for crab pots attached to shore or a pier?
2) Crab trawl.
    - 2a) Should RCGL holders be allowed to use a crab trawl?
    - 2b) Allow only single-rigged boats? Double rigged? Is headrope length the limit per trawl, or total combined length for double rigged boats? Should mechanical retrieval methods be allowed?
3) Tag or buoy color.
4) Recreational catch limit?
5) Definitions of commercial and non-commercial gear?

IV. Management Recommendations:

1. The specific number of pots allowed should be determined by geographic area, with 1 - 15 being the maximum allowed in any area.

While data are unavailable for the various geographic areas of the state, vessel license data indicate that the average number of pots set by recreational crabbers, who used a vessel, from 1983 through 1993 was 19. Table 3 shows the percentage of fishermen using various amounts of pots. These data show that a maximum pot limit of 15 per license would meet the reported needs of over 85% of recreational users.

Table 3. Vessel license data showing reported pot usage patterns for recreational crabbers.

	Percent						
Reported pot numbers	1991	1992	1993	1994	1995	1996	1997
0 to 5	78.7	77.1	79.8	82.3	75.3	75.4	77.8
6 to 10	9.8	10.9	9.6	7.8	9.1	7.9	11.4
11 to 15	3.1	3.3	3.2	2.4	2.4	2.0	2.6
16 to 20	1.4	1.8	1.6	1.5	1.9	1.9	1.8
21 to 50	4.0	4.3	3.3	3.2	4.6	4.2	3.2
51 to 100	1.5	1.2	1.3	0.7	3.3	4.1	1.5
101 +	1.5	1.5	1.2	1.8	3.3	4.5	1.6

1a. It is recommended that the crab pot exemption from the RCGL (FRA) for persons setting pots from shore or pier be repealed.

It is further recommended that individuals setting crab pots from shore or a pier be required to follow all gear marking requirements imposed on RCGL holders.

2. Crab trawls should be considered as a gear for RCGL-holders. If this gear is allowed the maximum headrope size for crab trawls should be 20 feet. However, a 3-year phase in period should be allowed for people owning larger nets. Only single rigged trawls using non-mechanical retrieval methods should be allowed.

Few recreational fishermen use crab trawls. Most of the crabs harvested by trawls

are the result of bycatch in the recreational shrimp fishery. The proposed 20 foot headrope size for crab trawls and single-rigged trawls using non-mechanical retrieval methods will match that proposed for shrimp trawls. By allowing a three-year phase in period, individuals owning larger trawls will be able to maximize the life of their current gear without incurring unnecessary expenses.

3. Tag or buoy color for recreational gear should be of a color not commonly used by commercial fishermen.

Yellow buoys are required for gill nets by the MFC. Buoy colors available from Keller Co. (Manteo, NC) are orange, white, pink, green, blue, red, and yellow. Carlon Rubber Co. can provide any color with a 300 buoy minimum order. Tag or buoy color for recreational gear should be of a color not commonly used by commercial fishermen (any color except yellow).

4. Consider recreational catch limits for the harvest of blue crabs by persons holding an RCGL.

While the status of the blue crab stock is unknown, we do not feel that restrictive catch measures need to be imposed on the commercial and/or recreational fishery at this time. Since holders of the RCGL will be restricted by the amount of pots they can set, catch limits could possibly force fishermen to leave their pots in the water longer to obtain their desired catch. For the trawl fisheries, shrimp and crab, catch limits would only result in waste of the resource.

5. Consider defining collapsible crab traps as non-commercial gear; no license required.

Currently collapsible crab traps (star traps) are considered commercial gear. This gear should be non-commercial since catch rates are controlled by the fishermen's level of activity.

Table 1. Reported number of crab pots in North Carolina, from vessel license data.

	Number of fishermen				Total number of reported pots				Average number of pots				Rate of increase in reported pot numbers			
Year	Full time	Part time	Recreational	Total	Full time	Part time	Recreational	Total	Full time	Part time	Recreational	Total	Full time	Part time	Recreational	Total
1983	1,278	2,233	3,707	7,218	198,226	105,604	46,549	350,379	155.11	47.29	12.56	48.54				
1984	1,247	2,152	3,100	6,499	207,273	101,239	36,777	345,289	166.22	47.04	11.86	53.13	4.56	-4.13	-20.99	-1.45
1985	1,350	1,989	3,203	6,542	216,907	83,092	49,558	349,557	160.67	41.78	15.47	53.43	4.65	-17.92	34.75	1.24
1986	1,327	1,981	3,346	6,654	229,861	99,729	51,422	381,012	173.22	50.34	15.37	57.26	5.97	20.02	3.76	9.00
1987	1,485	2,114	3,345	6,944	264,984	108,743	62,816	436,543	178.44	51.44	18.78	62.87	15.28	9.04	22.16	14.57
1988	1,676	2,020	3,096	6,792	328,091	107,846	72,935	508,872	195.76	53.39	23.56	74.92	23.82	-0.82	16.11	16.57
1989	1,918	2,296	3,606	7,820	357,007	119,864	77,384	554,255	186.14	52.21	21.46	70.88	8.81	11.14	6.10	8.92
1990	2,010	2,134	3,361	7,505	382,061	119,467	82,854	584,382	190.08	55.98	24.65	77.87	7.02	-0.33	7.07	5.44
1991	2,123	2,255	3,222	7,600	401,796	137,507	83,945	623,248	189.26	60.98	26.05	82.01	5.17	15.10	1.32	6.65
1993	2,295	2,012	2,800	7,107	498,179	120,829	68,960	687,968	217.07	60.05	24.63	96.80				
1994	2,992	2,413	3,113	8,518	697,276	154,861	99,571	951,708	233.05	64.18	31.99	111.73	39.96	28.17	44.39	38.34
1995	2,717	1,863	2,418	6,998	1,928,182	350,443	135,996	2,414,621	709.67	188.11	56.24	345.04	176.53	126.30	36.58	153.71
1996	2,691	1,548	1,924	6,163	2,989,731	410,875	181,497	3,582,103	1111.01	265.42	94.33	581.23	55.05	17.24	33.46	48.35
1997	2,347	1,458	1,754	5,559	870,199	135,344	57,788	1,063,331	370.77	92.83	32.95	191.28	-70.89	-67.06	-68.16	-70.32
1998	1,798	1,365	1,400	4,563	601,441	120,759	34,700	756,900	334.51	88.47	24.79	165.88	-30.88	-10.78	-39.95	-28.82

Table 2. State comparisons of blue crab management actions for the recreational/ non-commercial pot fishery.

State	License	License exemption	Harvest restrictions: Season	Harvest restrictions: Daily catch limits	Harvest restrictions: Time	Harvest restrictions: Days	Gear restrictions: Pots (max.)	Gear restrictions: Escape rings	Gear restrictions: Buoys	Size limits (inches): Hard	Size limits (inches): Soft	Size limits (inches): Peeler	Size limits (inches): Tolerance	Effort management
NEW JERSEY	Yes No fee	None	None	1 bushel	4:00am-9:00pm Bay, 24-hrs other waters	None	2	None terrapin excluder some areas	Reflective I.D. Sink line	4.5* prohibit sponge	3.5	3	Zero	None
DELAWARE	None		None	1 bushel	None	None	2	None	I.D. white	5	3.5	3	5% by number	None
MARYLAND [1]	None		Apr. 1-Nov.30	1 bushel 1 dozen peeler/ soft	5:30am-5:00pm sunset tribs.	None	2 Land owners only	1 (2-3/16 in) 1 (2-5/16 in)	I.D.	5 prohibit sponge	3.5	3	Zero	None
VIRGINIA	Yes	2 pots 1 bushel and 24 peelers daily limit	Apr. 1-Nov. 30	None	3 hrs before sunrise-sunset	Mon.-Sat. with License	5	1 (2-3/16 in) 1 (2-5/16 in)/ may close in some areas	Marked with the letter "R"	5	3.5	None	10 crabs/ bushel or 35/ barrel	None
NORTH CAROLINA	None unless use a vessel		None	50 crabs 100/vessel	1 hr before sunrise- 1 hr after sunset	None	None	2 (2-5/16 in) may close in one area	I.D.	5	None	None	10% by number/ container	None
SOUTH CAROLINA	None		None	None	5am-9pm 4/1-9/15 6am-7pm 9/16-3/31 None land based	None	2	None	I.D. yellow	5*	5*	5	Zero	None
GEORGIA	Yes Fishing Lic.	None	None	1 bushel 2 bushels/ vessel	None	None	6	2 (2- 3/8 in)	I.D.	5	5	3	Zero	None
FLORIDA	None		None	10 gallons/ person or vessel	1 hr before sunrise-1 hr. after sunset	None	None	3 (2-3/8 in) Degradable panel	Marked with the letter "R"	5* prohibit sponge	None	None separate from catch	5% by number/ container except bait	None
ALABAMA	None		None	None	None	None	5	None	None	None	None	None	N/A	None
MISSISSIPPI	None		None	None	None	None	6/household	None	I.D.	5* prohibit sponge	None	None	Zero	None
LOUISIANA	Yes	None	None	None	½ hr before sunrise- ½ hr after sunset	None	10	2 (2-5/16 in)	I.D. on trap tag	None prohibit sponge	None	None	N/A	None
TEXAS	Yes Fishing Lic. & Saltwater Stamp		None	None	½ hr before sunrise- ½ hr after sunset	None	6	2 (2-3/8 in) Degradable panel	white with color stripe gear tag- I.D. & date set	5* prohibit sponge	5	5	5% by number in separate container for bait only	None

* Includes mature female

[1] Maryland's Noncommercial Crabbing License does not include the use of crab pots.