

**2012 REVIEW OF THE FISHERY MANAGEMENT PLAN IN 2011 FOR
HORSESHOE CRAB
(*Limulus polyphemus*)**



Presented to the
ASMFC Horseshoe Crab Management Board

Prepared by the ASMFC Horseshoe Crab Plan Review Team:

Sheila Eyler, U.S. Fish and Wildlife Service
Stewart Michels, Delaware Department of Natural Resources and Environmental Control
Danielle Chesky, Chair, Atlantic States Marine Fisheries Commission

May 2012

2012 REVIEW OF THE 2011 ASMFC FISHERY MANAGEMENT PLAN FOR HORSESHOE CRAB (*Limulus polyphemus*)

I. Status of the Fishery Management Plan

The framework for managing horseshoe crabs along the Atlantic coast was approved in October 1998 with the adoption of the Interstate Fishery Management Plan for Horseshoe Crabs (FMP). The goal of this plan is to conserve and protect the horseshoe crab resource to maintain sustainable levels of spawning stock biomass to ensure its continued role in the ecology of coastal ecosystems, while providing for continued use over time.

In 2000, the Horseshoe Crab Management Board approved Addendum I to the FMP. Addendum I established a state-by-state cap on horseshoe crab bait landings at 25 percent below the reference period landings (RPL's), and *de minimis* criteria for those states with a limited horseshoe crab fishery. Those states with more restrictive harvest levels (Maryland and New Jersey) were encouraged to maintain those restrictions to provide further protection to the Delaware Bay horseshoe crab population, recognizing its importance to migratory shorebirds. Addendum I also recommended that the National Marine Fisheries Service (NMFS) prohibit the harvest of horseshoe crabs in federal waters (3-200 miles offshore) within a 30 nautical mile radius of the mouth of Delaware Bay, as well as prohibit the transfer of horseshoe crabs in federal waters. A horseshoe crab reserve was established on March 7, 2001 by NMFS in the area recommended by ASMFC.

In 2001, the Horseshoe Crab Management Board approved Addendum II to the FMP. The purpose of Addendum II was to provide for the voluntary transfer of harvest quotas between states to alleviate concerns over potential bait shortages on a biologically responsible basis. Voluntary quota transfers require Technical Committee review and Management Board approval.

In 2004, the Board approved Addendum III to the FMP. The addendum sought to further the conservation of horseshoe crab and migratory shorebird populations in and around the Delaware Bay. It reduced harvest quotas and implemented seasonal bait harvest closures in New Jersey, Delaware, and Maryland, and revised monitoring components for all jurisdictions.

Addendum IV was approved in 2006. It further limited bait harvest in New Jersey and Delaware to 100,000 crabs (male only) and required a delayed harvest in Maryland and Virginia. Addendum V, adopted in 2008, extends the provisions of Addendum IV through October 31, 2010. In early 2010, the Board initiated Draft Addendum VI to consider management options that will follow expiration of Addendum V. The Board voted in August 2010 to extend the Addendum V provisions, via Addendum VI, through April 30, 2013. The Board also chose to include language, allowing them to replace Addendum VI with another Addendum during that time, in anticipation of implementing the ARM framework.

The Board approved Addendum VII, which implements the ARM Framework, in February 2012 for use during the 2013 fishing season. The Framework considers the abundance levels of

horseshoe crabs and shorebirds in determining the optimized harvest level for the Delaware Bay states of New Jersey, Delaware, Maryland, and Virginia (east of the COLREGS).

II. Status of the Stock

No definitions for overfishing or overfished status have been adopted by the Management Board. However, the majority of evidence in the most recent stock assessment, the 2009 Benchmark Horseshoe Crab Stock Assessment (available at <http://www.asmfc.org/horseshoeCrab.htm>), indicates abundance has increased in the Southeast and Delaware Bay Regions. In the Delaware Bay Region, increasing trends were most evident in juvenile indices, followed by indices of adult males. Over the time series of the survey, no trend in the abundance of female crabs is evident. In contrast, declining abundance was evident in the New York and New England regions. Declines in the New England Region had been evident in the 2004 assessment; however, declines in the New York Region noted in the 2009 stock assessment represent a downturn from the 2004 assessment. Decreased harvest quotas in Delaware Bay have potentially redirected harvest to nearby regions. Current harvest within the New England and New York Regions may not be sustainable. Continued precautionary management is therefore recommended coastwide to anticipate effects of redirecting harvest from Delaware Bay to outlying populations. Under a general five-year trigger, the next horseshoe crab stock assessment will likely occur in 2014. As part of implementing Addendum VII for 2013, the PRT supports the Horseshoe Crab Technical Committee's efforts to update the coastwide indices prior to ARM Framework implementation.

The PRT and TC will continue to monitor any harvest increases in regions outside of Delaware Bay, which are coincident with harvest reductions within Delaware Bay. An overarching conclusion of recent coastwide assessments has been that management should be regional or embayment specific. Current harvest levels of the Delaware Bay population appear consistent with population growth. However, it is unclear whether harvest of crabs in the outlying regions is sustainable.

III. Status of Assessment Advice

The Stock Assessment was externally peer reviewed by a panel of experts. The panel included their comments and recommendations in the 2009 Horseshoe Crab Terms of Reference and Advisory Report, available at <http://www.asmfc.org/horseshoeCrab.htm>. Below is a selection of recommendations from their report.

Assessment Methodology

- The Panel considers the ARIMA method superior to the linear trend analysis, and recommends focusing on this approach in the future, in areas where more sophisticated modeling is not possible. The Panel concluded that the ARIMA method could supersede the linear trends analysis, provided the unsmoothed (input) index estimates are reported along with the smoothed (output) estimates.
- We are concerned the surplus production model for Delaware Bay is not suitable, given the life history of horseshoe crab and the presumed mechanism of density dependence. As noted in the report, surplus production models assume an instantaneous response of

the stock to changes in conditions, which seems unrealistic given the late age of maturity of horseshoe crab and the belief that density dependence operates at the egg stage. We urge that the sensitivity of the production model to this assumption be explored more thoroughly if it is to be used further. A simple age-structured operating model (e.g., Sweka et al. 2007) could be used to generate simulated data that are then fit to the surplus production model and the biomass/exploitation rate estimates compared to true values to test for biases.

- The catch-survey methodology appears to be a promising tool for assessment in Delaware Bay, but will require further examination of the evidence for differential catchability of primiparous and multiparous horseshoe crab. As a first step we suggest a spatial analysis of the catch data, using habitat variables as covariates that may explain differences in the distribution and thus catchability of the two life stages.

Biological Reference Points

- We recommend development of plausible biological reference points using life history information for horseshoe crab, comparisons to other species with similar life histories (e.g., long-lived, late maturing invertebrate species), and development of yield per recruit or egg per recruit models.
- We also suggest empirical reference points based on an estimated historic state are preferable to percentile-based reference points because of the vulnerability of the latter to the influence of the period for which past data are available. This is especially true when the reference point analysis is being used in an aggregated manner (i.e., across multiple surveys). Rather than basing the historical reference point on a single year, we recommend using the average across a range of years that represent, in the SASC's judgment, a period of relatively high abundance.

IV. Status of the Fishery

Bait Fishery

For most states, the bait fishery is open year round. However, because of seasonal horseshoe crab movements (to the beaches in the spring; deeper waters and offshore in the winter), the fishery operates at different times. State waters from New Jersey south to Virginia coastal waters are closed to horseshoe crab harvest and landing from January 1st through June 7th each year.

Reported coastwide bait landings in 2011 remained well below the coastwide quota (Table 2, Figure 1). Bait landings increased 7.6% from the previous year, due to increased landings in Massachusetts, Delaware, New York, and North Carolina. Except for North Carolina, which is pursuing a transfer of quota from Georgia for an overage in the 2011 season, there were no overages in quota. The overall harvest remains below the ASMFC-mandated coastwide harvest.

An alternative bait/gear workshop conducted under the auspices of ASMFC in 1999 introduced the concept of using bait savings devices (bait bags) in whelk (conch) pots. Free bait bags were distributed to whelk potters in the Mid Atlantic and southern New England regions through a state, federal, and NGO partnership. National Marine Fisheries Service funded the acquisition of the bait bags. The Ecological Research and Development Group (ERDG), Delaware, Maryland, New Jersey, Virginia, New York, Connecticut, Rhode Island and Massachusetts assisted in the

funding and distribution of the bags. The reductions in reported bait landings in excess of the 25% reductions required under Addendum I were largely attributed to the success of this program, with the widespread use of the devices by the commercial fishery. Massachusetts fishermen have been using bait cups in conch traps with success, and some form of bait-reduction device is mandated within the Delaware fishery. The cups use about a 10th of a crab and can be fished for 2-3 days in relatively cold waters.

Reported coastwide landings since 1998 show more male than female horseshoe crabs were annually harvested, though a large proportion of the reported landings in 1998 and 1999 were unclassified (Table 3). The American eel pot fishery prefers egg-laden female horseshoe crabs as bait, while the whelk (conch) pot fishery is less dependent on females. Unclassified landings have generally accounted for around 10% of the reported landings since 2000, although 2008 had a slightly higher proportion of unclassified landings (14%). Due to some staffing challenges, the numbers for Massachusetts by gender have yet to be tallied, putting the current level of unclassified landings at 20%. The PRT anticipates this number will drop closer to the normal 10% once numbers are available.

The hand, trawl, and dredge fisheries typically account for over 85% of the reported commercial horseshoe crab bait landings. Other methods that account for the remainder of the harvest include gill nets, pounds, and traps.

The dominance of the hand fishery was reflected in the seasonal distribution of landings. Most of the monthly reported coastwide harvest since 1998 came during May and June as crabs come ashore to spawn and, thus, were readily available to the fishery. There is typically a secondary mode in monthly landings during the late summer or fall. This secondary peak coincides with an increased demand for horseshoe crabs in the conch pot fishery, and these crabs are generally harvested by dredge or trawl.

An additional issue that has caused concern for the PRT and some states was the importation of frozen Asian horseshoe crabs for bait use in 2011. As detailed in the memo to the Board from Drs. Dave Smith and Mike Millard on July 12, 2011, the populations of Asian horseshoe crabs are rapidly declining, both due to bait and biomedical harvesting. In addition, invasive species and pathogen concerns are present with the import of a foreign species. The PRT recommends the Board continue to monitor this situation and investigate management opportunities to control the importation of Asian horseshoe crabs for bait at the state and federal levels.

Biomedical Fishery

The horseshoe crab is an important resource for research and manufacture of materials used for human health. There are four companies along the Atlantic Coast that process horseshoe crab blood for use in manufacturing Limulus Amebocyte Lysate (LAL): Associates of Cape Cod, Massachusetts; Lonza (formerly Cambrex Bioscience), Maryland; Wako Chemicals, Virginia; and Charles River Endosafe, South Carolina. There is one company that bleeds horseshoe crabs but does not manufacture LAL: Limuli Labs, New Jersey. Addendum III requires states where horseshoe crabs are collected for biomedical use to collect and report harvest data and characterize mortality.

The Plan Review Team annually calculates total coastwide harvest and estimates mortality. It was reported that 628,476 crabs (including crabs harvested as bait) coastwide were brought to biomedical companies for bleeding in 2011 (see Table 1 below). This represents a 28.7% increase over the average of the previous five years. Of this total, 83,312 crabs were reported as harvested for bait and counted against state quotas, representing an 11.3% increase over the average of the previous five years (Table 1: row C). These crabs were not included in the mortality estimates (Rows D, F, and G) below. It was reported for 2011 that 545,164 crabs were harvested for biomedical purposes only. Mobile gear types accounted for 50% of total biomedical harvest, whereas hand harvest accounted for 43% and 7% was unknown. Males accounted for 48% of total biomedical harvest; females comprised 34%; 18% of the harvest was unknown. Crabs were rejected prior to bleeding due to mortality, injuries, slow movement, and size. Based on state reports for 2011, approximately 8.3% of crabs (or 45,300 crabs) harvested and brought to bleeding facilities were rejected. Approximately 1.2% of crabs, collected solely for biomedical purposes, suffered mortality from harvest up to the point of release.

The Technical Committee has reviewed, multiple times, the available literature for estimating crab mortality during and after the bleeding process. It had previously concluded that using an estimate of 15% mortality is reasonable; most recently, in June 2011, the TC recommended using a range of values (5-30%) for estimating mortality, in order to include the known variances in conditions and situations that can occur over the geographical and temporal range of collecting and bleeding the horseshoe crabs. Total estimated mortality of biomedical crabs for 2011 was 80,827 crabs (at 15% post-release estimated mortality), with a range of 31,554 to 154,737 crabs (5-30% post-release estimated mortality).

Table 1. Characterization of Biomedical Use of Horseshoe Crabs

		2006	2007	2008	2009	2010	2011
A	Number of crabs brought to biomedical facilities (bait and biomedical crabs)	367,914	500,251	511,478	512,552	548,751	628,476
B	Number of biomedical-only crabs harvested (not counted against state bait quotas)	309,289	428,872	423,614	402,202	482,704	545,164
C	Number of bait crabs bled	38,625	71,379	87,864	110,350	66,047	83,312
D	Reported mortality of biomedical-only from harvest to release	4,639	3,599	2,973	6,298	9,665	6,917
E	Number of biomedical-only crabs bled	296,958	398,844	402,080	362,291	438,417	492,734
F	Estimated mortality of bled biomedical-only crabs post-release (15% est. mortality)	44,543	59,833	60,312	54,344	65,763	73,910
G	Total estimated mortality on biomedical crabs not counted against state bait quotas (15% est. mortality)	49,182	63,432	63,285	60,642	75,428	80,827

The 1998 FMP establishes a mortality threshold of 57,500 crabs, where if exceeded the Board is required to consider action. Based on an estimated total mortality of 80,827 crabs for 2011, this threshold has been exceeded. The PRT notes that estimated mortality from biomedical use is approximately 11.1% of the total horseshoe crab mortality (bait and biomedical) coastwide for 2011, down from 12.7% in 2010. The reported biomedical use of horseshoe crabs has increased 85% since the biomedical landings have been tracked (2004). This increase in harvest has corresponded to an approximate increase in mortality of 75% since 2004. Given the increased demand for LAL product and the continued increase in biomedical harvest and mortality, the PRT recommends the Board continue efforts to reduce mortality in the biomedical industry through development and implementation of Best Management Practices and other state efforts.

V. Status of Research and Monitoring

The Horseshoe Crab FMP set forth an ambitious research and monitoring strategy in 1999 and again in 2004 to facilitate future management decisions. Despite limited time and funding there are many accomplishments since 1999. These accomplishments were largely made possible by forming partnerships between state, federal and private organizations, and the support of over a hundred public volunteers.

Addendum III Monitoring Program

Addendum III requires affected states to carry out three monitoring components. All states who do not qualify for *de minimis* status report monthly harvest numbers and subsample of portion of the catch for gender and harvest method. In addition, those states with annual landings above 5% of the coastwide harvest report all landings by sex and harvest method. Although states with annual landings between 1 and 5% of annual coastwide harvest are not required to report landings by gender, the PRT recommends all states require gender reporting for horseshoe crab harvest.

States with biomedical fisheries landings are required to monitor and report harvest numbers and mortality associated with the transportation and bleeding of the crabs. Last, states must identify spawning and nursery habitat along their coasts. All states have completed this requirement and a few continue active monitoring programs.

Virginia Tech Research Projects

The VT benthic survey was conducted for its ninth year in a row for the Delaware Bay region. The survey was unable to sample in the NY Apex in 2009 and 2011, although the area was covered in 2010. Additionally, 2010 and 2011 marked the first years that the survey included tows within lower Delaware Bay.

Major findings through the 2011 survey include: 1) relative abundance of immature horseshoe crabs in the coastal Delaware Bay area was significantly lower in 2010 and 2011 than in 2009; 2) this difference is apparently due to large numbers of small immature crabs in the peripheral region associated with later sampling in 2009; 3) relative abundances of newly mature crabs in the coastal Delaware Bay area have been consistently below peaks in 2007 (males) or 2008 (females); 4) relative abundances of mature females and males in the coastal Delaware Bay area

have not changed significantly since 2002; 5) relative abundances of horseshoe crabs in the lower Delaware Bay and coastal Delaware Bay area did not significantly differ; and 6) mean sizes of newly mature and mature horseshoe crabs have remained consistent since 2002. As part of the trawl survey in 2011, gear efficiency studies began to better estimate the trends and abundances measured over the past decade by the survey.

Through donations by the biomedical and the fishing industry, which were matched by a grant from the National Fish and Wildlife Foundation, full funding for the 2011 survey was achieved. However, funding for the survey in 2012 has still not been found, and a long-term funding solution is not solidified. The PRT stresses the importance of the survey, as it is expected to provide the most reliable estimates of horseshoe crab population abundance. Even more importantly, the PRT stresses the need for the abundance data as inputs into the newly-approved ARM Framework for management under Addendum VII.

Spawning Surveys

The redesigned spawning survey was completed for the thirteenth year in 2011; however, results for 2011 are not yet available. For 2010, no trend was detected in the baywide index of female spawning activity for the time series (1999 – 2010). There was a significant increase in the index of male spawning activity over the time series. Both male and female indices of spawning activity were precise ($CV_{\text{males}} < 20\%$; $CV_{\text{females}} < 14\%$ over the entire series). Most spawning activity was observed in May in 2010. Sex ratios observed in the surveys have increasingly favored males, which is consistent with the sex-specific trends in spawning activity. The observed spawning sex ratio in 2010 was 4.2:1.

Egg Studies

The first coordinated baywide horseshoe crab egg sampling was completed in 2005. The purpose of this survey was to provide a baywide index of horseshoe crab surface egg abundance during the spring shorebird migration. Monitoring the availability of horseshoe crab eggs throughout the Delaware Bay is an important step in managing horseshoe crabs and migratory shorebirds. Such monitoring activities may be useful in establishing harvest thresholds, guiding beach nourishment activities, setting time-of-year restrictions, etc. Prior horseshoe crab egg surveys conducted by the states of Delaware and New Jersey were not designed to provide a baywide index of egg availability to migratory shorebirds. Survey design and implementation was the result of cooperation by numerous state and federal agencies, university researchers, and input from members of the horseshoe crab stock assessment and shorebird technical committees. A long-term funding source to ensure a continuation of the survey by both states has not been identified. Details in survey reporting responsibilities and format still need to be formalized.

Though the survey has been conducted on a baywide basis since 2005, the results have not been reported regularly. Survey researchers from both sides of the Delaware Bay have met to discuss reporting details and responsibilities. Concerns were raised over the large discrepancies in mean egg abundance found on Delaware beaches versus New Jersey beaches. Although the large differences in mean egg abundance between the two sides may be real, researchers conducted side-by-side sampling in 2008 to ensure these differences were not the result of sampling and/or counting procedures. The draft report of this study, summarizing data from 2005-09, concluded that the side-by-side differences, while not statistically significant, did raise concerns about the

consistently higher counts by Delaware samplers (35%) than by New Jersey samplers. Follow up side-by-side sampling and exchange of samples for counting occurred in 2011. The results did not compare different methods of enumerating eggs (volumetric versus counting), as both groups counted eggs individually. The results, which indicated a consistently higher count of eggs in Delaware, are being investigated for different processing methods that may lead to the differences in counts seen between the two states. Overall conclusions remain that egg densities are highly variable, in terms of season, year, and spatial distribution. Further coordination of sampling effort, in order to determine the source of the discrepancies, is expected in 2012.

Delaware includes a report on their egg sampling efforts in their annual compliance report. Results from Delaware indicated an average surface egg density of 49,115 eggs/m² for 2011, a significant decrease from 2010 but in line with previous years' sampling. Conditions in 2010 were particularly optimal for spawning, which could have resulted in the large increase in egg density. Again, as in the past, the highest mean egg density (greater than 100,000 eggs/m²) occurred in Mispillion Harbor.

Tagging Studies

The USFWS continues to maintain a toll-free telephone number as well as a website for reporting horseshoe crab tag returns and assists interested parties in obtaining tags. Tagging work continues to be conducted by biomedical companies and other parties involved in outreach and spawning surveys. As noted in past PRT and other reports, the tagging efforts would benefit by establishing clearly defined objectives and insuring better coordination among researchers. To increase quality of tagging data being collected and supplied to the USFWS in Annapolis, the Horseshoe Crab Technical Committee developed guidelines for the program specifying desired distribution of tags along the coast, data requirements for tagging and resighting, effort requirements for resighting, as well as required information for applying and receiving tags. An application based on these requirements is in development. The program guidelines will give the USFWS and the managers a better understanding of taggers' objectives and data that are more applicable to existing management questions. The PRT recommends all tagging programs, approved by the state, coordinate with the USFWS tagging program, in order to ensure a consistent coastwide program for providing management input.

Since 1999, over 195,000 crabs have been tagged and released through the USFWS tagging program along the Atlantic coast. Over 10% of tagged crabs have been recaptured and reported. Crabs have been tagged and released from every state on the Atlantic Coast from Georgia to Massachusetts. In the early years of the program, tagging was centered around Delaware Bay; however, in recent years, more tagging has occurred in the Long Island Sound and the Massachusetts Coast as well as new tagging programs in South Carolina and Georgia. The Technical Committee noted that recapture rates inside and outside Delaware Bay are likely not directly comparable due to increased re-sighting effort and spawning concentration in Delaware Bay compared to other areas along the coast. There may be data in the USFWS tagging database to determine differences in effort and recapture rates.

Adaptive Resource Management Modeling

The ARM Work Group is a subset of the ASMFC Horseshoe Crab (HSC) and the former USFWS Shorebird (SHBD) Technical Committees. The ARM Work Group is chaired by Dave Smith (USGS-Leetown), with lead modeler Conor McGowan (Auburn University).

The Work Group developed models to estimate horseshoe crab harvest levels that will support the energetic needs of the red knot population passing through Delaware Bay. A peer review of the ARM framework/model in 2009 concluded it is a useful tool for management and recommended improvements as it continues refinement. The Management Board sees value in this tool and adopted its use in management through Addendum VII. Although data will be available for implementation of the ARM harvest output for the 2013 fishing season, continued implementation of the ARM Framework is uncertain due to funding challenges for the Virginia Tech Trawl Survey, the source of horseshoe crab abundance data for the model.

VI. Status of Management Measures and Issues

ASMFC

Initial state-by-state harvest quotas were established through Addendum I. Addendum III outlined the monitoring requirements and recommendations for the states. Addendum IV set harvest closures and quotas, and other restrictions for New Jersey, Delaware, Maryland, and Virginia, which were continued in Addendums V and VI.

The Board approved Addendum VII, implementation of the ARM Framework, in February 2012 for implementation in 2013. Addendum VII includes an allocation mechanism to divide the Delaware Bay optimized harvest output from the ARM Framework among the four Delaware Bay states (New Jersey, Delaware, Maryland, and Virginia east of the COLREGS). Season closures and restrictions, present within Addendum VI, remain in effect as part of Addendum VII.

Shorebird

The US Fish and Wildlife Service formed the Shorebird Technical Committee in 2001 with the purpose of providing technical advice to the Board on how horseshoe crab management action might affect shorebird populations. This Committee was comprised of shorebird experts and a representative of the Horseshoe Crab Technical Committee and Stock Assessment Subcommittee. The group produced a peer-reviewed report that synthesized current literature and data on the status of shorebirds in the Delaware Bay and to determine their energetic dependency on horseshoe crab eggs. The report's findings led to the initiation of Addendum III. In 2010 the Board decided to form the Shorebird Advisory Panel, as well as the Delaware Bay Ecosystem Technical Committee, to split the roles of value-based and technical input.

The USFWS received petitions in 2004 and 2005 to emergency list the red knot under the Endangered Species Act. In fall 2005, it determined that emergency listing was not warranted at the time. As part of a court settlement, the USFWS agreed to initiate proposed listings of over 200 species, including the red knot. Consideration for listing the red knot will occur throughout 2012, with a proposed rule expected in the fall.

The state of New Jersey upgraded the state listing of the red knot from threatened to endangered in 2012 based on recent analysis using the Delphi Technique, a method for expert opinion to consider species population and trends, productivity, survival and mortality factors, habitat requirements, and threats to populations and habitats, and come to consensus.

VII. Implementation of FMP Compliance Requirements

Currently, the PRT recommends no jurisdiction is out of compliance with regard to their 2011 horseshoe crab programs. ME, NH, PRFC, SC, GA and FL have requested and qualify for *de minimis* status. Please see the PRT report on State Compliance for more information on each state's program.

In past years, Virginia had consistent overages. Through regulatory efforts in 2011, Virginia has accounted for the 2009 and 2010 overages.

All state reports for 2012 should continue to comply with the requirements of the FMP, Addendum I, Addendum III, and Addendum VI.

Washington, D.C. was added to the HSC Management Board to close a landings loophole that existed in the late 1990s. Since then DC has adopted regulations that prohibit landings of horseshoe crabs, thereby closing the loophole. In order to free DC of the requirement to submit compliance reports, the PRT recommends DC request removal from the HSC Board. Pennsylvania was in this same situation and was removed from the Board in 2006.

In November 2011, Maine requested removal from the HSC Management Board. Until Maine can legislatively change their permitting system for horseshoe crab harvests, the PRT recommends Maine disapprove any applications for horseshoe crab bait harvest.

Law Enforcement

There were no significant law enforcement cases regarding horseshoe crabs reported by states for 2011.

VIII. Research Needs/PRT Recommendations

Funding for Research and Monitoring Activities

The PRT strongly recommends the continuation of the VT benthic trawl survey in order to provide the critical information for stock assessments and the ARM model. A long-term benthic sampling program for horseshoe crabs has been repeatedly identified as a critical stock assessment need and now an ARM necessity to continue implementation. This effort provides a statistically reliable estimate of horseshoe crab relative abundance at a relatively low cost. Congressional funding seems unlikely, and the PRT recommends seeking funding from multiple avenues, including state and federal governments, as well as industry stakeholders and non-governmental organizations.

Tagging

All entities that currently have tagging programs are encouraged to continue. The PRT recommends using USFWS tags and reporting all data to the repository in the USFWS office in Annapolis.

Biomedical Industry

According to the FMP, the Board must consider potential restrictions on biomedical harvest because estimated mortality exceeded 57,500 horseshoe crabs in 2011.

The PRT reminds states that they are required to obtain the information outlined in Addendum III. This became a requirement in 2004. Please refer to Monitoring Requirement Component A₂. States must report this information in their annual compliance reports.

The PRT recommends that the Technical Committee continue to explore opportunities to engage the biomedical companies through improved reporting and development of best management practices, especially given the increasing trend in biomedical harvest and mortality. Multiple companies are already involved with tagging horseshoe crabs. Research underway in South Carolina, considering the mortality impacts of tagging bled crabs, has preliminary results indicating no appreciable difference between rates of returns of bled and unbled animals. In addition, South Carolina Department of Natural Resources performed a biomedical mortality study in 2011 with bled and unbled crabs held in ponds. Results indicate a significant bleeding effect of 20% mortality after two weeks, which is within the range of mortality (5 – 30%) suggested by the Horseshoe Crab Technical Committee.

Adaptive Resource Management Modeling

The application and continued refinement of the ARM modeling can provide a valuable tool to guide horseshoe crab management in the Delaware Bay area and support red knot recovery. The PRT recommends the Board continue to support development and use of the ARM Framework.

IX. Literature Cited

- Leschen, A.S., and S.J. Correia. 2010. Mortality in female horseshoe crabs (*Limulus polyphemus*) from biomedical bleeding and handling: implications for fisheries management. *Marine and Freshwater Behaviour and Physiology*, 43(2): 135-147.
- Sweka, J. A., D. R. Smith, and M. J. Millard. 2007. An age-structured population model for horseshoe crabs in the Delaware Bay area to assess harvest and egg availability for shorebirds. *Estuaries and Coasts* 30(2): 277-286.
- Thompson, M. 1998. Assessments of the population biology and critical habitat for the horseshoe crab, *Limulus polyphemus*, in the South Atlantic Bight. M.S. Thesis, Medical University of South Carolina, University of Charleston, Charleston, South Carolina. 50 pp. + appendices.

Table 2. Reported commercial horseshoe crab bait landings by jurisdiction.

Jurisdiction	RPL	Addendum IV Quota	State Quota ^a	2005	2006	2007	2008	2009	2010	2011
ME ^b	13,500	13,500	-	0	0	0	0	0	0	0
NH	350	350	-	0	0	5	0	41	0	0
MA	440,503	330,377	165,000	73,740	171,906	150,829	103,963	98,332	54,782	85,573
RI	26,053	26,053/19,540	13,586	8,260	15,274	15,564	15,549	18,729	12,502	12,632
CT ^c	64,919	48,689	-	15,311	26,889	25,098	32,565	27,065	30,036	20,538
NY	488,362	366,272	150,000	155,108	172,381	298,222	148,719	123,653	124,808	146,995
NJ	604,049	100,000	0	87,250	3,444	0	0	0	0	0
PA ^d	-	0	-	0	-	-	-	-	-	-
DE	482,401	100,000	-	154,269	147,813	76,663	102,113	102,659	61,751	95,663
MD	613,225	170,653	-	169,821	136,733	172,117	163,495	165,434	165,344	167,053
PRFC	-	0	-	0	0	0	0	0	0	0
DC	-	0	-	0	0	0	0	0	0	0
VA	203,326	152,495	-	97,957	155,704	79,570	68,149	187,546	144,649	95,009
NC	24,036	24,036	-	7,713	10,331	9,300	26,191	33,025	9,938	27,076
SC	-	0	-	0	0	0	0	0	0	0
GA	29,312	29,312	-	0	0	0	0	0	0	0
FL	9,455	9,455	-	0	469	186	50	0	993	0
TOTAL	2,999,491	1,345,139		769,429	840,944	827,554	660,794	756,484	604,548	650,539
Pct. Reduction Relative to RPL				74.3	72.0	72.4	78.0	74.8	79.8	78.3
Pct. Reduction Relative to Addendum IV Quota						38.5	50.9	43.8	55.1	51.6

States that qualify for de minimis status are not required to reduce landings by 25%

^a State quotas listed for states that have adopted quotas more restrictive than ASMFC.

^b Maine was removed as a member of the Horseshoe Crab Management Board in 2011. It no longer reports landings.

^c CT landings prior to 2000 are estimated based on bait usage in the eel and conch fisheries.

^d Pennsylvania was removed as a member of the Horseshoe Crab Management Board in 2007. It no longer reports landings.

RPL = Reference Period Landings

Table 3. Commercial horseshoe crab bait landings by sex by jurisdiction.

	2003			2004			2005			2006			2007		
	Males	Females	Unknown	Males	Females	Unknown	Males	Females	Unknown	Males	Females	Unknown	Males	Females	Unknown
ME	0	0	98	0	0	0	0	0	0	0	0	0	0	0	0
NH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
MA	60,877	64,487	0	28,469	36,153	3,814	36,549	37,191	0	82,525	80,734	8,647	72,433	68,972	9,424
RI	0	0	5,824	0	0	6,030	0	0	8,260	0	0	15,274	0	0	15,564
CT	0	0	13,386	0	0	23,788	0	0	15,240	0	0	25,280	0	0	24,761
NY	66,417	67,847	0	69,275	73,004	0	83,830	71,278	0	89,992	82,389	0	154,905	129,215	0
PA	0	0	0	0	0	0	0	0	0	-	-	-	-	-	-
NJ	84,518	29,422	0	33,725	12,844	0	58,426	18,665	10,159	2,028	1,416	0	0	0	0
DE	233,878	122,502	0	83,380	43,074	754	104,940	49,329	0	120,952	26,861	0	76,663	0	0
MD	95,792	73,073	0	96,955	64,973	0	108,707	61,114	0	46,833	89,900	0	70,568	101,549	0
PRFC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VA	28,862	56,940	20,775	19,344	41,987	33,382	28,825	44,296	24,836	61,597	70,768	23,339	39,017	39,203	1,350
NC	0	0	24,367	0	0	9,437	0	0	7,462	0	0	10,331	0	0	7,091
SC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FL	0	0	1,628	0	0	0	0	0	0	0	0	469	0	0	186
Total	570,344	414,271	66,078	331,148	272,035	77,205	421,277	281,873	65,957	403,927	352,068	83,340	413,586	338,939	58,381
Grand Total	1,050,693			680,388			769,107			839,335			810,906		

	2008			2009			2010			2011 Preliminary		
	Males	Females	Unknown	Males	Females	Unknown	Males	Females	Unknown	Males	Females	Unknown
ME	0	0	0	0	0	0	0	0	0	0	0	0
NH	0	0	0	0	0	41	0	0	0	0	0	0
MA	48,046	53,764	2,153	42,343	48,040	7,949	13,086	21,390	20,306	0	0	85,573
RI	0	0	15,549	9,835	7,064	1,830	6213	4851	1,438	6,493	6,139	0
CT	0	0	32,535	0	0	27,065	0	0	29,387	0	0	20,538
NY	78,581	67,353	2,785	60,961	60,670	2022	59,270	65,518	20	76,144	69,594	1,257
NJ	0	0	0	0	0	0	0	-	0	0	0	0
DE	102,113	0	0	102,659	0	0	61,751	0	0	95,663	0	0
MD	97,237	66,258	0	114,134	50,698	602	114,134	50,698	602	131,375	35,568	110
PRFC	0	0	0	0	0	0	0	0	0	0	0	0
DC	-	-	-	-	-	-	-	-	-	-	-	-
VA	29,756	23,529	14,864	112,654	64,892	0	87,629	55,031	1,989	58,930	36,079	0
NC	0	0	26,191	0	0	33,025	0	0	9,938	0	0	27,076
SC	0	0	0	0	0	0	0	0	0	0	0	0
GA	0	0	0	0	0	0	0	0	0	0	0	0
FL	0	0	50	0	0	0	0	0	993	0	0	0
Total	355,733	210,904	94,127	442,586	231,364	72,534	342,083	197,488	64,673	368,605	147,380	134,554
Grand Total	660,764			746,484			604,244			650,539		

Figure 1. Coastwide horseshoe crab landings for bait expressed as number of crabs.

