REPORT OF THE
VIRGINIA DELEGATION TO THE CHESAPEAKE BAY COMMISSION AND THE MARINE RESOURCES COMMISSION ON

ADDRESSING ISSUES RELATED TO THE MANAGEMENT OF THE BLUE CRAB

TO THE GOVERNOR AND
THE GENERAL ASSEMBLY OF VIRGINIA

HOUSE DOCUMENT NO. 61

COMMONWEALTH OF VIRGINIA
RICHMOND
1996

Chesapeake Bay Commission

Virginia Office
629 E. Main Street, Room 627
Richmond, Virginia 23219
804-762-4328
FAX 804-762-4319

March, 1996

To the Governor and the General Assembly:

On behalf of the Virginia Delegation to the Chesapeake Bay Commission, please accept this report in fulfillment of the requirements of House Joint Resolution 609 (1995).

Virginia must continue to pay close attention to the blue crab fishery and the habitat on with it depends for the benefit of the resource and those who earn their living from it.

I wish to thank all of the committee members for their participation in the study and especially Commissioner of Marine Resources William A. Pruitt and his staff.

With kind regards, I am,

Sincerely,

Robert S. Bloxom
1995 Chairman, Virginia Delegation to the Chesapeake Bay Commission

COMMONWEALTH of VIRGINIA

George Allen
Governor

Becky Norton Dunlop
Secretary of Natural Resources

Marine Resources Commission
P. O. Box 756
2600 Washington Avenue
Newport News, Virginia 23607-0756

William A. Pruitt
Commissioner

March 20, 1996

TO THE GOVERNOR AND THE GENERAL ASSEMBLY:

On behalf of the Virginia Marine Resources Commission, I am pleased to present this report in response to House Joint Resolution 609 (1995).

Over one year ago the Virginia Marine Resources Commission established new regulations designed to contribute significantly to the recovery of the blue crab. Recently, the Commission added several restrictions to ensure that the fishery does not expand until the resource improves. I am confident that these measures will result in the long term stability of the blue crab resources.

Please be assured that the Commission is committed to a future course of action that is responsible, science-based, and intended to enhance this valuable resource.

Sincerely,

William A. Pruitt

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APPENDICES

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HOUSE JOINT RESOLUTION NO. 609

Requesting the Virginia delegation to the Chesapeake Bay Commission, the Virginia Marine Resources Commission, and representatives of the seafood industry to (i) study the possible effects of changing minimum size limits of blue crabs allowed to be taken, of requiring cull rings in peeler pots and of preventing the taking of peeler crabs too early in the molting stage and (ii) prepare a blue crab fishery management plan.

Agreed to by the House of Delegates, February 25, 1995
Agreed to by the Senate, February 25, 1995

WHEREAS, the blue crab fishery is the most important commercial and recreational fishery in the Chesapeake Bay; and

WHEREAS, the blue crab population is now critically low; and

WHEREAS, factors such as the increased harvest pressure on the blue crab due in part to the decline of other Chesapeake Bay fisheries, particularly the oyster and rockfish fisheries, may prevent the blue crab population from recovering from its present low levels; and

WHEREAS, the blue crab population is also threatened by habitat loss due to the disappearance of submerged aquatic vegetation, which is particularly important for juveniles, and low oxygen levels in deep waters; and

WHEREAS, increased survival of juvenile crabs so that they may reproduce or be harvested at a larger size may contribute to the stability of the crab population; and

WHEREAS, a preliminary Virginia Institute of Marine Science investigation has concluded that the effect of the peeler crab harvest on the blue crab population is uncertain and requires study; and

WHEREAS, because large crabs produce more eggs than small crabs, and because there appears to be at least a partial genetic basis for blue crab size at maturity, the importance of increased survival of large female crabs to the stability of the crab population should be investigated; and

WHEREAS, the practice of capturing peeler crabs too early during the molting cycle may cause the crabs to die before they can be harvested as soft-shelled crabs; and

WHEREAS, the use of cull rings in peeler pots may have a positive impact on the crab population by preventing harvest of juvenile crabs; and

WHEREAS, it has been proposed that the minimum size of crabs allowed to be taken be changed from five inches in the transverse direction, which applies only to male crabs, to two and five-sixteenths inches in the longitudinal direction for male crabs in the Chesapeake Bay and its tributaries and two and three-sixteenths inches in the longitudinal direction for male crabs in other waters and for all female crabs; now, therefore, be it

RESOLVED by the House of Delegates, the Senate concurring, That the Virginia delegation to the Chesapeake Bay Commission, the Virginia Marine Resources Commission, and four representatives of the seafood industry be requested to undertake a joint study of the blue crab population and ways to promote its growth. The seafood industry representatives shall be appointed as follows: one working waterman and one crab processor appointed by the Speaker of the House; and one working waterman and one crab processor appointed by the Senate Committee on Privileges and Elections.

The study shall examine the proposed change in crab size limits, other possible changes in crab size limits, the inclusion of one or two cull rings in peeler pots, ways to prevent the capture of peeler crabs that are in an early stage of molting, and the effect of such measures. The Commissions and representatives shall consider and prepare a blue crab fishery management plan consistent with the standards for fishery conservation and management set out in Virginia Code § 28.2-203. The plan shall be designed so as to reverse any fishing practices, environmental stress and habitat deterioration negatively impacting the short-term and long-term viability and sustainability of the crab stock in Virginia waters. At a minimum, the plan shall include, but not be limited to:

1. Measures to protect and enhance crab habitat and nursery areas;

2. Measures to maintain water quality conditions necessary for blue crab survival and reproduction, including identification of areas where water quality is such that onshore mechanisms for water quality protection are needed to protect and restore crab populations and habitat areas; and

3. A review of current and proposed regulations and restrictions relating to (i) winter dredging, (ii) commercial licensing, (iii) spawning stock, (iv) nursing sanctuaries, (v) submerged aquatic vegetation, (vi) peeler and soft shell crabs, (vii) size limits, (viii) the use of cull rings and the use of crab pots, and (ix) time-of-day restrictions and closed seasons.

The Commissions and representatives shall recommend such legislative and regulatory changes as may be necessary to limit the commercial and recreational taking of crabs and protect crab habitat, crab nursery areas and water quality. The Commissions and representatives shall consider the economic impact to Virginia of proposed legislative and regulatory changes in making their recommendations.

All agencies of the Commonwealth shall provide assistance to the Virginia delegation to the Chesapeake Bay Commission and the Virginia Marine Resources Commission for this study, upon request.

The Virginia delegation to the Chesapeake Bay Commission, the Virginia Marine Resources Commission, and the representatives shall complete their work in time to submit their findings and recommendations to the Governor and the 1996 Session of the General Assembly as provided in the procedures of the Division of Legislative Automated Systems for the processing of legislative documents.

I. Introduction

House Joint Resolution 609 was adopted by the 1995 session of the General Assembly and directed a joint study on certain issues related to crab management by the Virginia Delegation to the Chesapeake Bay Commission and the Marine Resources Commission assisted by individuals representing the commercial crabbing industry. Specifically the committee was asked to address three specific issues as well as to prepare a fishery management plan for the blue crab.

The committee met four times, meeting agendas are attached as appendix 1.

II. Status of the Resource

According to the information presented to the committee, the crab population appears to be low at the current time. A technical report prepared by staff at the Virginia Institute of Marine Science indicates that spawning stock, as compared to historical averages remains at low levels and that conservation measures are appropriate.[1] In the report, VIMS suggests the spawning stocks have remained at low levels since the devastating impacts of Tropical Storm Agnes in 1972. The report also illustrates the relationship between blue crab abundance and the abundance of submerged aquatic vegetation (SAV). Information gathered by VIMS indicated that SAV is critical habitat for crabs, particularly young crabs.[2]

Data compiled by the Marine Resources Commission also show reason for concern. Although final figures are not available at this writing, VMRC staff predicts that the total catch in pounds for 1995 will be approximately 25 million pounds, as compared to a recent average of approximately 40 million pounds per year.[3] In addition, preliminary data for the 1995 also suggest a reduction in catch per unit effort,[4] a key indicator of stock health. VIMS researchers have also noted a steadily declining catch per unit effort over the last several years. Similar trends have also been identified in the Potomac River.[5]

In sum, the consensus of the committee is that the spawning blue crab stock appears to be in a low phase. While not at a crisis level, prudent management calls for a cap or reduction in effort.

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[1] Lipcius, R., et. al, "Status of the Blue Crab Stock", Crustacean Ecology Program Technical Report No. 1995(8), November 28, 1995.

[2] Lipcius, et.al

[3] VMRC Staff Presentation, HJR 609 Committee meeting, October 16, 1995.

[4] VMRC Staff Presentation, HJR 609 Committee, October 16, 1995.

[5] Potomac River Fisheries Commission, "Crab Landings Report", 1995 season (preliminary).

III. Specific Management Measures Addressed in HJR 609

HJR 609 requested the committee to address the following specific management issues.

1) Change in Minimum Size

The resolution asked the committee the following proposed change in the measurement of crabs:

Crab	Location	Current Measurement	Proposed
Male	Bay and Tribs.	5" transverse	2 5/16" longitudinal
Male	Other waters	5" transverse	2 3/16" longitudinal
Female	All waters	No minimum	2 3/16" longitudinal

The majority of the committee members voted to not change the current minimum sizes of crabs at this time primarily for reasons related to need for statewide consistency and consistency with Atlantic and Gulf coast states. In addition to the changes described in the chart above, several members of the committee also proposed a 4 1/2 inch minimum for all mature female crabs. The committee did not adopt this recommendation; it was, however, referred to VMRC staff for their review.

2) Use of One or Two Cull Rings in Peeler Pots

The committee voted not to endorse the requirement for one or two cull rings in peeler pots. Instead, the committee endorsed a proposal currently before the Marine Resources Commission to establish a minimum 3 1/2 inch size for soft crabs.

3) Capture of Crabs in the Early Stage of Molting

VMRC staff proposed a change in the Code of Virginia[6] to remove the reference to a "white line" which appears on a peeler crab.[7] Staff reports that so-called "white sign" peelers have a higher mortality in shedding operations. As an alternative to the staff proposal, the committee voted to recommend legislation which will allow VMRC to define, by regulation, peeler crabs in order to reduce mortality. (See appendix 2)

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[6] VA Code, §28.2-700.

[7] VMRC Staff Presentation, HJR 609 Committee Meeting, October 16, 1995.

IV. Management Plan Issues

The second component of HJR 609 was the direction to prepare a blue crab fishery management plan for Virginia.

In 1989, through the cooperative efforts of the states and the federal government through the auspices of the Chesapeake Bay Program, the first Chesapeake Bay Blue Crab Management Plan was developed (see appendix 5). A revision of the plan, begun in 1994 in now underway.

The HJR 609 committee recommends that Chesapeake Bay Blue Crab Management Plan be adopted as Virginia's Plan. The goal statement of the plan reads: "The goal of the 1995 Blue Crab Fishery Management Plan is to manage blue crabs in Chesapeake Bay in a manner which conserves the Baywide stock, protects its ecological value and optimizes the long-term use of the resource." The committee further recommends that the plan be revised as follows:

1: Enhance provisions regarding submerged aquatic vegetation (SAV):

SAV includes aquatic plants that live in shallow waters of may of the tributaries and along the mainstem of Chesapeake Bay. They are home to numerous species of finfish and invertebrates and are a particularly important nursery habitat for the blue crab. The decline of SAV in the Chesapeake Bay in the early 1970's highlighted the continued deterioration of the Bay ecosystem. Although there has been some rebound in several areas of the Bay and its tributaries since 1970, many areas remain devoid of SAV. In Virginia, there is virtually no SAV in the James, Piankatank, Rappahannock, and Potomac rivers. It is generally accepted that the lower sections of these rivers were very important nursery grounds in the past when SAV was abundant.

The Virginia Institute of Marine Science has been engaged in research to understand the role of SAV beds as nursery areas for the blue crab and other species, documenting historical trends in SAV distribution and abundance related to changes in water quality and establishing criteria and methodologies for re-establishment of this resource. Based on this ongoing research, VIMS has determined the following[8]:

- Ten to one hundred times more post-larva and very early instar crabs are found in SAV than in unvegetated areas.
- All SAV beds in the primary blue crab nursery region from the mouth of Chesapeake Bay to the Honga River on the eastern shore of Maryland and the Potomac on the Western Shore appear to be equally as important.
- SAV beds provide the greatest protection to the youngest crabs (less than 6-8 mm)

[8] Personnel communication from Robert J. Orth, December 18, 1995.

whose survival is significantly increased relative to those in non-vegetated areas.

- Total abundance of crabs is directly related to the abundance of SAV in the Bay.

- SAV abundance in the primary nursery area is approximately 50% of that present in the 1960's.

- SAV growth, distribution and abundance is governed primarily by water quality. Small improvement in water quality can result in large expansion in SAV populations, likewise declines in water quality parameter below certain thresholds can result in dramatic SAV declines.

As a result of these findings, the HJR 609 committee recommends that:

1. All state regulatory agencies should recognize the importance of SAV a critical nursery habitat for the blue crab and an important habitat for other species in Chesapeake Bay. Further, regulatory policy should embrace guideline set forth in the policies developed by the Chesapeake Bay Program and signed by the Chesapeake Executive Council.

2. The Virginia Marine Resources Commission should be given explicit authority in Code to protect SAV from direct impacts through their Habitat Permit process. (See appendix 3)

3. The Commonwealth should recognize the importance of improving water quality for the long term health of SAV and should include provisions dealing specifically with SAV in the Tributary Strategies now under development.

4. The Commonwealth should continue supporting efforts to monitor the distribution and abundance of SAV in Chesapeake Bay and promote programs aimed at either restoring SAV beds in areas here water quality is sufficient to support the growth of SAV or expanding existing grassbeds.

5. The Commonwealth should strive to educate and inform the general public, fishermen, and others whose activities may impact SAV on the important of SAV as a nursery for blue crabs and other commercially and ecologically important species.

2: Incorporate recent regulatory actions by Virginia

The most recent draft of the Baywide Blue Crab Management Plan does not include a series of initiatives adopted in 1994. The committee recommends that the following elements be added to the plan:

1. Expand Crab Spawning Sanctuary (now located at the mouth of Chesapeake Bay, to include the Eastern Shore Management Area. The new sanctuary will be closure to all commercial crabbing and recreational potting.

2. Prohibit crab dredging in the Hampton Roads Management Area at the mouth of the James River.

3. Limit crab dredge size to 8 foot width.

4. Require two cull rings per hard crab pot. (2-5/16", 2-3/16")

5. Require four cull rings (1-1/2") per peeler pound/trap.

6. Establish hard crab pot and peeler pot season of April 1 to November 30.

7. Limit peeler pots to 400 per person per vessel from April 1 to June 30. Limit peeler pots to 400 per person from July 1 to November 30 with a maximum of two licensed fishermen per boat.

The plan should also reflect any additional actions taken by VMRC in 1996.

V. Bi-state Coordination and Cooperation

Through their life cycle, blue crabs use the entire Chesapeake Bay. Therefore, cooperative management between Maryland and Virginia is necessary to recognize this biological fact. As part of the work of the HJR 609 committee a joint meeting was held on September 21, 1995 in Richmond between the committee and the Maryland Blue Crab Steering Committee (see appendix 4). Discussion followed that meeting and the consensus among those participating that a more formal entity be created to facilitate cooperation and coordination between the states.

A proposal for a standing bi-state advisory committee is currently under review. The HJR 609 committee supports this continued cooperation and dialogue.

Chesapeake Bay Commission

Virginia Office

Appendix 1

PROPOSED AGENDA
House Joint Resolution 609
June 30, 1995, 10:00 a.m.

10:00	I.	Call to Order and Opening Remarks
	♦	Delegate Robert S. Bloxom
10:10	II.	Review of HJR 609
	♦	Russ Baxter
10:15	III.	Overview of Crab Resource: Status and Trends
	♦	Dr. Rom Lipcius, VIMS
	♦	Dr. J. van Montfrans, VIMS
	♦	Dr. John McConaugha, Old Dominion University
11:15	IV.	Review of Interstate Chesapeake Bay Crab Management Plan and Maryland Efforts
	♦	Jack Travelstead
	Guest:	Sarah Taylor, Maryland Department of Natural Resources
11:30	V.	Current VMRC Management and Field Research
	♦	Jack Travelstead
11:45	VI.	Discussion of Crab Industry Problems, Proposed Study Plan and Future Meetings
	♦	Committee Members
1:00	VII.	Adjourn

629 E. Main Street, Room 627 ▪ Richmond, VA 23219 ▪ 804-698-4328 ▪ Fax 804-698-4319

Chesapeake Bay Commission

Virginia Office

PROPOSED AGENDA
HJR 609 Committee - Work Session
October 16, 1995
Newport News, Virginia

2:00 p.m. I. **Call to Order**
Delegate Robert S. Bloxom

2:10 II. **Consideration of Specific Management Issues raised in HJR 609**

Committee review and discussion of the following:

- *Use of one or two cull rings in peeler pots*
- *Proposed change in measurement of minimum size*
- *Capture of crabs in early state of molting*

3:00 III. **Consideration of Management Plan Elements**

Committee review and discussion regarding the management plan elements contained in HJR 609:

- *Winter Dredging*
- *Commercial Licensing*
- *Protection of Spawning Stock*
- *Nursing Sanctuaries*
- *Submerged Aquatic Vegetation (SAV) and Other Habitat Issues*
- *Management of Peelers and Soft Crabs*
- *Size Limits*
- *Cull rings*
- *Time of Day and Season Restrictions*

4:00 IV. **Public Comment**

4:30 V. **Establishment of Work Schedule for Remainder of Study**

4:45 VI. **Adjourn**

629 E. Main Street, Room 627 ▪ Richmond, VA 23219 ▪ 804-698-4328 ▪ Fax 804-698-4319

Chesapeake Bay Commission

Virginia Office

PROPOSED AGENDA
House Joint Resolution 609
Virginia Marine Resources Commission
Newport News, Virginia
December 13, 1995

2:30 p.m. I. Call to Order

2:35 p.m. II. Status of joint Virginia/Maryland efforts

- Staff Report

2:40 p.m. III. Report on recent VMRC actions

- Blue Crab Subcommittee
  Tim Hayes

- VMRC Staff Proposals
  Jack Travelstead

- Industry Proposals
  John Graham

3:40 p.m. IV. Committee Discussion of Elements of Report to the General Assembly

4:40 p.m. V. Public Comment

5:00 VI. Adjourn

629 E. Main Street, Room 627 ▪ Richmond, VA 23219 ▪ 804-698-4328 ▪ Fax 804-698-4319

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Appendix 2

HOUSE BILL NO. 531

Offered January 18, 1996

A BILL to amend and reenact § 28.2-700 of the Code of Virginia, relating to the definition of peeler crabs.

Patrons—Bloxom, Baker, Behm, Morgan and Murphy; Senator: Gartlan

Referred to Committee on Chesapeake and Its Tributaries

Be it enacted by the General Assembly of Virginia:

1. That § 28.2-700 of the Code of Virginia is amended and reenacted as follows:

§ 28.2-700. Definitions.

As used in this chapter, unless the context requires a different meaning:

"Crab dredge" means a device, which may have teeth on the bar, that is designed and used to catch crabs buried in the bottom.

"Crab pot" means a device made of wire or thread net used to catch crabs.

"Peeler crab", *until the Commission promulgates a different definition,* means a crab that has a soft shell fully developed under the hard shell, or a crab on which there is a pink or white line or rim on the edge of that part of the back fin next to the outer section of this fin.

"Peeler pot" means a wire mesh pot baited with only live adult male (jimmy) blue crabs.

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HB531

1/18/96 18:49

Official Use By Clerks

Passed By The House of Delegates		**Passed By The Senate**	
without amendment	☐	without amendment	☐
with amendment	☐	with amendment	☐
substitute	☐	substitute	☐
substitute w/amdt	☐	substitute w/amdt	☐

Date: _____ Date: _____

_____ _____

Clerk of the House of Delegates Clerk of the Senate

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Appendix 3

HOUSE BILL NO. 530

Offered January 18, 1996

A BILL to amend and reenact § 28.2-1205 of the Code of Virginia, relating to permits for use of bottomlands.

Patrons—Bloxom, Behm, Morgan and Murphy; Senator: Gartlan

Referred to Committee on Chesapeake and Its Tributaries

Be it enacted by the General Assembly of Virginia:

1. That § 28.2-1205 of the Code of Virginia is amended and reenacted as follows:

§ 28.2-1205. Permits for the use of state-owned bottomlands.

A. When determining whether to grant or deny any permit for the use of state-owned bottomlands, the Commission shall be guided in its deliberations by the provisions of Article XI, Section I of the Constitution of Virginia. In addition to other factors, the Commission shall also consider the public and private benefits of the proposed project and its effect on the following:

1. Other reasonable and permissible uses of state waters and state-owned bottomlands;

2. Marine and fisheries resources of the Commonwealth;

3. Tidal wetlands, except when this has or will be determined under the provisions of Chapter 13 of this title;

4. Adjacent or nearby properties; ~~and~~

5. Water quality*; and*

6. Submerged aquatic vegetation (SAV).

B. The Commission shall consult with other state agencies, including the Virginia Institute of Marine Science, the State Water Control Board, the Virginia Department of Transportation, and the State Corporation Commission, whenever the Commission's decision on a permit application relates to or affects the particular concerns or activities of those agencies.

C. No permit for a marina or boatyard for commercial use shall be granted until the owner or other applicant presents to the Commission a plan for sewage treatment or disposal facilities which has been approved by the State Department of Health.

D. All permits issued by the Commission for the use of state-owned bottomlands or to recover underwater historic property shall be in writing and specify the conditions, terms and royalties which the Commission determines are appropriate.

E. Any person aggrieved by a decision of the Commission under this section is entitled to judicial review in accordance with the provisions of the Administrative Process Act (§ 9-6.14:1 et seq.).

Official Use By Clerks

Passed By The House of Delegates		**Passed By The Senate**	
without amendment	☐	without amendment	☐
with amendment	☐	with amendment	☐
substitute	☐	substitute	☐
substitute w/amdt	☐	substitute w/amdt	☐

Date: _____ Date: _____

Clerk of the House of Delegates

Clerk of the Senate

Appendix 4

AGENDA

JOINT MEETING
MARYLAND BLUE CRAB STEERING COMMITTEE
and the
VIRGINIA BLUE CRAB COMMITTEE (HJR 609)

General Assembly Building, Room D
Richmond, VA
SEPTEMBER 21, 1995

10:30 A.M. **WELCOME**

Honorable Robert S. Bloxom
VA House of Delegates

10:35 A.M. **OPENING REMARKS**

John R. Griffin
Secretary, MD Department of Natural Resources

William A. Pruitt
Commissioner, VA Marine Resources Commission

10:45 A.M. **INTRODUCTION OF COMMITTEE MEMBERS**

- *Who do we represent?*
- *What do we hope to accomplish?*
- *How best do we coordinate our efforts?*
- *How do we organize our work schedule?*

11:30 A.M. ***PANEL DISCUSSION #1: A STATUS REPORT***

A MODELING ASSESSMENT:

CHESAPEAKE BAY BLUE CRAB STOCK ASSESSMENT (CBSAC STUDY) PROGRESS REPORT

M. Elizabeth Gillelan
NOAA

Anne Lange
CBSAC

AN ECOLOGICAL ASSESSMENT:

ABUNDANCE PATTERNS OF THE BLUE CRAB

Dr. Rom Lipcius
VIMS

QUESTIONS/COMMENTS FROM COMMITTEE MEMBERS

12:45 P.M. **BOX LUNCH (for Committee members)**

1:15 P.M. ***PANEL DISCUSSION #2: AN UPDATE***

A MANAGEMENT ASSESSMENT:

HARVEST STATUS AND REGULATORY STRUCTURE IN THE STATES

- *Update on Key Surveys*
- *1995 Catch and Effort Data (as available)*
- *Existing or Proposed Management Actions*
- *Probable Effects of Management Actions*

Pete Jensen
MD Department of Natural Resources

Jack Travelstead
VA Marine Resources Commission

QUESTIONS/COMMENTS FROM COMMITTEE MEMBERS

2:00 P.M. **PUBLIC COMMENT**

2:30 P.M. **WRAP-UP AND COMMITTEE LOGISTICS**

- Maryland Blue Crab Steering Committee
- Virginia Blue Crab Committee (HJR 609)

2:45 P.M. **ADJOURN**

Appendix 5

CHESAPEAKE BAY BLUE CRAB MANAGEMENT PLAN

1995

CHESAPEAKE BAY PROGRAM

DRAFT

~~01 MARCH 95~~

OCT 18 1995

ADOPTION STATEMENT

We, the undersigned, adopt the 1994 Chesapeake Bay Blue Crab Management Plan. The blue crab was designated a valuable species for baywide management in the 1987 Chesapeake Bay Agreement. In 1989, the first Chesapeake Bay Blue Crab Management Plan was completed. The 1994 revision of the original Plan is based on current research and accounts for new management measures since 1989.

We agree to accept the 1994 Blue Crab Management Plan as a guide to conserving and protecting the blue crab resource for long-term ecological, economic and social benefits. We further agree to work together to implement, by the dates set forth in the Plan, the management actions recommended to address increased fishing effort, wasteful harvesting practices, stock assessment deficiencies, regulatory issues, public health and consumer concerns and habitat degradation.

We recognize the need to commit long-term, stable, financial support and human resources to the task of managing the blue crab stock and adressing important research needs. In addition, we direct the Living Resources Subcommittee to periodically review and update the plan and report on progress made in achieving the plan's management recommendations.

Date _____

For the Commonwealth of Virginia _____

For the State of Maryland _____

For the Commonwealth of Pennsylvania _____

For the United States of America _____

For the District of Columbia _____

For the Chesapeake Bay Commission _____

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Edited by:

Blue Crab Fishery Management Plan Workgroup

and committees of the
Chesapeake Bay Program

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TABLES AND FIGURES

ACKNOWLEDGEMENTS

The Chesapeake Bay Blue Crab Management Plan was developed under the direction of the Fisheries Management Plan (FMP) Workgroup. Staff from the Maryland Department of Natural Resources (MDNR), Tidewater Administration, Fisheries Division were responsible for compiling the plan and addressing comments on the draft versions. Support was provided by staff from the Virginia Marine Resources Commission (VMRC), Fisheries Management Plans and Statistics Division. Special thanks is due to members of the FMP Workgroup who took the time to attend meetings at the Potomac River Fisheries Commission (PRFC) and guided the initial framework of the Plan. Staff from the Virginia Institute of Marine Science (VIMS) generated several figures included in this plan. We express gratitude to members of other Chesapeake Bay Program Committees and workgroups and to the public who commented on the plan.

Jack Brooks	Dorchester Seafood
K. A. Carpenter	Potomac River Fisheries Commission
Dr. Eugene Cronin	Coastal Consultant
Bonnie Fitch	Maryland Seafood Industry
Cpt. C.M. Frere	Maryland Natural Resources Police
William Goldsborough	Chesapeake Bay Foundation
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Members of Virginia's Blue Crab Advisory Committee

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EXECUTIVE SUMMARY

Introduction

The Chesapeake Bay is a shared resource. Biological, environmental, economic and social aspects of a fishery are shared among the Bay's jurisdictions and baywide management benefits not only the people of the Bay watershed, but the resource as well. In 1987, the Chesapeake Bay Agreement was adopted by the Commonwealth of Pennsylvania, the Commonwealth of Virginia, the State of Maryland, and the District of Columbia, as well as the U.S. Environmental Protection Agency and the Chesapeake Bay Commission. The Chesapeake Bay Agreement made a commitment to protect the Bay's living resources and the Chesapeake Bay Program is responsible for implementing the Agreement commitments. A Fisheries Management Workgroup was formed by the Program's Living Resources Subcommittee to develop and adopt a series of baywide fishery management plans (FMPs) for commercially, recreationally and selected ecologically valuable species. The Workgroup is composed of members from government agencies, the academic community, the fishing industry and environmental and public interest groups from the Bay jurisdictions and federal agencies.

Goal of the Chesapeake Bay Blue Crab Management Plan

> The goal of the 1995 Blue Crab Fishery Management Plan is to manage blue crabs in Chesapeake Bay in a manner which conserves the Baywide stock, protects its ecological value and optimizes the long-term use of the resource.

Problem Areas and Management Strategies for 1995

Problem 1: Increased Fishing Effort

The total amount of gear used and the number of participants in the crab fishery has increased over time. Research in both Maryland and Virginia indicates the number of young produced (recruited) is affected by low levels of adult spawning stock, as well as by environmental factors.

Strategy: In order to protect the reproductive potential of the blue crab stock, limits have been placed on fishing effort and on the number of participants. The new laws and regulations adopted in 1994 in Maryland and 1993 in Virginia to contain commercial and recreational fishing effort and protect stocks must be evaluated to determine their effectiveness. Both states will continue to monitor commercial catch, proceed with efforts to estimate effort by the recreational fishery, analyze the combined fisheries, determine safe levels of harvest, and, in Maryland, determine the maximum sustainable number of commercial harvesters.

Problem 2: Wasteful Harvesting Practices

Harvesting small crabs or crabs of poor quality does not maximize economic yield from the resource and small crabs retained in hard crab pots suffer high mortality rates due to predation by larger crabs. The practice of harvesting females may result in a loss of reproductive capability and late winter dredge crabs yield poor quality meat and do not maximize yield per recruit. Lost and abandoned crab pots often trap and eventually kill crabs and finfish. The mortality rate of green crabs (a peeler crab without red or pink coloration in the swim fin) held in shedding floats is high compared to peelers that are close to molting and mortality rates in poorly operated shedding systems may be high.

Strategy: Optimum use of the blue crab resource will be promoted by eliminating and/or minimizing wasteful harvest practices. Specific seasons when cull rings may not be obstructed and have minimal economic impact will be investigated. Landings and fishery-independent data will be reviewed to determine if low reproductive potential and poor spawning success result from female harvest and if harvest should be controlled. Causes of abandoned pots will be investigated, the deliberate abandonment of crab pots will be discouraged, and escape mechanisms in pots will continue to be researched. Information will be provided to shedders to minimize mortality in shedding operations.

Problem 3: Stock Assessment Deficiencies

Virginia instituted a new commercial reporting system in 1993 and Maryland followed suit in 1994. The new Maryland and Virginia systems are comparable. There is a lack of information about the biological and economic impacts from recreational crabbing in Chesapeake Bay. The population dynamics of the blue crab stock is not fully understood, and our understanding would be improved by obtaining additional information on natural and fishing mortality rates, the stock-recruitment relationship, and the effects of environmental variables and anthropogenic change on year-class strength and availability.

Strategy: New reporting methods will be used with continued fishery-independent surveys to monitor trends in catch and effort, produce reliable estimates of blue crab abundance and understand the fishery and the relationships between harvest and stock. There will be a Baywide effort to collect recreational catch and effort data and to evaluate the economic impact of the recreational harvest. The Baywide effort to collect population data on blue crabs will continue, and current methods will be improved to assure baywide uniformity of data sets and achieve reliable and more accurate catch estimates.

Problem 4: Regulatory Issues

The blue crab fishery consists of recreational and commercial faction which provide economic, social and recreational benefits to the community. Conflict between commercial crabbers and recreational boaters has become a serious problem in some of the more densely populated areas of Virginia and Maryland. Also, the interstate shipment of peelers and soft crabs may circumvent efforts to protect the Chesapeake Bay stock from illegal fishing activities.

Strategy: Conflicts among user groups and the general boating public can be minimized by rational application of time, area, and gear restrictions to allocate space and harvest of the resource. Coordinated interstate management is necessary to insure optimal baywide usage. Maryland and Virginia will continue to investigate the biological and economic effects of size limits on the soft crab fishery and the need to coordinate soft and peeler size limits.

Problem 5: Public Health and Consumer Concerns

Poor quality crabs yield less meat and quality crabs are often reserved for preferred customers while the lesser quality crabs are often all that is available to the small consumer. Also, regulations limiting effort in the Chesapeake blue crab fishery have generated fear that foreign markets will see reduced harvest as an opportunity to fill in for the demand.

Strategy: To maintain the quality of crabs available for public consumption, minimum weight and volume standards should be established for the various types of blue crabs. Present regulations are not expected to reduce harvest, but rather limit excessive growth of the fishery and prevent any future openings in the market for foreign producers to fill. Efforts will be made to insure that consumers are aware of the origin of the crab products they purchase.

Problem 6: Habitat Degradation

Nutrient influx and sediment runoff are responsible for spreading anoxic conditions and widespread declines in SAV throughout the Bay. The loss of SAV and intertidal wetlands has resulted in the loss of blue crab habitat, particularly for the juvenile and molting stages. The anoxic portion of the Bay has reduced the amount of habitat available to crabs, increased intraspecies competition, and compressed fishing effort. Blue crabs could also be affected by toxic accumulations and are most sensitive during their larval stages. Contamination also contributes to the loss of benthic foods.

Strategy: Maryland, Pennsylvania, and the District of Columbia have outlined a Tributary Strategy that will reduce the amount of nutrients from tributaries to the Bay 40%

by the year 2000 to meet the Bay Program's nutrient reduction goal. Virginia is in the process of formulating a tributary strategy which will reaffirm the 40% nutrient reduction goal. Oxygen content goals for the Chesapeake Bay are recommended by this plan and the Chesapeake Bay jurisdictions will work to restore SAV to their historic levels. The Chesapeake Bay Program will continue its commitment to toxics reduction and control, particularly in localized regions near discharge points and where accumulations occur.

Table i. Schedule for reviewing fishery management plans.

Species	Adoption Date	Review Date
Shad/Herring	1989	June, 1995
Blue Crab	1989	1995 and 1998
Oysters	1989	1994
Striped Bass	1989	August, 1995
Weakfish/Seatrout	1990	March, 1996
Bluefish	1990	June, 1995
Croaker/Spot	1991	1996
American Eel	1991	1996
Summer Flounder	1991	March, 1996
Black Drum	1993	1997
Red Drum	1993	1997
Catfish	1995	2000
Mackerel	1994	1998
Black Sea Bass	1995	2000
Tautog	1995	2000
Horseshoe Crabs	1994	1999

THE FISHERY MANAGEMENT PLAN PROCESS

What is a Fishery Management Plan?

A fishery management plan prepared under the 1987 Chesapeake Bay Agreement serves as a framework for conserving and wisely using a fishery resource. Each FMP contains a summary of the fishery under consideration, a discussion of problems and issues that have arisen, and recommended management actions.

Development of Fishery Management Plans

A management plan is not an endpoint in the management of a fishery; rather, it is part of a dynamic, ongoing process consisting of several steps. The first step consists of analyzing the complex biological, economic and social aspects of a particular fishery. The second step includes defining a fishery's problems, identifying potential solutions, and choosing appropriate management strategies. The development process begins with initial input by the Fishery Management Workgroup and the draft management proposal undergoes review by the public and appropriate Chesapeake Bay Program committees. A management plan is adopted when it is signed by the Chesapeake Bay Program's Executive Committee made up of the Governors from each jurisdiction, the Administrator for the U.S. Environmental Protection Agency and the Chairman of the Chesapeake Bay Commission. Upon adoption, implementation begins in the form of regulatory and legislative action and research. Annual reports chart the progress of management initiatives set out by each plan, and provide a yearly update of stock status. Periodic reviews of each FMP are conducted to incorporate new information and to update management strategies as needed.

Chesapeake Bay Blue Crab Management Plan

In 1989, the first Chesapeake Bay Blue Crab Fishery Management Plan (BCFMP) was adopted under the auspices of the Chesapeake Bay Agreement. In the five years since the adoption of the original plan, much has changed. More extensive data have become available and significant regulatory changes as a result of the 1989 Plan have occurred. The 1994 Plan retains some of the original goals of the 1989 Plan, such as the action to contain the commercial harvest, and also outlines a new direction based on current information.

In 1992, the Living Resources Subcommittee (LRSC) established an independent body to review all Chesapeake Bay Fishery Management Plans. The Fisheries Management Plan Re-Assessment Task Force (FMP RTF) evaluated the 37 prescribed actions of the BCFMP. The Task Force judged that there was measurable progress on 28 of the 37 actions, 13 of the 28 actions were delayed beyond the scheduled date, 4 actions were considered partially or minimally implemented

and 5 have not been implemented. Action items identified by the FMP RTF which were not fully implemented include:

Action 1.1.1 Contain the commercial harvest at present levels;

Action 1.2 Establish Bay-wide regulations concerning harvests and size limits;

Action 1.3.2 Resolve conflicts between user groups;

Action 2.3.C Investigate extent of mortality on mature female crabs used as bait in the eel fishery;

Action 3.2 Collect Bay-wide recreational catch and effort data and evaluate impact of recreational harvest.

The FMP RTF review was thorough but many of the actions listed as delayed or partially implemented or not implemented have now been accomplished by regulation and legislation effective in 1994 and 1995. The FMP RTF also produced recommendations for improving the effectiveness of the Fishery Management Plans, one of which is to conduct a substantive review at three to four year intervals to update, amend or revise the Plan.

The year 1992 produced poor crab harvests and generated great public concern. By the fall of 1992, after extensive public discussion, both states introduced regulations to curtail the increasing fishing pressure from commercial and recreational crabbers. Virginia passed legislation and regulatory measures in 1992 which took effect in 1993. To address the continuing concerns over harvest rates and increased effort, Maryland established the Blue Crab Advisory Board in November of 1992, similar to Virginia's Blue Crab Advisory Committee formed in 1987. After six months of deliberations, the Maryland Board's discussions produced the basis for the Maryland Crab Action Plan.

Managers from both jurisdictions are careful not to assume recent regulations will be completely effective in limiting effort and harvest of the fishery. The harvest of a fluctuating resource such as blue crab can be subject to a "ratchet effect." During relatively stable periods of high abundance, harvest rates and effort stabilize at a level which is excessive when abundance is average or below average. When the population is less abundant, the previously "normal" level of exploitation may result in overharvest and a potential for collapse of the population. A conservative approach to blue crab management in Chesapeake Bay is necessary to prevent overharvest. Recent measures to stabilize fishing effort must be evaluated for their effectiveness.

SECTION 1. BACKGROUND

General Information

The blue crab, *Callinectes sapidus*, is a dominant epibenthic predator in estuaries, lagoons and coastal habitats of the Western Atlantic, Caribbean and Gulf of Mexico (Williams, 1984). It is economically important throughout its range and has supported the largest single-species crab fishery worldwide over the past decade (FAO, 1990). The blue crab harvest from Chesapeake Bay alone accounted for over 50% of the national total during the past two decades (Orth and van Montfrans, 1990), and it consistently outranks harvests from other shellfish species in Chesapeake Bay by weight and total dollar value. The recreational fishery, which is estimated at about 25% of the total commercial and recreational catch in Chesapeake Bay, also contributes greatly to the economy of the region. Thus, the blue crab is an important natural resource requiring sound management to protect its long-term health and ecological and economic benefits.

Recent increases in fishing pressure, a corresponding decrease in catch per unit effort, and concurrent declines in other major exploitable fishery species (e.g., oysters and various finfish) have raised concerns over the potential for a major decline in the blue crab stock and emphasize the need for fishery management based on a sound ecological foundation. This is particularly important given the substantial interannual fluctuations in stock abundance, which places the species at risk of overexploitation. Causes of population fluctuations are poorly understood. Development of population models applicable to the blue crab and its fisheries requires an understanding of processes associated with postlarval and early juvenile stages. In particular, processes affecting transport (i.e., dominant wind patterns during the recruitment season and runoff), settlement, metamorphosis (nursery habitat availability, salinity effects, etc.) and post-settlement survival (mortality from fishery harvest and natural predation including cannibalism) that influence juvenile survival appear critical to understanding blue crab population fluctuations.

Life History

Larval and Postlarval Phases

The life history of the blue crab (Fig. 1) is similar to that of other marine species with complex life cycles and open populations. In Chesapeake Bay, larvae (zoeae) are released by mature females in high-salinity water near the mouth of the Bay (Van Engel, 1958; refer to life cycle in Fig. 1). Larvae are transported to the continental shelf where development proceeds for about 30-45 days through 7 or 8 developmental stages (reviewed in Millikin and Williams, 1984; McConaugha *et al.*, 1983; McConaugha, 1988). Larvae feed on zooplankton and plant material (Truitt, 1939). High salinities in excess of 30 parts-per-thousand (ppt) are required for optimal development (Costlow, 1967) and larvae are poorly adapted physiologically to undergo proper development at salinities much below 26 ppt, emphasizing the need for an oceanic environment for larval

development.

Metamorphosis to the postlarval (megalopa) stage occurs on the nearshore Atlantic shelf (Epifanio *et al.*, 1984). A retention mechanism has been postulated for blue crabs inhabiting Western Atlantic estuaries such as Chesapeake Bay. This involves an along-shore southerly flow of water that entrains early zoeal stages, coupled with a mid-shelf countercurrent and wind-generated flow of surface water to the north in which later-stage larvae and postlarvae return to the bay mouth.

Settlement and Recruitment of Postlarvae

In many marine species, larval or postlarval abundance and settlement set the limits within which population size is determined, since these individuals represent the survivors of early life-history phases. Blue crab postlarval abundance, though highly variable in the Bay, generally follows a neap-spring tidal cycle, with brief periods of high abundance following spring tides by several days. This suggests that entry into the Chesapeake Bay is facilitated by increased tidal excursion. Superimposed on this fortnightly pattern are peaks of abundance related to wind events that transport megalopae towards the coast and into Chesapeake Bay via non-tidal volume exchange (Goodrich *et al.*, 1989). Once within Chesapeake Bay, megalopae migrate vertically in response to light and tide, utilizing nocturnal flood tides to augment their transport up the estuary to shallow estuarine nursery habitats (Olmi, 1993). During transport into the Bay, megalopae undergo physiological changes which prepare them for the metamorphic molt into the first juvenile instar (Lipcius *et al.*, 1990; Metcalf and Lipcius, 1992).

Settlement of blue crab postlarvae has been assessed in the lower portion of Chesapeake Bay using artificial settlement substrates, and occurs primarily between July and mid-November each year. Settlement is characterized by episodic pulses during periods surrounding full and new moon events (Orth and van Montfrans, 1987; van Montfrans *et al.*, 1990). The potential exists that episodic settlement peaks, which account for more than half the annual total, may be the major determinants of adult population size, similar to that observed for tropical reef fishes and the Western Australian rock lobster. Alternatively, continuous settlement over the summer and early fall might also account for population fluctuations. Artificial settlement substrates may provide a measure of postlarval settlement which reflects both planktonic abundance and natural settlement and may serve as an indicator of reproductive and/or larval success, as well as future harvests.

Early Juvenile Stages

Late premolt postlarvae settle in the lower Bay and utilize submerged seagrass beds as nursery areas until approximately the fifth juvenile instar (Fig. 2; Orth and van Montfrans, 1987; Pile, 1993). Large juveniles migrate out of grass beds and are found in greatest abundance at upriver stations in lower bay tributaries and begin appearing in the upper-Bay Maryland waters. This evidence suggests the importance of lower salinity areas for larger juvenile crabs which ultimately

grow and segregate by habitat, with large males generally occupying the upper reaches of tributaries and females remaining in higher salinity (Hines *et al.*, 1987).

Adults and Reproduction

Blue crabs mature at approximately 12 to 18 months of age (Van Engel, 1958) with an expected average lifetime of two to three years. Most mating occurs from May through October in lower- and mid-Bay habitats where salinity preferences overlap. Female crabs initiate their final molt preceding maturity at approximately 4.5 inches carapace width (115 mm; Knotts, 1989), and after this final interval of growth, the average size of an adult female is 6.1 inches (155 mm; Knotts, 1989; Hines *et al.*, 1987). Males "cradle" the females until the shell hardens. Mating takes place while the female is in her soft-shell phase. Once the pairs separate, males remain in lower salinities of the Bay and tributaries and females migrate to higher salinities of the lower Bay.

Females develop an orange, external egg mass beneath their aprons containing 750,000 to 8,000,000 eggs, depending on crab size (Prager *et al.*, 1990). The egg mass darkens over a two-week period as the orange yolk is consumed by the developing larvae, which form large, black eyespots just prior to hatching. Blue crabs are serial spawners in that larval release is protracted and occurs over a period of one or two weeks. Spawning occurs from May to September, with a minor peak in June and a major peak in July and August (McConaugha *et al.*, 1983; Jones *et al.*, 1990). Individual females may spawn more than one time. Early reproductive females generally spawn prior to the coming winter while those maturing later spawn the following spring. Most males and many juveniles remain in lower salinities of the upper Bay and tributaries and overwinter in the sediment. Females overwinter in the mid and lower Bay mainstem and at entrances of lower tributaries.

Predator-prey Relationships

Blue crabs serve as both predator and prey in the benthic and planktonic food webs of Chesapeake Bay. Movement through the water column by postlarvae (Olmi, 1993) make them a food source for plankton feeders such as menhaden. Settled postlarvae and young juveniles become prey for eel, drum, spot, croaker, striped bass, trout, catfish, some sharks and cownose rays. Endangered Atlantic Ridley sea turtles migrate to the Bay every summer for their preferred food, blue crab. Cannibalism occurs commonly (Mansour, 1992) and may regulate population abundance. Recent concern has been raised over the recovery efforts of the striped bass where the resurgence of such a predator may deplete the blue crab resource. Goshorn and Casey (1993) and Mosca *et al.* (in prep.) examined the relationship between striped bass abundance and blue crab landings in Chesapeake Bay and found no significant relationship. Instances where blue crabs are plentiful in the stomachs of striped bass are likely the result of opportunistic feeding (Booth and Gary, 1993).

Prey of the blue crab include bivalves, crustaceans, fish, annelids, plants and detritus (Darnell,

1958; Tagatz, 1968; Alexander, 1986). Although the blue crab is an opportunistic predator that feeds on commonly occurring benthic prey (Laughlin, 1982; Mansour, 1992), recent research on feeding habits of blue crabs indicates that soft-shelled bivalves (e.g., *Macoma spp.* and *Mya arenaria*) are preferred food. When these resources become depleted, cannibalism on juvenile crabs increases in intensity (Mansour, 1992). The incidence of cannibalism in blue crabs from the York and Rappahannock Rivers averaged about 25-30 % over a two year period (1988-1989). Blue crabs may contro l some bivalve populations (Lipcius and Hines, 1986; Eggleston, 1990; Eggleston *et al.*, 1992; Mansour and Lipcius, 1993), and cannibalism may serve as a self-regulating control on crab populations, particularly during periods of high crab abundance or low alternative prey abundance (Mansour and Lipcius, 1993).

Habitat Requirements

Submerged Aquatic Vegetation (SAV)

Regionally, vegetated habitat area and commercial harvests of the blue crab are significantly correlated (Orth and van Montfrans, 1990). Lower Chesapeake Bay vegetated habitats are most important for juvenile crabs on a bay-wide basis (Heck and Thoman, 1981; Penry, 1982; Heck and Wilson, 1987; Orth and van Montfrans, 1987; Wilson *et al.*, 1987; Montane *et al.*, 1994). Beds of submerged vegetation composed of *Zostera marina* (eel grass) and *Ruppia maritima* (widgeon grass) fall within the salinity range of invading postlarvae. SAV also provides developing juveniles with protection from predators during initial growth (Pile, 1993) and sub-adults with molting refugia (Ryer *et al.*, 1990). In addition, juvenile crabs grow more rapidly in seagrass beds than in adjacent unvegetated areas.

Calculations of the total areal coverage of seagrass and unvegetated habitats less than 6 feet (2 m) in depth combined with estimates of juvenile abundance for the York and Rappahannock Rivers demonstrate the relative importance of vegetated habitats to young juvenile blue crabs. Total area covered by unvegetated bottom is approximately an order-of-magnitude greater than that of seagrass beds (Fig. 2). In contrast, juvenile blue crab densities are an order-of-magnitude greater in seagrass. Despite the significantly higher coverage of unvegetated bottom, there are more juvenile blue crabs in lower bay seagrass beds (an estimated 11 billion crabs) than in unvegetated habitats (approximately 6 billion, Fig. 2), indicating the importance of seagrass beds in the lower Bay to newly settled and young juvenile blue crabs.

As juveniles grow larger than about one inch (25 mm) in carapace width, they migrate out of grass beds and disperse throughout other shallow-water habitats. Tidal guts of small creeks and rivers in and around salt marshes provide shallow-water habitats for larger juveniles and mature crabs to feed and take refuge during molting (Orth and van Montfrans, 1987; Hines *et al.*, 1987; Thomas *et al.*, 1990). Vegetative cover in the upper Bay is sparse compared to the lower Bay, and no studies in the upper Bay of Maryland comparing vegetated and unvegetated bottom and

Table 1. Biological Profile

Natural Mortality Rate:	0.17 to 0.46
Fecundity:	750,000 to 8,000,000 eggs per spawn, may spawn 2 to 3 times.
Longevity:	2 to 3 years
Spawning and Larval Development:	
Spawning Season	May to September
Spawning Area	Concentrated in channel region between Cape Henry and Cape Charles and also outside the Bay.
Development Loc.	Lower Bay and coastal shelf out to 40 miles (25 Km)
Salinity	23 to 33 ppt
Temperature	66° to 84° F (19° to 29° C)
Young-of-Year:	
Location	Lower and central Chesapeake Bay, primarily shallow water in beds of submerged aquatic vegetation. Migration to the upper Bay and tributaries may begin as early as September through November.
Subadults and Adults:	
Location	Chesapeake Bay from Virginia Capes to tidal fresh water.
Salinity	0 to 33 ppt. Males most abundant in 3 to 15 ppt salinity, females most frequently found in >10 ppt. Most mating occurs where salinity preferences overlap.
Temperature	Upper limit approximately 90° F (32° C)
Dissolved Oxygen	Recommended Bay goal for blue crabs is 6.0 mg/L monthly average. Exposure to 0.5 mg/L at 77° F (25° C) is lethal within 4.3 hours; tolerance decreases with increased

their importance as nursery habitat have been conducted.

Grass beds are also important overwintering habitat for juvenile crabs in the lower bay (Orth and van Montfrans, 1987; Montane, *et al.*, 1994). Where SAV beds are sparse in northern parts of Chesapeake Bay, crabs bury in unvegetated creek and river channels (Hines *et al.*, 1987), and in deep channelled areas of the Bay mainstem (Lippson, 1969; 1970; 1971).

Dissolved Oxygen Content

Blue crabs are tolerant to hypoxic (low oxygen) conditions. Crabs exposed to dissolved oxygen levels of 3.0 mg/L showed no mortality after seven days, and less than 20% mortality after 25 days at approximately 70° F (20° to 21° C); however, tolerance decreased with increasing temperature (deFur *et al.*, 1990). Oxygen content less than 0.5 mg/L at 77° F (25° C) is lethal within 4.3 hours (Lowery and Tate, 1986). Jordan *et al.* (1992) recommended a monthly average dissolved oxygen content of 5 mg/L for target species in Chesapeake Bay which included blue crabs; however, juveniles may have a lower tolerance than adults (Stickle *et al.*, 1989). Juvenile mortality was 50% during 28 days of exposure to dissolved oxygen levels of 5.65 mg/L at 86° F (30° C; Stickle *et al.*, 1989). Oxygen tolerance limits for larvae and postlarvae are unknown.

Fisheries

The blue crab supports the largest single-species crab fishery worldwide in terms of landings (FAO, 1990) and is the most valuable commercial fishery, as well as a highly valued recreational species in Chesapeake Bay. Principal commercial fishery techniques for hard crabs include trotlines, crab pots and dredges. Trotlines are utilized in Maryland as a result of the prohibition of commercial crab pots in tributaries, but they are not commonly used in Virginia. The crab pot is the most widely used gear throughout Chesapeake Bay. Dredges are allowed only in Virginia waters. Scrapes, peeler pots and peeler pounds/traps are used for the capture of peeler crabs (i.e., crabs about to molt) for the soft-shell and bait industries. Recreational gears include baited hand lines, mesh rings, collapsible traps, crab pots, trotlines and dip nets.

Peeler crabs are harvested throughout spring and summer, and peak harvest occurs in the spring during "peeler runs" in both Maryland and Virginia. With the exception of a small percentage of larger males, most crabs caught by this segment of the fishery are harvested prior to reaching maturity. The minimum size for a peeler crab in Maryland and the Potomac River is three inches; Virginia has no size limit on peeler crabs. The impact of this fishery on the blue crab population is difficult to assess due to inadequate reporting methods in the past. While the peeler crab fishery constitutes the highest rate of economic return per pound of harvest, it is labor intensive and, consequently, has a higher cost for production. Crabs are held in shedding tanks after their initial harvest and may suffer high mortality if not cared for properly.

The hard crab fishery represents the largest commercial component on a bay-wide basis both in terms of total dollar value and landings. The Maryland trotline fishery targets primarily larger males in low salinity tributaries of the upper bay. The pot fishery in Maryland and Virginia targets both males and females; males represent an increasing proportion of the harvest in the upper bay and tributaries. Approximately 40% of hard crab landings in Maryland are females. Egg-bearing females represent a portion of the crab pot harvest in the lower bay during the summer in Virginia waters and make up a very small percentage of the population in Maryland where they are illegal to harvest. Another segment of the fishery, the winter dredge fishery, occurs exclusively in Virginia and targets hard crabs that overwinter in deeper water of the bay mainstem. This component is estimated to consist of between 85% and 98% mature, inseminated female crabs (Van Engel, 1962; Schaffner and Diaz, 1988). The baywide dredge survey found 53.5% of adult female crabs overwintered within commercial dredge boundaries in 1993 (data presented in Volstad *et al.*, 1994).

One year after 1992 produced the worst crab harvest in years, the 1993 commercial catch in Maryland was the largest recorded since the state began its commercial survey, and possibly the largest to date. The reported 1993 commercial harvest of over 57 million pounds in Maryland was worth approximately 35 million dollars at dockside (Fig. 3-4)[1]. Annual commercial landings in Maryland (1982-1992) have averaged 45.4 million pounds (MDNR data) and increased effort and/or participation in the Maryland fishery could account for some of the increased landings. Preliminary landings are estimated to be 36,280 pounds, and is well below average. Commercial hard crab landings for 1993 in Virginia were double the 1992 landings and the preliminary estimate of commercial landings from Virginia in 1993 is 50.6 million pounds (Figs. 3-4). Virginia implemented mandatory reporting for all commercial harvesters in 1993 and the large increase in landings for that year may be, in large part, an artifact of the new reporting system. Anecdotal observations in Virginia indicate 1993 was not an exceptional year for the fishery, and comparisons of reporting systems indicate 1993 is on scale with 1992 landings. Landings data for 1994 were not available in time to be included in this plan, however, 1994 was characterized by commercial harvesters as poor and landings estimates are expected to be low.

In 1992, there were 7,688 commercial crab licenses issued in Maryland, in addition to 1,540 Tidal Fish Licenses which permit commercial harvest of crabs, shellfish and finfish (MDNR data). The largest proportion of Maryland's commercial catch in 1992 was landed by crabbers licensed to fish more than 50 crab pots (34%), followed by tidal fish license holders (31%) and unlimited crab catcher licensees (23%) (Fig.5). These three license types represent crabbers who previously have not been limited in the amounts of gear they can fish. Limited crab catcher licenses (limited to 50 pots and trotline) in 1992 out-numbered all license types for unlimited gear combined and landed only 12% of Maryland's commercial harvest (Fig. 5). In 1993, Maryland issued 4,978 commercial crab licenses and 1,540 Tidal Fish Licenses. In 1994, Maryland issued 5,085 commercial crab licenses, in addition to 1,491 Tidal Fish Licenses to people who declared an intent to crab. As of April 1, 1994, no new licenses will be issued in Maryland until valid licenses drop below a number

[1] The increase in commercial landings in Maryland coincides with a change in the reporting system.

to be determined as mandated by limited entry legislation. As licenses are issued through the two-year delayed entry program, the number of licenses is expected to increase over the next two years as a result of applications received before the deadline when limited entry took effect.

Commercial crab licenses and Tidal Fish Licenses held by people who declared an intent to crab for 1995 is expected to total 6,306, and includes new licenses to be issued during 1995 as delayed entry requirements are fullfilled (119 new entries). The large increase is also due to the elimination of the Jr./Sr. Crabber (JSC) license, which was previously not counted with commercial licenses, and the subsequent replacement of those licenses with commercial limited crab catcher licenses. In 1994, there were 1,388 JSC licenses issued to residents 14 years of age or younger and residents 64 years of age or older. Crab pots are prohibited with the JSC license, and harvest is often for personal consumption. It is not believed that these licenses will represent only a minor portion of the commercial harvest for 1995, unless the licenses are later transferred to people wishing to harvest for profit.

Virginia issued 4,568 licenses to 1,845 commercial crabbers in 1993. From 1980 to 1992, the number of crab pot licenses increased steadily from 1,738 to 2,614, and has continued to increase over recent years (Fig. 6). In 1993, a commercial registration license and a recreational crab pot license was established. The new fee structure discouraged some participants and others acquired a recreational license in place of the commercial license which resulted in a decrease for that license category (Fig. 6). While delayed entry and the new registration fee slow growth, the crab pot fishery is an open-access fishery and is an avenue for increasing effort. Crab dredging is limited to the lower portion of the Bay mouth (prohibited in tributaries) and licenses exceeded 300 in 1989. In 1993, there were 315 licensed dredgers, an increase which can be attributed to the window of opportunity before limited entry went into effect (Fig. 6).

In 1993, 15,378 licenses were issued for noncommercial recreational crabbing in Maryland, more than double the number of licensed commercial crabbers (6,489), and represented 11% of the total reported landings for that year[2]. Noncommercial license holders could not sell their catch, but were permitted to use more gear than unlicensed sport crabbers. Maryland surveyed licensed and unlicensed recreational crabbers in 1990. The survey determined there were an estimated 500,000 recreational crabbers who made an estimated 2.5 million trips and harvested approximately 11 million pounds of crabs (Stagg *et al.*, 1992). Their catch was estimated to be 19% of the total commercial and recreational harvest combined for that year. Historical estimates of recreational harvest in Virginia are lacking, however, a recreational crab pot license for up to five pots was established in 1993 and 361 licenses were issued. Licenses are not required to fish up to 2 crab pots. Annual reporting by all licensed recreational crabbers in Virginia was required as of 1993 and should aid in understanding the influence of recreational crabbing in Chesapeake Bay.

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[2] The noncommercial license was eliminated in 1994.

Abundance, Catch Per Unit Effort, and Exploitation

The winter population of blue crab in Chesapeake Bay for 1993 was estimated by Volstad *et al.* (1994) to be 653.3 million crabs (Table 1), of which 366.7 million represented juvenile and adult crabs greater than one year of age (≥2" or ≥50mm). While these estimates are thought to be conservative when compared to total Baywide landings, they are the only estimates currently available. Little is known about the growth of crabs in the wild, and it is uncertain if crabs in the winter less than two inches will enter the fishery the following summer (Casey, pers. comm., Montane *et al.*, 1994). Assuming that these do not enter the fishery, the exploitation rate of crabs two inches and greater in 1993 was 83% (Table 1). This figure does not include harvest of soft and peeler crabs or recreational harvest which would increase the exploitation rate.

Catch statistics for the Virginia commercial dredge fishery show a significant decline in winter harvests from 1956 to 1992 (Fig. 7), and this decline is also reflected in the fishery independent trawl survey conducted in the James, York, and Rappahanock Rivers, indicating a decline in adult female abundance for the same time period (Fig. 8). When the two data sets are compared, they correlate well (Fig. 9). Similar declines have been observed in the soft and peeler fishery (Fig. 4), which is largely dependent on "peeler runs" during the spring months when females are approaching their final molt preceding maturity. These two fisheries, dependent on female abundance in the winter and spring, are preceded by the summer hard crab fishery which has enjoyed relatively stable landings when compared to the dredge fishery and soft and peeler fishery (Fig. 3). There is evidence in Maryland and the Potomac River that this stability in hard crab landings is due in part to a greater amount of effort initiated by commercial crabbers, and this increased effort is accompanied by a concurrent decrease in return per unit of effort (Fig. 10)[3]. Declines in the winter dredge fishery and spring peeler fishery are evidence that females are being intercepted at some earlier time.

Maryland Department of Natural Resources (MDNR) summer trawl survey data indicate that blue crab abundance was relatively high in 1977, low from 1978-1980, and was relatively high through 1986. Since then (1987-1993), considerable fluctuation has been observed. Virginia Institute of Marine Science/College of William and Mary (VIMS/W&M) trawl survey data from 1972-1988 indicate major interannual fluctuations in blue crab abundance, often asynchronous with abundance patterns of crabs in Maryland. Lipcius and Van Engel (1990) note that population abundance historically has remained high or low for two or more years before significant fluctuation in abundance is observed, and suggest some internal feedback mechanism within the population. However, this has not been the case in recent years. Winter dredge survey data from MDNR, University of Maryland and VIMS/W&M show fluctuations between single years with high population estimates in 1991 and 1993 and a very low estimate in 1992 (Volstad *et al.*, 1994). This tendency for recent and rapid fluctuation may be cause for concern.

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[3] Catch and effort data should become available for Virginia as data is collected from the new reporting system.

Current Estimates of Mortality and Exploitation

Maryland has conducted summer trawl surveys to sample crabs since 1973. A general connection between the abundance of recruit crabs from the survey and future harvest has been made for Chesapeake Bay (Dintamin, 1984) and Delaware Bay (Seagraves and Cole, 1989). Trends in mature crab (>4.7 inches or 12 cm) trawl catch per unit effort (CPUE) follow trends in commercial landings and effort (Hornick *et al.*, 1988; Lipcius and Van Engel, 1990). Casey *et al.* (1991) found that trawl CPUE and monthly CPUE of legal-size crabs was associated with that same month's harvest.

Summer trawl estimates of natural mortality and fishing mortality were similar to estimates from winter dredge samples (Rothschild *et al.*, 1991). Estimated natural mortality rates from winter dredge data were between 0.17 (16%) and 0.37 (31%) and fishing mortality rates were between 1.2 (70%) and 4.5 (99%). Fishing mortality rates of 1.6 (80%) to 2.0 (86%) were considered conservative estimates. Natural mortality rates from summer trawl data were between 0.1 (10%) and 0.5 (40%) and fishing mortality rates were between 1.3 (73%) and 2.0 (86%).

Fishing mortality of legal-size male crabs was estimated to be three to six times that of legal-size females in Maryland's summer fishery (Casey *et al.*, 1991). This difference was explained by migrations of legal-size male and female crabs. After mating, female crabs migrate down the Bay and out of Maryland's summer fishery to spawn. Male crabs are not as migratory and are subject to Maryland's fishery throughout the season. Natural mortality contained some fishing mortality due to the harvest of peeler crabs 3.0 inches and greater and soft crabs 3.5 inches and greater.

While the optimum harvest level is currently unknown for blue crabs, fishing mortality rates can vary among species and short-lived, highly fecund species such as blue crab can withstand relatively high rates. Fishing mortality rates for flounder (F=0.23), northern shrimp (<0.70), menhaden (1.0), lobster (0.52) and striped bass (<0.25) have been calculated for these species in various states of stock health. In comparison, the F of 1.8 (83%) for blue crabs is quite high. Volstad *et al.* (1994) also calculated exploitation rates for crabs subject to the fishery of 50% to 92% from 1991 to 1993 (Table 1). Rates of exploitation for 1991 and 1993 were high. Rothschild *et al.* (1992) suggested managers should be concerned with the calculated high rate of fishing mortality in light of the variability in stock size.

Table 2. Estimated absolute abundance and rate of exploitation in Chesapeake Bay from winter dredge survey (Volstad *et al.*, 1994).

Year	Absolute Number of Crabs (millions)	Crabs Harvested (millions)	(u) Exploitation Rate (all crabs)	(u) Exploitation Rate (≥ 50mm)
1991	893.3	274.5	0.31	0.92
1992	440.0	164.1	0.37	0.50
1993*	653.3	306.0	0.47	0.83

*1993 corrected for updated commercial landings

Problems and Concerns

Fishing Pressure

Lipcius and Van Engel (1990) used 14 years of Virginia trawl data to demonstrate a relationship between the number of spawners and the number of young (stock-recruit relationship) in this species. Preliminary investigations in Maryland show a similar relationship between low levels of spawning stock and subsequent recruitment (unpublished data). Although the size of blue crab stocks are initially controlled by entry and settlement of blue crab postlarvae (i.e., the survivors of the larval phase) in nursery habitats, subsequent natural mortality and fishing pressure are likely the major factors affecting the size of the reproductive population. Conservation of the blue crab at any stage of the fishery should enhance subsequent harvests and maintain adequate population levels (Ludwig *et al.*, 1993). There has been growing concern in recent years that declines in other important Chesapeake Bay fishery stocks (in particular, oysters) have led to increased fishing pressure on the blue crab. During years of relatively high levels of abundance, fishing effort is rewarded with exceptional harvest. Because blue crab abundance fluctuates annually, the potential exists for excessive fishing pressure during periods of low population levels to seriously affect future stock abundance, as has occurred in many other exploited species (Holmes, 1994). In a species with only one or two major year classes, overfishing of a year class can lead to a sharp decline in recruitment at low stock sizes and may result in population decline (Lipcius and Van Engel, 1990).

Maximum Sustainable Yield (MSY) is defined by Ricker (1975) as *the largest average catch or yield that can continuously be taken from a stock under existing environmental conditions.* In effect, it is the greatest poundage of the resource that can be harvested without reducing the capacity for the resource to replenish itself to the same level for harvest in future years. When

MSY is exceeded and stock replenishment is at risk, the resource is said to be overfished. Larkin (1977) argued MSY is not attainable on a sustainable basis. Often, MSY is modified for optimum yield by factoring in economic, social or ecological issues and is frequently used as justification for harvest exceeding MSY (NRC, 1994). The collapse of certain northeastern fish stocks has been attributed, in part, by Ludwig *et al.* (1993) to management based on MSY estimates.

In addition to Ricker's (1975) definition of MSY, he notes that for species with fluctuating recruitment (such as blue crab), the MSY might require taking fewer fish in some years than others, depending on abundance. For managers to apply such a method, abundance must be predicted with confidence prior to the harvest season. No benchmarks have been established for estimating optimum levels of harvest or at what point overexploitation might occur. Methods for defining margins of crab harvest in Chesapeake Bay are being developed.

Given the past failures of MSY and the lack of targets to guide harvest and warn of over-exploitation, two types of overfishing, recruitment and growth overfishing, are defined by this management plan. Recruitment overfishing is the rate of fishing above which recruitment to the exploitable stock is reduced and is characterized by a reduced spawning stock, a decreasing proportion of older and larger individuals in the catch, and generally very low production of young year after year (NMFS, 1993). Growth overfishing occurs when the losses in weight from harvest and natural mortality exceed the gain in weight due to reproduction and growth in weight. Hence, there is a net loss of biomass from one year to the next (NMFS, 1993). A visible result of growth overfishing is a decline in the average size of crabs in the catch.

Various indices based on long-term data sets indicate a significant decrease in catch per unit effort (CPUE) for the fishable segment of the stock, as well as for juvenile blue crabs. The blue crab population in Chesapeake Bay appears to have been and continues to be in a low phase of population abundance. The decline in CPUE is also reflected in dredge fishery landings, and in comparable measures of adult female abundance from Virginia's trawl survey (Fig. 9). Concurrently, fishing effort has increased substantially in the blue crab fisheries, and commercial harvest per unit of effort has declined in recent years (Fig. 10) . Finally, the most recent Baywide indices for juveniles and the fishable stock indicate that the blue crab population is likely to remain in a low phase through 1995. These collective patterns are symptomatic of a fishery in the process of being overharvested. Prudent management practice argue strongly for controls on fishing effort to prevent a major decline in the fishery, or worse yet, a collapse if environmental conditions coincidentally deteriorate. A strategy to prevent overfishing, limited entry accompanied by constraints on fishing effort, has been instituted in various fisheries for the blue crab and should be implemented baywide for all forms of crab harvest.

Female Harvest

Of most serious concern is the effect of fishing pressure on the spawning stock, given the demonstrated relationship between spawning stock and recruitment of the blue crab in Chesapeake Bay. This relationship dictates that the number of crabs recruiting to Chesapeake Bay

in any given year relies, in part, on the size of the spawning stock from which the recruits originated. The spawning stock includes all females that survive natural and fishing mortality to reproduce, and is not merely limited to those crabs possessing an egg mass, nor to those mated females which do not show eggs. Juvenile and prepubertal females larger than 80-100 mm in carapace width (approximately 3.2-3.9 inches) suffer relatively low natural mortality (except during molting), and will likely reproduce if they are not removed by the fishery.

Portions of the potential spawning stock is removed from the population by various segments of the fishery. Females composing the potential spawning stock throughout the Chesapeake Bay, are susceptible to the hard crab pot fishery, winter dredge fishery and soft crab fishery. Conservative estimates in Virginia reveal the hard crab pot fishery harvests a greater portion (over 50%) of potential spawners than any other gear type. In Maryland, 65% of hard crabs are harvested by the pot fishery. Approximately 33% of Maryland's hard crab harvest is female crabs, and crab pots caught approximately 21% of the total female hard crab harvest in 1993. While Virginia's dredge harvest consists almost completely of mature females, the size of the fishery is significantly smaller than the pot fishery, and only harvests about 15% of females in Virginia's combined annual harvest. Under regulated conditions, the dredge fishery is a sustainable harvest method (O'Reilly *et al.*, 1989; Lipcius and van Montfrans, pers. comm.). The soft and peeler fishery is estimated to be responsible for about 10% of female harvest. O'Reilly *et al.* (1989) note, "The crab fishery is one of the few reliable fisheries in Virginia; however, further escalation of fishing pressure will strongly test the stock's resiliency." When regulating harvest and effort, due consideration should be given to the fisheries and their respective harvest of potential spawning stock.

Wasteful Harvesting Practices

Size limits for soft and peeler crabs reduce juvenile mortality in the fishery (Rothschild *et al.*, 1992) and promote recruitment to the brood stock. Small crabs contain less meat, and harvesting small crabs as soft shells before they recruit to the hard crab fishery and the larger soft shell fishery may not maximize yield from the resource. Increased size limits may also potentially make Chesapeake Bay's product more competitive; the preference for larger crabs shipped into Maryland from out-of-state demonstrates a market demand for larger softshell crabs (Uphoff *et al.*, 1993). A new market for "thumbnail size" soft-shell crabs may be opening in Virginia and, reportedly, these small crabs bring a greater price-per-pound than any crab from the Bay (Chowning, 1994). Some argue that crabs less than three to four inches are highly susceptible to natural mortality and should, therefore, be harvested before they die from natural predation. This argument is not justified in any other fishery; no formal studies have been conducted to determine the economic benefit or resource capacity for such an exception in the blue crab fishery. Managers should be careful to consider that while soft and peeler landings by weight are relatively small compared to hard crab landings, soft crabs are harvested at a smaller size and weigh less. Hence, soft and peeler landings by weight represent a greater number of crabs removed by the fishery, and number of crabs is the more important measure of impact to the stock.

Blue crabs are cannibalistic predators, and sub-legal crabs retained in crab pots with larger crabs

have high mortality rates (Eldridge *et al.*, 1979). Cull rings installed in the mesh of a crab pot provide a circular opening that allows undersized crabs to escape. A study by Eldridge (1979) in South Carolina tested 2.4" and 2.5" diameter cull rings in standard crab pots for their efficiency in allowing small crabs to escape. Pots with two 2.4" rings reduced sublegal crab catch by 62% and pots with two 2.5" rings reduced sublegal catch by 76%. Raynie and Casey (1992) investigated the use of one to three cull rings 2.25" in diameter in crab pots for practical use in Chesapeake Bay. No legal sized crabs escaped through the rings and pots retained 83%-89% less sublegal crabs. These results are slightly higher than Eldridge, and the South Carolina study was more statistically sound. Commercial watermen have expressed concern for the potential loss of small peeler crabs and mature females that are legal to harvest. Virginia investigated the loss of small, mature females from cull rings and found that a cull ring with a 2 3/16" inside diameter allowed only minimal losses (Bower, 1994 report to VMRC). Self-culling crab pots save time culling crabs by hand and reduce injury to sublegal crabs. Some watermen have developed their own techniques and use cull rings voluntarily, however, widespread participation and standardized methods are necessary for adequate protection of sublegal crabs.

Crab pots lost to storms or left abandoned at the end of the fishing season, also referred to as ghost pots, are attractive refuge sites for blue crabs. Crabs and fish trapped inside abandoned pots die and act as attractants for other animals that feed on the carcasses (Guillory, 1993). This process of self-baiting is cited as a cause for concern in many other pot fisheries including lobster, king crab, snow crab and black cod. As a cannibalistic species, blue crabs may be attracted by dying crabs impounded in abandoned traps (Guillory, 1993). A study in Louisiana found 55% mortality of impounded crabs (Guillory, 1993). A similar study by Casey and Wesche (1981) in Sinepuxent Bay from July through December examined 40 un-baited pots on a weekly basis. A total of 1,033 crabs were impounded and 33% of the impounded crabs were unable to escape and subsequently died. Abandoned pots during winter months in Chincoteague Bay caught less crabs but mortality increased to 100%, presumably due to decreased water temperature and crabs' inability to bury in sediments (Casey and Daugherty, 1989).

Watermen interviewed from the Chesapeake Bay region cited estimates of a 10 to 30 percent rate of pot loss annually (Casey, 1990). Management of the lobster fishery has called for action regarding ghost pots in New England (New England Fish. Mgt. Counc., 1983) by developing biodegradable escape panels. Casey (1990, 1992) studied materials for their degradibility in Chesapeake Bay. Escape panels made of jute decayed within two months. This may not be accepted by watermen who would have to replace them frequently throughout a season. Cotton twine was unreliable and decay rates varied. Materials that degraded in six to nine months also proved impractical, and fouling tended to clog escape vents as panels degraded. Other options are non-galvanized wire mesh over a portion of the pot or burning off galvanizing with a torch in a section chosen for escape. Variability of pots and the degradation of escape vent materials under different environmental conditions needs to be examined more thoroughly before a recommendation can be made.

International Trade and Implications for the Chesapeake Bay

World-wide, the United States is the largest exporter of crabs and crab products. Chesapeake Bay blue crab harvest has accounted for over 50% of national landings for the past two decades (Orth and van Montfrans, 1990). Crab fisheries have been developing worldwide in recent history, particularly for crabs of the genus *Portunus* which are similar in appearance and marketability to blue crab (Petrocci and Lipton, 1994). Worldwide landings of *Portunus* have increased from 56,400 metric tons in 1982 to 227,100 metric tons in 1991. Landings of blue crab worldwide have been increasing during the same time period (99,900 mt to 111,700 mt), though not as rapidly as for *Portunus*. However, the fisheries for *Portunus* include numerous species, whereas, the blue crab fisheries harvest a single species.

In addition to being the world's largest exporter of crabs, the United States is the fifth largest importer of crab and crab products (FAO, 1990). Imports in 1993 were worth over $150 million (Petrocci and Lipton, 1994 from NMFS unpublished data). As more countries develop crab fisheries and processing techniques, the crab supply worldwide will continue to grow. From 1982 to 1991, landings of crab species worldwide have increased by almost 60%. Petrocci and Lipton provided recommendations for the Chesapeake Bay product to remain competitive in the domestic and international market. In particular, they stressed the importance of distinguishing the Chesapeake product as one of superior quality and taste and the development of value-added products to stimulate and maintain consumers' desire for the region's product.

Petrocci and Lipton assessed Asian crab fisheries and production and predict Asia will grow in international importance for crab harvest and productivity. Asian resources are reportedly abundant and underutilized which makes their product inexpensive. Petrocci and Lipton stress the importance of acknowledging the potential for competition from abroad and the relationship between the long-term health of the resource and the ability to compete in an international market. In the Chesapeake region, Petrocci and Lipton warn of the effects of overcapitalization, high levels of fishing pressure and competition that drive the product price up. Limited access to the fishery was recommended to prevent overcapitalization, increase productivity and lower the cost of harvesting crabs. In conclusion, Petrocci and Lipton urge managers and the industry to focus concern on the health of the resource rather than short-term availability from one season to the next to remain competitive in the global market. Their conclusion is in accordance with the goal of this management plan and the recommendation that limited entry and fishing effort be implemented baywide as a management strategy.

Water Quality

Blue crabs that overwinter in sediments are externally exposed to accumulations of toxincants, and their preference for benthic bottom feeders, such as filter feeding bivalves, make them likely candidates for food chain bioaccumulation, as well. However, blue crabs' migratory nature and short life history may make them less susceptible to accumulations of toxicants. Crabs examined in the two most polluted tributaries of the Chesapeake Bay, the Elizabeth River (Norfolk, VA)

and Patapsco River's Baltimore Harbor (MD), were highly tolerant of toxic environments (Garreis and Murphy, 1986). Minimal amounts of contaminants were found in muscle tissue; however, toxicants were accumulated in the hepatopancreas. Blue crab larvae, on the other hand, may be highly sensitive to water quality and sublethal doses of toxicants have been found to slow larval development (Epifanio, 1984). Van Heukelem (1991) summarized literature on contaminants to blue crabs including petroleum hydrocarbons, polynuclear aromatic hydrocarbons, polychlorinated biphenyls, kepone, mirex, malathion, halogenated compounds, chlorine and chlorine produced oxidants and heavy metals including cadmium, chromium and mercury. No literature was found for arsenic, copper, lead, mercury, nickel or zinc.

Submerged Aquatic Vegetation

Worldwide, estuaries are experiencing water quality problems as a result of human population growth in coastal areas. Chesapeake Bay, one of the world's largest estuaries, has experienced deterioration of water quality from nutrient enrichment, sediment inputs and high levels of contaminants, resulting in declines in living resources and anoxic or hypoxic conditions (Horton and Eichbaum, 1991). One of the major factors contributing to the high productivity of Chesapeake Bay has been the historical abundance of submerged aquatic vegetation (SAV). SAV is of primary importance as settlement (Orth and van Montfrans, 1987) and molting (Ryer *et al.*, 1990) habitat for blue crabs. Vegetated habitats, which comprise less than 10% of the available shallow water habitat in less than 2m water depth, account for more than an estimated 60-70% of the total blue crab juvenile abundance in the lower Chesapeake Bay (Fig. 2). Beds of submerged aquatic vegetation are limited by light availability and growth is restricted to shallow water areas. Shallow waters of creeks and marsh guts are also areas of high productivity and provide an abundance of food for young crabs.

Channel dredging and shoreline structures such as bulkheads, revetment and breakwaters alter habitat and reduce the area of shallow water available for crabs and SAV. Heavy crab scrapes dragged through grass beds to collect soft and peeler crabs alter SAV habitats and grasses sliced at the base offer no refuge until recovery. Areas of high frequency scraping may be scarified the same way high frequency propeller contact scars grass beds, often resulting in permanent alteration of the habitat (Fonesca *et al.*, 1992). Larger boats are being utilized more by crab scrapers, and the crab scrape fishery is expanding as more watermen drop out of the oyster fishery and outfit their boats and power rigging for the crab fishery. The use of power winders to haul scrapes has not been investigated for the potential to damage SAV habitat. Virginia prohibits mechanized hauling of crab scrapes which must be pulled in by hand, and, consequently, limits the weight of scrapes that can be hauled. Clam dredging may also cause local SAV destruction (Hurley, 1991).

A baywide decline of all SAV species in Chesapeake Bay occurred in the late 1960's and early 1970's (Orth and Moore, 1983; 1984). The decline has been attributed to increasing amounts of nutrients and sediments in the Bay as a result of development of the Bay's shoreline and watershed (Kemp *et al*, 1983; Twilley *et al*, 1985). Soil runoff is greatly increased as the loss of wetlands

and forests to development and agriculture allows eroded soil and nutrients that were once trapped and utilized by terrestrial and wetland plants to enter water bodies directly (Schlesinger, 1991). Nitrogen and phosphorus from agricultural and urban landscape fertilizers enter the Bay as runoff after rains or as dissolved ions percolated through the soil. Atmospheric nitrogen oxide from the burning of fossil fuels is deposited to bodies of water either as acid rain or dry particulates (Schlesinger, 1991). Suspended sediments and excess nutrients in the water have impacted SAV in varying ways, primarily through light-related perturbations.

Light attenuation within the water column is a function of not only the water itself, but of its dissolved and particulate components, which serve to reflect, refract, absorb and scatter the incident radiation. Organic and inorganic particles washed in from surrounding uplands or resuspended from bottom deposits and can severely limit light penetration in shallow waters. Inorganic nutrients enhance the growth of water column phytoplankton as well as epiphytic algae which absorb light before it reaches the leaf surface. The spectral character of the light may also be changed so that attenuation is greatest in the photosynthetically important blue and red wavelengths of the visible spectrum (Champ *et al*, 1989; Pierce *et al*, 1986), thereby placing additional stress on SAV growth and survival. Thus, light availability is a function of a complex interaction of factors which are directly or indirectly related to water quality and ultimately to the health of SAV.

Currently, there are approximately 25,000 hectares of SAV in Chesapeake Bay (Orth *et al*, 1991), and this amount is estimated to be approximately 10% of historical abundance (Stevenson and Confer, 1978). Fortunately, most of the major SAV declines in Chesapeake Bay have occurred outside the primary settlement and nursery areas for the blue crab. However, these vegetated habitats are of such vital importance to maintaining historically high population abundances of crabs that they should be recognized and preserved.

Anoxia

High levels of nitrogen and phosphorous in waters and tributaries create favorable conditions for explosive algae blooms. Phytoplankton in the water column are so abundant during such blooms that they block sunlight to bottom dwelling grass beds and phytoplankton deeper in the water column which subsequently die and decompose. Massive decomposition uses up oxygen at an accelerated rate, inhibits SAV respiratation, reduces forage habitat and kills benthic food organisms.

During the months of May to September, deeper waters of the mid-Bay mainstem from Baltimore to the mouth of the Potomac River are subject to anoxic conditions. The anoxic portion of the Bay varies from year to year and while it is, in part, a result of natural conditions in the Bay, the anoxic portion has generally been increasing in size and duration over recent history. First documentations of oxygen depletion were mainly hypoxic areas, or areas of reduced oxygen content, which over recent years have worsened to anoxic conditions (Officer *et al.*, 1984). Historically, the affected area was limited to a narrow strip of the deep channeled area of the Bay

but it now covers a much wider area with fringes of hypoxia stretching across almost the width of the Bay and down to the Bay mouth during some years (Officer *et al.*, 1984). Cross-current winds and low pressure storms push anoxic water into shallow areas.

Heavy loads of nutrients and organic matter into the Bay are believed to be the cause for the historical increase of anoxia throughout the Bay. In May, when waters begin to warm, accumulated organics from the previous summer and fall beneath the halocline begin to decompose and anoxic conditions continue in deep waters through September (Officer *et al.*, 1984; Taft *et al.*, 1980). As winter approaches, decomposition slows to a halt and oxygen supplies are replenished with the diminished halocline until the following spring. The depletion of filter feeders in the Bay, particularly oysters, may have had some added effect. Oysters overwinter, unlike other phytoplankton feeders, and spring warming stimulates feeding early in the season. Today, a large portion of the spring phytoplankton bloom goes ungrazed (Newell, 1988), adding to organic accumulations later in the season and potentially further contributing to anoxia.

Chesapeake Bay Program Efforts

Nutrient Reduction[4]

The 1987 Chesapeake Bay Agreement, signed by the jurisdictions of Maryland, Virginia, Washington, DC, and Pennsylvania, established a goal of reducing controllable sources of nutrients to the Bay by 40% by the year 2000. Controllable sources include runoff from agriculture, urban and suburban areas, shoreline erosion, and point sources such as sewage treatment plants. It has been estimated through analysis of computer models, that achieving the 40% reduction goal would reduce anoxic conditions in the Bay by 20 to 25% in an average year. The same model also estimates that anoxic conditions will increase by 15 to 20% over a ten year period if no nutrient reduction occurs. From 1984 to 1992, phosphorous concentrations in the Bay declined by 16% and nitrogen levels held steady with no decline. Effects of nutrient reduction efforts take several years before results are visible (Kunishi, 1988), and there has been no consistent pattern of improvement in the Bay's dissolved oxygen or a reduction of algae to date (Chesapeake Bay Program, in prep.).

Uncontrollable sources of nutrients not included in the 40% reduction goal, most notably, atmospheric deposition, have been found to be significant sources of additional nitrogen to the Bay. Atmospheric nitrogen deposited directly into the water may account for 10% of the nitrogen load to the Bay. Furthermore, accounting for atmospheric nitrogen deposition in the entire Bay watershed increases the estimate to 40%. Nitrogen released to the atmosphere from the burning of fossil fuels is regulated on the federal level by the Clean Air Act. The federal Act mandated a 2

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[4] Reviewed in: Chesapeake White Paper. 1993. Nutrients and the Chespeake: Refining the Bay cleanup effort. Alliance for the Chesapeake Bay. Baltimore, MD; Richmond, VA; Harrisburg, PA.

million ton reduction in nitrogen oxide emissions by the year 2000, however, it does not establish a cap for total nitrogen oxide emissions to compensate for future growth and fossil fuel demand. The Clean Air Act also requires automobiles built after 1993 to have 60% reduced nitrogen oxide emissions. While this mandate is expected to reduce nitrogen emissions, the result will be much less than 60%, due to the growing demand for automobiles and the continued use of vehicles manufactured prior to 1994. Studies by the Maryland Department of the Environment and the United States EPA conclude that future growth will cancel out much of the reduction of atmospheric nitrogen resulting from the Clean Air Act, and by the year 2010, the net result may only be about a 5% reduction.

Minimum Dissolved Oxygen Requirments

Action 6.1.2 of this Plan recommends minimum standards for dissolved oxygen in Chesapeake Bay waters for blue crabs. Achieving the minimum standards is hinged on three factors.

1. The Bay jurisdictions must accomplish the goal of 40% reduction in controllable nutrient sources.

2. Without capping nutrient loads, the minimum dissolved oxygen requirements recommended by this plan can not be maintained. In 1992, the jurisdictions agreed to cap nutrient loads to the Bay, once the 40% reduction is accomplished, to control the effects of population growth.

3. Reductions in atmospheric nitrogen greater than that required by the federal Clean Air Act are necessary. One way to achieve this is through a stronger committment by the Bay jurisdictions. The Bay states are leaders in resource conservation and have set major precedents for watershed management. A stronger committment to reducing atmospheric pollution would be of great benefit to the Chesapeake Bay, set precendent for air quality as an integral part of watershed management, and provide new leadership for regional watershed management.

A fourth possible mechanism for nutrient reduction is through biological control. Oyster repletion efforts in the Bay are underway with a revised management plan with progressive new strategies (Chesapeake Bay Program, 1994). However, disease and parasites will affect the recovery rate for oysters, and repletion goals are long-term. Other Bay species are also considered beneficial for their uptake and removal of nitrogen, though it is unknown how much nutrient input into the Bay can be compensated for by biological means.

SAV Protection and Restoration

Action 6.2.1 of this Plan outlines the Chesapeake Bay Program directive for SAV restoration, and the goals are supported and reinforced by this Plan. The success of SAV restoration and protection is most dependent on nutrient reduction, as discussed above. In addition, protection of

existing SAV and future restoration efforts is dependent on efforts to reduce sediment loads to the Bay and protect the physical habitat. The Chesapeake Bay Program is currently drafting a document which identifies physical threats to SAV and recommends actions by state and federal agencies with resource management responsibilities to protect existing and restored SAV habitat. The draft recommends giving highest priority to protecting shallow water habitat that supports existing or potentially restored SAV down to the 1 meter depth contour from physical disruption, and also recommends protection of shallow water habitat to the 2 meter contour (Chesapeake Bay Program, In prep.$_b$). Shallow water habitat is important to blue crabs, and protection of shallow water habitats and SAV is of direct benefit.

The Chesapeake Bay Program Riparian Buffer Directive (Chesapeake Bay Program, 19) seeks to protect and restore riparian buffers, and will reduce sediment loads to the Bay by reducing shoreline erosion and run-off from agriculture and development. The Chesapeake Bay Agreement established a "no net loss" policy for wetlands in the Chesapeake Bay watershed, with a long-term goal of net gain. Wetland protection and restoration benefit SAV by trapping sediments before they can enter the water.

Toxics Reduction Strategy

In 1994, the Chesapeake Bay Program adopted the Toxics Reduction Strategy. The goal of the toxics strategy is *a Chesapeake Bay free of toxics by reducing or eliminating the input of chemical contaminants from all controllable sources to levels that result in no toxic or bioaccumulative impact on the living resources that inhabit the Bay or on human health.* The strategy commitments go beyond point-source control, and begin to address the more difficult tasks of controlling stormwater runoff and atmospheric deposition. Implementation of efforts to identify the origin of non-point source toxics will be used to develop strategies to reduce contaminants from those sources in the future.

Conclusion

The human population residing in the Bay watershed in 1988 was 13.6 million people. By the year 2020, that number is expected to increase to 16.2 million. As more people move to the Bay, demand for shoreline development will continue to rise. More people translate to more cars and demand for electricity, hence, greater air pollution that rain nutrients into the Bay. It also translates to an ever increasing number of people finding leisure on the water whether it be bathing, boating, or fishing for crabs. The most important challenge for managers of the Bay will continue to be dealing with finite resources in the face of continued human growth. Basic tools for managing blue crabs involve continuous and reliable estimates of the number of people making demands on the resource, the extent of their demands and how much of that demand can be satisfied without long-term crab population reduction. With those tools in hand, integrated management of land, water and living resources can insure stability of the species and preserve those pleasures enjoyed by everyone for future generations.

RESEARCH NEEDS

1. Develop criteria that would define overfishing and methods for recovering the stock should it become overfished.

2. Determine annual estimates of spawning stock size and size of the recruiting year class through post larval and juvenile sampling and baywide trawl and dredge surveys.

3. Determine the level of spawning stock which would insure prudent protection from overfishing.

4. Develop Chesapeake Bay-wide estimates of catch and effort by life history stage, sex and gear type in the commercial and recreational fisheries.

5. Quantify the carrying capacity of habitats for different sizes of blue crabs to identify critical areas of habitat which provide maximum blue crab productivity.

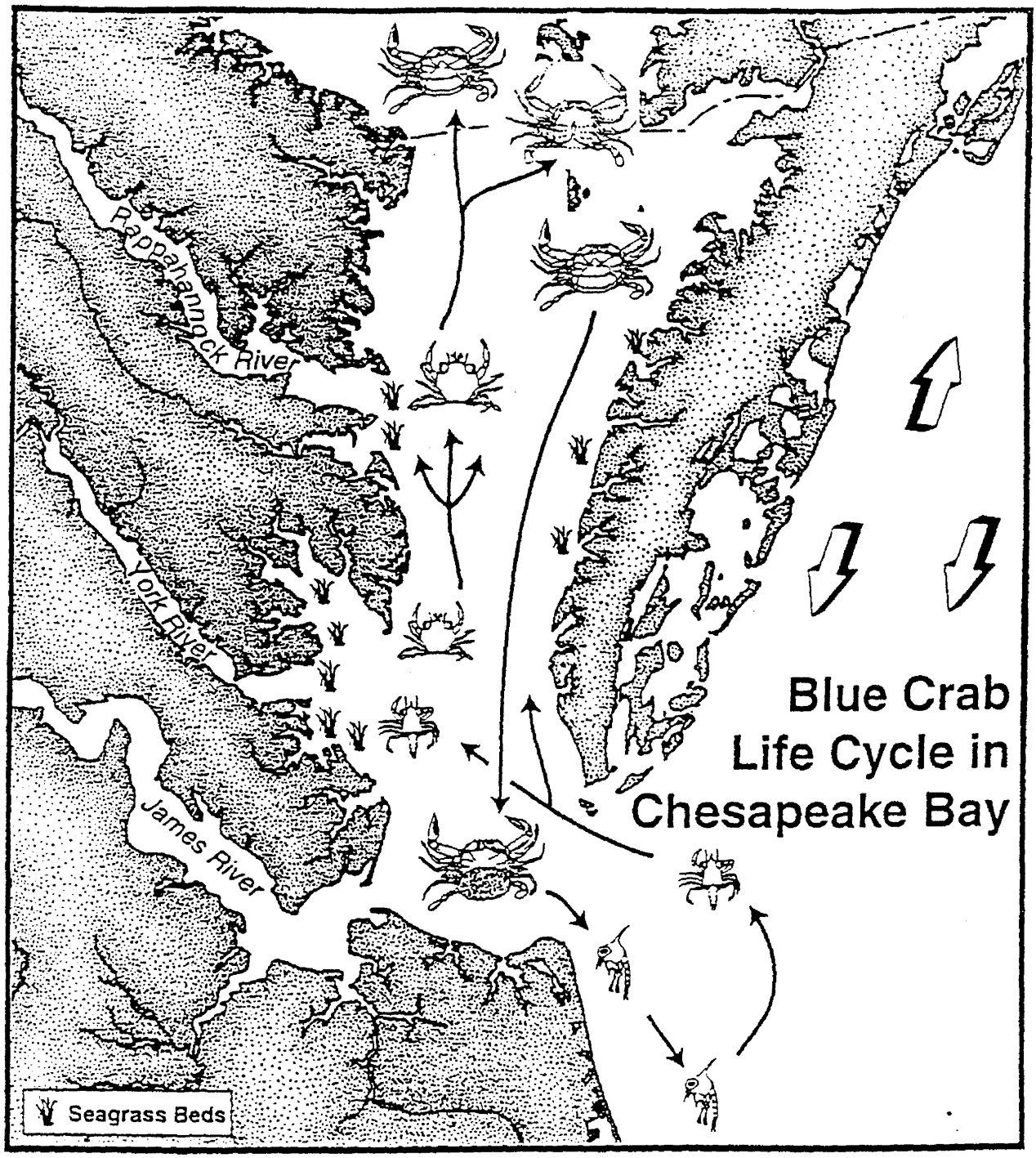


Figure 1. Life history of the blue crab in Chesapeake Bay (Maryland waters not depicted). Large open arrows indicate dominant summer water flow.

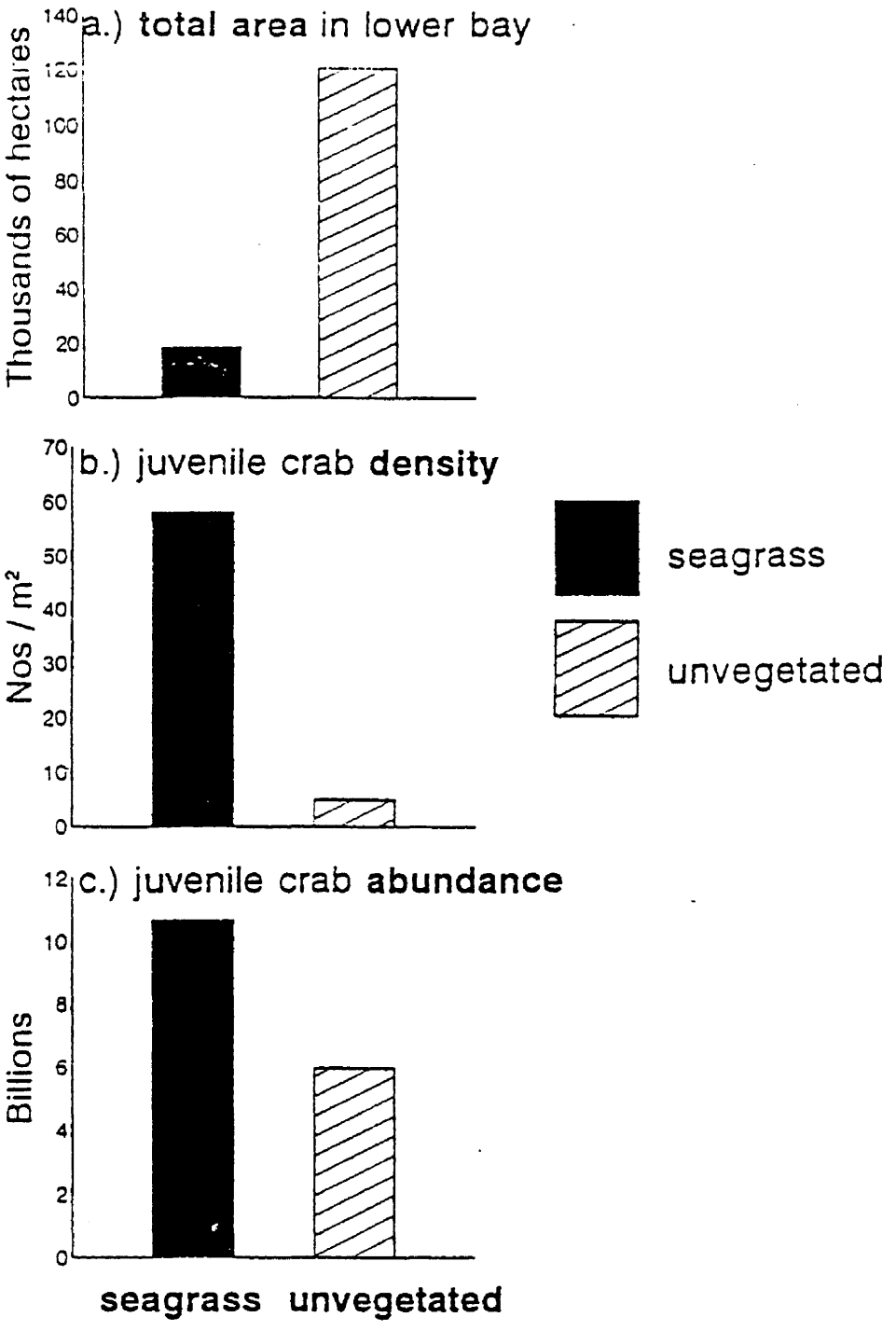


Figure 2. Estimates of the total number of blue crabs in the middle/lower Chesapeake Bay. Figure *a* denotes the total area of submersed bottom in the middle/lower Bay which is less than 2 meters in depth. Figure *b* represents the mean density of juvenile crabs in vegetated and unvegetated areas of the middle/lower Bay. Figure *c* shows the resulting estimate of juvenile crab abundance in vegetated and unvegetated middle/lower Bay habitats occurring in less than 2 meters of water.

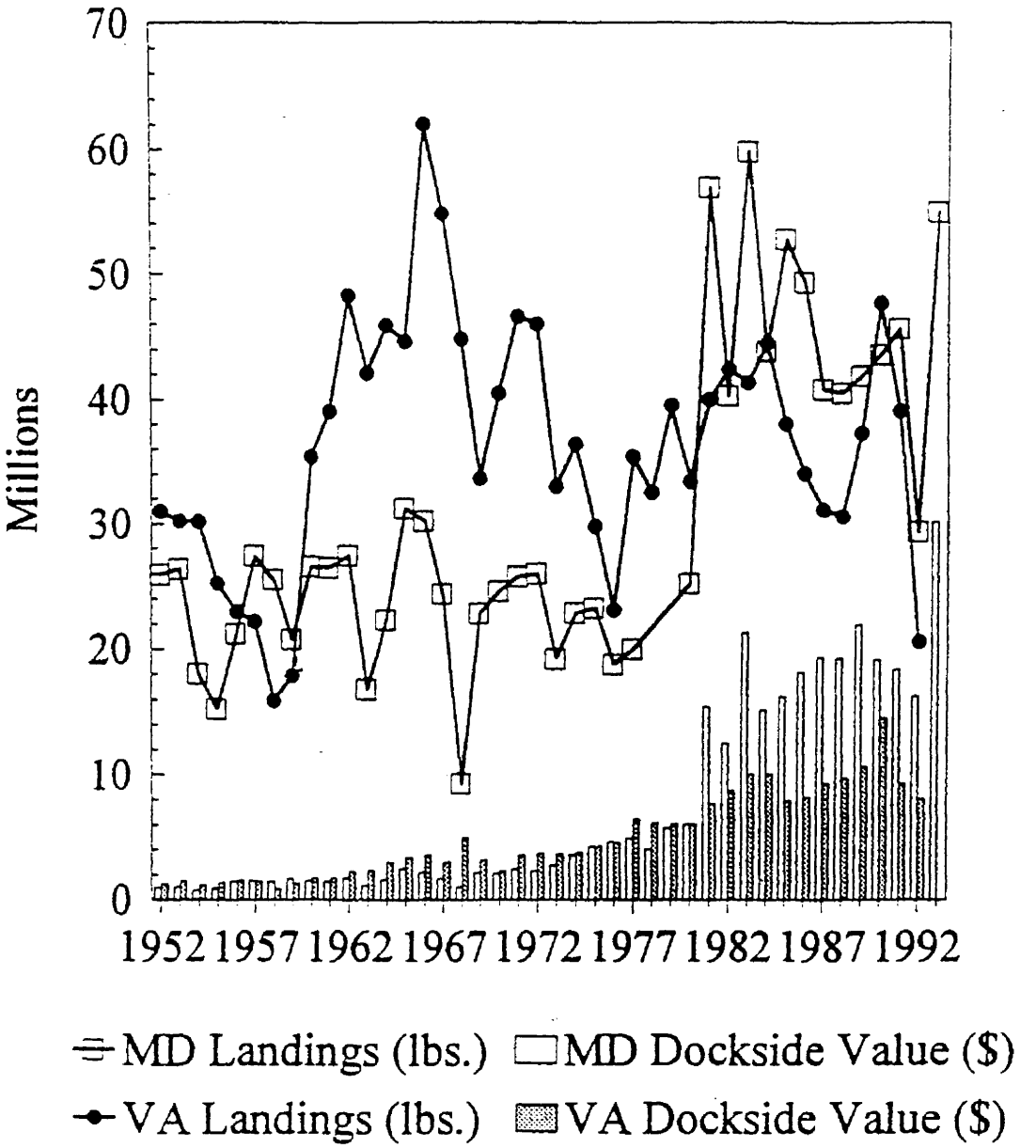


Figure 3. Hard crab landings in Chesapeake Bay.

Source:
VA - 1952-72, NMFS; 1973-93, VMRC
MD - 1952-79, NMFS; 1980-93, MDNR

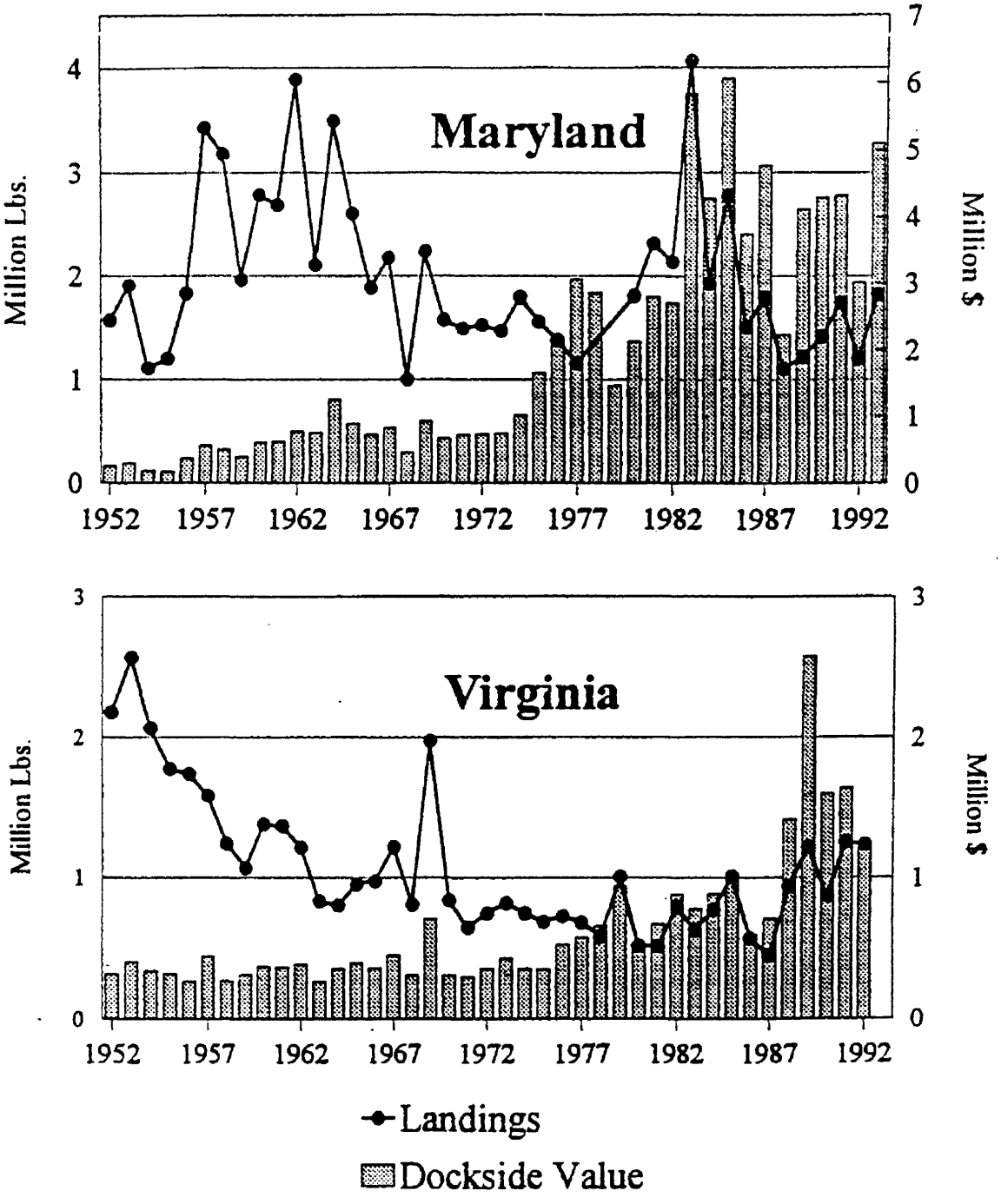


Figure 4. Soft and peeler landings and values in Chesapeake Bay.

Source:
VA - 1952-72, NMFS; 1973-93, VMRC
MD - 1952-79, NMFS; 1980-93, MDNR

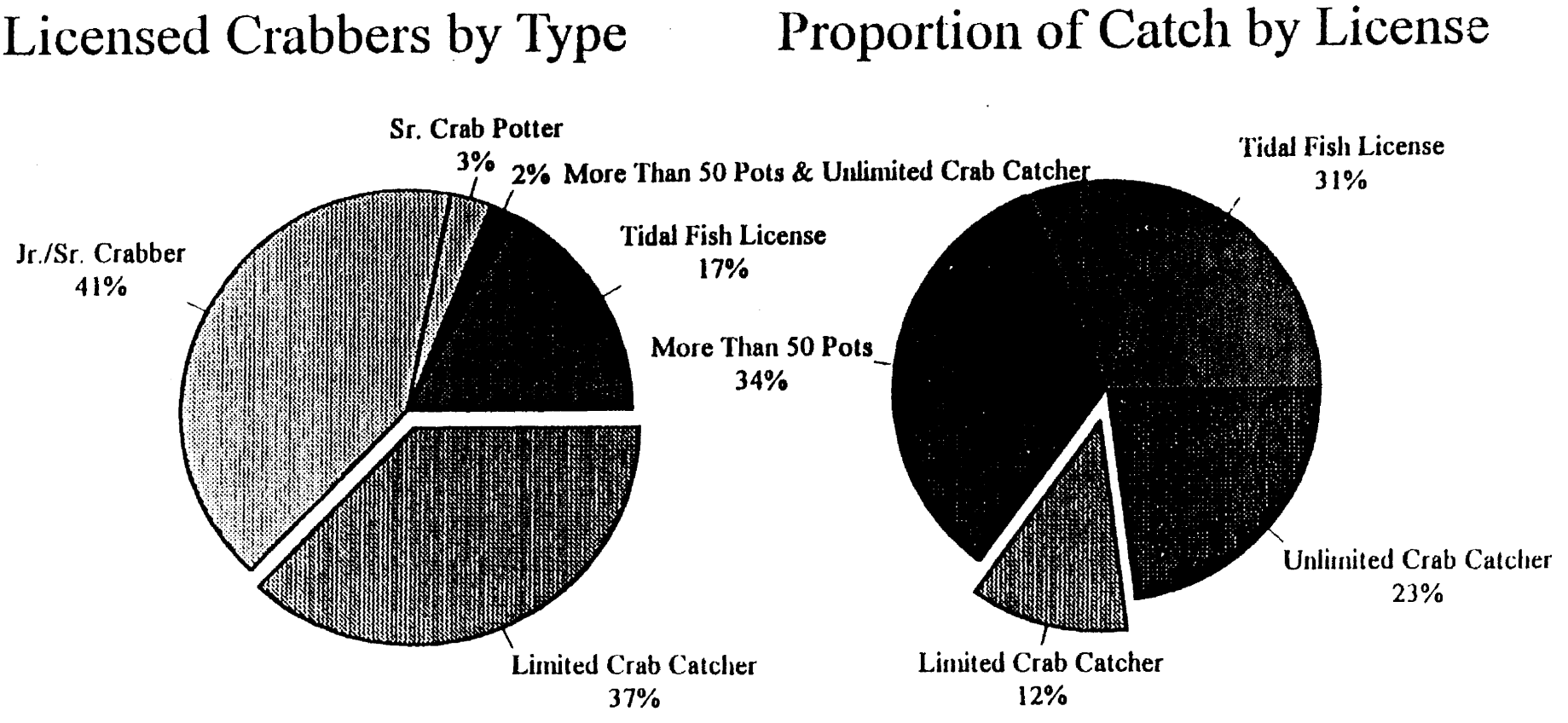


Figure 5. Maryland commercial license structure, 1992. Based on MDNR data.

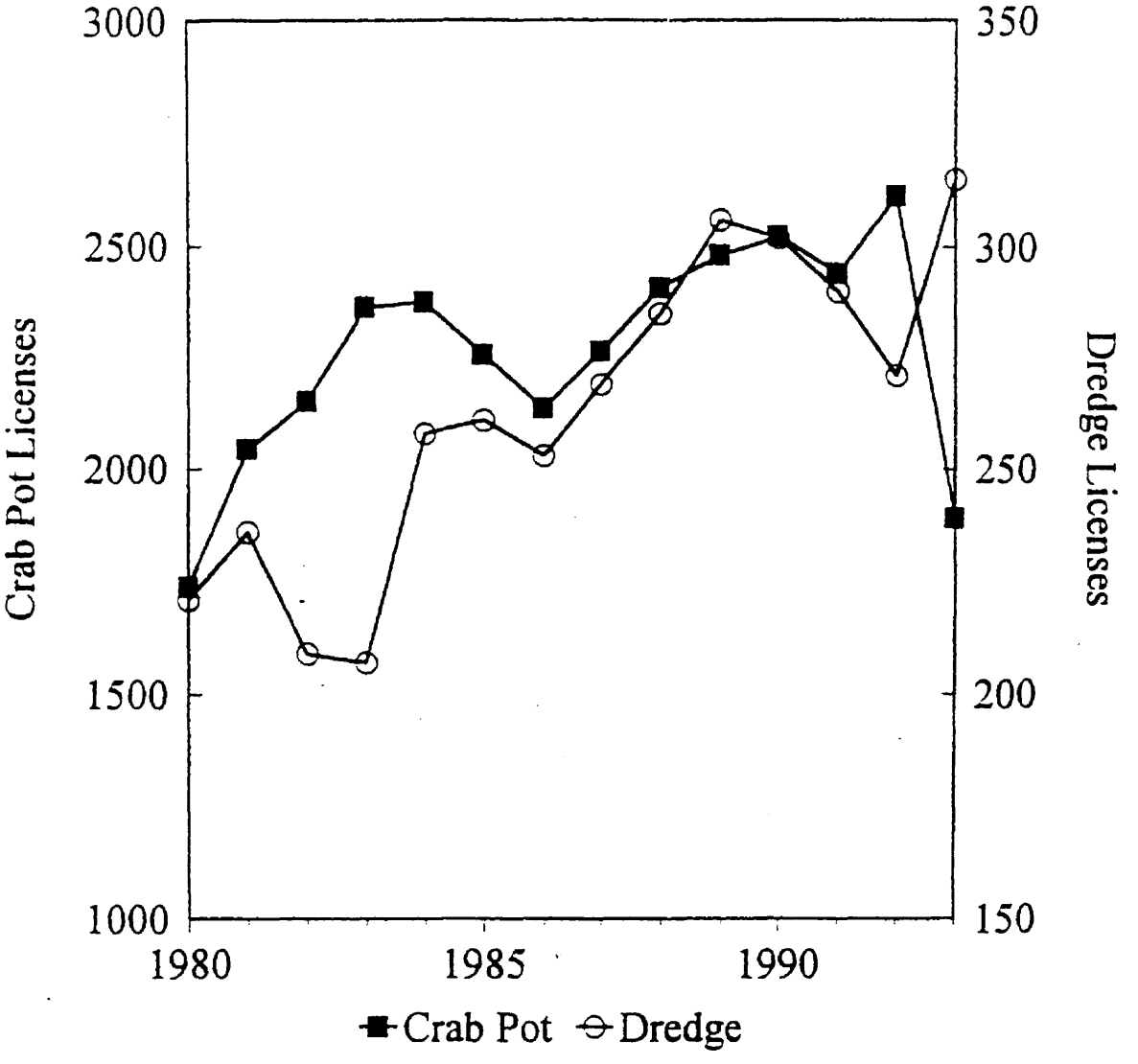


Figure 6. Licenses issued in Virginia. In 1993, a commercial registration license was established, as well as a recreational crab pot license. The commercial crab pot license fee structure was changed and a limited entry window for the 1993-94 crab dredge season was adopted.

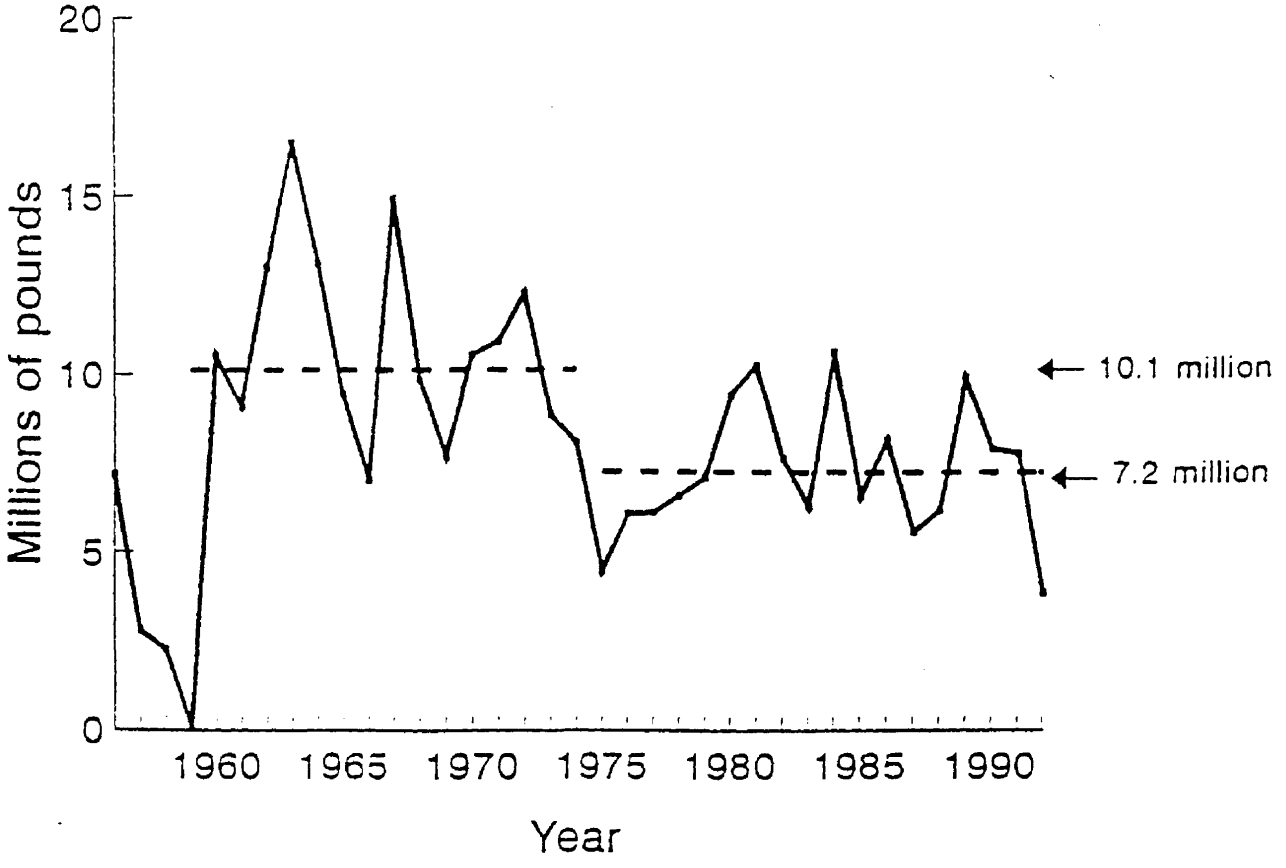


Figure 7. Landings from Virginia's commercial dredge fishery, 1956-1992 (VMRC data). Dashed lines represent means for the periods indicated.

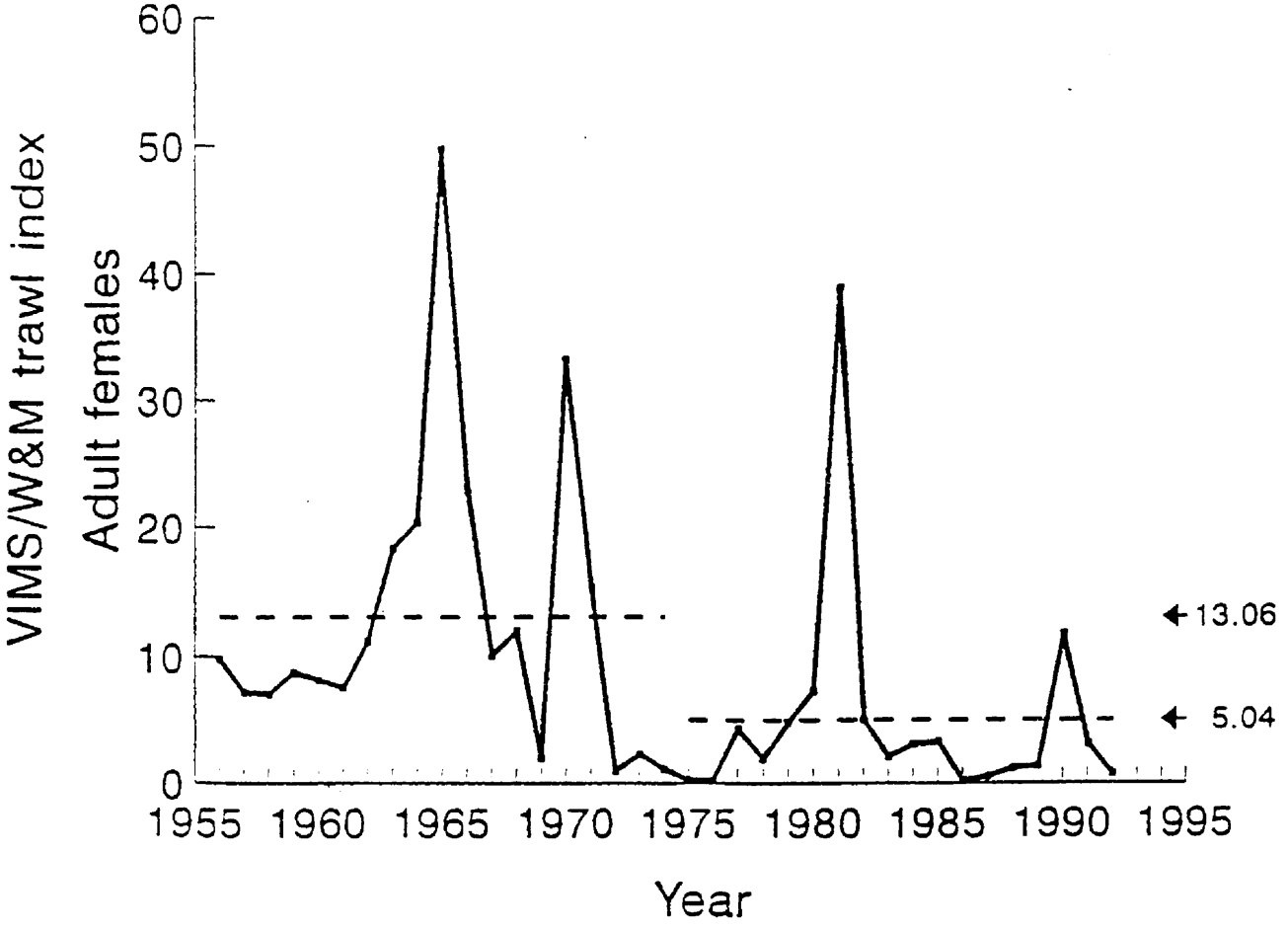
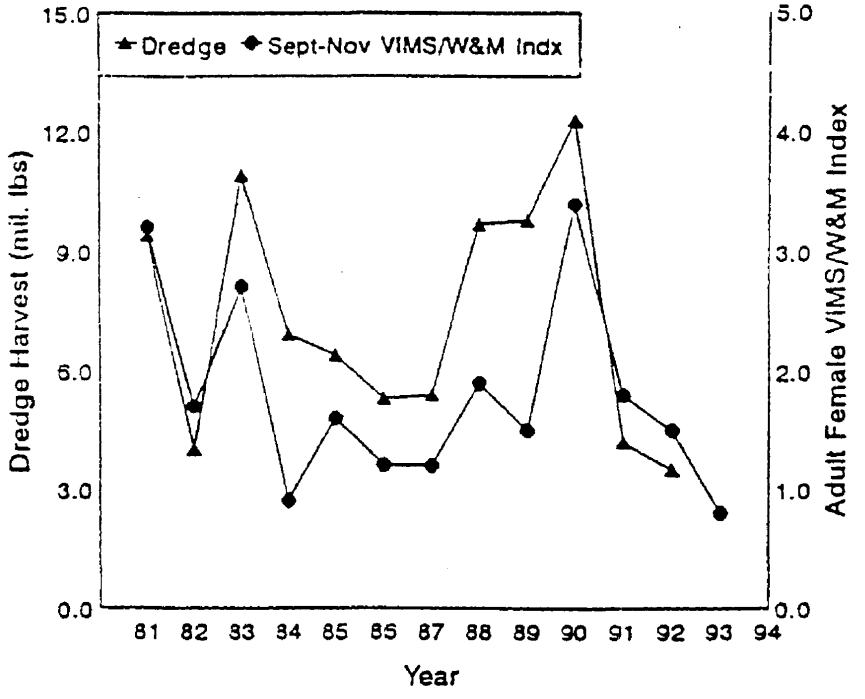


Figure 8. Adult female crab abundance (catch per unit effort) from VIMS/W&M trawl survey by year for 1956-1992. Note the relatively low level of abundance during the past two decades. Dashed lines indicate means for each period shown. Survey areas were the York, James and Rappahannock Rivers.



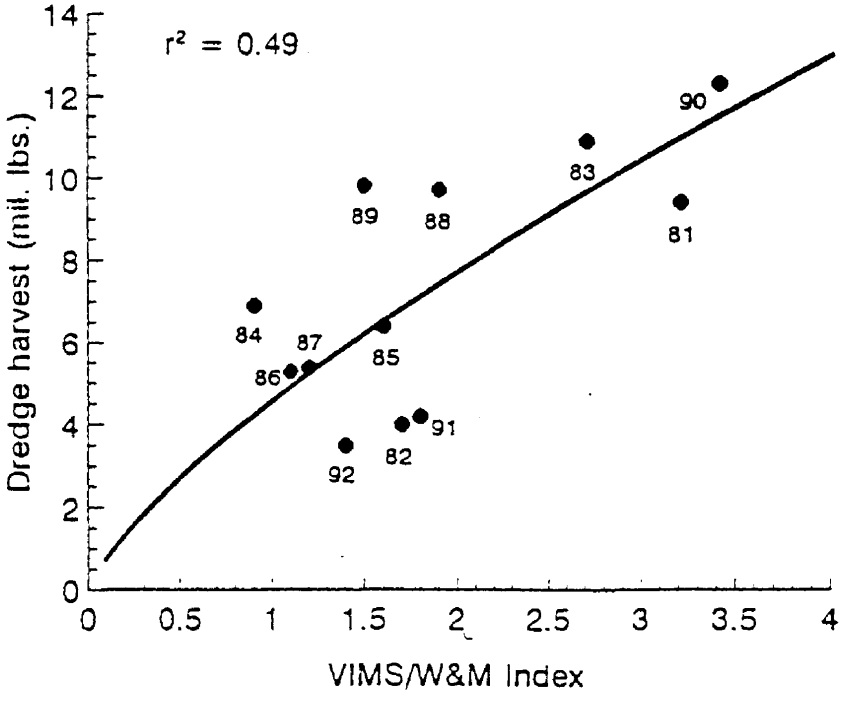


Figure 9. Indices of stock abundance (catch per unit effort) for 1981-1993. Shown are the commercial dredge harvest and the adult female index from the VIMS/W&M trawl survey. The lower plot is the resulting regression of dredge harvest on adult female index, with years indicated.

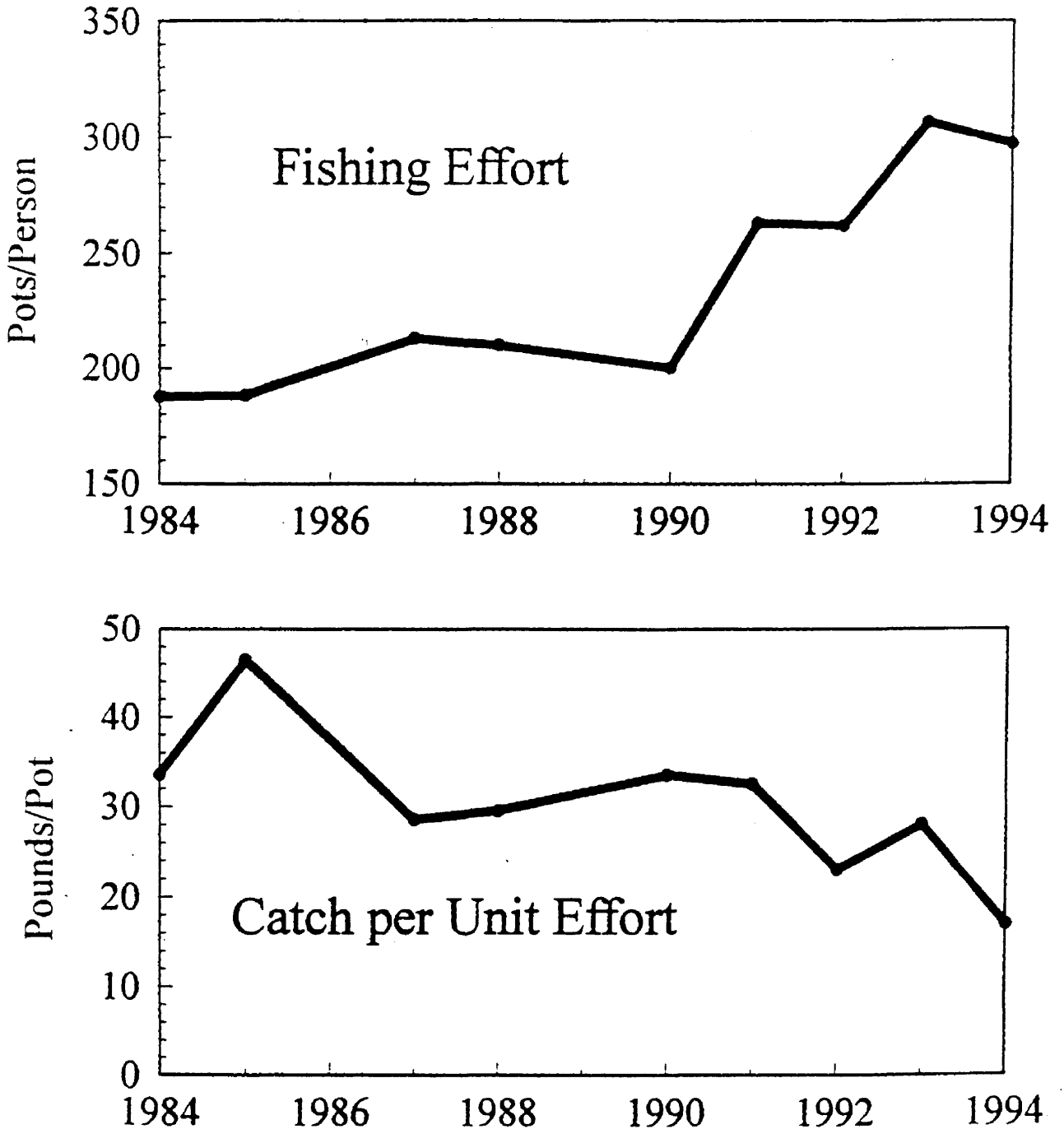


Figure 10. Catch and effort in Maryland's crab pot fishery

Source: MDNR

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SECTION 2. BLUE CRAB MANAGEMENT IN CHESAPEAKE BAY

The harvest of a fluctuating resource such as blue crab can be subject to a "ratchet effect." During relatively stable periods of high abundance, harvest rates and effort stabilize at a level which is excessive when abundance is average or below average. When the population is less abundant, the previously "normal" level of exploitation may result in overharvest and a potential for collapse of the population. A conservative approach to blue crab management in Chesapeake Bay is necessary to prevent overharvest. This approach should include reducing over-all effort bay-wide through limited entry, coupled with gear and time restrictions.

The Fisheries Target Setting Task Force, established by the Chesapeake Bay Program, was assigned the task of establishing targets for the blue crabs as a fishery, to be used as a tool for problem prevention. This will be achieved through analysis of historical fishery-independent data sets, such as the winter dredge surveys and summer trawl surveys, and historical landings data to identify relationships between abundance and harvest. Targets for blue crabs may include measures of optimum levels of abundance, fishing mortality, spawning stock biomass and/or yield per recruit. Such targets can be used as an index from year to year to determine if fishing pressure is increasing and should allow for early detection when rates of harvest are too high to be sustained by the resource. In the event that the blue crab resource does become overfished, targets will be used to regulate harvest so that restoration can occur.

The Technical Subcommittee of the Chesapeake Bay Stock Assessment Committee has also undertaken a stock assessment of blue crabs in the Chesapeake Bay. This analysis will be based on data from the Maryland and Virginia trawl surveys, the Bay-wide winter dredge survey, the various components of the commercial fishery, the recreational fishery, and estimates of natural mortality, growth and weight-at-size obtained from previous studies. This analysis will provide annual Bay-wide estimates of fishing mortality, stock size, and total exploited biomass. The understanding obtained from this analysis of the impact of the fishery on the stock will provide guidance needed by management to prevent overfishing of this stock.

Current Management Strategy

Management of the baywide blue crab stock across geographic regions and state boundaries is a dynamic and complicated process. One of the management strategies shared by Maryland and Virginia is to limit fishing effort. Maryland's Crab Action Plan (CAP) and respective legislation and regulations in Virginia responded to the strategy of effort stabilization with commercial and recreational restrictions. Many of the recent measures meet the expectations of problem areas in the 1989 BCFMP. The following section outlines recent management measures that resulted from commitments in the 1989 Plan.

Management Measures, 1992 - 1994[1]

Virginia Regulations and Legislation, 1992 - 1994:

The 1992 session of Virginia's General Assembly passed a law which requires that all commercial fishermen obtain a registration license and a two-year delay process is in effect for new entrants. The Virginia Marine Resources Commission (VMRC) was given authority to limit entry, establish a maximum number of license holders and to require catch reports. A mandatory reporting program was established which requires that all commercial fishermen report their catch.

In 1994, Virginia's General Assembly authorized the VMRC to promulgate regulations limiting the size of dredges. For the 1994-1995 dredge season, the maximum dredge width of 8 feet was reestablished. A committee will be assembled to evaluate dredge size limits offer a recommendation for the 1995/96 season.

In October, 1994, Virginia approved a regulatory package of conservation measures and limits on effort in the commercial fishery for blue crabs. A winter crab sanctuary was established upriver from the Hampton Roads Bridge Tunnel and dredging is prohibited in that area. A second summer spawning sanctuary was established bayside of Kiptopeke on the eastern shore and crabbing is prohibited June through September 15. Language was removed from past regulation allowing obstruction of cull rings during economic hardship. A second, smaller cull ring with an inside diameter of 2 3/16" was mandated in all hard crab pots. To address the issue of small females escaping through larger cull rings in certain areas, the larger 2 5/16" cull ring may be closed within dredge boundaries and Pocomoke and Tangier sounds to retain more legal crabs. Gear limits were set on peeler pots with 400 pots per vessel allowed during the spring peeler boon April through June; 400 pots per person are allowed July through November. After November, peeler pots and hard crab pots must be removed from the water and cannot be set again until April 1.

Maryland 1994 Regulations and Legislation:

Maryland's Limited Entry Bill was passed as legislation in 1994, and limits new entries into the commercial fishery. Maryland has had a delayed entry program since 1988, and requires that a person wait two years upon application before receiving a commercial license. Any person whose name was on the two year waiting list in Maryland prior to April 1, 1994, will receive a license two years after the date of application. The Limited Entry Bill gives the Department of Natural Resources authority to establish a prescribed number of people to participate in any given fishery. Once the two year waiting list is exhausted, no new licenses will be issued for that fishery until the number of licenses drops below the prescribed number. As licenses are lost voluntarily, by revocation, expiration or death, the fishery will be capped at a maximum number of participants, and fishing effort will be limited.

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[1] See Appendix B for complete list of regulations in effect.

In recent years prior to 1994, there was no limit on the number of crab pots a commercial fisherman could fish in Maryland. The new license structure to take effect in 1995 retains the Limited Crab Harvester License (up to 50 pots) and consolidates licenses for more than 50 pots and all other gears into one Crab Harvester License. Crab Harvesters are limited to 300 crab pots per vessel, and licensees may buy single and double allocations for one to two crew members which permits 300 additional pots per allocation, not to exceed 900 pots per boat. The Tidal Fish License, which consolidates finfish, shellfish and crabs in one license, is also limited to 300 pots with allocations up to 900 pots per boat. The deadline for crew authorization was August 31, 1994 and new authorizations are issued only as they become available through attrition.

Times when commercial and recreational crabbers can set and fish their gear in Maryland were defined in regulation in 1994 (see Appendix A). To limit effort in the number of man hours spent fishing, start and end times were staggered to minimize conflicts between user groups.

The noncommercial crab license was eliminated through legislation. Maryland currently has no licensing system for recreational crabbers, which now includes crabbers who were previously licensed as noncommercial crabbers. Unlicensed recreational crabbers were limited to 5 crab traps and/or rings per person while the licensed noncommercial crabber was allowed up to 50 traps and/or rings. All recreational crabbers are now limited to 10 traps and/or rings per person, not to exceed 25 traps and/or rings per boat. Trotline, which was limited to 500 feet for recreational crabbers and unlimited for noncommercial crabbers, is now limited for all recreational crabbers to 1000 feet per person, not to exceed 2000 feet per boat. Recreational harvest is now limited to no more than one bushel per person and no more than 2 bushels per boat.

Cull rings which enable undersized crabs to escape have been used on a voluntary basis for several years. Current Maryland regulation requires one cull ring 2 5/16 inches in diameter or one section of 2" by 2" square mesh with four openings in all crab pots with mesh size greater than 1 1/2 inches or less than 2 inches. The cull ring may be obstructed at any time of year for the purpose of catching peelers.

The maximum number of crab pots which can be set from private property in Maryland is two. Some counties prior to 1994 were allowed four. The proposal that pots be set or constructed so trapped air-breathing animals could survive until released was rejected.

Potomac River, 1995 Limited Entry

The Potomac River Fisheries Commission (PRFC) implemented limited entry into the commercial crab pot fishery, beginning in 1995. Entrants have until January 31, 1995, to renew existing licenses or to become eligible to receive a commercial license. Issuance of commercial crab pot licenses will be capped at 500.

Improvements in Catch Statistics Since 1993

Until recently, commercial reporting systems in Virginia and Maryland surveyed a portion of harvesters (MD) or dealers (VA) each month. Reporting in Virginia was voluntary and Maryland conducted random samples. Since 1993, both states have converted to mandatory reporting by all commercial harvesters and collect information on amounts of gear, effort and biological characteristics of the catch. Because the blue crabs' life history spans the entire Bay and is a unified stock across state lines, uniform Bay-wide catch records for both commercial and recreational harvests are necessary to adequately monitor the resource.

Evaluation

Implementing a combination of effort control management strategies, i.e. gear, time and license reductions or stabilization, may be effective at containing harvest (NRC, 1994). While the current regulations on the harvest of blue crabs are significant for both states, it is not yet clear at what level effort may stabilize. Maryland's gear limit for crab potters may still allow for growth in the fishery. When surveyed, crab potters declared an average of about 200 pots per person with maximum ranges from 800 to 1,400 pots. Surveys reveal there are many more people who use 200 pots or less than people who fish the upper ranges up to 1,400 pots. A limit of 300 pots per person may permit effort in the fishery to increase before it stabilizes. In addition, crew allocations allow for up to 900 pots per boat and crew members may be unlicensed. License stabilization in the form of the 1994 limited entry law is a giant step towards stabilizing effort in the entire Maryland crab fishery. However, that stabilization will not be achieved until applicants on the state's two year delayed entry list are exhausted. Maryland has not yet defined what number of licenses the fishery will be capped at. Levels of harvest and harvest rates in following seasons will likely determine whether the fishery should be capped at current license levels or if reduction is necessary.

Virginia has implemented a reporting system for licensed recreational crabbers, however, it will still not be known how many unlicensed crabbers participate in the fishery, or the amount they harvest. While Virginia will be successful in reducing effort to historic levels through limited entry in the winter dredge fishery, the state may still experience growth in the hard and peeler crab pot fisheries. Excluding the winter dredge fishery, Virginia's crab fishery is open access with a two year delayed entry (as of 1993). While delayed entry is expected to reduce the rate of entry into fisheries, as it did in Maryland, the program will require monitoring to control future growth. Virginia has explored additional gear, time and harvest limits. In particular, gear limits and defined seasons have been implemented in the peeler pot fishery, as well as a reduction in the season for hard crab pots. Also proposed recently were various limits on sponge crabs and soft and peeler crabs, but were not passed at this time. In its third year of depressed crab harvests, support from Virginia's crab industry for conservation measures has increased.

Conclusion

Managers from both jurisdictions are careful not to assume recent regulations will be completely effective in limiting effort and harvest of the fishery. These new restrictions and their effectiveness

at stabilizing fishing effort must be evaluated. If these actions prove successful in limiting fishing effort on the blue crab stock in Chesapeake Bay, this management plan will have succeeded in the objective of being a "problem preventing" tool rather than solely a "problem solving" plan which many of the earlier management plans have been. If these actions prove successful, effort will stabilize, catch per unit effort will cease to decline, landings will stabilize within some range over time and spawning stock will remain at a level adequate for stock replenishment. If stabilization occurs at a reduced stock size, targets made available in 1996 will enable managers to trim effort so that the stock size can rebuild to its former capacity and sustain a larger harvest in the future.

Future management decisions will depend on the effectiveness of current regulations. Over the course of the next several years intensive research and monitoring will be necessary to evaluate whether the Bay states have insured the long term survival of the blue crab resource or whether new solutions must be sought to preserve the resource. The Blue Crab Bay-wide planning effort has been a model cooperative program to date.

Goal Statement and Objectives

The goal of the 1995 Blue Crab Fishery Management Plan is to manage blue crabs in Chesapeake Bay in a manner which conserves the Baywide stock, protects its ecological value, and optimizes the long-term use of the resource.

In order to achieve the Goal, the following objectives must be met:

1. Maintain the spawning stock at a size which minimizes low reproductive potential (from harvest) as a cause of poor spawning success.

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

3. Minimize conflicts among user groups and between jurisdictions by coordinating management efforts throughout Chesapeake Bay.

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 its fisheries and the rationale for management efforts to solve these problems.

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

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

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

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

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

Fishery activity on the tidewater portion of the Potomac River is managed by the Potomac River Fisheries Commission, a six member body empowered under the Maryland-Virginia Compact of 1958. The Commission meets quarterly to establish and maintain a program of conservation and improvement of the fishery resources of the river. The Commission will develop appropriate Actions and Implementation plans along with Maryland and Virginia to address the Problems and Strategies identified in this Management Plan which are within the purview of the Commission.

Problems, Issues, and Solutions for 1994 - 1998

1. Increased Fishing Effort

Problem 1.1: Fishing Effort

The total amount of gear used and the number of participants in the crab fishery has increased over time. Research indicates there is a significant stock/recruitment relationship in the Chesapeake Bay blue crab population. Research in both Maryland and Virginia indicates the number of young produced (recruited) is affected by low levels of adult spawning stock, as well as by environmental factors. Good recruitment requires sufficient spawning stock and favorable environmental conditions.

Strategy: In order to protect the reproductive potential of the blue crab stock, limits have been placed on fishing effort and on the number of participants. The new laws and regulations adopted in Maryland and Virginia to contain commercial and recreational fishing effort and protect stocks must be evaluated to determine their effectiveness. Both states will continue to monitor commercial catch, proceed with efforts to estimate catch and effort by the recreational fishery, analyze the combined fisheries, determine safe levels of harvest, and, in Maryland, determine the maximum allowable number of commercial harvesters. The following research is identified as necessary to accomplish this strategy:

1. Develop criteria that would define overfishing and methods for recovering the stock should it become overfished.

2. Estimates of the size of each year's spawning stock and the size of the year class produced annually through post larval and juvenile sampling and baywide trawls and dredge surveys.

3. Estimate of the size of the spawning stock which would insure prudent protection from overfishing.

4. Chesapeake Bay-wide estimates of catch and effort by life history stage, sex and gear type in the commercial and recreational fisheries.

Actions:

1.1.1 Maryland, Virginia and Potomac River Fisheries Commission have modified reporting methods to acquire more accurate and detailed data. Maryland and Virginia's mandatory reporting systems collect data on areas fished, gear types and amounts, hours fished, amounts harvested and biological data. This data will be analyzed to determine actual harvest, biological composition of catch, and the effectiveness of current regulations for maintaining safe levels of harvest.

Implementation: In effect

1.1.2 Reliable and standardized reporting methods are critical to evaluating the performance of the revised regulations and laws in Maryland and Virginia. New reporting methods for commercial harvest will be compared with previous methods to standardize catch data in the two periods.

Implementation: Maryland, 1994
Virginia, Indeterminate

1.1.3 Maryland will determine a maximum number of commercial crabbing licenses and licenses with crew allocations as required under new Limited Entry law (Sect. 4-210), based on recommendations of the Tidal Fisheries Advisory Board, the Chesapeake Bay Program and any other appropriate management body. The Department shall consider the number of people historically participating in the fishery, annual harvest, mortality, total biomass, size, number, incidental catch, target species, and any other factors which are necessary and appropriate.

Implementation: 1996

1.1.4 The impact of regulations and law to cap effort in Maryland and Virginia will be evaluated. Evaluating the new limits on crabbing effort will take several years:

A. It will take several years before limited entry reduces the number of licenses through attrition.

B. Evaluation of the effects of limited entry will require several years of information from licensing data and the catch reporting system.

C. The effects of stabilized fishing effort on stocks will be difficult to evaluate and must be done through fishery independent studies and commercial landing data.

D. Sport crabbing surveys in Maryland must be conducted consistently to evaluate the effects of time and gear restrictions. It will take several years for Virginia to accumulate a data base.

A joint panel from Maryland and Virginia consisting of scientists, managers, representatives of the industry and fishery and other interests will convene after four years to review the status of the resource baywide and the effectiveness of current regulations and will make recommendations. If the performance of the new

requirements is determined to be insufficient, new regulations defining harvest seasons, additional gear restrictions, catch limits, and/or size limits will be considered to stabilize harvest and effort at levels which protect the reproductive potential of the blue crab stock.

Implementation: 1998, prior to which, the jurisdictions will continue with additional strategies, as necessary, to cap effort.

1.1.5 Targets will be established through analysis of historical fishery independent data sets and landings data to identify relationships between abundance and harvest. Targets for blue crabs may include measures of optimum levels of abundance, fishing mortality, spawning stock biomass and/or yield per recruit. Such targets can be used as an index from year to year to determine if fishing pressure is increasing and should allow for early detection when rates of harvest are too high to be sustained by the resource. Should overfishing be detected, measures will be taken to reduce fishing mortality to levels that are within the boundaries of defined targets and which permit restoration of the stock to its former capacity.

Implementation: 1996

1.1.6 Maryland and Virginia will monitor recreational crab data to determine if further restrictions on the recreational fishery are necessary.

Implementation: Maryland: See Action 3.2.2 - 3.2.3
Virginia: Ongoing

2. Wasteful Harvesting Practices

Problem 2.1: Economic Yield

Harvesting small crabs or buckrams does not maximize economic value of the resource. For example, the economic yield of crabs is not always optimized if buckrams (recently shed crabs whose shell is no longer soft, but is still in the process of hardening), which yield small amounts of meat, are brought to market.

Strategy: Optimum use of the blue crab resource will be promoted by eliminating and/or minimizing wasteful harvest practices, and by informing the consumer of poor quality or poor value crabs and discourage their purchase.

Actions:

2.1.1 Maryland and Virginia will continue to promote the release of buckrams through brochures and/or newsletters which identify buckrams and demonstrate the potential weight gain through time.

Implementation: Ongoing

2.1.2 Since buckrams weigh considerably less than hard crabs, i.e. 25 lbs./bushel as compared to 36-40 lbs./bushel for hard crabs, Maryland will investigate publicizing optimal bushel weight ranges for the various types of crabs and establishing minimum weight limits for each.

Implementation: 1996

2.1.3 Maryland and Virginia will educate the consumer about wasteful harvesting practices and their effects on the resource so they may be better informed when purchasing crabs.

Implementation: 1996

Problem 2.2: Cull Apparatus

Small crabs retained in hard crab pots suffer high mortality rates due to predation by larger crabs. Cull rings, which allow small crabs to escape, have been instituted in all jurisdictions; however, regulations allow cull rings in hard crab pots to be obstructed when fishing for peelers in Maryland. Cull rings may allow the escape of small, legal size peelers and mature females during certain seasons.

Strategy: The biological benefits and economic impact of cull rings in crab pots will be investigated in Virginia, and Maryland will determine specific seasons when cull rings may be obstructed with minimal impact on the resource and the greatest economic benefit. Cull rings are also being considered as an alternative to size limits on soft and peeler crabs which are easily damaged during handling.

Actions:

2.2.1 Maryland will define seasons for peeler fishing with hard crab pots (pots with mesh size 1.5 inches or greater) for which cull rings may be obstructed to minimize the impact on the resource and maximize economic benefits. Outside of the defined season, the unobstructed cull ring requirement will be enforced.

Implementation: 1997

2.2.2 Virginia will continue the mandatory use of cull rings throughout the hard crab pot season

Implementation: Ongoing

2.2.3 Virginia is investigating the use of cull rings in peeler pots to allow small crabs to escape.

Implementation: Ongoing

Problem 2.3: Female Harvest Rates

The practice of harvesting sponge crabs and females at other life history stages results in a loss of reproductive capability. Late winter dredge crabs yield poor quality meat and do not maximize yield per recruit.

Strategy: Landings and fishery independent data will be reviewed to determine if low reproductive potential and poor spawning success are resulting from female harvest.

Actions:

2.3.1 Maryland will investigate the interstate trade of blue crabs for the purpose of quantifying the number of sponge crabs (which may not be legally harvested in Maryland) coming into the state, and investigate the economic impact of prohibiting possession or sale within the state.

Implementation: 1996

2.3.2 Virginia will consider the expansion (time and/or area) of the spawning sanctuary. Additional sanctuaries or closed areas may be established.

Implementation: 1995

2.3.3 Maryland will evaluate the use of female crabs as eel bait in eel pots.

Implementation: 1996

2.3.4 Virginia and Maryland will continue to collect data on female size at maturity, migration, distribution and harvest by sex to study the effect of female harvest on crab population dynamics. This data can be used to determine management measures that

protect the reproductive potential of blue crabs.

Implementation: Ongoing

Problem 2.4: Abandoned Pots

Lost and abandoned crab pots are attractive refuge sites and often trap and eventually kill significant numbers of crabs and finfish. Weak and dead crabs attract other crabs into abandoned pots, and are self-baiting. Abandoned pots also trap and drown air breathing animals such as terrapins that inhabit tributaries. Biodegradable materials and escape panels have been the subject of preliminary investigation in Maryland. Abandoned pots are also navigational hazards for boats. Enforcement is difficult and fines are not significant enough to discourage deliberate abandonment. Pots are also lost when boat propellers cut buoy lines, during storms, by sabotage and crushed by clam dredging.

Strategy: Causes of abandoned pots will be investigated, the deliberate abandonment of crab pots will be discouraged, and escape mechanisms in pots will continue to be researched.

Actions:

2.4.1 Virginia and Maryland will continue to address regulation of abandoned crab pots, including significant fines that may discourage deliberate abandonment.

Implementation: 1996

2.4.2 Virginia and Maryland will continue to investigate materials for biodegradable escape panels and latches in crab pots and escape mechanisms for air breathing animals.

Implementation: Ongoing

2.4.3 Maryland and Virginia will investigate the feasibility of establishing used pot disposal sites in Bay counties and other incentives which would encourage proper disposal of damaged or spent crab pots.

Implementation: 1997

2.4.4 Maryland and Virginia will educate commercial crabbers about the problems of abandoned crab pots and Maryland will educate property owners about the effects of pots left unfished.

Implementation: 1996

2.4.5 Maryland and Virginia will investigate placement of identification on crab pots so that lost pots may be returned and purposeful abandonment will be discouraged.

Implementation: 1996

Problem 2.5: Shedding Mortality

The mortality rate of green crabs (a peeler crab without red or pink coloration in the swim fin) held in shedding floats is high compared to peelers that are close to molting. Mortality rates in shedding floats and poorly operated shedding systems may be high.

Strategy: Information will be provided to shedders to minimize mortality in shedding operations.

Actions:

2.5.1 Maryland and Virginia will continue to provide technical information to shedding operations that promote reduction of peeler mortalities associated with holding practices and problems related to green crab mortality.

Implementation: Ongoing

2.5.2 Virginia established a commercial shedding license, effective January 1, 1994, and will monitor data reports.

Implementation: Ongoing

2.5.3 Maryland will investigate a joint venture with commercial watermen's associations to establish a state-of-the-art shedding facility for the purpose of research and to educate the shedding industry.

Implementation: 1996

3. Stock Assessment Deficiencies

Problem 3.1: Commercial Reporting

Maryland introduced a new reporting system in 1994 which collects information on effort by gear type and person, time spent fishing, and biological characteristics (hard females, #1 and #2 male hard crabs, soft/peelers, culls) of the harvest. Virginia instituted a mandatory reporting system in January, 1993 which collects information on effort by gear type, water body, amount of time gear has been fishing and amount harvested per day. The new Maryland and Virginia systems are comparable. Potomac River has mandatory reporting by all fishermen which collects data on effort and biological characteristics (age, sex, soft/peeler, hard crabs) of blue crab harvest.

Strategy: New reporting methods will be used with continued fishery independent surveys to monitor trends in catch and effort, produce reliable estimates of blue crab abundance, and understand the fishery and the relationships between harvest and stock.

Actions:

3.1.1 Maryland and Virginia will monitor commercial records in order to evaluate the relationship between fishery dependent and fishery independent estimates of abundance.

Implementation: Ongoing

Problem 3.2: Recreational Harvest

There is a lack of information about the blue crab recreational catch and effort and the economic impact of recreational crabbing in Chesapeake Bay. Virginia has instituted mandatory reporting for all licensed recreational crabbers, including the amount harvested per day, amount and types of gear used and area. A license is required in Virginia for recreational use of up to 5 crab pots, 300 feet of trotline and/or one crab pound/trap. Maryland was unsuccessful in attempts to require recreational licenses during 1994 and 1995 and currently requires no reporting by recreational crabbers.

Strategy: There will be a Baywide effort to collect recreational catch and effort data and to evaluate the economic, social, and biological impact of the recreational harvest.

Actions:

3.2.1 Beginning in 1993, Virginia required annual reporting by all licensed recreational crabbers including weight harvested, location of harvest, days fished, and amount of gear used. This data is being used to estimate recreational harvest and effort.

Implementation: Ongoing

3.2.2 Maryland will seek a recreational crabbers license requirement.

Implementation: 1996

3.2.3 Maryland will develop a method of estimating recreational catch to improve monitoring of the blue crab resource. Data collected will be compatible with Virginia. In addition, a recreational survey for Maryland and Virginia is being designed.

Implementation: 1995

Problem 3.3: Research Needs

The population dynamics of the blue crab stock is not fully understood. Our understanding would be improved by obtaining additional information on natural and fishing mortality rates, the stock-recruitment relationship, and the effects of environmental variables and fishing mortality on year class strength and availability.

Strategy: The Baywide effort to collect population data on blue crabs will continue, and current methods will be improved.

Actions:

3.3.1 Maryland and Virginia will continue cooperation in the Baywide winter dredge survey and continue to refine data analysis as a consistent annual assessment of the abundance, distribution, and mortality of the crab resource.

Implementation: Ongoing

3.3.2 Maryland and Virginia will continue to encourage research on recruitment-stock and stock-recruitment relationships and how environmental parameters affect fluctuations in crab abundance.

Implementation: Ongoing

4. Regulatory Issues

Problem 4.1: Commercial/Recreational Conflict

The blue crab fishery provides economic, social and recreational benefits to the community. Conflict between commercial crabbers and recreational boaters has become a serious problem in some of the more densely populated areas of Virginia and Maryland. From the recreational boater's point of view, crab pot floats are interfering with recreational boating. From the commercial waterman's perspective, recreational boaters are interfering with crab potting because they inadvertently run over and cut off crab pot floats. There is competition for trotline space in Maryland tributaries.

Strategy: Conflicts among user groups and the general boating public can be minimized by rational application of time and gear restrictions to allocate the resource.

Actions:

4.1.1 Maryland and Virginia will continue to monitor conflicts between crabbers and recreational boaters and enforce existing regulations on open and closed crabbing areas and buoy-free channels.

Implementation: Ongoing

4.1.2 Maryland has staggered start and end times for recreational and commercial crabbing. The effectiveness of these time limits will be monitored.

Implementation: Ongoing

Problem 4.2: Interstate Trade

The interstate shipment of peelers and soft crabs may circumvent efforts to protect the Chesapeake Bay stock from illegal fishing activities. For example, undersized crabs in Maryland are illegally harvested and shipped to states which have no minimum size limits.

Strategy: Maryland and Virginia will continue to investigate the biological and economic effects of size limits on the soft crab fishery and the need to coordinate soft and peeler size limits.

Actions:

4.2.1 Maryland will consider a ban on the importation of crabs which do not meet State requirements.

Implementation: 1996

4.2.2 Maryland and Virginia will work to achieve consistent minimum sizes or comparable conservation measures for all crabs harvested in Chesapeake Bay.

Implementation: 1996

5. Public Health and Consumer Concerns

Problem 5.1: Personal Consumption

Buckram crabs yield less meat and bring lower prices. It is a concern in Maryland that quality crabs are often reserved for preferred customers such as restaurants and seafood markets, while the lesser quality crabs are often all that is available to the small consumer who buys whole crabs, usually by the bushel, for personal consumption.

Strategy: In order to maintain the quality of the supply of crabs available for public consumption, minimum weight standards and volume will be considered for the various types of blue crabs.

Actions:

5.1.1 Maryland will evaluate the necessity of establishing a minimum bushel weight for various grades of crabs.

Implementation: 1996

5.1.2 Maryland will define by regulation the minimum volume of a crab bushel, as well as potential substitutes, such as the waxed cardboard seafood box.

Implementation: 1996

Problem 5.2: Foreign Import

Regulations limiting effort in the Chesapeake blue crab fishery have generated fear that foreign markets will see reduced harvest as an opportunity to move in on the market. Present regulations are not expected to reduce harvest, but rather limit excessive growth of the fishery. Over the past several years there has been an increase in imports of crabmeat from warmwater areas that compete with processed Chesapeake Bay crabmeat. The industry has made strong efforts to differentiate the Chesapeake Bay product as a higher-quality product than imported meat in order to maintain a higher price for its product. Maryland passed legislation in 1994 that requires crab meat with foreign content be labeled as such. Regulations are pending in Virginia concerning the repacking and subsequent labeling of crabmeat.

Strategy: Efforts will be made to insure that consumers are aware of the origin of the crab products they purchase.

Actions:

5.2.1 Maryland and Virginia will continue to monitor the origin and labeling of crabmeat.

Implementation: Ongoing

6. Habitat Degradation

Problem 6.1: Anoxia

Excess nutrients entering the Bay from agricultural and urban runoff, sewage treatment plants and atmospheric deposition from the burning of fossil fuels results in algal blooms which produce anoxic conditions in the Bay. The anoxic portion of the Bay has been steadily increasing in size and duration over time and is reducing the amount of habitat available to crabs, increases intraspecies competition, compresses fishing effort and harms commercial fishing due to the high mortality of crabs retained in pots in anoxic and hypoxic areas.

Strategy: Maryland, Pennsylvania, and the District of Columbia have outlined a Tributary Strategy that will reduce the amount of nutrients from tributaries to the Bay 40% by the year 2000 to meet the Bay Program's nutrient reduction goal. Oxygen content goals for the Bay are also recommended.

Actions:

6.1.1 Major goals outlined by the jurisdictions include:

Maryland:

* Upgrade 50 waste water treatment plants to control nitrogen and phosphorus discharges.
* Encourage farmers to implement nutrient management plans and plant cover crops.

Pennsylvania:

* Implement nutrient control efforts in state farm lands.
* Fence hundreds of miles of streams to keep livestock out.

District of Columbia:

* Upgrade Blue Plains waste water plant, the greatest source of nutrients from the district.
* Control combined sewer overflow to reduce the frequency of overloads.
* Control additional runoff at construction sites, new development, public education, and habitat restoration.

Virginia is in the process of formulating a tributary strategy which will reaffirm the

40% nutrient reduction goal and is expected to be adopted in 1995. Virginia also plans to continue tributary monitoring in support of tributary modeling.

Implementation: 2000

6.1.2 Dissolved oxygen standards for baywide adoption are recommended and goals for optimum survival of juvenile and adult blue crab should be as follows:

a. All waters of Chesapeake Bay and its tidal tributaries should contain a minimum of 1.0 mg/L dissolved oxygen at all times, and
b. a minimum duration of 12 hours of dissolved oxygen content between 1.0 and 3.0 mg/L with a 48 hour minimum return frequency of $\leq$3.0 mg/L and $\geq$1.0 mg/L, and
c. all above pycnocline waters of Chesapeake Bay and its tidal tributaries should contain a monthly average of 6.0 mg/L dissolved oxygen.

Implementation: Recommendation in effect upon adoption of plan.

Problem 6.2: Submerged Aquatic Vegetation and Intertidal Wetlands

Shoreline development that reduces shallow water habitat, channel dredging, heavy boat traffic, crab scraping and clam dredging have all been identified as sources of local destruction of submerged aquatic vegetation (SAV). Crab scraping in Virginia is restricted to hauling by hand and hard crab bycatch is illegal. In Maryland heavy scrapes with power winders are used during the early season to catch hard crabs. Nutrient influx, as discussed in problem 6.1, and sediment runoff are responsible for widespread declines in SAV throughout the Bay. The loss of SAV and intertidal wetlands has resulted in the loss of blue crab habitat, particularly for the crabs' juvenile and molting stages.

Strategy: The Chesapeake Bay Program is committed to achieving a net gain in SAV distribution, abundance and species diversity in the Bay and tidal tributaries over present populations. The Bay jurisdictions will maintain a priority status on protection of SAV and intertidal wetlands.

Actions:

6.2.1 The Chesapeake Bay jurisdictions will work to restore SAV to their historic levels. Restoration goals are as follows:

Tier I Restore SAV Baywide to 114,000 total acres. At the current rate of recovery, this acreage will be achieved by 2005.

Tier II Restore SAV to all shallow water areas delineated as existing or

potential SAV habitat down to the 1 meter depth contour. Total restoration area: to be determined.

Tier III Restore SAV to all shallow water areas delineated as existing or potential SAV habitat down to the 2 meter depth contour. Total restoration area: 611,000 acres.

Implementation:
Tier I: Ongoing
Tier II: 2005 or following full implementation of Tier I
Tier III: Following full implementation of Tier II

6.2.2 Maryland and Virginia will prepare a report on blue crab habitat and biology and identify critical habitat utilized by the species, evaluate projected growth to the Bay watershed and make recommendations on regulating coastal development for permitting agencies.

Implementation: 1996

6.2.3 Maryland will consider limits on scraping for hard crabs in the early crabbing season.

Implementation: 1995

Problem 6.3: Water Quality

The blue crab appears to be a resilient species. Its migratory nature and short life span make it less susceptible to bioaccumulation of contaminants. Toxicology studies in Baltimore Harbor and the Elizabeth River, the two most heavily polluted areas of the Bay, found minimal accumulation of toxins in tissues of blue crabs. Once toxins are allowed to accumulate their effects are difficult or impossible to reverse. Blue crabs could be affected by the loss of benthic foods and/or toxins may accumulate beyond some threshold which exceeds the crab's level of tolerance. Blue crabs are most sensitive during their larval stages, and environmental requirements of larval and juvenile crabs are not well known.

Strategy: The Chesapeake Bay Program will continue its commitment to toxins reduction and control, particularly in localized regions near discharge points and where toxins are accumulated.

Actions:

6.3.1 Regions of concern will be identified within criteria set by the Chesapeake Bay Toxics

Strategy. Within regions of concern the sources and amounts of pollution will be determined, control methods will be explored and implemented and important habitats within the area and land uses with negative effects will be identified.

Implementation: Ongoing

Appendix A. Implementation Matrix

Chesapeake Bay 1995 Blue Crab Fishery Management Plan
Implementation Matrix

PROBLEMS AND STRATEGIES	ACTIONS	DATE	COMMENTS
1. Increased Fishing Effort *1.1 Fishing Effort* New laws and regulations adopted in MD and VA to contain commercial and recreational fishing effort and protect stocks must be evaluated to determine their effectiveness. Both states will continue to monitor commercial catch, proceed with efforts to estimate catch and effort by the recreational fishery, analyze the combined fisheries, determine safe levels of harvest, and, in Maryland, determine the maximum allowable number of commercial harvesters.	*1.1.1* New reporting methods will be used to determine actual harvest, biological composition of catch, and the effectiveness of current regulations for maintaining safe levels of harvest.	1994	
	1.1.2 New reporting methods for commercial harvest will be compared with previous methods to standardize catch data in the two periods.	MD, 1994 VA, indeterminate	
	1.1.3 Maryland will determine a maximum number of commercial crabbing licenses and licenses with crew allocations as required under new Limited Entry law (Sect. 4-210).	1995	
	1.1.4 The impact of regulations and law to cap effort in Maryland and Virginia will be evaluated. A joint panel from MDand VA consisting of scientists, managers, representatives of the industry and fishery and other interests will convene after four years to review the status of the resource baywide and the effectiveness of current regulations and will make recommendations.	1998	
	1.1.5 Targets will be established through analysis of historical fishery independent data sets and landings data to identify relationships between abundance and harvest. Should overfishing be detected, measures will be taken to reduce fishing mortality to levels that are within the boundaries of defined targets and which permit restoration of the stock to its former capacity.	1995	
	1.1.6 Maryland and Virginia will monitor recreational crab data to determine if further restrictions on the recreational fishery are necessary.	MD, see Action 3.2.2-3 VA, ongoing	

2. Wasteful Harvesting *2.1 Economic Yield* Optimum use of the blue crab resource will be promoted by eliminating and/or minimizing wasteful harvest practices, and by informing the consumer of poor quality or poor value crabs and discourage their purchase.	*2.1.1 MD and VA will continue to promote the release of buckrams.*	*Ongoing*	
	2.1.2 MD will investigate publicizing optimal bushel weight ranges for the various types of crabs and establishing minimum weight limits for each.	*1996*	
	2.1.3 MD and VA will educate the consumer about wasteful harvesting practices and their effects on the resource so they may be better informed when purchasing crabs.	*1996*	
2.2 Cull Apparatus The biological benefits and economic impact of cull rings in crab pots will be investigated to determine specific seasons when cull rings may be obstructed with minimal impact on the resource and the greatest economic benefit. Cull rings may also be considered as an alternative to size limits on soft and peeler crabs which are easily damaged during handling.	*2.2.1 Maryland will define seasons for peeler fishing with hard crab pots (pots with mesh size 1.5 inches or greater) for which cull rings may be obstructed to minimize the impact on the resource and maximize economic benefits.*	*1997*	
	2.2.2 VA will continue the mandatory use of cull rings throughout the hard crab pot season.	*Ongoing*	
	2.2.3 VA has initiated studies to determine the economic impact of the cull ring requirement and will continue research to determine the significance of allowing obstructed cull rings for short periods of time.	*Ongoing*	
	2.2.4 VA is investigating the use of cull rings in peeler pots and will consider mandatory cull rings in peeler pots and peeler pounds.	*1995*	
2.3 Female Harvest Landings and fishery independent data will be reviewed to determine if low reproductive potential and poor spawning success are resulting from female harvest.	*2.3.1 MD will investigate the interstate trade of blue crabs to quantify the number of sponge crabs and other types of crabs (which may not be legally harvested in MD) coming into the state.*	*1996*	
	2.3.2 MD will investigate the effects of prohibiting the import of sponge crabs, or crabs from which the egg packet has been removed, and consider regulations if the action is deemed biologically necessary.	*1995*	
	2.3.3 VA will consider the expansion (time and/or area) of the spawning sanctuary. Additional sanctuaries or closed areas may be established.	*1995*	
	2.3.4 MD will evaluate the use of female crabs as eel bait in eel pots.	*1996*	
	2.3.5 VA and MD will continue to collect data on female size at maturity, migration, distribution and harvest by sex to study the	*Ongoing*	

2.4 Abandoned Pots Causes of abandoned pots will be investigated, the deliberate abandonment of crab pots will be discouraged, and escape mechanisms in pots will continue to be researched.	*2.4.1* VA and MD will continue to address regulation of abandoned crab pots, including significant fines that may discourage deliberate abandonment.	*1995*	
	2.4.2 VA and M will continue to investigate materials for biodegradable escape panels and latches in crab pots and escape mechanisms for air breathing animals.	*Ongoing*	
	2.4.3 VA and MD will investigate the feasibility of establishing used pot disposal sites in Bay counties and other incentives.	*1996*	
	2.4.4 VA and MD will educate commercial crabbers about the problems of abandoned crab pots and MD will educate property owners about the effects of pots left unattended.	*1996*	
	2.4.5 VA and MD will investigate placement of identification on crab pots so that lost pots may be returned and purposeful abandonment will be discouraged.	*1995*	
	2.4.6 MD will identify sources of abandoned pots.	*1995*	
2.5 Shedding Mortality Information will be provided to shedders to minimize mortality in shedding operations.	*2.5.1* MD and VA will continue to provide technical information to shedding operations that promote reduction of peeler mortalities associated with holding practices.	*Ongoing*	
	2.5.2 VA established a commercial shedding license, effective January 1, 1994, and will monitor data reports.	*Underway*	
	2.5.3 MD and VA will continue to educate watermen on problems related to green crab mortality.	*Ongoing*	
	2.5.4 MD will investigate a joint venture with commercial watermen's associations to establish a state-of-the-art shedding facility for the purpose of research and to educate the shedding industry.	*1996*	

Creel Limit:

Maryland	All recreational crabbers -	1 bushel/person/day 2 bushels/boat limit
Virginia	Unlicensed sport crabbers -	1 bushel/person/day 2 dozen peelers/person/day
	Licensed sport crabbers -	No limit
Potomac	Unlicensed sport crabbers -	1 bushel/person/day 3 dozen soft or peelers/person/day
	Licensed sport crabbers -	No limit

Harvest Quotas:

Maryland	None in effect	
Virginia	Winter dredge fishery (Dec. 1 - March 1)	20 barrels/boat/day
	Spring crab pot fishery (April 1 - May 31)	51 bushels/boat/day 17 barrels/boat/day
Potomac	None in effect	

By-catch Restrictions:

Maryland	Sponge crabs prohibited
Virginia	Possession of hard crabs prohibited while scraping
Potomac	Prohibit possession of sponge crabs, spawn crabs, blooming females, mother crabs, or females from which the egg pouch or bunion has been removed.

Gear Restrictions:

Maryland

<u>Crab Pots</u>
Cubic and rectangular pots permitted
Cubic pots cannot exceed 24" on any side
Rectangular pot size limit 12" x 24" x 48"
All pots must be wire mesh 1" or greater
One 2 5/16" cull ring or one panel of 2"x2" square mesh with four openings

required in upper parlor of pots with mesh <1.5" or >=2", may be closed when fishing for peelers

Must be marked with a buoy attached to the pot and clearly visible on the surface and marked with ID number with 2" letters

Commercial limit 300 pots per licensee, additional allocations for up to two crew members, up to 900 pots per boat

Shoreline property owners limit 2 pots per property from piers or poles within 100 yds. of shore for personal consumption only and must be marked with name and address

Trotlines

Unlicensed sport crabber limit 1000' not to exceed 2000' per vessel

Length measured along the baitline

May not be set within 100 feet of another trotline

Scrapes or Dredges

Total width may not exceed 60"

Teeth prohibited

Diver, chain or other device to hold it to the bottom prohibited

Flat plate on scraping bar prohibited

Limit 2 scrapes or dredges per engine powered boat, only one overboard

Scrapes may not be affixed to each other

Bank Traps

Enclosure no more than 4' long and 4' wide

Limit 1 row of hedging no more than 75' long

Hedging may not exceed 1/3 the distance across the body of water in which its placed

Channel Pounds

Enclosure no more than 8' long and 4' wide

Limit 2 rows of hedging no more than 100' long

Hedging may not exceed 1/3 the distance across the body of water in which its placed

Bank Traps and Channel Pounds

Must be spaced 100 yards apart

A 12" air space from surface of water at mean high tide required

Must be marked with name and license number with 2" letters

Seines

Maximum length 50'

Must be hauled up in water

Collapsible Traps

License required for six or more traps

Limit 10 traps or rings for noncommercial crabbers from shore, bridge or pier

Limit 25 per vessel for noncommercial crabbers

Flat bottom and not more than 4 sides, each <= 1 ft^2

Must have manual tension on the closing mechanism

Those not attached to structures must be marked with a buoy with owner ID

6 Habitat Degredation *6.1 Anoxia* MD, PA, and DC have outlined a Tributary Strategy that will reduce the amount of nutrients from tributaries to the Bay 40% by the year 2000 to meet the Bay Program's nutrient reduction goal. Oxygen content goals for the Bay are also recommended.	*6.1.1* Implement goals of tributary strategies. *6.1.2* Dissolved oxygen standards for baywide adoption are recommended and goals for optimum survival of juvenile and adult blue crab should be as follows: a. All waters of Chesapeake Bay and its tidal tributaries should contain a minimum of 1.0 mg/L dissolved oxygen at all times, and b. a minimum duration of 12 hours of dissolved oxygen content between 1.0 and 3.0 mg/L with a 48 hour minimum return frequency of $\leq$3.0 mg/L and $\geq$1.0 mg/L, and c. all above pycnocline waters of Chesapeake Bay and its tidal tributaries should contain a monthly average of 6.0 mg/L dissolved oxygen.	*2000* *In effect upon adoption of Plan* *Teir 1: Ongoing* *Teir !!: 2005* *Teir 111: after teir II*	
6.2 SAV and Intertidal Wetlands The Chesapeake Bay Program is committed to achieving a net gain in SAV distribution, abundance and species diversity in the Bay and tidal tributaries over present populations. The Bay jurisdictions will maintain a priority status on protection of SAV and intertidal wetlands.	*6.2.1* The Chesapeake Bay jurisdictions will work to restore SAV to their historic levels. *6.2.2* MD and VA will prepare a report on blue crab habitat and biology and identify critical habitat utilized by the species, evaluate projected growth to the Bay watershed and make recommendations on regulating coastal development for permitting agencies. *6.2.3* MD will consider limits on scraping for hard crabs in the early crabbing season.	*1996* *1995*	
6.3 Water Quality The Chesapeake Bay Program will continue its commitment to toxins reduction and control, particularly in localized regions near discharge points and where toxins are accumulated.	*6.3.1* Regions of concern will be identified within criteria set by the Chesapeake Bay Toxics Strategy. Within regions of concern the sources and amounts of pollution will be determined, control methods will be explored and implemented and important habitats within the area and land uses with negative effects will be identified.	*Ongoing*	

APPENDIX B. LAWS AND REGULATIONS

Limited Entry:

Maryland — Once all commercial tidal fish licenses from two year delayed entry program prior to April 1, 1994, are issued, no new licenses will be issued until the number of licenses drops below a number that will be prescribed.

Virginia — No crab dredge licenses will be issued to any new applicant after March 31, 1994, until the number of licenses drops to 220 or below as of December 10 of any year.

Potomac — Only Maryland and Virginia residents may commercially crab. Commercial crab pot licenses limited to 500 as of January 31, 1995.

Minimum Size Limit:

	Virginia	Maryland	Potomac	Tolerance
Peelers	No minimum size	3"	3"	
Soft Crabs	No minimum size	3.5"	No minimum size	
Male, Hard Crabs	5"	5"	5"	MD & VA 10/bushel VA - 35/barrel Potomac - 4/bushel 10/barrel
Females, Mature	No minimum size	No minimum size	No minimum size	MD and Potomac - Sponge crabs prohibited
Female, Immature	5"	5"	5"	VA - 10/bushel, 35/barrel

3. Stock Assessment Deficiencies *3.1 Commercial Reporting* New reporting methods will be used with continued fishery independent surveys to monitor trends in catch and effort, produce reliable estimates of blue crab abundance, and understand the fishery and the relationships between harvest and stock.	*3.1.1* MD and VA will monitor commercial records in order to evaluate the relationship between fishery dependent and fishery independent estimates of abundance.	*Ongoing*	
3.2 Recreational Harvest There will be a Baywide effort to collect recreational catch and effort data and to evaluate the economic impact of the recreational harvest	*3.2.1* As of 1993, VA requires annual reporting by all licensed recreational crabbers including weight harvested, location of harvest, days fished, and amount of gear used. This data will be used to estimate recreational harvest and effort. *3.2.2* MD will seek a recreational crabbers license requirement. *3.2.3* MD will develop a method of estimating recreational catch to improve monitoring of the blue crab resource. Data collected will be compatible with Virginia.	*Underway* *1995* *1995*	
3.3 Research Needs The Baywide effort to collect population data on blue crabs will continue, and current methods will be improved to assure baywide uniformity of data sets and achieve reliable and more accurate catch estimates.	*3.3.1* MD and VA will continue cooperation in the Baywide winter dredge survey and continue to refine data analysis as a consistent annual assessment of the abundance, distribution, and mortality of the crab resource. *3.3.2* MD and VA will continue to encourage research on recruitment-stock and stock-recruitment relationships and how environmental parameters affect fluctuations in crab abundance.	*Ongoing* *Ongoing*	

4 Regulatory Issues *4.1 Commercial/Recreational Conflict* Conflicts among user groups and the general boating public can be minimized by rational application of time, area and gear restrictions to allocate space and harvest of the resource.	4.1.1 MD and VA will continue to monitor conflicts between crabbers and recreational boaters and enforce existing regulations on open and closed crabbing areas and buoy-free channels. *4.1.2* Maryland has staggered start and end times for recreational and commercial crabbing. The effectiveness of these time limits will be monitored.	*Ongoing* *1994*	
4.2 Interstate Trade MD and VA will continue to investigate the biological and economic effects of size limits on the soft crab fishery and the need to coordinate soft and peeler size limits.	*4.2.1* MD will consider a ban on the importation of crabs which do not meet State requirements. *4.2.2* MD and VA will work to achieve consistent Baywide standards for minimum sizes of all crabs harvested in the Bay. *4.2.3* MD will investigate the extent of importation of southern blue crab.	*1995* *1995* *1995*	
5 Public Health and Consumer Concerns *5.1 Personal Consumption* Minimum weight standards and volume will be considered for the various types of blue crabs.	*5.1.1* MD will evaluate the necessity of establishing a minimum bushel weight for various grades of crabs. *5.1.2* MD will define by regulation the minimum volume of a crab bushel, as well as potential substitutes, such as the waxed cardboard seafood box.	*1996* *1996*	
5.2 Foreign Import Efforts will be made to insure that consumers are aware of the origin of the crab products they purchase.	*5.2.1* Imported crab meat shall be identified as such in Maryland as required by Section 21-339 of Annotated Code of Maryland, Health Article. *5.2.2* In addition to foreign crab meat, the interstate shipment of crab products shall be surveyed in Maryland.	*1994* *1997*	

Maryland

Cannot be set within 100 feet of trotline
SCUBA Diving
Capture of crabs using diving apparatus prohibited

Virginia

Crab pots
Wire or thread mesh 1.5" or greater
Crab pot buoys must display assigned number
One 2 5/16" and one 2 3/16" cull ring in upper parlor on opposite sides;
the 2 5/16" cull ring may be obstructed within comm. dredge boundaries in the Bay, and in Pocomoke and Tangier Sounds
Unlicensed sport crabber limit 2 pots
Licensed sport crabber limit 5 pots
Recreational pots must display "R" on buoys
Peeler Pots
Wire mesh, no minimum mesh size
Bait only with live adult male hard crabs and food for these crabs
Baiting prohibited Sep. 16 to May 14
No cull ring required
Limit 400 pots/vessel April-June
Limit 400 pots/person July-Nov.
Limit 2 licensees per boat
Trot Line
Sport crabber limit 300'
Scrapes
Mouth not to exceed 4' overall
No teeth on bar
Haul by hand only
Limit 2 scrapes/boat overboard at one time
No tolerance for hard crabs
Dredges
Inside mouth not to exceed 8'
Teeth permitted
When 2 or more dredges are fixed together, total width may not exceed 16'
Use of more than 2 dredges at one time prohibited
One dredge on each side of boat or two dredges joined over stern
Hydraulic methods to dislodge crabs prohibited
Rakes, Dredges, and Scrapes (except hand rakes)
May not be used on seaside of Eastern Shore in water less than 4' at mean low tide
Traps/Pounds
Four 1.5" cull rings in retention box

Potomac

Crab pots, trotlines, dip nets, patent trotlines, and peeler traps permitted
One 2 5/16" cull ring required in all crab pots, may be closed May and June

Dredges and scrapes prohibited
Culling container on all vessels, must be cleared before leaving area of crabbing

Area Restrictions:

Maryland
Crab pots permitted in waters of Chesapeake Bay proper, Pocomoke Sound and waters of Somerset County in Tangier Sound
Crab pots prohibited
-in all other bays, sounds, and tributaries
-in less than 4' of water except in designated areas
-within 200 yards of a public beach May 1 - Sept. 30
Crab scrapes prohibited in portions of Choptank River, Little Choptank River, St. Mary's River, Calvert Bay, Smith Creek, and all submerged lands leased for oyster cultivation.
Minimum distance of 100' between trot lines
Bank traps/crab pounds only permitted in Somerset and St. Mary's Co. and waters surrounding Eastern Neck Is.
One stake may be set in riparian waters by the respective landowner or leasee marking site for bank traps or channel pounds between March 1 and March 14.
After March 15, 8 a.m., any licensee may stake sites for bank traps and pounds
Bank traps and hedging must be in place by May 1 to maintain stake, and bank traps and pounds must be removed by Dec. 1.
Hand-drawn net scrapes only permitted in waters of Queen Anne's Co. and Kent Co.

Virginia
Minimum distance of 100 yards between crab traps or crab pounds
Crab pots prohibited in marked navigational channels
Dredges prohibited in rivers, estuaries, inlets, or creeks except seaside of Accomack and Northampton counties
Unlawful to take crabs for resale from lower Bay crab sanctuary area June 1 to Sept. 15, inclusive
Fixed fishing devices prohibited within 300 yards of Chesapeake Bay Bridge Tunnel
Crab scraping permitted in Tangier Island crab scrape sanctuary, unlawful to set crab pots or take hard crabs by any gear
Dredges prohibited upriver of Hampton Roads Bridge Tunnel

Potomac
Crab pots prohibited within 200 yards of any public beach May through September

Season/Time Restrictions:

Maryland	Closed season for hard crabs January 1 to March 31 Closed season for crab scrapes Oct. 31 to April 14 Scraping from April 15 to Oct. 30 one hour before sunrise to sunset Commercial crabbing with crab pots, bank traps, channel pounds, collapsible traps, net rings, handlines, or dipnets prohibited 5 p.m. to 4:30 a.m. and trotlines between 5 p.m. and 3 a.m. Recreational crabbing prohibited between 5 p.m. and 5:30 a.m. in Chesapeake Bay or sunset to 5:30 a.m. in tidal Bay tributaries. No limits from shore, bridges, or piers.
Virginia	Crab dredging prohibited April 1 to November 30 Crab dredging prohibited on Saturday Commercial crabbing prohibited on Sunday (except peeler traps or floats, pens or onshore facilities for soft crab shedding) Commercial crabbing prohibited between sunset and 3 hours before sunrise Crab dredging prohibited sunset to sunrise Crab pots (hard and peeler) prohibited Dec.1 - March 31 Crab traps/pounds must be removed by December 31 Crabbing prohibited June 1 to Sep. 15 in lower Bay crab sanctuaries
Potomac	Commercial crabbing prohibited between sunset and one hour before sunrise No closed season