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Mating In The Moonlight: The Battle To Save The American Horseshoe Crab

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MATING IN THE MOONLIGHT: THE BATTLE TO SAVE THE AMERICAN HORSESHOE CRAB

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> *"To waste, to destroy our natural resources, to skin and exhaust the land instead of using it so as to increase its usefulness, will result in undermining in the days of our children the very prosperity which we ought by right to hand down to them amplified and developed."*
>
> -Theodore Roosevelt

I. INTRODUCTION

Horseshoe crabs have survived largely unchanged for over 350 million years.[1] Their ancestors saw the dinosaurs rise and fall; they outlasted ice ages, asteroid impacts, and climate changes. However, despite demonstrating a remarkable ability to survive such adversity, the existence of the horseshoe crab is now threatened by human activities.[2] Since the early 1990s, horseshoe crabs along the Atlantic seaboard of the United States have been in increasing demand by both the biomedical and commercial fishing industries. While horseshoe crabs were once abundant along the seaboard, overuse of the horseshoe crab resource by these industries has caused a significant decline in their population.[3] Biomedical companies refine horseshoe crab blood to produce a clotting agent that facilitates the easy detection of toxins in injectable drugs and medical implants before they are sold to the public.[4] At the same time,

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1. Jim Berkson & Carl N. Shuster, Jr., *The Horseshoe Crab: The Battle for a True Multiple-Use Resource*, 24 FISHERIES 6, 6 (1999).
2. WILLIAM SARGENT, CRAB WARS 114 (2002).
3. Carl N. Shuster, Jr. et. al., *Horseshoe Crab Conservation: A Coast Wide Management Plan, in* THE AMERICAN HORSESHOE CRAB 358, 358-359, 367 (Carl N. Shuster, Jr. et al. eds., 2003).
4. Berkson & Shuster, *supra* note 1, at 7.

commercial fishermen harvest horseshoe crabs to bait their eel pots and whelk traps.[5] It is not only human interests, however, that depend on the continuing abundance of horseshoe crab populations. Migratory birds, such as the Red Knot, rely on horseshoe crab eggs as nourishment, enabling them to complete their long migrations to arctic breeding grounds.[6]

Due to these intertwined and varied uses, the decline of the horseshoe crab population has spurred interest from a diverse range of people, including birders, environmentalists, commercial fishermen, eco-tourists, biomedical companies, coastal residents, and local business owners.[7] Over the past two decades, these competing interests have resulted in a battle that will determine the future of the horseshoe crab species. Conservation efforts have faced additional challenges because of the horseshoe crab's long maturation time, its ease of harvesting, and the difficulties in determining its population size.

The Atlantic States Marine Fisheries Commission[8] (ASMFC) developed a fishery management plan for the horseshoe crab resource in the late 1990s, which it has amended multiple times since then. Although the plan has been moderately successful in stopping the rapid decline of the species, more must be done at both state and federal levels to restore the horseshoe crab population to a healthy size and preserve the resource for future generations.

In Part II, this Comment will explore the history and biology of the horseshoe crab, including its current uses by the biomedical and fishing industries. Part III of this Comment will examine the various state and federal regulatory attempts at conservation. Part IV will examine the effectiveness of governmental conservation efforts to date. Finally, Part V will explore future possibilities and previously overlooked solutions to horseshoe crab conservation issues.

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5. Mark L. Botton, *Horseshoe Crabs,* 49 BIOLOGIST 193, 196-97 (2002).

6. Lawrence J. Niles et al., *Effects of Horseshoe Crab Harvest in Delaware Bay on Red Knots: Are Harvest Restrictions Working?*, 59 BIOSCIENCE 153, 153 (2009).

7. Berkson & Shuster, *supra* note 1, at 6.

8. *See* Press release, Atlantic Marine Fisheries Commission, Horseshoe Crab Board Initiates Addendum VII to Implement Adaptive Management (Aug. 4, 2011), *available at* http://www.asmfc.org ("The Atlantic States Marine Fisheries Commission was formed by the 15 Atlantic coastal states for the promotion and protection of coastal fishery resources. The Commission serves as a deliberative body of the Atlantic coastal states, coordinating the conservation and management of nearshore fishery resources, including marine, shell and anadromous species.").

II. BACKGROUND AND HISTORY

A. Biology

Horseshoe crabs have long fascinated scientists because their evolution appears to have come to a standstill despite the passage of millions of years.[9] As one researcher remarked, "[h]orseshoe crabs are paradigms of living fossils, with examples of distant relatives dating back to the Cambrian."[10] In fact, if one were to look at a 150-million-year-old fossil of *Mesolumulus walchi*, an ancient ancestor of the modern horseshoe crab, it would appear to be so similar to modern-day horseshoe crabs that one could easily be confused for the other.[11] The modern horseshoe crab, like its ancestors, has an easily identifiable three-part skeletal structure.[12] A dome-shaped prosoma protects the crab's mouthparts, legs, and major organs, and also houses the crab's brain and eyes.[13] Behind the parsoma, a slightly flatter section with protruding spines and sensors encases the crab's gills.[14] Lastly, the ominous looking horseshoe crab tail, or telson, is used by the crab not as a weapon, but as a means to right itself if it is overturned.[15]

Despite the misleading name, horseshoe crabs are not crabs at all, but are included in the subphylum Chelicerata, more closely related to spiders, ticks, and scorpions than modern crabs.[16]

There are four species of horseshoe crabs in the world today, three of which are found throughout Southeast Asia, from India to Japan.[17] The fourth species, the Atlantic Horseshoe Crab, inhabits the waters from Mexico's Yucatan peninsula to the State of Maine, and is the largest and

9. PBS Documentary, *Nature*: *Crash: A Tale of Two Species* (Argo Films and Thirteen/WNET New York, 2008), *available at* http://video.pbs.org/video/1200406235/ [hereinafter PBS Documentary].

10. Botton, *supra* note 5, at 193.

11. *Id.* (explaining that even though *Mesolumulus* was somewhat flatter than our modern horseshoe crab, the basic body structures are remarkably similar.)

12. Carl N. Shuster, Jr. & Lyall I. Anderson, *A History of Skeletal Structure: Clues to Relationships Among Species, in* THE AMERICAN HORSESHOE CRAB, *supra* note 3, at 157-59.

13. Botton, *supra* note 5, at 193.

14. *Id.*

15. *Id*.

16. Botton, *supra* note 5, at 193. Unlike true crabs, horseshoe crab exoskeletons are not mineralized. The shells consist solely of chitin and thus decompose more easily than crab shells, which incorporate calcium carbonate. This might explain the relative absence of a fossil record for such an ancient species. *Id.* at 194.

17. *Id.* at 193.

most abundant of the species.[18] One factor aiding the horseshoe crab in its perseverance throughout the millennia is that they are "ecological generalists."[19] Horseshoe crabs "can tolerate wide fluctuations in temperature, salinity, and other physical variables . . . and are not tied to highly specialized habitats or food resources."[20]

Each spring, as they have done for a hundred million years, horseshoe crabs migrate from deeper water to the Atlantic shorelines and estuaries to lay their eggs during the high tides of the full and new moon phases.[21] At night, female horseshoe crabs emerge from the water, frequently with a male already clasping to their shell, and will spawn approximately 80,000 of their eggs, in batches of 2,000 to 4,000, within a few days.[22] Females lay their eggs ten to twenty centimeters below the surface and then drag attached males over the eggs to fertilize them.[23] After about a month buried in the sand, surviving eggs reach their trilobite larval stage and return to the sea with the help of high tides.[24] However, these young horseshoe crabs will not reach sexual maturity, and therefore be unable to breed, for another decade as they transform through eighteen developmental stages.[25]

B. The Horseshoe Crab "Resource"

1. Historical Uses

Humans have used the abundant horseshoe crab as a resource throughout the history of North America. Early uses by Native Americans included using horseshow crab tails as spearheads and fertilizing fields with horseshoe crab remains.[26] This latter use was adopted by Colonial Americans, who used horseshoe crabs as field fertilizer as well as chicken feed.[27] The current decline in the horseshoe

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18. *Id.*
19. *Id.*
20. *Id.*
21. H. Jane Brockmann, *Nesting Behavior: A Shoreline Phenomenon, in* THE AMERICAN HORSESHOE CRAB, *supra* note 3, at 33-36.
22. *Id.* at 34.
23. *Id.*
24. Botton, *supra* note 5, at 195.
25. Carl N. Shuster, Jr. & Koichi Sekiguchi, *Growing up Takes About Ten Years and Eighteen Stages, in* THE AMERICAN HORSESHOE CRAB, *supra* note 3, at 103, 117-123; Botton, *supra* note 5, at 195.
26. SARGENT, *supra* note 2, at 67.
27. *Id.*

crab population is certainly not the first to be created by humans. From the mid-1800s until the early 1960s, horseshoe crabs were caught, ground up, and used for fertilizer or livestock feed on a previously unprecedented scale.[28] Ironically, because horseshoe crabs are easily "trapped in pound nets and get caught in seines and trawls," many commercial fishermen have historically considered them a nuisance.[29] By the early 1960s, due to declining horseshoe crab populations, competition from alternative fertilizers, and public health and nuisance concerns, commercial horseshoe crab fishing on the Atlantic seaboard had largely ceased.[30] Consequently, between the 1960s and the early 1990s, populations of horseshoe crabs rebounded significantly.[31]

2. Biomedical Industry

Horseshoe crabs have a long history of use by the biomedical industry. For over seventy years, horseshoe crab eyes have been considered valuable experimental models in vision research.[32] However, it was not until the mid-1960s that scientists began to discover new and valuable uses for these living fossils. During that time, Jack Levin and Frederik Bang developed a technique to use modified horseshoe crab blood to detect bacterial contamination in pharmaceuticals, intravenous medications, and implanted prosthetic devices.[33] Horseshoe crab blood is a pale blue color due to its copper-based respiratory protein, hemocyanin.[34] Unlike mammalian blood, horseshoe crab blood contains only one type of blood cell, an amoebocyte.[35] When a horseshoe crab is injured and bacteria enters its blood, these cells "undergo exocytosis and release their contents into the external environment," which causes the cells to coagulate and produce a type of blood clot.[36] This clotting helps seal off the wound and traps bacteria, resulting in one of the earliest

28. Berkson & Shuster, *supra* note 1, at 7.
29. *Id*.
30. *Id*.
31. *Id*.
32. M. Errigo et al., *Visually Guided Behavior of Juvenile Horseshoe Crabs*, 201 BIOLOGICAL BULL. 271, 271 (2001).
33. Botton, *supra* note 5, at 196.
34. *Id*.
35. Peter B. Armstrong, *Internal Defense Against Pathogenic Invasion: The Immune System, in* THE AMERICAN HORSESHOE CRAB, *supra* note 3, at 288, 290.
36. Botton, *supra* note 5, at 196; Jack Levin et al., *Clotting Cells and Limulus Amebocyte Lysate*, *in* THE AMERICAN HORSESHOE CRAB, *supra* note 3, at 310, 314-15.

evolutionary examples of an immune system.[37] It was through the use of this immune-like function that Jack Levin and Frederik Bang were able to create a new biomedical industry.

Up until the 1960s, pharmaceutical and biomedical companies tested injectable drugs and implantable medical devices for contamination by toxins, like gram-negative bacteria, on large colonies of live rabbits.[38] If after the administration of a sample the rabbit developed a fever, the sample was contaminated.[39] However, this method was costly, sometimes inaccurate, and created poor publicity.[40] By the 1970s, horseshoe crab blood was being refined into *Limulus* amebocyte lysate (LAL) and could be used to detect bacterial contamination faster, more accurately, and at a cheaper rate than that of the rabbit colonies.[41] In 1977, after a decade of research, the U.S. Food and Drug Administration (FDA) finally approved and licensed the use of LAL for toxin detection.[42] LAL is now the primary method used in Europe and North America to test for endotoxins pathogenic to humans.[43]

Since the FDA's approval, the use of horseshoe crabs by the biomedical industry has steadily increased. In 1989, 130,000 crabs were caught and bled, and by 1997, that number was over 260,000.[44] By 2010, over half a million crabs were caught each year for use in the biomedical industry.[45] Horseshoe crabs can be successfully bled without injury to the crab and the FDA regulations require that the crabs be returned to the water as soon as possible after bleeding.[46] Although certainly not as destructive to the horseshoe crab population as the commercial bait industry, discussed below, horseshoe crabs nevertheless suffer a significant mortality rate during the bleeding process. Studies vary, but it is estimated that fifteen to thirty percent of horseshoe crabs ultimately do not survive the bleeding process.[47]

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37. Botton, *supra* note 5, at 196; Peter B. Armstrong, *Internal Defense Against Pathogenic Invasion: The Immune System, in* THE AMERICAN HORSESHOE CRAB, *supra* note 3, at 288, 288.

38. Jack Levin et al., *supra* note 36, at 316.

39. *Id*.

40. *See id*. at 316-318; *see also* Botton, *supra* note 5, at 196.

41. Botton, *supra* note 5, at 196.

42. Jack Levin et al., *supra* note 36, at 326.

43. Botton, *supra* note 5, at 196.

44. Berkson & Shuster, *supra* note 1, at 7.

45. SHEILA EYLER ET AL., ATL. STATES MARINE FISHERIES COMM'N, 2011 REVIEW OF THE FISHERY MANAGEMENT PLAN IN 2010 FOR HORSESHOE CRAB 6 (2011).

46. Jack Levin et al., *supra* note 36, at 328.

47. EYLER ET AL., *supra* note 45, at 5.

The economic revenue created by horseshoe crabs for the biomedical industry far out-shadows all other horseshoe crab resource uses.[48] Of the estimated $260 million generated annually by horseshoe crab-related industries, over $220 million was attributed to the biomedical industry.[49] Additionally, the biomedical industry pays ten times the price for a live horseshoe crab than a horseshoe crab fisherman can hope to obtain for a dead crab sold as bait.[50] However, even this drastic price differential has not stopped the commercial bait fishery.

3. Commercial Bait Fishery

Since World War II, the primary use of horseshoe crabs by the commercial fishing industry is for bait to catch American eel, whelk (commonly referred to as conch), and catfish. [51] Through the second half of the 20th century, as other ground fisheries became more regulated, fishermen increasingly harvested horseshoe crabs for bait, a process that was substantially less regulated, and in some areas, completely unregulated.[52] Large egg-bearing females made the best eel bait and were harvested preferentially.[53] Unfortunately, these mature females were also the crabs that were best able to replenish the now rapidly dwindling population. From 1992 to 1997, reported crab harvests grew twenty-fold from about 100,000 per year to a high of over 2 million, but during this time no states had mandatory reporting of horseshoe crab landings, therefore the accuracy of these figures is uncertain.[54] This unregulated bait harvesting was exacerbated by two dangers which make horseshoe crabs particularly vulnerable to overfishing. First, "horseshoe crabs are easily harvested with minimal financial investment."[55] Second, it takes at least ten years for crabs to reach sexual maturity, creating a great time lag in population recovery.[56]

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48. Carl N. Shuster, Jr., *Horseshoe Crab Conservation: A Coast-Wide Management Plan*, *in* THE AMERICAN HORSESHOE CRAB*, supra* note 3, at 358, 358-359.
49. *Id*. at 359.
50. SARGENT, *supra* note 2, at 114.
51. Berkson & Shuster, *supra* note 1, at 7.
52. *Id*.
53. Botton, *supra* note 5, at 196.
54. Niles et al., *supra* note 3, at 153.
55. Berkson & Shuster, *supra* note 1, at 8.
56. *Id*.

4. Migratory Shorebirds: "Green Eggs and Sand"[57]

Bait fishermen and biomedical companies are not the only ones who depend on the continued abundance of the horseshoe crab for their survival; so do migratory shorebirds, such as the Red Knot. Each spring, the Red Knot embarks on its annual migration from southern Argentina to the Arctic, covering over 18,000 miles.[58] This journey is "one of the longest distance migrations in the animal kingdom."[59] The Red Knot's last stopover before reaching its Arctic breeding grounds is the Delaware Bay, where it consumes enormous quantities of horseshoe crab eggs to refuel before the last leg of its journey.[60] This nutrient-rich food source is crucial for the Red Knot's survival and successful breeding because food is scarce when they arrive in the Arctic.[61] Additionally, the horseshoe crab's eggs are a particularly important food resource for long-distance migratory birds like the Red Knot because they are an easily accessible and digestible food source.[62] After a long flight from South America, the Red Knot's digestive organs are shrunken and initially unable to digest its normal food source, hard-shelled bivalves.[63] Therefore, it is of particular importance to these birds that they have plentiful horseshoe crab eggs available.[64]

Red Knots are not the only migrating shorebirds that use the Delaware Bay as a stopover, and horseshoe crab eggs as a primary food source; it is estimated that over one million shorebirds migrate through the Bay during the spring months.[65] The largely unregulated harvesting of horseshoe crabs during the 1990s "led to a dramatic decrease in spawning crabs and thus in the availability of crab eggs for shorebirds."[66] Consequently, the numbers of shorebirds began to decline; "peak counts of knots in 2003-2007 averaged 66% less than counts for 1998-2002."[67]

57. Niles et al., *supra* note 6, at 155.

58. *Id*. at 153.

59. Jeffery B. Hyman et al., *Symposium: Animal Migration Conservation*, 41 ENVTL. L. 407, 419 (2011).

60. *See* Niles et al., *supra* note 6, at 153.

61. *Id*.

62. *Id.* at 154.

63. *Id*.

64. *Id*.

65. *Id.* Aside from the Red Knot, there are five species of shorebirds that rely on a migratory stopover in the Delaware Bay including the Ruddy Turnstone, Sanderling, Dunlin, and the Short Billed Dowitcher. *Id*. at 153.

66. *Id*. at 153-154.

67. *Id.* at 154. In 2006, the United States Fish and Wildlife Service responded to a petition to list the Red Knot under the Endangered Species Act by stating that listing the

The peculiarities of the shorebird's egg feeding may be partly responsible for this rapid decline. Horseshoe crabs lay their eggs fifteen to twenty centimeters below the surface of the sand; at this depth they are inaccessible to shorebirds.[68] These eggs are sometimes brought to the surface by wave action, but more often by other female horseshoe crabs as they bury their own clutch of eggs.[69] Accordingly, "[w]ithout a large population of horseshoe crabs, most eggs remain buried and unavailable to shorebirds."[70] Red Knot populations, like those of horseshoe crabs, are also being negatively affected by collateral human activities, such as shoreline projects and beach development.[71] These activities limit the breeding grounds available to the horseshoe crab and disrupt the bird's feeding habits.[72]

The rapid decline of the Red Knot population in the late 1990s has helped bring attention to the horseshoe crab resource problem.[73] A life-long observer and researcher of horseshoe crabs, William Sargent, commented that one should "[n]ever underestimate the persistence of birders."[74] It is largely due to the tireless efforts of those interested in protecting the feeding grounds of migratory shorebirds that great measures have been taken to protect horseshoe crabs.[75]

Each spring, with the arrival of horseshoe crabs and migrating shorebirds, thousands of eco-tourists flock to the mid-Atlantic coastal states to observe the abundance of natural wildlife.[76] Migrating shorebirds, and to a lesser extent, horseshoe crabs, have generated an eco-tourism industry for the Delaware Bay area with revenue estimated at $34 million per year.[77] Similar revenue estimates from Cape May, New Jersey range from $7 to $10 million dollars annually.[78] Local businesses, which rely on this influx of seasonal tourism, have been hit hard by the rapid decline of the shorebirds and horseshoe crabs.[79] With the backdrop of these various competing interests, the battle for the

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Red Knot as threatened was "warranted but precluded by other, higher priority activities." Hyman et al., *supra* note 59, at 420.

68. Niles et al., *supra* note 6, at 155.
69. *Id*.
70. *Id*.
71. Hyman et al., *supra* note 59, at 420.
72. *Id*.
73. SARGENT, *supra* note 2, at 78-85.
74. *Id.* at 82.
75. *Id*.
76. Shuster, *supra* note 48, at 361.
77. Niles et al., *supra* note 6, at 153.
78. Shuster, *supra* note 48, at 361-362.
79. PBS Documentary, *supra* note 9.

protection and conservation of horseshoe crabs has been complicated and hard fought.

III. CONSERVATION

A. Initial Conservation Attempts

Prior to the 1990s, although the use of the horseshoe crab resource had been dramatically increasing, little had been done to regulate or manage the crab fishery.[80] By the early 1990s, the need for a management plan protecting the horseshoe crab on the Atlantic seaboard was becoming increasingly apparent, especially in light of the affected shorebird populations.[81] Early on in the controversy, the most affected states, including New Jersey, Delaware, and Maryland, began placing restrictions on the number of horseshoe crabs harvested.[82] South Carolina has prohibited all harvesting of horseshoe crabs, except for harvesting by the biomedical industry, since 1991.[83]

However, these initial regulations were only marginally effective, due to enforcement problems and ease of evasion.[84] For example, fishermen could simply catch horseshoe crabs in one of the regulated state's waters and then land their catch in an unregulated port.[85] Additionally, even when horseshoe crabs were collected in an unregulated state's waters, the "impact on other horseshoe crab populations was soon felt up and down the Atlantic coast."[86] As tensions between bait fishermen and conservationists escalated, it became apparent that there was simply not enough data for either side to reliably estimate the status of the horseshoe crab population.[87] Fishermen "believed that the crabs were just as numerous as they had ever been," while conservationists maintained that the crabs were declining at a dangerous rate.[88] This brewing controversy led to the creation of a coast-wide management plan.

80. Shuster, *supra* note 48, at 374.
81. *Id*. at 366.
82. *Id. at* 368; *see also* Berkson & Shuster, *supra* note 1, at 8.
83. ATL. STATES MARINE FISHERIES COMM'N, INTERSTATE FISHERY MANAGEMENT PLAN FOR HORSESHOE CRAB 5 (1998) [hereinafter ASMFC 1998 PLAN].
84. *See* Shuster, *supra* note 48, at 368.
85. *See id.*
86. *Id.* at 366.
87. *Id.* at 367-68.
88. *Id.* at 367.

B. Atlantic States Marine Fisheries Commission (ASMFC) 1998 Plan

In 1997, the ASMFC organized a task force to develop a plan to manage the horseshoe crab fisheries throughout the Atlantic seaboard.[89] In 1998, the task force presented its report to the ASMFC, outlining a conservation plan and providing a recommendation that extensive studies be performed to assess the resource and the effect upon it from human activities.[90] An annual volunteer effort to determine the spawning populations of horseshoe crabs had been underway since 1990, but it lacked the resources to produce sufficient data on which to base a coast-wide plan.[91] The ASMFC fully adopted the recommended Horseshoe Crab Fisheries Management Plan (FMP) in 1998.[92] The four major goals of this plan were: "to conserve and protect the horseshoe crab resource, to maintain sustainable levels of spawning stock biomass, to ensure the continued role of *Limulus* in the ecology of coastal ecosystems, and to provide for continued use of horseshoe crabs over time."[93] The FMP seeks to manage the horseshoe crab resource for continued use by fishermen, the non-fishing public, the biomedical industry, migrating shorebirds, and other dependent wildlife.[94]

To accomplish these objectives, the FMP laid out a multifaceted approach at both the state and federal levels.[95] In alignment with the original task force's recommendations, the FMP stated that "a comprehensive monitoring plan must be instituted throughout the Atlantic Coast."[96] This monitoring plan was designed to overcome one of the greatest obstacles facing horseshoe crab conservation—that the dynamics of the horseshoe crab population "are poorly understood due to the limited amount of information collected regarding stock levels."[97] This monitoring program would include mandatory monthly reporting by horseshoe crab harvesters, surveys of spawning horseshoe crab numbers and egg density, evaluations of mortality rates after biomedical bleeding, and habitat identification research.[98] The monitoring of spawning populations of horseshoe crabs is "difficult because spawning crabs can

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89. *Id.* at 374.
90. *See* ASMFC 1998 PLAN, *supra* note 83.
91. Berkson & Shuster, *supra* note 1, at 8.
92. ASMFC 1998 PLAN, *supra* note 83, at 5.
93. Shuster, *supra* note 48, at 375.
94. *See* ASMFC 1998 PLAN, *supra* note 83, at iii.
95. *See id*., at iii-iv.
96. *Id.* at iv.
97. *Id.* at iii.
98. *Id.* at iv.

be found throughout hundreds of miles of beaches only a few weeks a year, and their distribution among beaches can change dramatically from season to season and from year to year based on weather and other factors."[99] After this short breeding season, the crabs return to deeper waters off the continental shelf and are even more difficult to accurately count.[100]

As part of the FMP, each state would be "responsible for implementing management measures and protecting horseshoe crab habitat within its jurisdiction."[101] These measures were to include developing a cap on landings for commercial bait fishermen and perhaps a two-day per week fishery closure period between April 15 and June 15—the peak crab-spawning months.[102] States that already had laws and regulations related to the horseshoe crab fishery were to keep those in effect.[103] The plan focused on protecting vital "spawning beaches and juvenile nursery habitat" in order to ensure the future of the resource.[104] The FMP also suggests that states should consider buying land next to spawning beaches, protecting such areas through deed restrictions, or establishing conservation easements to ensure that the protection efforts have long-term stability.[105] Finally, the prohibition of all-terrain vehicle and beach watercraft from these beaches was strongly encouraged.[106]

1. Compliance

Although some sections of the plan were merely suggestions to the states on how to address this problem, compliance with much of the FMP is mandatory under federal law.[107] Under the authority of the U.S. Secretary of Commerce, "upon completion and approval of a management plan, states are obliged to implement its requirements."[108] If a state fails to comply with the FMP, the Secretary has the power to "impose a moratorium on that state's particular fishery."[109]

99. Berkson & Shuster, *supra* note 1, at 8.
100. Shuster, *supra* note 48, at 369-370.
101. ASMFC 1998 PLAN, *supra* note 83, at iv.
102. *Id*.
103. *Id*.
104. *Id*.
105. *Id*.
106. *Id*.
107. *See* 16 U.S.C.A. § 5103 (2012).
108. ASMFC 1998 PLAN, *supra* note 83, at 30.
109. *Id*.

2. Addendums to the 1998 Fishery Management Plan for the Horseshoe Crab

Since the initial 1998 FMP, there have been six major changes to the plan, each taking the form of a new addendum.[110] Before any addendum is approved by the ASMFC Horseshoe Crab Management Board, supporting information is made available to the public and presented at state public hearings.[111] After the Management Board reviews the information from these public hearings, along with recommendations from a technical committee and an advisory board, it can approve the addendum for implementation.[112]

The Management Board was required by the initial 1998 FMP to "develop a cap on landings for commercial bait fisheries . . . to be implemented in 2000 through the adaptive management procedures."[113] Pursuant to this requirement, the Management Board approved Addendum I to the FMP in the spring of 2000.[114] This addendum "established a state-by-state cap on horseshoe crab bait landings at twenty-five percent below the reference period landings (RPLs), and *de minimis* criteria for those states with a limited horseshoe crab fishery."[115] The RPLs were meant to be based on state-reported landings between 1995 and 1997, but because many states did not have reliable landing data for that time period, they were allowed to use data from 1998, 1999, or average yearly data from the various available years.[116] The addendum also "encourage[d] states with more restrictive harvest levels to maintain those regulations, until such time that the state comes forward with a plan for adjusting their harvest that has been reviewed by the Technical Committee and approved by the Management Board."[117] Additionally, Addendum I included two recommendations to the National Marine Fisheries Service (NMFS).[118] First, the NMFS was encouraged to establish an area in federal waters within a thirty nautical mile radius of the mouth of the Delaware Bay, where all harvesting of

110. *See* EYLER ET AL., *supra* note 45, at 2.
111. *See, e.g.*, ATL. STATES MARINE FISHERIES COMM'N, ADDENDUM I TO THE FISHERY MANAGEMENT PLAN FOR HORSESHOE CRAB 3 (2000) [hereinafter ADDENDUM I].
112. *See, e.g., id.*
113. ASMFC 1998 PLAN, *supra* note 83, at 26.
114. ADDENDUM I, *supra* note 111, at 3.
115. EYLER ET AL., *supra* note 45, at 2.
116. ADDENDUM I, *supra* note 111, at 4-7.
117. *Id.* at 5.
118. *Id.*

horseshoe crabs, for any purpose, would be prohibited.[119] Second, "the NMFS should prohibit the transfer of horseshoe crabs at sea in federal waters."[120]

The *de minimis* status was established so as to not unduly burden states with minimal horseshoe crab populations, and therefore, little impact on the goals of the FMP.[121] The ASMFC defines *de minimis* as "a situation in which, under existing condition of the stock and scope of the fishery, conservation, and enforcement actions taken by an individual state would be expected to contribute insignificantly to a coast-wide conservation program required by a Fishery Management Plan or amendment."[122] To qualify for this status, a state must show that its combined average of horseshoe crab landings for the past two years is less than one percent of the total coast-wide crab bait landings.[123] Once qualified, a state is "not required to implement any horseshoe crab harvest restriction measures," but is required to comply with the FMP monitoring programs.[124] However, all states subject to the FMP, regardless of their status, are required to have "adequate law enforcement capabilities for successfully implementing the jurisdiction's horseshoe crab regulations."[125]

In the spring of 2001, the Management Board approved the second addendum to the FMP.[126] This addendum was in response to the problem that "[s]tates that have traditionally imported crabs . . . may have difficulty obtaining enough crabs to meet their bait demand."[127] This addendum instituted a quota transfer program to alleviate the bait shortages, whereby one state could transfer its extra horseshoe crab harvest to states that fell below their harvest landings cap.[128] The ASMFC wanted the program to be implemented on a "biologically responsible basis"; thus, all quota transfers were subject to review and approval by the Technical Committee and Management Board.[129]

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119. *Id*.
120. *Id*.
121. *See id*.
122. *Id*.
123. *Id*.
124. *Id*.
125. *Id.* at 6.
126. ATL. STATES MARINE FISHERIES COMM'N, ADDENDUM II TO THE FISHERY MANAGEMENT PLAN FOR HORSESHOE CRAB 1 (2001) [hereinafter ADDENDUM II].
127. *Id*.
128. *See id.* at 1-2.
129. EYLER ET AL., *supra* note 45, at 2.

In the three years following Addendum II, several new developments necessitated a new addendum.[130] First, the U.S. Fish and Wildlife Service (USFWS) completed its report to the Management Board emphasizing the rapid decline of migratory shorebird populations and their critical reliance on horseshoe crab eggs.[131] Second, the Technical Committee realized that there were inefficiencies and problems related to the current biomedical industry regulations and coast-wide monitoring programs.[132] To address the migratory shorebird issues and protect the fishery, Addendum III "further reduce[d] commercial harvest of horseshoe crabs for bait in and around the Delaware Bay" by lowering the landings cap in Delaware, Maryland, and New Jersey.[133] The addendum also established a "closed season" for bait harvest in those three states, which prohibited "the harvest and landing of horseshoe crabs for bait" for a month during the crab's breeding season.[134] Furthermore, monitoring programs were revised to provide more accurate population data and to fill gaps in research on areas such as juvenile crabs.[135]

Addendum III also legitimized a practice that had been in place for years, where commercial bait fisherman bought horseshoe crabs that had just been bled by the biomedical industry off the trucks as they were supposedly being returned to the ocean in accordance with the FMP regulations.[136] Recognizing that the transportation of bled crabs to the ocean was causing unnecessary mortality and waste, the ASMFC formally adopted the practice of allowing bled crabs to enter the bait market.[137]

Two years later, in response to increasing concerns over the decline of the Red Knot and other migratory shorebird populations, and recommendations from the USFWS, the ASMFC approved Addendum

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130. ATL. STATES MARINE FISHERIES COMM'N, ADDENDUM III TO THE FISHERY MANAGEMENT PLAN FOR HORSESHOE CRAB 3 (2004) [hereinafter ADDENDUM III].

131. *Id*. at 3-4; U.S. FISH AND WILDLIFE SERV. SHOREBIRD TECHNICAL COMM., DELAWARE BAY SHOREBIRD-HORSESHOE CRAB ASSESSMENT REPORT AND PEER REVIEW 3 (2003) [hereinafter DELAWARE BAY REPORT].

132. ADDENDUM III, *supra* note 130, at 4-5.

133. *Id*. at 5.

134. *Id*. at 5-6.

135. *Id*. at 5.

136. SARGENT, *supra* note 2, at 106; *see also* ADDENDUM III, *supra* note 130, at 4. The 1998 FMP required that "Horseshoe crabs taken for biomedical purposes shall be returned to the same state or federal waters from which they were collected." ASMFC 1998 PLAN, *supra* note 83, at 27.

137. ADDENDUM III, *supra* note 130, at 4.

IV.[138] Adopted in the spring of 2006, this addendum further limited bait harvest levels in New Jersey and Delaware, prohibited bait harvests from January to June in many states, and prohibited female crab harvesting altogether in some areas.[139] As with previous restrictions, biomedical companies were largely exempted.[140] These new restrictions were set to expire in the fall of 2008.[141]

However, concerns over the Red Knot's possible extinction persisted and, in 2008, the Management Board approved Addendum V, which ultimately extended Addendum IV's restrictions through October 2010.[142] Then, in the summer of 2010, the Management Board approved Addendum VI, further extending Addendum IV's restrictions through April of 2013.[143] In February of 2012, the ASMFC issued a press release announcing the approval of Addendum VII to the FMP.[144] The addendum "implements the Adaptive Resource Management (ARM) Framework, which incorporates both shorebird and horseshoe crab abundance levels to set optimized horseshoe crab harvest levels for the Delaware Bay area."[145] The stated goal of the ARM was to "transparently incorporate the views of stakeholders along with predictive modeling to assess the potential consequences of multiple, alternative management actions."[146] An overview of the ARM framework is as follows:

> ARM involves several steps: 1) building models that make predictions about how a system will respond to management actions, 2) implementing management actions based on those predictions, 3) monitoring the ecosystem to evaluate the accuracy of model predictions, 4) inserting new data into the

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138. ATL. STATES MARINE FISHERIES COMM'N, ADDENDUM IV TO THE FISHERY MANAGEMENT PLAN FOR HORSESHOE CRAB 2 (2006) [hereinafter ADDENDUM IV].

139. *Id*. at 4.

140. *Id*. at 4-5.

141. *Id*. at 4.

142. ATL. STATES MARINE FISHERIES COMM'N, ADDENDUM VI TO THE FISHERY MANAGEMENT PLAN FOR HORSESHOE CRAB 1 (2010) [hereinafter ADDENDUM VI]; *see also* EYLER ET AL., *supra* note 45, at 2.

143. EYLER ET AL., supra note 45, at 2; ADDENDUM VI, *supra* note 142, at 2.

144. Press Release, Atl. Marine Fisheries Comm'n, Horseshoe Crab Board Approves Addendum VII (Feb. 9, 2012), *available at* http://www.asmfc.org [hereinafter ASMFC Press Release].

145. *Id.*

146. ATL. STATES MARINE FISHERIES COMM'N, ASMFC STOCK ASSESSMENT OVERVIEW: HORSESHOE CRAB 5 (2010) *available at* http://www.asmfc.org/species Documents/horeseshoeCrab/HSCStockAssessmentOverview.pdf [hereinafter 2010 OVERVIEW].

> models to generating [sic] updated predictions, and 5) revising management actions as necessary to reflect the latest state of knowledge about the ecosystem. ARM is an iterative process that evolves continuously as new information is gathered and the effects of management actions are evaluated.
>
> Within this ARM framework, a set of alternative multispecies models have been developed for the Delaware Bay Region to predict the optimal horseshoe crab harvest strategy that would still allow enough eggs to be available for red knot population needs. These models incorporate uncertainty in model predictions and will be updated with new information as monitoring progresses.[147]

The ARM structure represents the future of the ASMFC horseshoe crab conservation efforts.[148] The next addendum, Addendum VII, which will start to incorporate the ARM plan and further restrict the harvesting of horseshoe crabs, especially egg-bearing females, is scheduled to be implemented by January 1, 2013.[149]

3. Carl N. Shuster, Jr. Horseshoe Crab Reserve

Largely in response to the ASMFC recommendations in Addendum I, in 2001 the NMFS closed an area consisting of approximately 1,500 square nautical miles to all horseshoe crab fishing.[150] This closed area of federal waters off the mouth of the Delaware Bay became effective March 7, 2001, and was "designed to provide additional protection for local stocks, as well as protect the declining population of migratory shorebirds that feed on horseshoe crab eggs."[151] Within the boundaries of this sanctuary, all fishing of horseshoe crabs, and even the possession of horseshoe crabs on a trawl or dredge vessel, is strictly prohibited.[152]

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147. *Id*.

148. *Id*.

149. ATL. STATES MARINE FISHERIES COMM'N, ADDENDUM VII TO THE FISHERY MANAGEMENT PLAN FOR HORSESHOE CRAB 1-7 (2012) [hereinafter ADDENDUM VII].

150. NAT'L MARINE PROTECTED AREAS CTR., MARINE PROTECTED AREA (MPA) PROCESS REVIEW: CASE STUDIES OF FIVE MPA ESTABLISHMENT PROCESSES 10 (2003) [hereinafter MPA REVIEW]. This federally protected area was named "the Carl N. Shuster Jr. Horseshoe Crab Reserve in honor of retired College of William & Mary professor who is a leading horseshoe crab biologist and researcher." *Id*.

151. Michelle Baldwin et al., Recent Development, *A Review of Developments in Ocean and Coastal Law 2000-2001*, 6 OCEAN & COASTAL L.J. 413, 429 (2001).

152. 50 C.F.R. § 697.23(f) (2010).

Furthermore, any crab accidentally caught in the area "must be returned to the water immediately without further harm."[153] Unlike many of the ASMFC addendums, this regulation has no sunset provision and will remain effective for the foreseeable future.[154] The U.S. Coast Guard, in combination with state authorities, is charged with enforcing the provision and there have been no documented reports of violations thus far.[155]

IV. ASSESSING EFFECTIVENESS OF CONSERVATION EFFORTS

A. Population Dynamics

Establishing reliable estimates of the horseshoe crab population along the Atlantic Seaboard has been a challenging task for researchers since conservation began in the late 1990s.[156] Consequently, determining the effectiveness of conservation efforts continues to be problematic.[157] Even though no specific definitions have been adopted by the ASMFC Management Board regarding overfishing or overfished status, general trends in horseshoe crab populations can still be ascertained from recent assessment efforts.[158] According to the 2009 Benchmark Horseshoe Crab Assessment, there is an increased abundance of horseshoe crabs in the southeast Atlantic coast and Delaware Bay regions, especially among juveniles and adult males.[159] A significant increase in adult female horseshoe crabs was also noted in the same area in a recent Virginia Tech Benthic Trawl Survey, though the increase was not as dramatic as the increases found in juveniles and males.[160] As male horseshoe crabs mature faster than females, these staggered increases may indicate that the horseshoe crab population is recovering.[161]

However, while the data from the southeast Atlantic and Delaware Bay is encouraging, there has been a declining abundance of horseshoe

153. *Id*.
154. MPA REVIEW, *supra* note 150, at 10.
155. *Id.* at 17.
156. *See* David Hata & Jim Berkson, *Abundance of Horseshoe Crabs (Limulus polyphemus) in the Delaware Bay Area*, 101 FISHERY BULLETIN 933, 933 (2003).
157. Niles et al., *supra* note 6, at 162-163.
158. EYLER ET AL., *supra* note 45, at 3. Horseshoe crab abundance assessment data is available on the ASMFC website, http://www.asmfc.org/horseshoecrab.htm. *Id.*
159. *Id*.
160. *Id.*
161. *Id.*

crabs in the New York and New England regions.[162] One explanation is that decreased harvest limits in the Delaware Bay and surrounding regions may have redirected horseshoe crab harvesters to more northern regions.[163] Due to this decrease, the ASMFC is concerned that the current harvest levels in many northern Atlantic regions may not be sustainable.[164] Based on a five-year-trigger in the FMP, the ASMFC will conduct another horseshoe crab stock assessment in 2014, which should allow for a better analysis of population trends.[165] The overall conclusion of the ASMFC 2011 review of the FMP is that, while the Delaware Bay and some surrounding regions have achieved a sustainable harvest level, the harvest levels in outlying regions may not be sustainable.[166]

It is also important to consider that human activities might not be the only factor affecting horseshoe crab population dynamics.[167] Though direct anthropogenic factors are undeniably responsible for a great deal of the recent decline in horseshoe crab populations, other factors, such as climatic change, could also be precipitating the decline.[168] One recent study found that the only area on the Atlantic coast that did not suffer a horseshoe crab population decline over the last few decades is an isolated region off the coast of Mexico.[169] A possible explanation is that rising sea levels may be eliminating some of the crabs' former breeding grounds along the American Atlantic seaboard and forcing a migration south.[170] Additionally, smaller horseshoe crab populations have resulted in less genetic diversity, possibly further stunting a population recovery.[171] Global climactic changes and their possible effects on horseshoe crab populations must also be taken into account when developing a plan for conservation.

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162. *Id*.
163. *Id*.
164. *Id*.
165. *Id*.
166. *Id*.
167. *See* Soren Faurby et al., *Population Dynamics of American Horseshoe Crabs – Historic Climatic Events and Recent Anthropogenic Pressures*, 19 MOLECULAR ECOLOGY 3088, 3089 (2010).
168. *Id*.
169. *Id*. at 3092-3096.
170. *See Id.* at 3096. Horseshoe crabs often breed in and around sea level, on sandy beaches in coastal estuaries. Even a slight sea level rise can dramatically affect these delicate regions. *See* JAMES G. TITUS ET AL., U.S. CLIMATE CHANGE SCI. PROGRAM, COASTAL SENSITIVITY TO SEA-LEVEL RISE: A FOCUS ON THE MID-ATLANTIC REGION app. I at 205 (2009).
171. Faurby et al., *supra* note 167, at 3096.

V. ALTERNATIVE SOLUTIONS AND RECOMMENDATIONS

A. Creative Alternatives

Fishery management programs have been relatively successful in halting the sharp decline of the horseshoe crab species. However, the current methods being employed are not the only possible solutions. Some other possible solutions, explored below, must be instituted and supported at the state and federal levels if horseshoe crab populations are to increase to their previous abundance. Innovative scientists and conservationists have come up with creative solutions to the horseshoe crab problem, but without significant financial and legal support, their ideas will not be able to affect a coast-wide, multi-state problem.

One possibility is to augment natural populations of horseshoe crabs by breeding them in captivity.[172] In 2009, an associate professor and coordinator of the marine biology program at the University of New Haven accomplished just such an endeavor.[173] After eleven years of experimentation to achieve the correct water temperature, sand consistency, and a multitude of other factors, Professor Carmela Cuomo finally "succeeded in getting captive horseshoe crabs to spawn from May to October—yielding more eggs than she knew what to do with."[174] According to Cuomo, the next challenge is to optimize a diet that could reduce the ten-year period it normally takes a horseshoe crab to reach breeding size and maturity.[175] Though such methods would likely prove too costly to interest the commercial bait fishery, they may be tempting to the lucrative biomedical industry.[176] Just as fish-farming has revolutionized other fisheries, the captive breeding of horseshoe crabs has the potential to similarly affect the horseshoe crab fishery.

Another innovative solution to problems facing the horseshoe crab fishery is the use of bait bags to increase the efficiency of crab bait used.[177] These bait bags are constructed of plastic netting and are placed

172. Carolyn Y. Johnson, *A Horseshoe Crab Fertility Plan*, BOSTON GLOBE, Apr. 19, 2010 at B7.

173. *Id*.

174. *Id*. (Initially acting after a light-hearted challenge from one of her colleagues, Professor Cuomo invested thousands of dollars of her own money to transform her basement into a laboratory lined with tanks for the experiment).

175. *Id*.

176. *See id*.

177. Journal Staff 2002, *A Review of Developments in Ocean and Coastal Law 2001-2002*, 7 OCEAN & COASTAL L.J. 367, 370 (2002).

at the bottom of whelk pots, secured by a bungee cord.[178] These bags prevent unwanted species from consuming the horseshoe crab bait and thus result in higher whelk catches compared to the amount of bait used.[179] Some whelk fishermen have reported a seventy-five percent reduction in the amount of horseshoe crab bait used.[180] Bait bags have little downside because they not only increase the amount of whelk caught by fishermen, but also reduce the amount of crabs used as bait.[181] Thus, it is no surprise that some states, like Virginia, have begun requiring the use of bait bags by all commercial fishermen using horseshoe crab bait.[182] This technique has been championed by the NMFS, which has awarded several $10,000 grants to organizations for the development, promotion, and distribution of bait bags along the Atlantic Seaboard.[183] With so little disadvantage for fishermen, and such a substantial return for conservationist efforts, the use of bait bags should be required throughout commercial fisheries.

Biomedical scientists have been discussing a third possible alternative solution since lysate production was first developed in the 1970s: the creation of artificial lysate.[184] However, likely due to economic considerations, those discussions have never developed into serious artificial lysate production research.[185] As William Sargent explains below, with current technology and methods, the production of artificial lysate is a dream that will not come to fruition any time soon:

> On average it takes ten years and $800 million to develop a new drug based on genetic engineering. But once you have discovered the gene, what do you do with it? Besides, lysate involves several genes. In the old days biotechnology companies built large new plants complete with shiny copper-colored vats for growing drugs from genes inserted into yeast. But then they discovered it was much cheaper simply to insert the gene into a

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178. *Id*.

179. Press Release, Nat'l Ocean and Atmospheric Ass'n, NOAA Fisheries Awards $10,000 Grant to Continue Horseshoe Crab Conservation (Feb. 22, 2002), *available at* www.publicaffairs.noaa.gov/releases2002/feb02/noaa02rl08.html [hereinafter NOAA Feb. 22, 2002 Press Release].

180. *Id*.

181. *Id*.

182. *See id*.

183. *See, e.g., id*. One of the recipients of such a grant, the Ecological Research and Development Group, uses the funds to give bait bags to fisherman free of charge, concentrating its efforts on more northern Atlantic fisheries. *Id.*

184. SARGENT, supra note 2, 118.

185. *Id*.

> goat and collect the drug from her milk. The same would be true with horseshoe crabs. If you could isolate a single gene responsible for lysate, what would you want to do with it? Put it right back into a horseshoe crab and have the same system as present. Who would invest $800 million to develop a system that duplicates nature—and will not make a profit?[186]

However, as technology rapidly becomes more sophisticated, the creation of artificial lysate may one day become a viable alternative to the bleeding of live crabs.

A fourth creative solution to address the horseshoe crab population decline is the artificial nourishment of beaches to create better and more productive crab-breeding sites.[187] In the spring of 2002, a study was conducted on several Delaware beaches to "evaluat[e] the effect of nourishing an estuarine beach with gravel to enhance spawning rates by horseshoe crabs."[188] The test beaches were covered in a layer of coarse sand and gravel with the hope that this would not only attract more crabs, but also increase the nutritious water flow through the sand to developing eggs.[189] Over the 2002 mating season, the average density of spawning female horseshoe crabs on the test beach increased considerably and egg density increased by over 200 percent.[190] In comparison, the average density of spawning female crabs on the control beach decreased and the egg density increased by only twenty percent.[191] However, a much higher percentage of egg pouches were displaced or torn on the test beach when compared to the control beach.[192] This destruction of egg pouches was likely caused by the higher concentration of crabs or the more easily excavated coarse-grain sand.[193] Due to the small sample size and the fact that horseshoe crab appearances on specific beaches can naturally vary from year to year, the results are less than conclusive.[194] What can be determined from this study is that coarse grain beaches can affect horseshoe crab site selection, and finer grain size improves egg survival.[195] Along a coast line with an increasing amount of destroyed or

186. *Id*.
187. Nancy L. Jackson et al., *Evaluation of a Small Beach Nourishment Project to Enhance Habitat Suitability for Horseshoe Crabs*, 89 GEOMORPHOLOGY 172, 173 (2007).
188. *Id.* at 172.
189. *See id*. at 174.
190. *Id.* at 180.
191. *Id*.
192. *Id.* at 181.
193. *See id*.
194. *See id.* at 184.
195. *Id*.

degraded beaches, beach nourishment programs are the key to ensuring the long-term breeding success and survival of the horseshoe crab.[196] Further studies to expand the currently rudimentary understanding of the interaction between beach nourishment and horseshoe crab breeding should be encouraged at both the state and federal level as part of a multifaceted approach to sustainably increase the horseshoe crab population.

While it is unlikely that one of these alternative solutions alone could solve the horseshoe crab resource problem, if employed together on a large scale they might be able to have a significant effect. That would, of course, entail funding and support at federal, state, and local levels. Regulations like those imposed by the FMP can be effective in stopping specific detrimental activities; however, proactive and creative solutions, like those discussed above, are needed to create real change and long-term solutions.

B. Moving Forward: Recovery Strategies

Long-term, successful conservation of the horseshoe crab resource will require not only a continuation of the methods discussed throughout this Comment, but an increased commitment and stronger application of conservation techniques. It is undeniable that the ASMFC will continue to take a lead role in horseshoe crab conservation efforts and thus will likely be able to have the greatest impact on the future of the species.[197] In recent years, the ASMFC has been moving away from a program focused exclusively on horseshoe crab recovery and toward one focused on a multispecies ARM framework, which includes considerations for migratory birds, such as the Red Knot, and other interested stakeholders.[198] This plan has yet to be fully implemented and it will take an extraordinary effort in order for it to be successful.

One of the major problems facing the ARM and horseshoe crab conservation efforts as a whole continues to be incomplete or unreliable horseshoe crab stock assessments.[199] The techniques used to measure horseshoe crab populations, such as trawl net surveys, were originally designed for other species and do not take into account the horseshoe crab's unique populations and biological dynamics.[200] New horseshoe

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196. *See id.* at 173.
197. *See generally* EYLER ET AL., *supra* note 45.
198. *See* 2010 OVERVIEW, *supra* note 146, at 5.
199. Niles et al., *supra* note 6, at 163; *see also* EYLER ET AL., *supra* note 45, at 3.
200. Niles et al., *supra* note 6, at 163; *see also* EYLER ET AL., *supra* note 45, at 3-4.

crab data collection and assessment techniques need to be developed to accurately estimate horseshoe crab population size and dynamics. These new types of surveys should focus on collecting data on horseshoe crabs throughout their developmental stages in order to achieve a better picture of the horseshoe crab population as a whole.[201] More complete and accurate surveys and assessments would reduce the uncertainty of current stock estimates and enable conservation efforts to set, and know if they achieve, concrete goals.[202]

The Virginia Tech Benthic Trawl Survey is one of the most effective horseshoe crab assessment studies to date.[203] While this study has been helpful in assessing regional horseshoe crab populations, it is not inclusive of the entire Atlantic horseshoe crab habitat.[204] A long-term and coast-wide benthic trawl study is essential to both the successful continuation of current conservation plans and the implementation of new plans, such as the ARM.[205] Since significant Congressional funding for such a study has been lacking, alternative funding sources must be secured in order to provide support for such a project. Such sources should include, but are not limited to: state and federal governments, biomedical and commercial industry stakeholders, and non-governmental environmental organizations.[206] Through its application to multiple species, the introduction of the ARM plan will likely increase the number of parties interested in conservation efforts and thus, the number of available sources of funding.

However, horseshoe crab conservationists should be wary of embracing the promises of the ARM plan too completely. While the ARM framework may enable the application of additional human and financial resources to the horseshoe crab conservation effort, the program dilutes the focus on the horseshoe crab.[207] The 1998 FMP and following addenda focused exclusively on the horseshoe crab resource, while the ARM plan seeks to combine the interests of horseshoe crab and migratory bird conservationists.[208] Although these two groups have

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201. 2010 OVERVIEW, *supra* note 146, at 5.
202. *See generally id.*
203. *See* EYLER ET AL., *supra* note 45, at 11.
204. *See id.*
205. *Id.*
206. *Id.*
207. MICHAEL JONES, ET. AL., STOCK ASSESSMENT REPORT NO. 09-02 OF THE ATLANTIC STATES MARINE FISHERIES COMMISSION: TERMS OF REFERENCE & ADVISORY REPORT TO THE HORSESHOE CRAB STOCK ASSESSMENT PEER REVIEW 17 (2009) [hereinafter 2009 STOCK ASSESSMENT].
208. *See id.*

compatible interests and plans on many issues, the problem of how to solve their potentially conflicting objectives and methods still remains.[209] For example, if one course of action benefits the Red Knot substantially more than the horseshoe crab, but only limited resources are available, how is the appropriate course of action decided? Additionally, the complexities of modeling and effectively implementing a multi-species plan, as opposed to one for a single species, impose severe constraints on such a program.[210] Consequently, the ASMFC should adopt the ARM as part of its overall FMP for the horseshoe crab, supplementing it, but not allowing it to control or replace the work that has already been implemented.

So far, the tagging of individual crabs has been an underutilized tool in horseshoe crab conservation efforts. While the USFWS has a limited tagging program in place, it lacks the scope and funding to achieve maximum benefit from this proven conservation tool.[211] Furthermore, the present tagging program relies on the cooperation of the general public, volunteer resources, and commercial fishermen.[212] A successful coast-wide tagging program could provide data on "distribution, movement, longevity, and mortality of horseshoe crabs" and this data could be used to make informed management decisions about sustainable conservation efforts and strategies.[213] In order to make the most of this important conservation tool, not only should current tagging programs continue, but a coast-wide uniform tagging program that feeds into national USFWS databases, and is conducted by professional researchers, needs to be implemented.[214]

In addition to implementing new conservation methods, loopholes and problems with the current FMP need to be addressed and remedied. For example, the biomedical industry has been largely exempt from the increasingly stringent restrictions imposed on the harvesting of horseshoe

209. *Id.*
210. *Id.*
211. *See* MARYLAND FISHERY RESOURCES OFFICE: HORSESHOE CRAB TAGGING PROGRAM, http://www.fws.gov/northeast/marylandfisheries/projects/Horseshoe%20crab.html (last visited Apr. 13, 2012) [hereinafter MARYLAND FISHERY RESOURCES OFFICE]. The USFWS uses tagging to collect data throughout its nationwide conservations efforts and it has proven an essential and effective way to monitor and study wildlife populations. *See, e.g.*, USFWS: Dexter National Fish Hatchery and Technology Center, http://www.fws.gov/southwest/fisheries/dexter/Tagging.html (last visited Apr. 13, 2012).
212. MARYLAND FISHERY RESOURCES OFFICE, *supra* note 211.
213. *See id.*
214. *See generally* EYLER ET AL., *supra* note 45, at 11.

crabs.[215] This has continued to be true despite an estimated biomedical-related mortality of over 57,000 crabs in 2010.[216] Though the biomedical companies are less damaging to the horseshoe crab population than the commercial bait fishery, they still account for significant mortality figures. More importantly, the biomedical industry is exceedingly more profitable than the bait industry and thus better able to sustain the costs of additional research and conservation. Therefore, not only should more stringent restrictions on biomedical harvesting be imposed by the ASMFC, but the industry should also bear some of the financial burden in monitoring, research, and conservation efforts.[217]

Aside from government regulation, another important piece in solving horseshoe crab conservation issues is enlisting the support of the public and local communities. On a seaboard where horseshoe crabs are increasingly competing with human development for beach space, support of private residents is crucial. The Ecological Research & Development Group (ERDG) has been at the forefront of these efforts since its founding in 1995.[218] One of the ERDG's most successful efforts has been the "Just flip 'em!" program, which has brought attention to the high rate of crab mortality that occurs when crabs are stranded upside down during spawning, and encourages citizens to right the crabs.[219] ERDG has also been involved in funding horseshoe crab spawning surveys, implementing alternative gear and bait bag programs, encouraging the creation of private horseshoe crab beach spawning sanctuaries, and promoting horseshoe crab knowledge and involvement through educational and outreach programs.[220] Through programs like these, there has been an increase in local communities voluntarily protecting horseshoe crabs, which historically have been thought of as a nuisance. While governmental regulations are imperative to protect the horseshoe crabs, the importance of non-profit organizations and public involvement cannot be overstated.

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215. *See, e.g.*, ADDENDUM IV, *supra* note 138, at 4-5

216. EYLER ET AL., *supra* note 45, at 11.

217. *See id.*

218. Ecological Research & Dev. Grp., *The Horseshoe Crab*, http://www.horseshoecrab.org/misc/erdg.html (last visited Apr. 13, 2012). The Ecological Research & Development Group (ERDG), founded in 1995, is a non-profit wildlife conservation organization whose primary focus is the conservation of the world's four remaining horseshoe crab species. *Id.*

219. *Id.* It is estimated that ten percent of naturally occurring horseshoe crab deaths are a result of overturned crabs, which then die either as a result of exposure or being eaten by passing predators. *Id.*

220. *Id.*

VI. CONCLUSION

Though the ASMFC fishery management programs have brought a stop to the precipitous decline of the horseshoe crab population, they alone are not sufficient to ensure a recovery to pre-1990 levels. Current efforts are plagued by a lack of funding, incomplete knowledge of the horseshoe crab population size and dynamics, inconsistent enforcement and compliance, and a poor understanding of the horseshoe crab's relation to the surrounding ecosystems. As outlined in this Comment, there is still much more that can be done to help the recovery of the horseshoe crab.

Foremost, research, monitoring, and data collection efforts have to be greatly increased to eliminate uncertainty about the size and dynamics of the horseshoe crab population. This lack of information is currently hampering the effectiveness of conservation programs. These efforts need to include coast-wide tagging and specifically tailored assessment mechanisms. Next, further harvesting restrictions should be placed on, and strictly enforced upon, both commercial bait fisheries and the biomedical industry until sustainable harvest levels can be established. In addition, alternative solutions such as bait bagging, captive breeding, artificial lysate production, and beach nourishment projects ought to be explored further and appropriately funded. Funding for increased research and alternative projects can be found through increased federal involvement in the conservation efforts, requiring involved industries to bear some of the financial burden, and through public and non-governmental organizational support.

Though the horseshoe crab now faces grave threats from commercial fishing, the biomedical industry, and habitat loss, the species has proven to be remarkably resilient throughout history. As long as all reasonable measures are effectively implemented to preserve spawning beaches and limit the harvest amount to a sustainable level, the horseshoe crab may well survive for another half-a-billion years.