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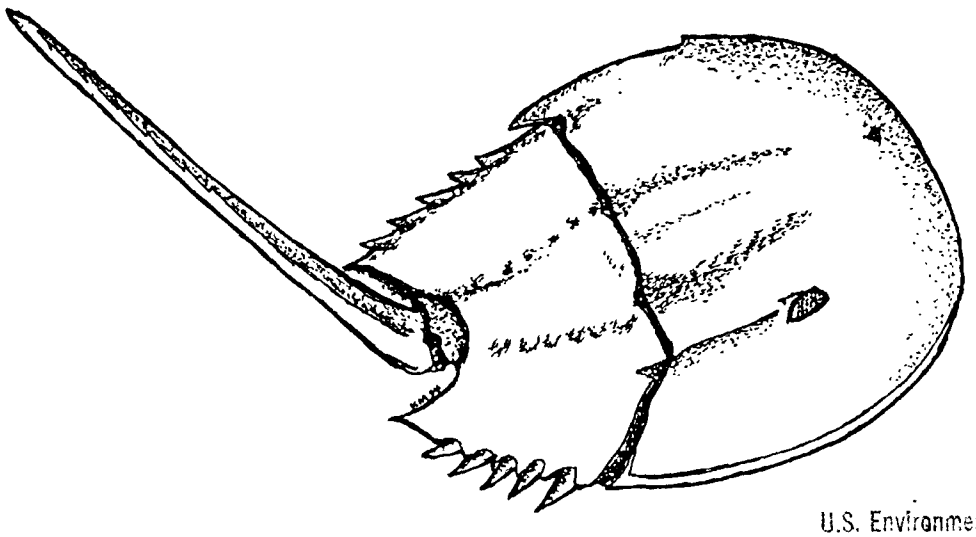
Chesapeake Bay and Atlantic Coast Horseshoe Crab Fishery Management Plan



U.S. Environmental Protection Agency
Region III Information Resource
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Philadelphia, PA 19107

Agreement Commitment Report 1994

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Chesapeake Bay and Atlantic Coast Horseshoe Crab Fishery Management Plan

Agreement Commitment Report

U.S. Environmental Protection Agency
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Center (3PM52)
841 Chestnut Street
Philadelphia, PA 19107

October 1994

Edited By Nancy H. Butowski

Printed by the U.S. Environmental Protection Agency for the Chesapeake Bay Program

Adoption Statement

We, the undersigned, adopt the *1994 Chesapeake Bay and Atlantic Coast Horseshoe Crab Fishery Management Plan*, as a continuing effort to fulfill the Living Resources Commitment of the 1987 Chesapeake Bay Agreement.

We agree to accept the Horseshoe Crab Plan as a guide to protecting the resource in the Chesapeake Bay and Atlantic Coast, insuring its continued role in the ecology of coastal ecosystems, and providing for its commercial, recreational and medical usage over time We further agree to work together to implement, by the dates set forth in the Plan, the management actions recommended to address its ecological value, stock status, the fishery, and habitat considerations.

We recognize the need for long-term, stable financial support and human resources for the task of enhancing the horseshoe crab resource. In addition, we direct the Living Resources Subcommittee to review and update the Horseshoe Crab Plan yearly and to prepare an annual report addressing the progress made in achieving the Plan's management recommendations

Signatures

Date Oct. 14, 1996

For the Commonwealth of Virginia George F. Allen

For the State of Maryland William Donald Schaefer

For the Commonwealth of Pennsylvania Robert Casey

For the United States of America _____

For the District of Columbia _____

For the Chesapeake Bay Commission Elmo G. Crow, Jr.

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The Chesapeake Bay and Atlantic Coast Horseshoe Crab Fishery Management Plan was developed under the direction of the Fisheries Management Plan Workgroup. Staff from the Maryland Department of Natural Resources (MDNR), Tidewater Administration, Fisheries Division were responsible for writing the plan and addressing comments on the draft versions. Support was provided by staff from the Virginia Marine Resources Commission (VMRC). Thanks are due to members of the Living Resources Subcommittee, the Virginia Finfish Subcommittee, and to the public who reviewed and commented on the plan.

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EXECUTIVE SUMMARY

Introduction

One of the strategies for implementing the Living Resources Commitments of the 1987 Chesapeake Bay Agreement is to develop and adopt a series of baywide fishery management plans (FMPs) for commercially, recreationally, and selected ecologically valuable species. The FMPs are to be implemented by the Commonwealth of Pennsylvania, Commonwealth of Virginia, District of Columbia, Potomac River Fisheries Commission, and State of Maryland as appropriate. The original FMP development schedule was amended to include horseshoe crabs with a completion date of 1994. The Horseshoe Crab FMP was drafted by staff from the Maryland Department of Natural Resources (MDNR) with support from the Virginia Marine Resources Commission (VMRC) staff. A FMP workgroup consisting of members from government agencies, the academic community, the fishing industry and public interest groups reviewed and commented on the plan. The management plan contains a summary of the fishery under consideration, a discussion of problems and issues that have arisen, and recommended management actions.

Goal and Objectives

The goal of the Horseshoe Crab Fishery Management Plan is:

> ***Protect the horseshoe crab resource in the Chesapeake Bay and Atlantic Coast to insure its continued role in the ecology of coastal ecosystems, while providing the opportunity for commercial, recreational and medical usage over time.***

In order to meet this goal, a number of objectives must be met. These objectives are incorporated into the areas of concern and management strategies summarized below.

Areas of Concern and Management Strategies

Ecological Value: Horseshoe crabs play an important ecological role in the food web. Adult horseshoe crabs are a major item in the diet of juvenile loggerhead turtles. Several shorebird species rely on horseshoe crab eggs to replenish their fat supply on their way to Canadian breeding grounds. Horseshoe crab eggs are also a seasonally preferred food item of several finfish species. The jurisdictions will protect the ecological role of horseshoe crabs by protecting horseshoe crab spawning areas and monitoring harvest. The hand collection of horseshoe crabs from beaches, and the trawling, scraping and dredging of crabs from the Bay and within 1 mile of the coast, will be prohibited in Maryland from May 1 through June 7. Virginia will prohibit the hand collection of horseshoe crabs during the same time period and continue their ban on trawling in state waters.

Stock Status: The present status of the horseshoe crab stock is unclear. The stock was relatively stable between 1975 and 1983. Neither commercial exploitation nor medical usage have changed significantly over the last 9 years. Recent spawning stock estimates and fishery independent trawl data from Delaware indicate a drop in the number of horseshoe crabs. There is a need to obtain better information on horseshoe crab population dynamics. The jurisdictions will coordinate with Delaware and develop a spawning stock census in the Chesapeake Bay region which will serve as the basis for determining management recommendations as appropriate.

The Fishery: Current levels of commercial harvest along the northeastern Atlantic coast are approximately 1.0 million pounds. Horseshoe crabs are commercially harvested for use as eel, conch, and catfish bait. Crabs are also used for medical research and bled to obtain Limulus amoebocyte lysate, a clotting agent used to detect human pathogens in drugs. Horseshoe crabs are vulnerable to overfishing because of their late maturity (9-11 years), their dependence on coastal and bay spawning beaches, the selective nature of the bait fishery for egg-bearing females, and their seasonally abundant, inshore spawning aggregations. The jurisdictions will monitor the commercial and medical harvest of horseshoe crabs and improve the quality of data obtained from the commercial fishery.

The Habitat: Horseshoe crabs are generalists and not as severely restricted by environmental conditions as many other aquatic species. Protected beach areas are essential habitat for horseshoe crab spawning. Activities which impact spawning areas will have a negative impact on the horseshoe crab population. The jurisdictions will define and protect horseshoe crab spawning areas, and work to define water quality requirements.

THE FISHERY MANAGEMENT PLAN PROCESS

What is a fishery management plan?

A Chesapeake Bay fishery management plan provides a framework for the Bay jurisdictions to take compatible, coordinated management measures to conserve and utilize a fishery resource. A management plan includes pertinent background information, management strategies, recommended actions, and an implementation date.

A fishery management plan is not an endpoint in the management of a fishery but part of a dynamic, changing process consisting of several steps. The first step consists of analyzing the complex biological, economic and social aspects of a particular finfish or shellfish fishery. The second step includes defining the concerns of a fishery, identifying potential solutions, and choosing appropriate management strategies. Once specific goals have been defined, it is important to measure progress towards meeting the goals, establish accountability and engage the general public. Plans must be adaptive and flexible to meet the changing needs of a particular resource. They are annually reviewed and updated in order to respond to the most current information on the fishery.

Management Plan Background

As part of the 1987 Chesapeake Bay Agreement's commitment to protect and manage the natural resources of the Chesapeake Bay, the Bay jurisdictions developed a series of fishery management plans for commercially, recreationally, and selected ecologically valuable species. A comprehensive and coordinated approach by the various local, state and federal groups in the Chesapeake Bay watershed is necessary for successful fishery management. Bay fisheries are traditionally managed separately by Pennsylvania, Maryland, Virginia, the District of Columbia, and the Potomac River Fisheries Commission. There is also a federal Mid-Atlantic fishery Management Council (MAFMC) which has management jurisdiction for offshore fisheries (3-200 miles), and a coastwide organization, the Atlantic States Marine Fisheries Commission (ASMFC), which coordinates the management of migratory species in state waters (internal waters to 3 miles offshore) from Maine to Florida.

A Fisheries Management Workgroup, under the auspices of the Chesapeake Bay Program's Living Resources Subcommittee, was formed to develop baywide fishery management plans. The workgroup's members represent fishery management agencies from the District of Columbia, Maryland, Pennsylvania, the Potomac River Fisheries Commission, Virginia, and the federal government; the Bay area academic community; the fishing industry; conservation groups; and interested citizens. Establishing Chesapeake Bay FMPs, in addition to coastal FMPs, creates a forum to specifically address problems

that are unique to the Chesapeake Bay. They also serve as the basis for implementing regulations in the Bay jurisdictions.

The Chesapeake Bay Program's Fishery Management Planning Process

The planning process starts with initial input by the Fisheries Management Workgroup and development of a draft plan. This is followed by a review of the management proposals by Bay Program committees, other scientists and resource managers, and the public. Comments are incorporated into a final draft of the management plan. It is endorsed by the Chesapeake Bay Program's Living Resources Subcommittee (LRSC), the Implementation Committee (IC), and the Principal Staff Committee (PSC). Finally, the plan is sent to the Executive Council (EC) for adoption.

Upon adoption by the EC, the appropriate management agencies implement the plan. In 1990, the Maryland legislature approved Section 4-215 of the Natural Resource Article giving the Maryland Department of Natural Resources authority to regulate a fishery once a FMP has been adopted by regulation. In Virginia, FMP recommendations are pursued either by legislative changes or through a public regulatory process conducted by the Commission. A periodic review of each FMP is conducted by the Fisheries Management Workgroup to incorporate new information and to update management strategies as needed.

The first group of fishery management plans was completed in 1989. Additional plans have been completed each year encompassing 16 finfish and shellfish species. With time and changes, it became apparent that a substantive review of each FMP at regular intervals would be necessary. The FMP workgroup developed a review schedule to upgrade each plan (Table 1). The revised FMP must be sent through the regular Chesapeake Bay Program's fishery management planning and adoption process. Since the major review schedule extends over a 5-year period, important minor changes are addressed through an amendment procedure. This entails developing a description of the proposed changes and sending it through the FMP workgroup for endorsement. The amendment must be published for public comment and reviewed by the LRSC and the IC for their comment and approval. The PSC has been given authority by the EC to approve amendment changes.

Table 1. Schedule for reviewing fishery management plans

SPECIES	ADOPTION DATE	REVIEW DATE
Shad/Herring	1989	June 1995
Blue Crab	1989	1994
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 Red Drum	1993 1993	1997
Catfish	July 1995	2000
Mackerel	1994	1998
Black Sea Bass	July 1995	2000
Tautog	December 1995	2000
Horseshoe Crabs	1994	1999

Section 1. Biological Background

Horseshoe crabs, Limulus polyphemus, are benthic or bottom-dwelling organisms that utilize both estuarine and continental shelf habitats. The horseshoe crab belongs to the largest group of all living animals, the phylum known as arthropods. This group includes insects, spiders, scorpions and crabs. Although it is called a "crab," it is not a true crab. Crabs have two pairs of antennae, a pair of mandibles or jaws, and five pairs of legs. Horseshoe crabs lack antennae and mandibles and have seven pairs of legs (chelicera, 5 pairs of ambulatory/gustatory legs, and chilaria). The presence of chelicera and book gills, and lack of jaws and antennae make horseshoe crabs more similar to spiders and scorpions than to "true" crabs. There are three genera and four species which comprise the living members of the subclass Xiphosura. Of these living species, Limulus is the only member common to the northwestern Atlantic coast and Gulf of Mexico. All the other members (Tachypleus tridentatus, T. gigas, and Carcinoscorpius rotundicauda) are found along the Asian coast from Japan and Korea south through the East Indies and Philippines. Serological data from three of the four extant species indicates they are con-generic (Shuster 1962). Horseshoe crabs are the closest living relatives of trilobites and their external appearance has remained relatively unchanged over the last 360 million years.

Limulus ranges from the Yucatan peninsula to northern Maine. Each major estuary along the coast is believed to have a discrete horseshoe crab population (Shuster 1979). These populations can be distinguished from one another by adult size, carapace color, and eye pigmentation. They can also be distinguished by their serological responses and through protein electrophoresis (Cohen 1979). Along the Atlantic coast, horseshoe crabs are most abundant between Virginia and New Jersey with Delaware Bay at the center of the species distribution. Within Delaware Bay, the largest concentration of horseshoe crabs is found along the Cape May shore of New Jersey (Shuster and Botton 1985). Although populations are believed to be discrete from estuary to estuary, gene flow between Delaware Bay and Chesapeake Bay populations is probable. Adult horseshoe crabs have been found as far as 56 kilometers offshore. This distribution pattern would allow an overlap between Delaware and Chesapeake individuals.

Horseshoe crabs are well known for their highly visible mating activities. Migrating adults move inshore from deep bay and coastal waters in late spring to spawn. Inshore movement appears to be related to lengthening daylight hours. Spawning in the Chesapeake and Delaware areas usually begins during the latter part of May when large numbers of horseshoe crabs move onto beaches to mate and lay eggs. The peak in spawning activity usually coincides with the full moon and evening spring tides. Adults prefer beach areas

within bays and coves which are protected from surf. Spawning areas are limited by the availability of sandy beach habitat. Wave height also affects spawning activity with rough water (waves over 12") preventing spawning. Eggs are laid in clusters or nest sites along the beach, usually between the tide marks. In a Delaware study, the average number of eggs per cluster was 3,650 (Shuster and Botton 1985). Several nests are made during one beach trip and females will return on successive tides to lay more eggs. Fecundity, the total number of eggs per female per year, is approximately 88,000 (Shuster 1982). Egg development is dependent on temperature, moisture and oxygen and usually takes a month or more. Upon hatching, the larvae are motile and spend about a week swimming around until they settle to the bottom and molt. Although there is the possibility of wide dispersion during the free-swimming period, most larvae settle in shallow, intertidal areas near the beaches where they were spawned. There is some evidence from a Maryland geological core survey that small horseshoe crabs bury themselves in intermittently submergent shoal areas in the coastal bays (J. Casey, pers. comm.). Juvenile horseshoe crabs generally spend their first and second summer on the intertidal flats (Shuster 1982). Only 1 juvenile (horseshoe crabs between 1" and 5" carapace width) has been caught in Maryland's coastal bay area in over 20 years of trawling and seining. Juvenile crabs have been observed in the Chesapeake Bay but more information is needed on this life stage. Older crabs move out of intertidal areas and are found several kilometers offshore except during breeding migrations (Botton and Ropes 1987a).

Limited data on the distribution and abundance of horseshoe crabs in the Chesapeake Bay exist but are largely unpublished. Horseshoe crabs are present year-round near the mouth of the Bay and have been documented in the Rappahannock River, the Miles River, Eastern Bay, the Chester and Choptank rivers. Horseshoe crab exoskeletons are a common occurrence on Bay beaches north of the Bay bridges. Spawning has been observed around the mouth of the Patuxent River (H. Hornick, MDNR, pers. comm.) and probably occurs in other areas throughout the Bay. Spawning areas in the Bay have not been well documented because spawning does not occur in easily observed, large concentrations and prime spawning habitat is scattered throughout the Bay (Shuster 1985). Horseshoe crabs have been observed spawning in the coastal bay areas in early June (J. Casey, MDNR, pers. comm.). Horseshoe crab eggs and developing young have been found subtidally, in the sandy substrate in the Isle of Wight Bay during May and June (A. Wesche, MDNR, pers. comm.).

In order to grow, the horseshoe crab must molt or shed its chitinous exoskeleton. Molting occurs several times during the first two to three years. As the horseshoe crab grows larger there is more and more time between molts. It usually takes at least 16 to 17 molts to reach sexual maturity over a period of 9 to 12 years. Males develop specialized clasping claws during their final molt for holding the female during reproduction. Females reach

maturity one year later than males and consequently, go through an additional molting stage. Once sexual maturity is reached, horseshoe crabs no longer molt and can live an average of 14 to 18 years in the northern part of their range. Adult horseshoe crabs feed mainly on marine worms and shellfish including razor clams and soft-shell clams (Shuster 1950, Botton 1984). Because they lack jaws, horseshoe crabs crush and grind their food items using the spiny bases of their legs then push the small food particles into their mouths. Horseshoe crabs can tolerate a wide range of temperatures and have special physiological processes that enable them to survive low oxygen environments. Adult horseshoe crabs have been found burrowed into anoxic muds on intertidal flats at low tide but spawning adults will avoid anaerobic sediments in beach areas (Botton et al. 1988). They can move out of the water during spawning and survive extended periods of time out of the water if their book gills are kept moist. Effects of temperature on Limulus were reported by Shuster (1978) from Mayer (1914). Mayer observed differences in thermal response between specimens collected from northern and southern locations. Limulus from Florida could tolerate warmer temperatures (46.3°C) than Limulus from Massachusetts (41°C). Maximum activity was reported at 41°C for Florida individuals and 38°C for Massachusetts individuals.

Horseshoe crabs play an important ecological role in the food web for migrating shorebirds and juvenile Atlantic loggerhead turtles (Botton 1983, Keinath et al. 1987). Delaware Bay is the principal breeding location for horseshoe crabs and is also the second largest staging area for shorebirds in North America. Migratory shorebirds arrive in Delaware Bay and Maryland's Atlantic coast at the peak of horseshoe crab mating in mid-May and June and typically spend two weeks in the area. At least 20 species of migratory birds rely on horseshoe crab eggs to replenish their fat supply during their trip to Canadian breeding grounds. The food supply provided by the eggs has been estimated at 320 tons (Delaware Dept. of Nat. Res. 1987). The importance of this feeding area has been recognized by Delaware and New Jersey and, consequently, twenty-five miles of shoreline have been set aside as a reserve for shorebirds and horseshoe crabs. The reserve is the first in a proposed International Shorebird Reserve System. Eleven sites have been identified as critical stop-over areas used by shorebirds during their flights between southern wintering sites and northern breeding grounds. Because these areas are regularly used by large numbers of shorebirds at specific times of the year, they are particularly vulnerable to disruption. The collection of horseshoe crabs by hand from spawning beaches disturbs the feeding of shorebirds. A decrease in the number of horseshoe crabs would leave a large portion of migrating shorebirds without the necessary food resources to complete their trip to the breeding grounds.

Adult horseshoe crabs also form a significant part of the diet of juvenile Atlantic loggerhead turtle, a threatened species that

utilizes the Chesapeake Bay as a summer nursery area (Keinath et al. 1987, Lutcavage and Musick 1985). Horseshoe crab eggs and larvae are also a seasonally preferred food item of invertebrates and finfish. All crab species and several gastropods, including whelks, feed on horseshoe crabs. In the Delaware River from May through August, striped bass and white perch eat horseshoe crab eggs. Eggs and larvae are also eaten by American eels, killifish, silver perch, weakfish, kingfish, silversides, summer flounder and winter flounder (Shuster 1982).

Biological Profile

Spawning and Larval Development

Spawning season:	Varies latitudinally but in the Delaware Bay area, generally peaks in late May-June during the high tide and full moon. Have been observed spawning in the Maryland coastal bay areas in early June.
Spawning area:	Center of abundance is in Delaware Bay with adults occurring as far north as Maine and as far south as the Gulf coast of Florida and the Yucatan peninsula.
Location:	Protected sandy beaches between tide marks within bays and coves.

Juveniles

Location:	Inhabit intertidal and shallow waters associated with tidal marshes, usually near breeding beaches. They move further and further from the beaches with increasing age.
Salinity:	Can tolerate lower salinities than adults, 5 ppt to 32 ppt. (Shuster 1982).
Temperature:	Can withstand a wide range of temperatures, probably similar to adults, 15-40°C (Shuster 1982).
Dissolved oxygen:	Specific oxygen requirements have not been cited in the literature. The rate of oxygen consumption is inversely related to body weight, thus smaller animals have a greater oxygen consumption than larger ones (Shuster 1982).

Adults

Location:	In the Chesapeake Bay, coastal bays and several kilometers offshore except during breeding migrations.
Fecundity:	88,000 eggs per female
Age at maturity:	9 to 12 years
Longevity:	14 to 18 years
Age Estimate:	Since adults do not molt, the appearance of the carapace is a general indicator of age. With increasing age, carapace abrasion from sand-abrasive environments and abundance of epibionts changes. Epibionts are organisms that attach to the shell and include crustaceans (barnacles), coelenterates (jellyfish), mollusks, and algae. Based on this information, the following age estimates can be made: 9-10 years old--clean, lustrous carapace; 10-15 years old--moderate erosion of carapace usually with epibionts; 15+ years--carapace nearly or entirely blackened; with epibionts (These darkened individuals are preferred as bait by watermen).
Temperature:	15-40°C with an optimum between 25-30°C
Salinity:	Usual range is from 11 to 31 ppt but encounter salinities up to 35 ppt on the continental shelf.
Dissolved oxygen:	Specific oxygen requirements have not been cited in the literature. Given the horseshoe crabs physiology, it is assumed they can survive low oxygen environments. Spawning adults will avoid anoxic sediments.

Fishery

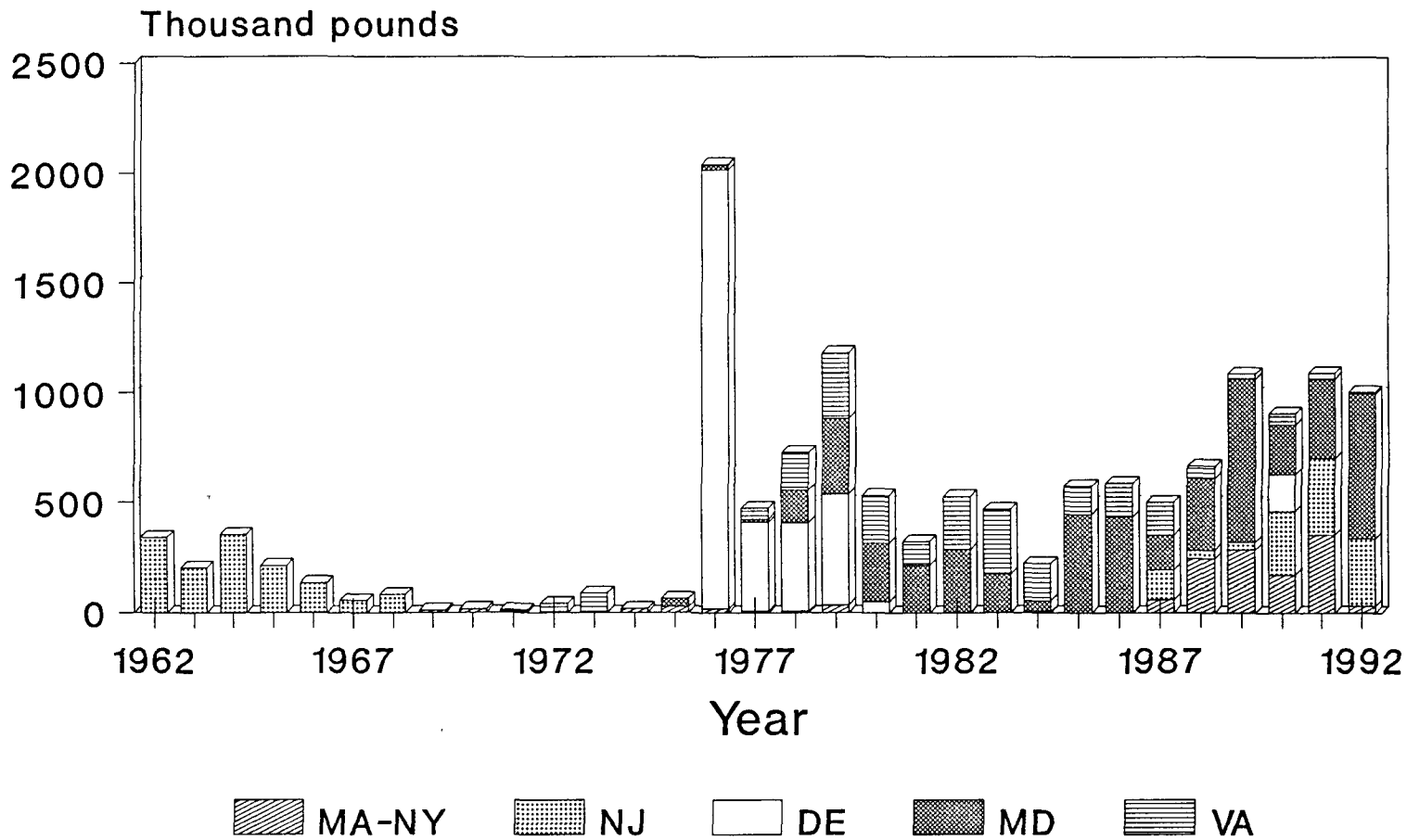
Historical records (Bureau of Commercial Fisheries) from the Delaware Bay indicate that commercial horseshoe crab landings were over 4.0 million crabs in the 1800's. By the 1920's the harvest had dropped to 1.8 million and continued to decline. During the 1940's and 1950's, horseshoe crab stocks were exhausted and brought a low

dockside value. Historically, horseshoe crabs were harvested for fertilizers and poultry and livestock food. Currently, horseshoe crabs are commercially harvested for use as eel, conch, and catfish bait along the Atlantic coast. The bait eel fishery prefers female horseshoe crabs with eggs. Commercial harvest from the northeastern Atlantic coast has ranged between 10,000 pounds and 2.0 million pounds over the last thirty years (Figure 1). Since 1988, commercial landings have averaged 950,000 pounds. The commercial statistics are based on an average weight of 4 pounds per horseshoe crab. Reported dockside value from the northeastern Atlantic coast has ranged between $300 (1967) and $132,000 (1989) (Figure 2). Fishery statistics probably underestimate the catch of horseshoe crabs because the sale of crabs for bait is often arranged between private individuals rather than through centralized dealers (Botton and Ropes 1987b).

Maryland has been responsible for harvesting between 23% and 78% of the total commercial catch of horseshoe crabs from the northeastern Atlantic coast since 1980 (Figure 1). The Maryland harvest comes from a small directed ocean fishery and bycatch from the clam fishery. Between 1978 and 1992, the commercial harvest of horseshoe crabs has ranged between 50,000 pounds (1984) and 746,000 pounds (1989) with a 10 year average of 357,000 pounds. Preliminary 1993 landings indicate Maryland harvest has increased to 1.0 million pounds. Reported dockside value has ranged between $1000 (1977) and $121,000 (1993) (Figure 3). In the last 10 years, over half of the commercial catch was reported between August and October when adult horseshoe crabs are migrating offshore. Over 33% of the catch was reported between April and May as horseshoe crabs are moving into beach areas to spawn. Historically, horseshoe crabs have been caught by clam dredges, otter trawls and hand clam rakes. In Maryland, most of the horseshoe crab harvest is taken by otter trawls. Currently, trawling is banned in the Chesapeake Bay and within 1 mile of the Maryland coast. In Virginia, the commercial harvest of horseshoe crabs averaged 190,000 pounds between 1980 and 1988. Since the ban on trawling within state waters (to 3 miles offshore) was implemented in 1989, horseshoe crab landings have decreased considerably with landings averaging 22,000 pounds . Reported dockside value has ranged between $200 (1976) and $26,000 (1987) (Figure 4). To date, Virginia has limited their conch pot fishery to 20 permits which limits the amount of horseshoe crabs used for baiting pots.

Horseshoe crabs have been an important animal for medical research. Scientists have used horseshoe crabs in eye research, surgical sutures and wound dressing development, and detection of bacteria in drugs. The discovery of Limulus amoebocyte lysate (LAL), a clotting agent in horseshoe crab blood, has made it possible to detect human pathogens like spinal meningitis and gonorrhea in patients and in drugs. Any drug produced by a pharmaceutical company must pass an LAL test. In order to obtain LAL, manufacturing companies catch large horseshoe crabs and bleed

Figure 1. Horseshoe crab landings from the NE Atlantic region, 1962-1992



from NMFS data

Figure 2. Dockside value of horseshoe crabs from the NE region, 1962-1992

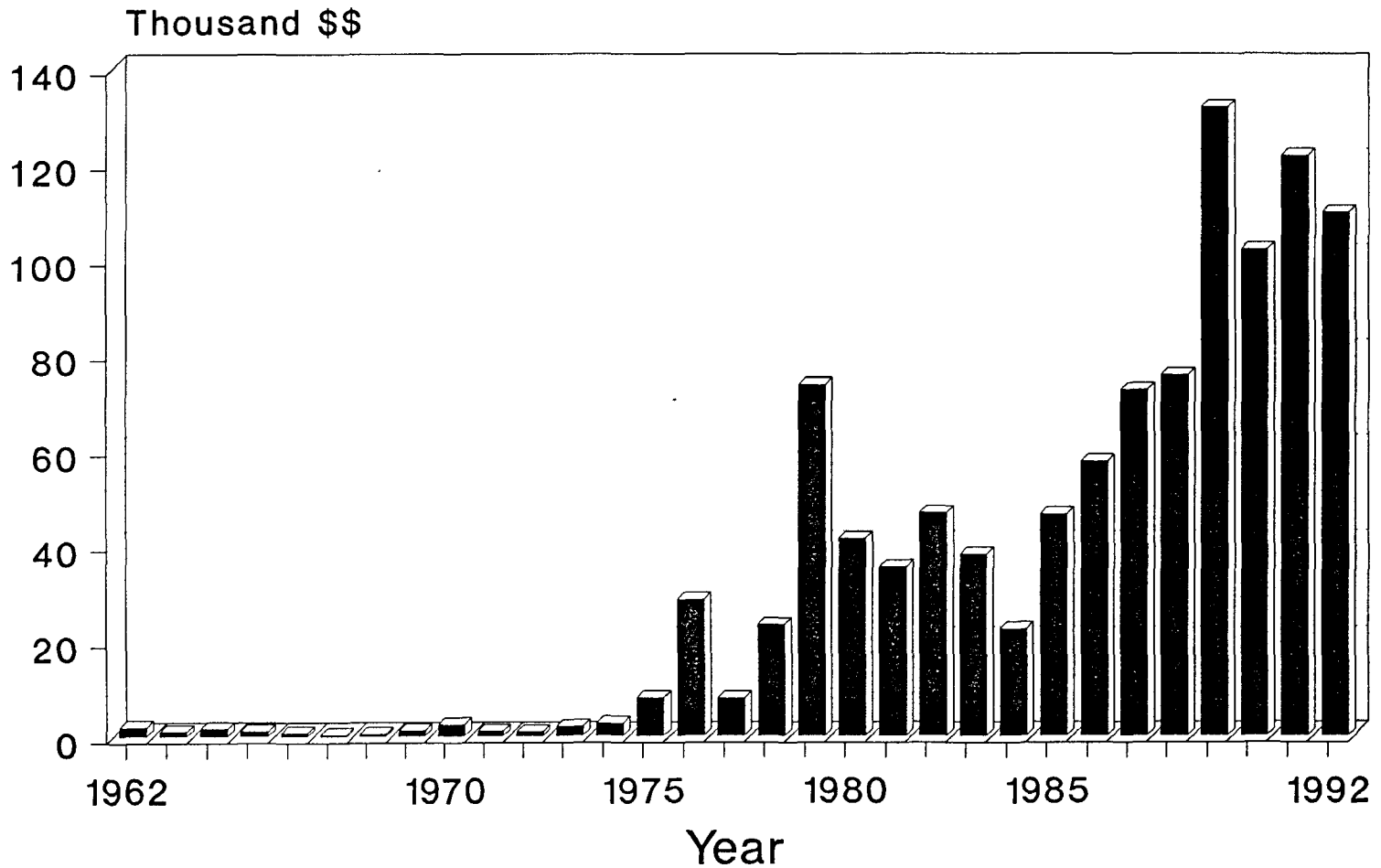
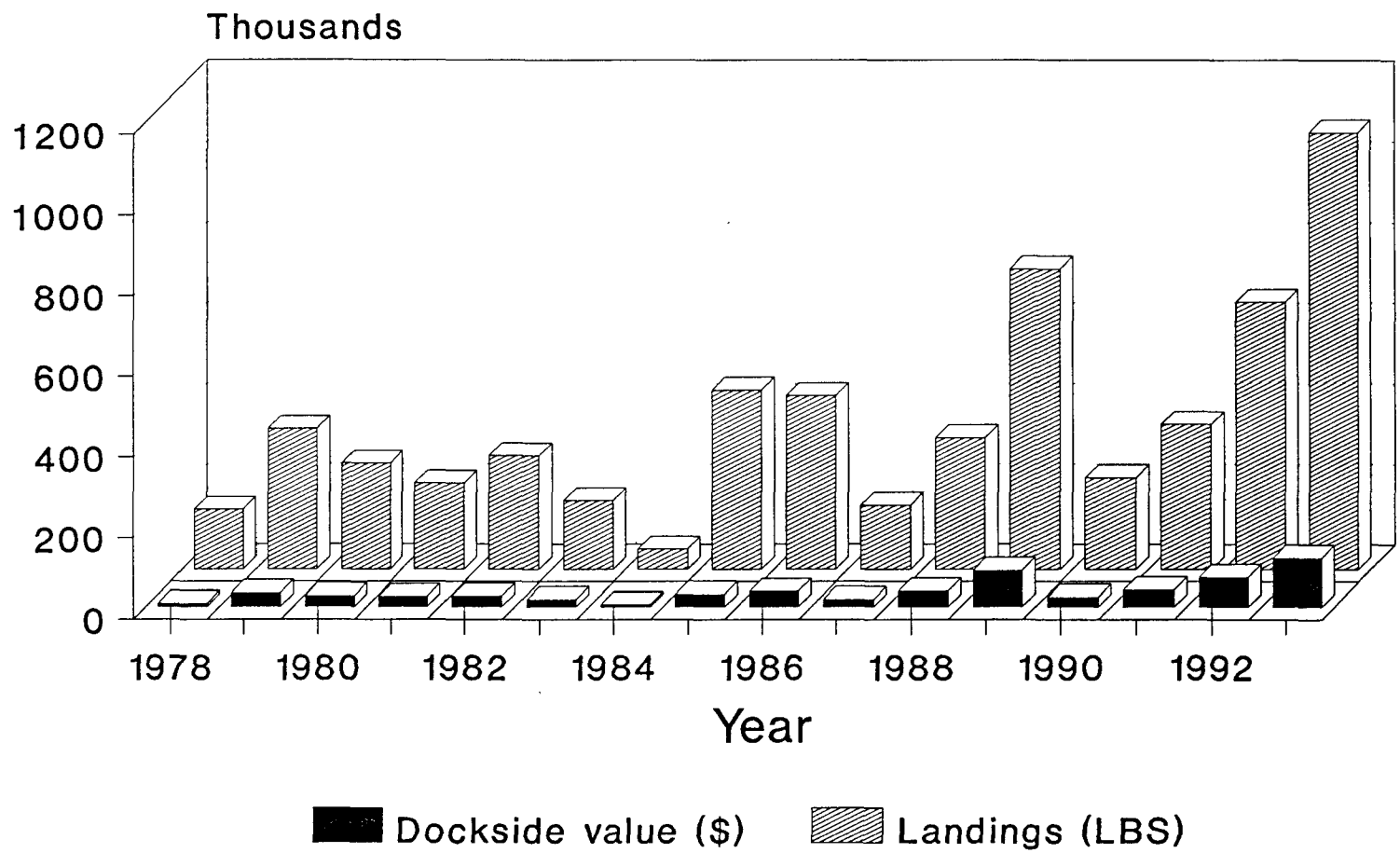
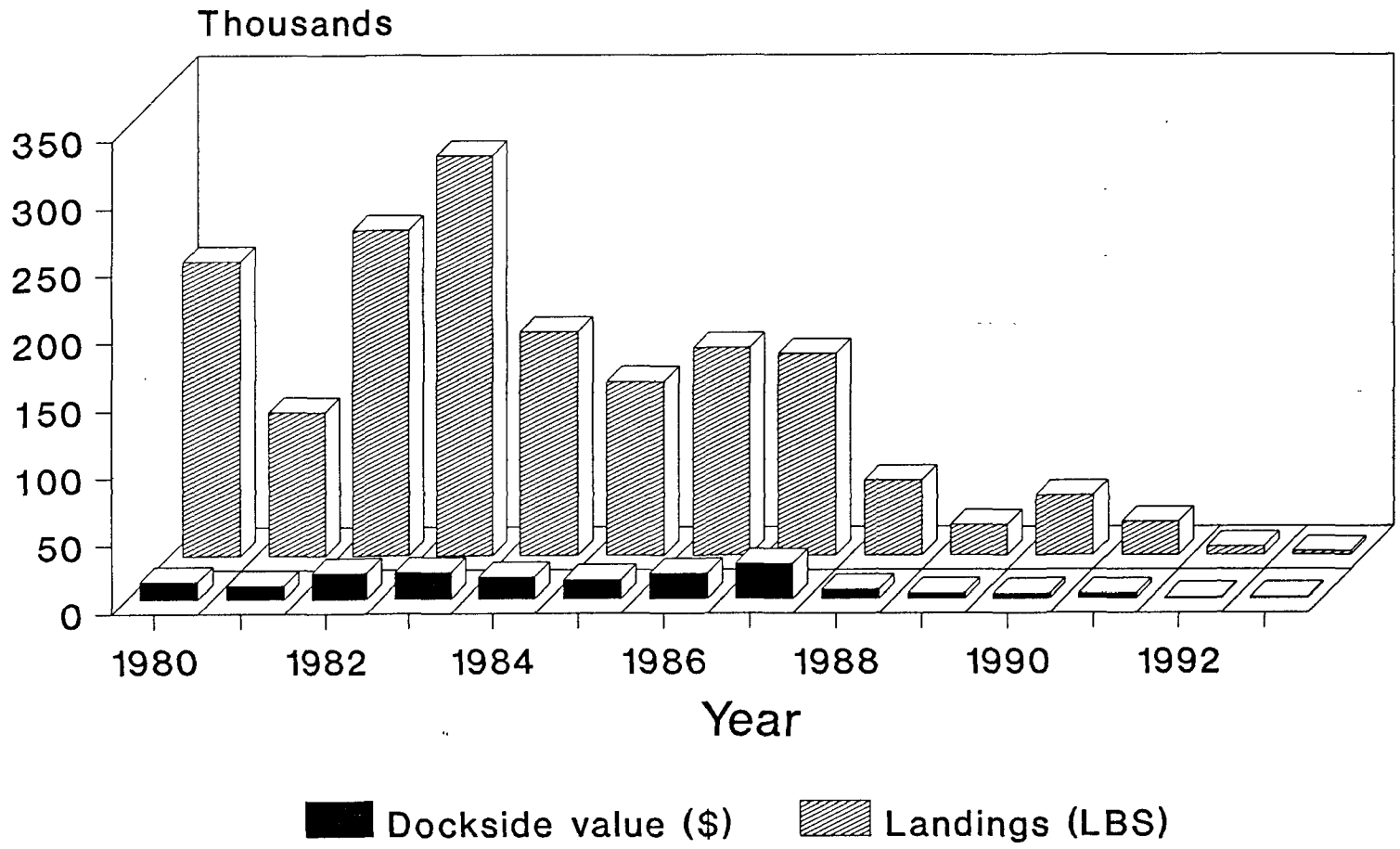


Figure 3. Maryland commercial horseshoe crab landings & dockside value



from NMFS data

Figure 4. Virginia commercial horseshoe crab landings & dockside value



from NMFS data; 1993-preliminary data

them. The extracted blood is centrifuged to separate the amoebocytes from the blood plasma, freeze-dried and processed for pharmaceutical uses. In 1989, the U.S. Food and Drug Administration (FDA) reported 130,000 horseshoe crabs were bled for the production of LAL. Although the exact number of horseshoe crabs bled by each company is considered confidential information, the current estimate of medical usage is 200,000 horseshoe crabs (B. Swan, pers. comm.). There is a mandated conservation measure by the FDA requiring the return of bled horseshoe crabs to the environment. Although the adults are released alive, they have approximately a 10% greater mortality than unbled horseshoe crabs (Rudloe 1983). Horseshoe crabs caught for medical use comprise an additional source of mortality and are not included in the commercial catch statistics.

Habitat Issues

Since horseshoe crabs undertake inshore and offshore migrations, they are potentially affected by environmental degradations in both estuarine and oceanic habitats. Activities which alter protected sandy beaches will ultimately have a negative impact on the horseshoe crab population since these areas are used for spawning. Many of the sites utilized by horseshoe crabs and shorebirds are also utilized by man. The rate at which coastal wetlands and beach areas are lost is directly related to the density of human population (Gosselink and Baumann 1980). Coastal land development and beach erosion practices such as bulkheading and placing rip-rap, alter beach topography and make beaches unsuitable for spawning. Beach replenishment activities may also have an effect on horseshoe crab habitat. Tidal flat areas are extremely important to newly-hatched larvae. Landfills and revetment activities turn tidal flats into pebble beaches which larvae cannot use. Channel dredging and overboard spoil disposal could also have unknown effects. In Japan, extensive diking, polder (an area of low-lying land that has been reclaimed from a body of water and is protected by dikes) construction and pollution have reduced the Japanese horseshoe crab, Tachypleus tridentatus, population to the status of endangered species (Itow 1993). The Japanese horseshoe crab is ecologically similar to the American horseshoe crab.

Water quality requirements for horseshoe crabs have not been well defined. There is little information on the effects of toxics, contaminants, and inorganic compounds on horseshoe crabs. Limulus is relatively tolerant to petroleum hydrocarbons but the tolerance decreases with increasing temperature. Horseshoe crab eggs and juveniles exhibited delayed molting and elevated oxygen consumption after exposure to oil and chlorinated hydrocarbons (Laughlin and Neff 1977). A high incidence of deformities in horseshoe crab eggs and larvae was noted in the Seto Island Sea, Japan, and related to

elevated levels of arsenic, chromium, cadmium, lead, and mercury. Horseshoe crabs are physiologically adapted to tolerate low oxygen levels and can probably withstand short-term, anoxic conditions.

Stock Status

Data from the Northeast Fisheries Center (NEFC) bottom trawl and ocean clam surveys (Georges Bank to Cape Fear, North Carolina), indicate that horseshoe crab abundance was relatively stable between 1975 and 1983. During this time period, the horseshoe crab population was estimated between 2.3 and 4.5 million individuals and the commercial fishery harvested an average of 176,000 individuals (approximately 700,000 pounds). Medical companies utilized about 160,000 individuals which contributed an additional 10% mortality or 16,000 individuals to the total annual exploitation. Current fishery statistics suggest that exploitation has not increased over the last 9 years (1984-1992) with commercial exploitation averaging 184,000 individuals or 737,000 pounds. Medical usage has increased slightly to approximately 200,000 individuals or an additional mortality of 20,000 individuals. Mean number of horseshoe crabs per tow from the NEFC bottom trawl survey was greatest north and south of Delaware Bay and off the Maryland coast (Botton and Ropes 1987b). Seasonal surveys suggest that horseshoe crabs found between Virginia and New Jersey consist of Chesapeake and Delaware Bay individuals.

The spawning horseshoe crab population in Delaware is currently being monitored by an annual census which started in 1990. Recent population estimates from Delaware beach surveys indicate a drop in horseshoe crabs from 1.2 million in 1990 and 1991 to less than 400,000 in 1992 and 1993 (Swan et al. 1991). Spawning population estimates, however, are not statistically robust. Trawl surveys were conducted by the Delaware Division of Fish and Wildlife in Delaware Bay during April to December, 1990-1993. The Delaware trawl survey indicated a decrease in catch per unit of effort (CPUE) from 18.6 in 1990 to 3.71 in 1992. How the migration of adults between estuaries and the continental shelf affect the trawl catch is unknown. Approximately 90% of the standing stock of horseshoe crabs is located between Virginia and New Jersey (Botton and Ropes 1987a).

Current Laws and Regulations

Virginia

There are no specific laws or regulations that pertain to horseshoe crabs. There is a ban on trawling within state waters (up to 3 miles offshore). Most horseshoe crabs are taken by dredge as incidental catch but some are taken directly for use as bait. Special scientific collection permits have been issued to trawlers to catch horseshoe crabs for medical purposes.

Maryland

There are no specific laws or regulations that pertain to horseshoe crabs. There is a ban on trawling within the Chesapeake Bay and coastal bays, up to 1 mile off the Maryland Atlantic coast. There is some directed trawling for horseshoe crabs for bait and for use in medical research.

Delaware

Horseshoe crab regulations were adopted in January 1992 and include the following restrictions: prohibition on the collection or dredging of horseshoe crabs between May 1 and June 7 unless one holds a valid scientific permit; prohibition on dredging horseshoe crabs from leasable shellfish grounds unless it is your own leased ground; prohibition on the possession of more than 6 horseshoe crabs for persons under the age of 16 unless accompanied by a person who has been issued a valid permit; a limitation on the number of persons who may assist the holder of a commercial collecting permit to three; prohibition on the possession of more than 6 horseshoe crabs unless that person has a valid receipt from a person who holds a valid horseshoe crab commercial permit; and an exemption for commercial eel licensees from horseshoe crab limits so long as an annual report on horseshoe crab catch is submitted to the Department of Natural Resources and Environmental Control and the crabs are only used for bait.

New Jersey

Horseshoe crab regulations were implemented in May 1993 and include: requirement of a free horseshoe crab permit in order to harvest crabs by hand or by any lawful gear; collection of horseshoe crabs for scientific purposes is legal so long as a scientific collection permit is obtained; prohibition on the taking of crabs from the Cape May Canal to Stow Creek in Cumberland County (the area considered to be the most important horseshoe crab spawning areas) from May 1 through June 7 except on Monday, Wednesday and Friday from one hour after sunset until one hour before sunrise; and a requirement for horseshoe crab harvesters to provide monthly reports on the size of harvest, area of collection, gear usage, and any other information the Department deems necessary.

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Section 2. Horseshoe Crab Management

There is currently no coastal management plan for horseshoe crabs. The source documents for the development of the Chesapeake Bay and Atlantic Ocean Fishery Management Plan for Horseshoe Crabs were definitive works by C. N. Shuster, Jr., M.L. Botton and J.W. Ropes, and A. Rudloe. The following management strategies have been developed and serve as the basis for identifying the goal and objectives.

A. GOAL AND OBJECTIVES

The goal of this plan is to:

> Protect the horseshoe crab resource in the Chesapeake Bay and Atlantic Coast to insure its continued role in the ecology of coastal ecosystems, while providing the opportunity for commercial, recreational and medical usage over time.

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

1) Promote harvesting practices which minimize waste and maximize the biological and economic return from the horseshoe crab resource.

2) Promote studies to improve the understanding of life history aspects and population dynamics of horseshoe crabs.

3) Determine the optimum spawning stock biomass for horseshoe crabs that can support harvest practices, medical research, and migratory shorebird populations.

4) Improve collection of catch and effort statistics for the commercial horseshoe crab fishery.

5) Make Chesapeake Bay and Atlantic coast management actions compatible where possible with Delaware and New Jersey actions.

6) Develop guidelines for identifying and protecting horseshoe crab spawning, juvenile and adult habitat.

B. HORSESHOE CRAB MANAGEMENT STRATEGIES

1) Ecological Value: Horseshoe crabs play an important ecological role in the food web of migrating shorebirds. At least 20 species of migratory birds rely on horseshoe crab eggs to replenish their fat supply on their way to Canadian breeding grounds. Migratory shorebirds are present in the Delaware/Chesapeake Bay region from mid-May through June. During this time, horseshoe crabs leave the water to deposit their eggs on certain spawning beaches. Horseshoe

crabs are vulnerable to human disturbances when they are out of the water. Shorebirds are also affected by human disturbances when they are feeding on the beaches. A decrease in the number of horseshoe crabs would leave a large portion of migrating shorebirds without the necessary food resources. Horseshoe crab eggs are also a seasonally preferred food item of several finfish species. In the Chesapeake Bay, adult horseshoe crabs are a major item in the diet of juvenile loggerhead turtles, a threatened species. Both Delaware and New Jersey have implemented regulations to protect migratory shorebirds and horseshoe crabs. Their regulations include: a prohibition on taking horseshoe crabs between May 1 and June 7 during the peak in shorebird migration and horseshoe crab spawning; a recreational possession limit; and a commercial permit. Limits on horseshoe crab harvest in Delaware and New Jersey could increase fishing pressure in Maryland due to market demand. The offshore distribution of horseshoe crabs suggests that there may be some gene flow between Delaware Bay and Chesapeake Bay populations.

Strategy 1.1
Maryland and Virginia will protect the ecological role of horseshoe crabs by protecting horseshoe crab spawning areas and monitoring harvest.

Action 1.1
Maryland and Virginia will prohibit the hand collection of horseshoe crabs from beaches during the peak time of shorebird migration, May 1 through June 7.

Implementation 1.1
1995

Action 1.2
a) Maryland will prohibit the scraping, trawling or dredging of horseshoe crabs between May 1 and June 7 within the Chesapeake Bay, coastal bay areas, and 1 mile of the Atlantic coast.
b) Virginia will continue its ban on trawling within state waters (up to 3 miles offshore).

Implementation 1.2
a) 1995 b) Continue

Action 1.3
Virginia will prohibit a directed horseshoe crab fishery between May 1 and June 7, continue mandatory reporting in the conch dredge fishery and monitor the bycatch of horseshoe crabs.

Implementation 1.3
1995

2) Stock Status: Data from trawl and clam surveys indicate horseshoe crab abundance was relatively stable between 1975 and 1983. During the same time period, an average of 700,000 pounds of horseshoe crabs was harvested from the northeastern Atlantic coast. Commercial exploitation has not significantly changed over the last 9 years (1984-1992) and landings have averaged 736,000 pounds. Medical usage has slightly increased from 160,000 individuals to approximately 200,000 individuals. There is about a 10% mortality associated with bleeding crabs. Most horseshoe crabs are caught during the spring and summer, the time when they are reproductively active. Egg-bearing females are targeted for the eel and conch bait fisheries. Recent spawning stock estimates and fishery independent trawl data from Delaware indicate a drop in the number of horseshoe crabs. There is a need to improve the spawning stock survey so it is statistically robust. There is also a need to obtain better information on horseshoe crab population dynamics, especially from the Chesapeake Bay area.

Strategy 2.1
Maryland and Virginia will coordinate with Delaware and begin to develop a spawning stock census of horseshoe crabs which will serve as the basis for determining management recommendations as appropriate.

Action 2.1
Maryland and Virginia will coordinate and implement a horseshoe crab spawning stock census in the Chesapeake Bay, coastal bays and along the Atlantic coast.

Implementation 2.1
1995

Action 2.2
Maryland and Virginia will promote and encourage research on horseshoe crab estimates of population abundance, age and size composition, mortality estimates, and migration.

Implementation 2.2
Open

3) The Fishery: Since 1987, the commercial harvest of horseshoe crabs along the northeastern Atlantic coast has gradually increased. Current levels (1989-1992) of harvest are approximately 1.0 million pounds. Commercial horseshoe crab statistics are incomplete, especially in Maryland. Preliminary data indicate the Maryland harvest increased to 1.0 million pounds during 1993. Increased landings may be the result of better reporting methods but information on fishing effort is needed in order to evaluate commercial landings statistics. Horseshoe crabs are commercially harvested for use as eel, conch, and catfish bait. Horseshoe crabs are also important laboratory animals for medical research. They are captured and bled to obtain Limulus amoebocyte lysate (LAL), a

clotting agent used to detect human pathogens in drugs. Although the crabs are released alive, they experience a greater mortality than unbled horseshoe crabs. Horseshoe crabs are particularly vulnerable to being overfished because of their late maturity (9-11 years), their dependence on coastal and bay spawning beaches which are being lost as a result of the development of coastal areas, the selective nature of the bait fishery for egg-bearing females, and their seasonally abundant, easily harvested, inshore spawning aggregations. The evidence for overharvest of a year-class would not be apparent for at least 9 or 10 years. Under these circumstances, prudent management recommendations are warranted.

Strategy 3.1
Maryland and Virginia will monitor the commercial and medical harvest of horseshoe crabs and improve the quality of data obtained from the commercial fishery.

Action 3.1
a) Maryland will require horseshoe crab harvesters to provide monthly reports on the size of harvest, area of collection, gear usage and any other information the Department deems necessary.
b) Maryland will determine if a special permit to harvest horseshoe crabs is necessary after evaluating the new federal reporting system and the results of the monthly reports.

Implementation 3.1
1995

Action 3.2
Virginia will continue their mandatory reporting procedures implemented in January, 1993.

Implementation 3.2
Continue

Action 3.3
Maryland and Virginia will survey American eel harvesters and their use of horseshoe crabs by sex for bait.

Implementation 3.3
1995

4) The Habitat: Limulus is a generalist and is not as severely restricted by environmental conditions as many other aquatic species. Protected beach areas are essential habitat for horseshoe crab spawning. Beach stabilization practices such as the placement of "clean fill," i.e., bricks, cinderblocks and coarse gravel, in the intertidal zone may seriously affect egg-laying habitat.

Activities which impact spawning areas will have a negative impact on the horseshoe crab population. Habitat destruction has seriously reduced the horseshoe crab population in Japan.

Strategy 4.1.1
The jurisdictions will define and protect horseshoe crab spawning areas and areas that are used by migrating shorebirds.

Action 4.1
Maryland and Virginia will initiate a study to delineate the geographic distribution of horseshoe crab spawning habitat in the Chesapeake Bay and coastal bays if funding is available.

Implementation 4.1
Dependent on funding

Action 4.2
The jurisdictions will promote research to define the water quality requirements for horseshoe crabs.

Implementation 4.2
Open

Action 4.3
The jurisdictions will continue to work with the Chesapeake Bay Program, the Coastal Bay Initiative and water quality improvement goals for the Bay and coastal areas.

Implementation 4.3
Continue

CHESAPEAKE BAY HORSESHOE CRAB MANAGEMENT PLAN
IMPLEMENTATION MATRIX

PROBLEM AREA	ACTION	DATE	COMMENTS
1. Ecological Value	1.1 MD & VA will prohibit the hand collection of horseshoe crabs from beaches during the peak time of shorebird migration, May 1-June 7.	1995	Dates may need to be adjusted as more information becomes available for MD & VA.
	1.2 a) MD will prohibit the scraping, trawling or dredging of horseshoe crabs between May 1 and June 7 within the Chesapeake Bay, coastal bay areas and within 1 mile of the Atlantic coast. b) VA will continue its ban on trawling within state waters.	1995 Continue	
	1.3 VA will prohibit a directed horseshoe crab fishery between May and June 7, continue mandatory reporting in the conch dredge fishery and monitor bycatch.	1995	
2. Stock Status	2.1 MD & VA will coordinate and implement a horseshoe crab spawning stock census in the Chesapeake Bay, coastal bays and along the Atlantic coast.	1995	
	2.2 MD & VA will promote and encourage research on horseshoe crab estimates of population abundance, age and size composition, mortality estimates and migration.	Open	
3. The Fishery	3.1 a) MD will require horseshoe crab harvesters to provide monthly reports on the size of harvest, area of collection, gear usage and any other information the Department deems necessary. b) MD will determine if a special permit to harvest horseshoe crabs is necessary after evaluatinng the new federal reporting system and the results of the monthly reports.	1995	
	3.2 VA will continue their mandatory reporting procedures.	Continue	Implemented in January, 1993.
	3.3 MD & VA will survey American eel harvesters and their use of horseshoe crabs by sex for bait.	1995	
4. The Habitat	4.1 MD & VA will initiate a study to delineate the geographic distribution of horseshoe crab spawning habitat in the Bay and coastal bays if funding is available.	Open	Dependent on funding.
	4.2 The jurisdictions will promote research to define the water quality requirements for horseshoe crabs.	Open	
	4.3 The jurisdictions will continue to work with the Chesapeake Bay Program, the Coastal Bay Initiative, and water quality improvement goals for the Bay and coastal areas.	Continue	