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The Chesapeake Bay's Oysters: Current Status and Strategies for Improvement

The Chesapeake Bay's Oysters: Current Status and Strategies for Improvement

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I. INTRODUCTION

The Chesapeake Bay is the largest and most diverse estuary in the United States.[1] The Bay has a shoreline of over 4500 miles, a surface area of over 3000 square miles, and over 150 streams and rivers drain into the Bay.[2] The health of the Chesapeake Bay has rapidly declined in the twentieth century, primarily because of urban sprawl, agricultural and industrial development, increased human population in the watershed, and sewage treatment plant discharges.[3] As Bay health has declined, so has the abundance of the once viable Eastern oyster (*Crassostrea virginica*).[4]

The Eastern oyster was once one of the most commercially important species in the Chesapeake Bay, but its population is in severe decline.[5] The oyster's decline is inextricably linked with the overall decline in the health of the Chesapeake Bay, as well as the oyster diseases Dermo and MSX and overharvest.[6] In an effort to create a sustainable commercial fishery and restore the estuary in general, states, the federal government, and a multitude of nonprofit organizations and

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1. Michael T. Palmer, *The Chesapeake Restoration Act of 2000: New Requirements for Federal Agencies,* 28 WM. & MARY ENVTL. L. & POL'Y REV. 375, 378 (2004).

2. U.S. ARMY CORPS OF ENGINEERS, MD. DEP'T OF NATURAL RES. & VA. MARINE RES. COMM'N, DRAFT PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT FOR OYSTER RESTORATION IN CHESAPEAKE BAY INCLUDING THE USE OF A NATIVE AND/OR NONNATIVE OYSTER § 3-1 (2008).

3. Palmer, *supra* note 1, at 379.

4. *See* discussion *infra* Part II.C.

5. *Id.*

6. *Id.*

citizens' groups are working to develop effective policies to restore the ecological and economic viability of the Chesapeake Bay's oyster population.[7] Individually, Maryland and Virginia have passed their own laws and regulations regarding oyster harvest and habitat protection and restoration.[8] This comment will discuss and analyze the decline of the Chesapeake Bay oyster population, the current policies regarding the Eastern oyster population in the Chesapeake Bay, and possible policy changes, including policies currently under review.

II. BACKGROUND

The Eastern oyster's range extends from the Gulf of St. Lawrence, Canada along the Atlantic Coast to the Gulf of Mexico.[9] In most of these aquatic systems, including the Chesapeake Bay, the Eastern oyster is a keystone species.[10] Oysters provide food for other species in the ecosystem, help maintain water quality by filtering particulate organic matter and other substances from the water column, and provide habitat for other species.[11]

A. Life History of the Eastern Oyster

Oysters are benthic bivalves.[12] Eastern oysters are grayish in color, with an irregular oval shape, and when mature, are approximately ten inches long by four inches wide.[13] Oysters are active suspension feeders, meaning they regulate the volume of water filtered through their gills based on content and size of particles in the water.[14]

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7. *See* discussion *infra* Part III.B.

8. *Id.*

9. Hunter S. Lenihan et al., *The Influence of Multiple Environmental Stressors on Susceptibility to Parasites: An Experimental Determination with Oysters,* 44 LIMNOLOGY AND OCEANOGRAPHY 910, 911 (1999).

10. A keystone species is "a species that is disproportionately important in the maintenance of community integrity and without which drastic alterations of the community would occur." JAMES W. NYBAKKEN, MARINE BIOLOGY 497 (Benjamin Cummings 5th ed. 2001). *See also*, Roger I.E. Newell, The Crucial Ecological Role of Oysters in the Chesapeake Bay at the Oyster Research and Restoration in U.S. Coastal Waters Symposium (Sept. 8-9, 2003), *available at* http://www.mdsg.umd.edu/issues/chesapeake/oysters/research/meeting/abstracts/abstract11.html.

11. *See* discussion *infra* Part II.D.1.

12. Benthic organisms are "organisms that occur on the sea bottom." Nybakken, *supra* note 10, at 494.

13. *See* NORMAN A. MEINKOTH, NATIONAL AUDUBON SOCIETY FIELD GUIDE TO NORTH AMERICAN SEASHORE CREATURES 547 (Alfred A. Knopf 1981); LELAND W. POLLOCK, A PRACTICAL GUIDE TO THE MARINE ANIMALS OF NORTHEASTERN NORTH AMERICA 160 (Rutgers Univ. Press 1998).

14. Lenihan, *supra* note 9, at 920-921.

Eastern oysters will attach to both hard and soft substrate, although they are incapable of forming substantial populations on soft substrate.[15] Eastern oysters live in the intertidalzone,[16] shallow estuarine and coastal waters.[17] They can live in water temperatures of zero to thirty-six degrees Celsius and salinities of zero to forty parts per thousand. However, this species is most productive in waters that are twenty to thirty degrees Celsius and in the salinity range of fifteen to thirty parts per thousand.[18]

A distinct feature of Eastern oysters is that they often form reefs or bars.[19] Reefs regulate conditions for the oysters including the speed of water flow.[20] Water flow speed naturally increases above the sea floor and reefs redirect this flow, causing water to accelerate around the reef.[21] Flow speed around an oyster reef decreases sediment deposit on the reef and regulates temperature, salinity, and dissolved oxygen.[22] These conditions positively impact individual oyster survival and growth.[23] Reefs not only provide a regulated habitat for the oyster, but a number of other species inhabit the oyster reefs, including the naked goby, striped bass, oyster toadfish, and skillet fish.[24]

The Eastern oyster generally starts spawning in the spring when water temperatures reach sixteen to twenty degrees Celsius, and may continue throughout the spring and summer.[25] Oyster gamete fertilization occurs in the water column when sperm and eggs are simultaneously released and then fused to form larvae.[26] For approximately the next twenty days, the oyster larvae are planktonic, and therefore mobile.[27] During the late planktonic larval stages, the larvae begin to settle on the estuary's bottom.[28] At initial settling, the larvae are still somewhat mobile and are able to crawl around the bottom in search

15. *See* Meinkoth, *supra* note 13, at 548; Pollock, *supra* note 13, at 160.

16. The intertidal zone is the "benthic area lying between the extremes of high and low tides." Nybakken, *supra* note 10, at 497.

17. Lenihan, *supra* note 9, at 911.

18. *Id.*

19. *Id.*

20. *Id.*

21. *Id.*

22. Lenihan, *supra* note 9, at 911.

23. *Id.*

24. Loren D. Coen & Mark W. Luckenbach, *Developing Success Criteria and Goals for Evaluating Oyster Reef Restoration: Ecological Function or Resource Exploitation?*, 15 ECOLOGICAL ENGINEERING 323, 327 (2000).

25. Richard K. Wallace, *Cultivating the Eastern Oyster, Crassostrea virginica,* S. REG'L AQUACULTURE CTR. PUBL'N No. 432, Aug. 2001, at 1, *available at* http://aquanic.org/publicat/usda_rac/efs/srac/432fs.pdf.

26. *Id.* at 2.

27. *Id.*

28. *Id.*

of a suitable substrate for attachment.[29] Oyster larvae prefer to settle on oyster shell[30] near other juvenile oysters.[31] Once suitable substrate is found, the larva cements itself to the substrate and becomes a juvenile oyster or "spat."[32] The spat grow and become sexually mature oysters in about one year.[33] Oysters are alternative hermaphrodites, meaning that their sex changes within their life span, usually between spawnings.[34] Most spat are male.[35] Generally, the proportion of females in the population increases in correlation with the size of the individuals.[36] Oysters can reach harvestable size in twelve to thirty-six months, depending on conditions.[37]

B. Brief History of the Chesapeake Bay Oyster Industry

From the earliest accounts, it is apparent the Chesapeake Bay supported an abundant Eastern oyster population.[38] George Percy of the Jamestown expedition wrote in 1607 that "oysters 'lay on the ground as thicke [sic] as stones.'"[39] As early as the turn of the nineteenth century, New England had already depleted its own oyster fisheries and began exporting oysters from the Chesapeake Bay in 1808.[40] When Maryland and Virginia passed legislation limiting the export of spat to other regions, New England packing houses opened facilities in Maryland and Virginia.[41] In 1858, the Chesapeake was producing approximately 20,000,000 bushels (or 100,000,000 pounds) of oysters a year.[42] By 1880, the Chesapeake Bay had exceeded the rest of the world in commercial oyster production.[43]

Many other regions with oyster fisheries have historically supported large-scale oyster aquaculture, but historically, Virginia and Maryland

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29. *See* VICTOR S. KENNEDY & LINDA L. BREISCH, MARYLAND'S OYSTERS RESEARCH AND MANAGEMENT 67 (Univ. of Maryland Sea Grant 1981) (*out-of-print*), http://nsgd.gso.uri.edu/aqua/mdut81003.pdf.; Wallace, *supra* note 25, at 2.

30. John J. Alford, *The Role of Oyster Management in Chesapeake Oyster Production*, 63 GEOGRAPHICAL REV. 44, 51 (1973).

31. Kennedy, *supra* note 29, at 73.

32. Wallace, *supra* note 25, at 2.

33. B.J. Rothschild et al., *Decline of the Chesapeake Bay Oyster Population: A Century of Habitat Destruction and Overfishing*, 111 MARINE ECOLOGY PROGRESS SERIES 29, 34 (1994).

34. Kennedy, *supra* note 29, at 65.

35. Wallace, *supra* note 25, at 2.

36. Rothschild, *supra* note 33, at 34.

37. Wallace, *supra* note 25, at 2.

38. Alford, *supra* note 30, at 44.

39. *Id.*

40. *Id.* at 45.

41. *Id.* at 44.

42. *Id.*

43. *Id.*

never embraced it.[44] The oystermen of the Chesapeake fought oyster aquaculture because they feared that they would become laborers for large, corporate oyster facilities and would thereby lose their independent, self-employed status.[45] Still, neither state has allowed private leasing of natural oyster beds.[46]

Maryland's attempts to adopt oyster aquaculture have been historically unsuccessful.[47] In Maryland, coastal counties were over-represented in the General Assembly until the 1960s, allowing watermen to block attempts to enact laws allowing oyster farming and conservation.[48]

Virginia's attempts to adopt oyster "farming" policy have been marginally more successful. While watermen originally opposed the practice, they lacked the over-representation in the legislature found in Maryland.[49] As a result, legislators allowed a few leases which were wildly successful, making watermen more receptive to aquaculture.[50]

C. Decline in the Oyster Population

Before describing the factors causing the decline in the Eastern oyster population, it is helpful to have an idea of the historic and present populations of the species. The oyster harvest of 1884 was 614,000 tons, but in 1992 it was only 12,000 tons.[51] In Maryland, harvests were fourteen million bushels in 1874, two million bushels in 1985, and less than 100,000 bushels per year over the last ten years.[52] Oyster habitat is at least fifty percent smaller now than it was historically and biomass per

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44. *See* Alison Rieser, *Oysters, Ecosystems, and Persuasion*, 18 YALE J. L. & HUMAN. 49, 52 (2006).

45. *Id.*

46. Merrill Leffler, *Crisis and Controversy: Does the Bay Need a New Oyster?*, 1 CHESAPEAKE QUARTERLY 2, 8 (2002).

47. The decline of the Maryland oyster industry has been compared to the "Tragedy of the Commons" as described by Garrett Hardin. *See* Garrett Hardin, *The Tragedy of the Commons*, 172 SCIENCE 1243 (1968). In evaluating the Chesapeake's oyster industry, Garrett Power noted,

> Although the oystermen realized that they were depleting the resource upon which their livelihood depended, they had no incentive to reduce their catch or otherwise cultivate the bed (and thereby sustain the yield) since there was no guarantee other oystermen would follow suit.

Garrett Power, *More About Oysters Than You Wanted to Know*, 30 MD. L. REV. 199, 200 (1970).

48. Rieser, *supra* note 44, at 51.

49. *Id.*

50. *Id.*

51. Rothschild, *supra* note 33, at 29.

52. *See* Kennedy, *supra* note 29, at 103. *See also*, Newell, *supra* note 10.

unit of habitat is a mere one percent of what it was in the 1890s.[53] Oyster bar acreage declined by more than fifty percent from 1907 to 1982.[54]

No single factor is responsible for the decline in oyster population. A variety of factors, most anthropogenic and some natural, has led to the Eastern oyster's decline.[55] The primary causes are overharvest, pollution, and breakouts of the oyster diseases Dermo and MSX.[56] A general principle of ecology states, "poor physiological condition from past environmental stress predisposes organisms to greater risks from exposure to additional stressors."[57] These factors do not work independently of one another and none is primarily to blame; they are inextricably related and equally culpable for the oyster's decline.[58]

1. Overharvest

Overharvest appears to have caused declining oyster populations primarily as a result of the increasingly destructive oyster-fishing gear used.[59] Hand tongs were the tool of choice from the 1600s to the 1860s; however, tongs limited catch-size and harvest area so an alternative method was sought.[60] In 1865, the first oyster dredges were legalized.[61] The dredges were not only more efficient for harvesting, they were also more efficient at destroying the oyster reefs.[62] Not long after the introduction of the dredges, in 1887, the hand-operated patent tong was introduced, allowing oystermen to delve into even deeper oyster reefs.[63] The latest and most destructive equipment, the hydraulic-powered patent tongs, were introduced in 1950.[64] They act like an industrial crane, taking "bites" out of oyster reefs and the Bay floor, causing nearly irreversible damage to the habitats of oysters and other marine life.[65]

Over a century of progressively more intense harvesting techniques have contributed to leveling of the Bay's oyster bars.[66] Reduced reef height reduces the speed of the flow of the water around the reef, thereby

53. Rothschild, *supra* note 33, at 36.
54. *Id.* at 32.
55. *See* discussion *infra* Parts II.C.1, II.C.2, II.C.3.
56. *Id.*
57. Lenihan, *supra* note 9, at 910.
58. *See* Jeremy B. Jackson et al., *Historical Overfishing and the Recent Collapse of Coastal Ecosystems*, 293 SCIENCE 629, 635 (2001).
59. Rothschild, *supra* note 33, at 29.
60. *Id.*
61. *Id.*
62. *Id.* at 30.
63. *Id.*
64. Rothschild, *supra* note 33, at 30.
65. *Id.*
66. *Id.*

subjecting oysters to increased sedimentation and decreased quality of suspended food matter, also resulting in a decreased physiological condition of the oysters.[67]

2. Pollution

Beginning in the 1970s, Maryland and Virginia became acutely aware that the Chesapeake Bay was in poor health and that nutrient pollution was largely to blame.[68] The most prevalent nutrients are nitrogen and phosphorus entering the Bay primarily from urban runoff, sewage treatment, agriculture, and industrial activity.[69] This nutrient pollution leads to a process called eutrophication.[70] The excess nutrients, which are dissolved in water that flows into the Chesapeake Bay from its watershed, cause algal blooms.[71] When the algae dies and falls to the bottom, microorganisms break it down.[72] In this microbial process, the available dissolved oxygen in the bottom waters is used, causing anoxic[73] conditions in the bottom waters of the Bay.[74] The problem is exacerbated in the summertime due to the thermocline[75] that develops.[76] Since the mid-1980s, most water below the thermocline remains anoxic for extended periods during summer.[77] Healthy adult oysters can withstand hypoxic[78] conditions for extended periods at low temperatures,

67. Sedimentation occurs when particulate matter suspended in the water column settles out of the water column. When flow speeds are high, the sediments remain suspended. When flow speeds slow, these particulates begin falling out of the water column and settle onto the bottom. Sedimentation stresses the oyster, as filter feeding becomes less efficient because the oyster must filter more particulates to derive the same amount of food. High levels of sedimentation may suffocate oysters. *See* Lenihan, *supra* note 9, at 911; Rothschild, *supra* note 33, at 32.

68. Palmer, *supra* note 1, at 379.

69. *See id.* at 386-389.

70. *See* Don Meritt & Merrill Leffler, *Oyster Restoration in the Chesapeake Bay: Looking Back, Looking Forward*, 2000-04 MARYLAND AQUAFARMER 1, 2 (2000), http://www.mdsg.umd.edu/programs/extension/aquaculture/Aquafarmer/Fall00/.

71. *Id.*

72. *Id.*

73. Anoxic means "without oxygen." Nybakken, *supra* note 10, at 494.

74. Meritt, *supra* note 70, at 2.

75. A thermocline is "that portion of the water column where temperature changes most rapidly with each unit change in depth." Nybakken, *supra* note 10, at 500.

76. Meritt, *supra* note 70, at 2.

77. Roger I.E. Newell, *Ecological Changes in Chesapeake Bay: Are They the Result of Overharvesting the American Oyster, Crassostrea virginica?*, 129 CHESAPEAKE RESEARCH CONSORTIUM PUBLICATION 536, 537 (1988).

78. Hypoxia means "oxygen deficiency; any state wherein a physiologically inadequate amount of oxygen is available to use or is used by issue, without respect to cause or degree (adj. hypoxic)." U.S. Army Corps of Engineers, *supra* note 2, at xix.

but survival time in hypoxic waters decreases as water temperature increases or if the oysters are not healthy.[79]

Sedimentation is another pollutant especially harmful to oysters.[80] It causes increased turbidity, accretion in waterways, and contributes to nutrient and toxic chemical pollution.[81] Sediments reduce oyster gill function and metabolic efficiency because filtering them causes an increase in pseudofaeces[82] production.[83] Exposure to sediment also causes decreased growth and reproduction efficiency, as well as increased susceptibility to disease and mortality.[84] The quality and quantity of spat habitat is reduced, as spat will not settle on oyster shell covered by sediment.[85]

3. Disease

It appears that oyster disease is "currently the most significant limiting factor affecting ecological restoration" of Eastern oysters.[86] The two deadliest pathogens to Chesapeake Bay oysters are the parasitic diseases commonly referred to as MSX and Dermo.[87] The deadliness of these parasites may be exacerbated by a general principal of parasitic disease: when the host suffers physiological stress from its environment it may become more susceptible to parasite infection and less likely to survive such an infection.[88] In other words, since the Eastern oysters are already stressed by pollution and harvest pressure, they are less equipped to combat infection.

a. MSX

MSX (*Haplosporidium nelsoni*) is a parasite that has been infecting Chesapeake Bay oysters since at least 1959.[89] When it first appeared,

79. Lenihan, *supra* note 9, at 911.
80. *See* Palmer, *supra* note 1, at 386-389.
81. *Id.*
82. Pseudofeces is "material rejected by suspension feeders or deposit feeders as potential food before entering the gut." U.S. Army Corps of Engineers, *supra* note 2, at xxii.
83. Rothschild, *supra* note 33, at 33.
84. *Id.*
85. *Id.*
86. BLUE RIBBON OYSTER PANEL, REPORT AND RECOMMENDATIONS 2 (2007), http://www.mrc.state.va.us/fmac/Blue_Ribbon_Oyster_Panel_May_2007.pdf.
87. *Id.*
88. Lenihan, *supra* note 9, at 910.
89. *See* Kennedy, *supra* note 29, at 81; Rothschild, *supra* note 33, at 35. "This acronym [MSX] originally stood for 'multinucleated sphere unknown,' and the disease is still commonly referred to as MSX, in spite of the fact that the parasite has since been identified." Alford, *supra* note 30, at 53 n.26.

MSX killed oysters at annual mortality rates of fifty to sixty percent of the population.[90] MSX is ingested by the oyster through its gills while the oyster feeds.[91] In the gills, the parasite rapidly multiplies, eventually breaking into the oyster's circulatory system and infecting the rest of the organism.[92] The oyster dies shortly thereafter.[93]

Generally, infections occur yearly through May, June, and July, and oyster mortality peaks in August.[94] Infections may also occur in late summer, in which case mortality does not occur until the following spring, due to winter dormancy of MSX.[95] MSX is most fatal in salinities above fifteen parts per thousand and temperatures above twenty degrees Celsius.[96] In years with warm winters, droughts, and high salinities, MSX spreads quickly through the Bay, while in years with cold winters, high rainfall and low salinities, MSX spreads more slowly.[97]

Little is known about MSX's life cycle.[98] The only known life stages of MSX are those seen in the oyster, the spore and plasmodia stages, but scientists believe there are more stages and probably another carrier-host.[99] It is believed MSX is the same parasite found in the Pacific oyster, *Crassostrea gigas*.[100] MSX is sometimes carried by the Pacific oyster, but seldom sickens that species of oyster.[101] It is possible MSX was introduced through small-scale introductions of the Pacific oyster by scientists, growers or through ballast water discharges, or a combination, but until the intermediate host is discovered, a definitive answer will not be available.[102]

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90. J.D. Andrews, *Oyster Diseases in Chesapeake Bay*, 41 MARINE FISHERIES REV. 45, 47 (1979).

91. Michael W. Fincham, *The Mystery Invasion of the Chesapeake Bay*, 5 CHESAPEAKE QUARTERLY 4, 7 (2006).

92. *Id.*

93. *Id.*

94. Eugene M. Burreson, Current State of Knowledge on MSX Disease Caused by *Haplosporidium nelsoni*, and Priorities for Future Research at the Oyster Research and Restoration in U.S. Coastal Waters Symposium (Sept. 8-9, 2003), http://www.mdsg.umd.edu/issues/chesapeake/oysters/research/meeting/abstracts/abstract07.html.

95. *Id.*

96. *Id.*

97. Fincham, *supra* note 91, at 7.

98. Burreson, *supra* note 94.

99. Fincham, *supra* note 91, at 7.

100. *See id.* at 9-12.

101. *Id.* Gene Burreson, a scientist who has extensively researched MSX introduction to Chesapeake Bay, observed, "MSX was like smallpox coming in with the Europeans, and the Native Americans were wiped out, because they were naïve to it. They hadn't seen it." *Id.* at 12.

102. Erica Goldman & Michael W. Fincham, *The Missing Link: MSX Middleman Remains Elusive,* 5 CHESAPEAKE QUARTERLY 14, 14 (2006).

b. Dermo

Dermo (*Perkinsus marinus*) is also a parasite.[103] It was first discovered in the Chesapeake Bay in 1949.[104] It is now considered the primary killer of oysters in the Chesapeake Bay.[105] The parasite is ingested by oysters with other particulates while the oyster feeds.[106] Dermo breeds in the oyster tissue, causing decreased growth and condition.[107] The oyster dies and opens, releasing the parasite into the water column to infect other oysters.[108]

Dermo's virulence and rate of infection increase with a variety of conditions. When water temperatures increase, so does the occurrence of Dermo infections; the parasite is dormant in the winter.[109] Dermo also prefers higher salinities, and is most prevalent at salinities of sixteen to twenty parts per thousand.[110] When oysters are in poor physiological condition due to environmental stressors, such as reduced water flow speeds, they become more susceptible to Dermo.[111] Also, oysters infected with Dermo are less able to survive hypoxia than uninfected oysters.[112]

D. The Bay Needs the Oyster as Much as the Oyster Needs the Bay

1. Ecological Role

The Eastern oyster is an integral part of the Chesapeake Bay. Restoration of the Bay and restoration of oyster populations are inextricably linked. The Chesapeake Bay relies on oysters for their filtering capabilities, as a food source for other organisms inhabiting the Bay, and for the oyster reefs that serve as habitat for other organisms.[113]

Oysters produce pseudofeces, which is important in sediment production and deposition. Pseudofeces produce sites for remineralizing

103. Rothschild, *supra* note 33, at 35.
104. *Id.*
105. Michael W. Fincham, *The Culture of Disease*, 5 CHESAPEAKE QUARTERLY 8, 8 (2006).
106. Lenihan, *supra* note 9, at 912.
107. *Id.*
108. *Id.*
109. *Id.*
110. *Id.* at 917.
111. Lenihan, *supra* note 9, at 917.
112. *Id.* at 921.
113. *See* discussion *infra* Part II.D.1. *See also, supra* Part II.A.

bacterial action, and is a food source for deposit feeders.[114] In this way, pseudofeces links pelagic[115] and benthic food webs.[116] In some parts of Chesapeake Bay, benthic biomass is lower as result of reduction in pseudofeces production by oysters.[117] Bivalves, such as oysters, provide a natural control on adverse effects of eutrophication by filtering excess nutrients from the water column.[118] Oysters consume about seventy percent of the particulate matter they filter.[119] "[P]re-1870 oyster populations in the Chesapeake Bay could potentially filter the entire water column during the summer in less than three to six days. . . . However, with the current oyster stocks, [this] turnover time has dramatically increased to 325 days. . . ."[120] "By 1988, the oyster population had declined to such an extent that it [was] only capable of removing about 0.7% of the daily carbon from Maryland's waters and 0.4% baywide."[121]

2. Socioeconomic Role

Not only are oysters a keystone species in the Chesapeake Bay, they are economically and culturally significant to Maryland and Virginia. The Chesapeake Bay is the primary tourist destination in Maryland and Virginia for the region's "hunting, fishing, sailing, hiking, historical landmarks, dining, and shopping."[122] If the Chesapeake Bay's health continues to decline, the region will not only lose a valuable ecological resource, but will lose its tourism base as well.

The Chesapeake Bay is also important for recreation in Maryland and Virginia. While people do not tend to harvest oysters for recreation, the oyster is important to many species that are recreationally valuable, such as fish and blue crabs.[123] In 2001, over 700,000 people purchased recreational fishing licenses in Maryland and over one million did so in Virginia.[124] In both states, in-state and out-of-state residents are able to

114. FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, SPECIES FACT SHEETS: CRASSOSTREA VIRGINICA, http://www.fao.org/fishery/species/2669 (last visited Oct. 13, 2008).

115. Pelagic means "the part of a body of water that is located in the open water column." U.S. Army Corps of Engineers, *supra* note 2, at xxi.

116. Newell, *supra* note 77, at 536.

117. *Id.* at 541.

118. *Id.* at 537.

119. *Id.* at 536.

120. *Id.* at 539.

121. Newell, *supra* note 77, at 540.

122. U.S. Army Corps of Engineers, *supra* note 2, § 3, at 31.

123. *See supra* Part II.D.1.

124. U.S. Army Corps of Engineers, *supra* note 2, § 3, at 42.

obtain fishing licenses,[125] illustrating that fishing is valuable for both the tourism and recreational industries.

The seafood industry provides Maryland and Virginia with valuable revenue, and if oyster populations improve, the industry should provide the states with even more revenue in the future.[126] While far from being the largest employer in the region, the seafood industry in both states employs around 6500 watermen and around 12,000 workers in seafood processing facilities.[127]

Many Bay-front communities were originally, and still are, based around the seafood industry.[128] Most watermen work year-round, harvesting crabs in summer months and harvesting oysters in the winter.[129] This allows them to earn income throughout the year and maintain their cultural identity.[130] One survey found that eighty-three percent of Chesapeake Bay watermen had lived in their communities for over twenty years.[131] Many watermen come from families that have been watermen for generations.[132] Even to those individuals who are not oystermen, oysters carry "a cultural meaning as one symbol of a productive, healthy, beautiful Chesapeake Bay."[133]

III. ANALYSIS

A. The Importance of a Multifaceted Approach and Cooperation among Stakeholders

The preceding sections discussed the dire condition of the Eastern oyster population in the Chesapeake Bay, how the population reached such a condition and why the oyster is essential to the future of the Chesapeake Bay. The Chesapeake Bay as a whole relies on the oyster for its important ecological roles of improving water quality, providing food for other species, and providing habitat.[134] The oyster, in turn,

125. *Id.*

126. *Id.* at 38. Currently in Maryland, the seafood industry accounts for about $400 million per year out of the state's total GDP (Gross Domestic Product) of over $255 billion. In Virginia, the seafood industry accounts for about $500 million per year out of the state's total GDP of over $380 billion. *Id.*

127. *Id.*

128. *Id.* § 3, at 37.

129. *Id.* § 3, at 39.

130. U.S. Army Corps of Engineers, *supra* note 2, § 3, at 38-39.

131. *See* George D. Santopiertro & Leonard A. Shabman, *Can Privatization be Inefficient? The Case of the Chesapeake Bay Oyster Fishery*, 26 J. ECON. ISSUES 407, 414 (1992).

132. U.S. Army Corps of Engineers, *supra* note 2, § 3, at 38.

133. *Id.*

134. *See supra* Part II.D.1.

relies on the Chesapeake Bay to provide it with unpolluted waters, dissolved oxygen and low sedimentation.[135] It is impossible to know whether a sustainable Eastern oyster population and a healthy Chesapeake Bay can exist without the other, and hopefully no one will ever have to find out.

The remainder of this comment will discuss the current policies regarding oysters in Maryland and Virginia and proposed changes to those policies. Through this discussion it will become more apparent that there is a need for 1) a multi-faceted approach to restore a sustainable population of oysters to the Chesapeake Bay, as no single alternative will ensure population restoration, 2) continued cooperation among stakeholders, including the states of Maryland and Virginia, federal agencies, nongovernmental organizations and watermen, and 3) disciplined long-term planning.

B. Current Laws, Regulations, and Policy

1. Laws and Regulations

a. Harvest restrictions

Both Maryland and Virginia have established similar regulations regarding oyster harvesting on public grounds.[136] In Maryland, all oysters must be at least three inches long from hinge to bill to be harvested.[137] In Virginia, oysters generally must be three inches long.[138] However, in the Rappahannock River, oysters must be more than two and one-half inches[139] and less than four and one-half inches.[140] This maximum harvest size was established to "protect potentially disease tolerant oysters in the Lower Rappahannock River."[141] Both states require undersized oysters and empty shells be returned to the bar where they were collected.[142] Both states also recognize an exception to this rule in instances where the undersized oysters are so closely adhered to market-sized oysters that removal would result in destruction of the undersized oysters.[143] In addition, both states place restrictions on the

135. *See id.*
136. MD. CODE REGS. 08.02.04.11 (2010); 4 VA. ADMIN. CODE § 20-260-30 (2009).
137. MD. CODE REGS. 08.02.04.11 (2010).
138. 4 VA. ADMIN. CODE § 20-260-30 (2009).
139. *Id.*
140. 4 VA. ADMIN. CODE § 20-260-35 (2009).
141. *Id.*
142. MD. CODE REGS. 08.02.04.11 (2010); 4 VA. ADMIN. CODE § 20-260-30 (2009).
143. MD. CODE REGS. 08.02.04.11 (2010); 4 VA. ADMIN. CODE § 20-260-30 (2009).

amount of empty shell and undersized oysters that may be present in an oystermen's catch.[144]

In Maryland, oyster season is generally October 1 until March 31, Monday through Friday from sunrise until 3 p.m.[145] Some exceptions exist, primarily relating to skipjacks[146] and power dredges.[147] Those individuals in violation of harvest regulations will be charged with a misdemeanor and fined less than five hundred dollars for a first offense. Second offenses may be punished by imprisonment for less than one year or fined less than one thousand dollars.[148]

In Virginia, oyster season generally spans October 1 to April 30, depending on the harvest grounds.[149] For example, the Tangier-Pocomoke Sounds area allows harvesting from December 1 to February 28.[150] Harvest is only allowed Monday-Friday and generally from sunrise to 2 pm, although there are variations depending on the harvest grounds and type of equipment used.[151] Violators of harvest regulations will be charged with a misdemeanor and fined less than five hundred dollars for a first offense; a second offender may be punished by imprisonment for less than one year and/or fined less than two thousand five hundred dollars.[152] Violators will also be subject to seizure of their harvest equipment and forfeiture of their oyster licenses and permits until they appear before the Virginia Marine Resources Commission.[153]

b. Oyster Bars

Both Maryland and Virginia have oyster beds comprised of both public and private oyster bars.[154] A public oyster bar allows anyone who is licensed by the state to harvest oysters there.[155] A private oyster bar only allows those who lease or own the oyster bar to harvest there.[156] In

144. MD. CODE REGS. 08.02.04.11 (2010); 4 VA. ADMIN. CODE § 20-260-40 (2009).
145. MD. CODE REGS. 08.02.04.03 (2010).
146. Skipjacks are sailboats that have been used in the Chesapeake Bay since the 1890s to dredge for oysters. Currently there are less than thirty skipjacks remaining in working condition, and only a few of those are still used for oyster harvesting. *See*, Maryland State Archives.com, Maryland State Boat-Skipjack (2008), http://www.msa.md.gov/msa/mdmanual/01glance/html/symbols/boat.html (last visited Mar. 31, 2010).
147. MD. CODE REGS. 08.02.04.03 (2010).
148. MD. CODE ANN., [NAT. RES.] § 4-1201 (2010).
149. 4 VA. ADMIN. CODE § 20-720-40 (2009).
150. *Id.*
151. 4 VA. ADMIN. CODE § 20-720-60 (2009).
152. 4 VA. ADMIN. CODE § 20-720-110 (2009).
153. *Id.*
154. U.S. Army Corps of Engineers, *supra* note 2, § 3, at 40.
155. *Id.*
156. *Id.*

Maryland, the vast majority of oyster bars are public (ninety-four percent), while in Virginia only about two-thirds of oyster bars are public (sixty-seven percent).[157] To highlight some of the differences between the oyster industries, in the 1990s, over ninety-six percent of the oyster harvest in Maryland came from public beds, while less than forty percent of Virginia's oyster harvest was from public beds.[158] In both states, oysters are harvested from public grounds in winter.[159] In Virginia, oysters on private bars are generally harvested in summer.[160]

Both states have also established oyster sanctuaries. Oyster sanctuaries are oyster bars where harvesting is illegal.[161] Illegal harvest is a misdemeanor in both states.[162] In Maryland, violators may face a fine of less than three thousand dollars.[163] In Virginia, first time violators will be fined less than five hundred dollars, while subsequent violators face imprisonment of less than one year and/or fines of less than two thousand five hundred dollars.[164]

c. Licensing and Catch Limits

Commercial oystermen in Maryland and Virginia are required to annually obtain licenses. In Virginia licenses are obtained based on the type of gear used to harvest.[165] For example an oyster dredging license is fifty dollars, a hand tonging license is ten dollars per person, and a double-rigged patent tong license is seventy dollars per boat.[166] In 2001, there were 320 gear specific licenses issued and in 2004 there were 420 issued.[167] Daily harvest is limited to eight bushels per licensed commercial waterman per day.[168]

In Maryland, commercial oystermen must first obtain an Oyster Harvest License (fifty dollars) or a Tidal Fishing License (three hundred dollars).[169] The harvester must also pay a three hundred dollar oyster surcharge.[170] There is also a 250 dollar fee for oyster dredge boats.[171] In

157. *Id.*
158. *Id.* § 3, at 39.
159. *Id.*
160. *Id.* § 3, at 37.
161. MD. CODE REGS. 08.02.04.15 (2010); 4 VA. ADMIN. CODE § 20-650-10 (2009).
162. MD. CODE REGS. 08.02.04.15 (2010); 4 VA. ADMIN. CODE § 20-650-10 (2009).
163. MD. CODE ANN., [NAT. RES.] § 4-1201 (2010).
164. 4 VA. ADMIN. CODE § 20-650-40 (2009).
165. 4 VA. ADMIN. CODE § 20-1090-30 (2009); U.S. Army Corps of Engineers, *supra* note 2, § 3, at 39.
166. 4 VA. ADMIN. CODE § 20-1090-30 (2009).
167. U.S. Army Corps of Engineers, *supra* note 2, § 3, at 39.
168. 4 VA. ADMIN. CODE § 20-720-80 (2009).
169. U.S. Army Corps of Engineers, *supra* note 2, § 3, at 39.
170. *Id.*
171. *Id.*

2001 over one thousand watermen paid the oyster surcharge, while only 284 paid it in 2004.[172] Daily catch limits in Maryland are dependent on the type of harvesting equipment used.[173] Watermen harvesting with tongs may harvest fifteen bushels of oysters per licensee, but no more than thirty bushels per boat.[174] Dredge boats may harvest 150 bushels per boat.[175] Watermen utilizing power dredges may harvest twelve bushels of oysters per licensee, but are limited to twenty-four bushels per boat.[176] All Maryland oystermen are required to submit a monthly report to the Maryland Department of Natural Resources indicating their daily catch in bushels, the fishing gear used, the oyster bar harvested from, and who the oysters were sold to.[177]

2. Policy

a. Restoration

Both Maryland and Virginia have independently attempted to restore oyster populations in their respective portions of the Chesapeake Bay. Unfortunately, these restoration efforts have had only limited success due to poaching in oyster sanctuaries and reserves, continuing sedimentation of oyster beds, and unyielding Dermo and MSX disease pressure.[178] Both states have utilized the same types of management and restoration practices.[179] One of the primary methods is some form of "shell reclamation," where oyster shells are collected, washed and redistributed to oyster beds to provide a clean surface for spat settlement.[180] Shells are obtained by dredging the Chesapeake Bay for old oyster shells or purchasing shells from processing facilities.[181] Maryland's Department of Natural Resources (MD DNR) is also in the planning stages of implementing a program to retrieve previously planted shells that have been buried by sediment.[182]

172. *Id.*
173. MD. CODE REGS. 08.02.04.06 (2010).
174. *Id.*
175. *Id.*
176. *Id.*
177. MD. CODE REGS. 08.02.13.06 (2010); MD. CODE REGS. 08.02.04.06 (2010); Maryland Department of Natural Resources, 2009-2010 Maryland Monthly Oyster Report, http://dnr.maryland.gov/fisheries/oysters/pdfs/oyharvestform09.pdf (last visited Mar. 31, 2010).
178. U.S. Army Corps of Engineers, *supra* note 2, § 1, at 16.
179. *See id.* § 1.
180. *Id.* § 1, at 13.
181. *Id.*
182. *Id.*

A variation on the first method is "seed-area planting."[183] Clean oyster shells are placed on oyster bars with high spat settlement, usually in waters with high salinity during spawning.[184] When spat settle onto the shells, the shells are moved to oyster bars with lower salinity to mature, since disease prevalence is generally lower there.[185] This method has been used with more success in Maryland because Virginia lacks large areas of low salinity water for spat transplantation.[186] In recent years, this method has been used with caution, as many believe this practice has spread Dermo and MSX into low salinity areas.[187]

Artificial reef building is another restoration method gaining popularity.[188] Reef building is designed to mimic the nature of historic reefs by elevating oysters above the estuary bottom.[189] Reef building raises oysters higher in the water column above the sedimentation layer and potentially anoxic bottom waters.[190] Preliminary research on concrete artificial reefs by the Virginia Marine Resource Commission (VA MRC) and the Army Corps of Engineers has showed promise, although most reefs have been in place less than ten years making it difficult to evaluate their long-term success.[191] Cost is the primary drawback to widespread use of artificial reefs; however, if the reefs are successful restoration tools, initial expense may be justified by long-term success.[192] Artificial reefs prevent harvest by common harvest methods, as use of common harvest methods will damage the artificial reef and harvesting equipment.[193] This may be a positive, as artificial reefs could limit poaching and may promote development of less destructive harvest methods.[194]

183. U.S. Army Corps of Engineers, *supra* note 2, § 1, at 14.
184. *Id.*
185. *Id.*
186. *Id.*
187. *Id.*
188. U.S. Army Corps of Engineers, *supra* note 2, § 1, at 15.
189. *Id.*
190. *Id.*
191. *Id.; see also See* Karl Blankenship, *Great Wicomico Site of Thriving Native Oyster Reef*, 19 BAY J., Sept. 2009, at 1, 12-13.
192. U.S. Army Corps of Engineers, *supra* note 2, § 1, at 15.
193. *Id.* at 16.
194. *Id.*

b. Cooperation Among Stakeholders[195]

i. Chesapeake Bay Program

The Chesapeake Bay Program (CBP) consists of representatives from Maryland, Pennsylvania, Virginia, Washington, D.C., the Chesapeake Bay Commission, the United States Environmental Protection Agency, federal agency partners, academic partners and other partners including citizen's action groups.[196] The CBP is responsible for establishing the various *Chesapeake Bay Agreements*, most recently the *Chesapeake 2000 Agreement*, which establish goals and priorities for Chesapeake Bay restoration.[197] The CBP also conducts environmental monitoring and establishes environmental standards and goals for the Chesapeake Bay region.[198]

The Chesapeake Bay Commission (CBC) is the legislative section of the CBP and acts as an advisor to the General Assemblies of Maryland, Pennsylvania and Virginia on Chesapeake Bay issues.[199] The CBC consists of twenty-one members, made up of state legislators, each state's natural resource cabinet secretaries, and citizen representatives.[200] To date, the CBC has been instrumental in passing legislation to reduce nutrient run-off and upgrade sewage treatment facilities.[201]

ii. Virginia: Blue Ribbon Oyster Panel

The Blue Ribbon Oyster Panel (BROP) was established by the VA MRC to review the agency's strategies and expenditures in Eastern oyster restoration and make recommendations for future policy.[202] The BROP consists of Virginia state officials including the Secretary of Natural Resources and a former governor. Other members include representatives from seafood packing companies, private oyster farmers, representatives of watermen's associations, scientists at the Virginia

195. There are a variety of stakeholders consisting of federal and state agencies, citizens' action groups, and environmental organizations. Discussing all of them would go well beyond the scope and purposes of this paper, so only a few are mentioned here.

196. Chesapeake Bay Program Home Page, http://www.chesapeakebay.net (last visited Mar. 31, 2010).

197. *Id.*

198. *Id.*

199. Chesapeake Bay Commission Home Page, http://www.chesbay.state.va.us/index.htm (last visited Mar. 31, 2010).

200. *Id.*

201. *Id.*

202. Blue Ribbon Oyster Panel, *supra* note 86, at 1.

Institute of Marine Science, representatives of non-profits, and federal representatives.[203]

iii. Maryland: Oyster Advisory Commission

The Maryland Oyster Advisory Commission (OAC) was established to advise state agencies on oyster restoration.[204] The OAC has twenty-one members including scientists, representatives of environmental organizations, representatives from Maryland, Virginia and the federal agencies, politicians, businessmen and watermen.[205] The OAC has divided into two workgroups: one focuses on economic oyster restoration and the other focuses on ecological oyster restoration.[206] The economic workgroup is examining oyster aquaculture, while the ecological workgroup is evaluating policy changes to restore the oyster's ecological role in the Chesapeake Bay.[207]

iv. Chesapeake Bay Foundation

The Chesapeake Bay Foundation (CBF) is a non-profit organization that operates throughout the Chesapeake Bay watershed, but has offices in Virginia, Maryland, and Pennsylvania.[208] The CBF is engaged in a variety of activities, including restoring the Chesapeake Bay and its tributaries, lobbying for state and federal regulations to promote conservation and reduce pollution, educating the public about the Chesapeake Bay, and litigating to enforce environmental regulations and laws.[209] The CBF has oyster aquaculture[210] and shell recycling programs.[211]

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203. *Id.*

204. Maryland Department of Natural Resources, In Focus—Oysters Home Page, http://www.dnr.state.md.us/dnrnews/infocus/oysters.asp (last visited Jan. 30, 2009).

205. Press Release, Maryland Department of Natural Resources, Maryland Establishes New Oyster Advisory Commission (Sept. 18, 2007), http://www.dnr.state.md.us/dnrnews/pressrelease2007/091807.html.

206. Maryland Department of Natural Resources, *supra* note 204.

207. *Id.*

208. Chesapeake Bay Foundation, About Us, http://www.cbf.org/Page.aspx?pid=259 (last visited Mar. 31, 2010).

209. *Id.*

210. *See* CHESAPEAKE BAY FOUNDATION, VIRGINIA OYSTER RESTORATION CENTER 2008 YEAR END SUMMARY 9 (2008), http://www.cbf.org/Document.Doc?id=333.

211. *See* Chesapeake Bay Foundation, Save Oyster Shell—Maryland, http://www.cbf.org/Page.aspx?pid=1456 (last visited Mar. 31, 2010); *see* CHESAPEAKE BAY FOUNDATION, VIRGINIA OYSTER RESTORATION CENTER 2008 YEAR END SUMMARY 15 (2008), http://www.cbf.org/Document.Doc?id=333.

C. *The Future of Oyster Laws and Regulations in the Chesapeake Bay*

This section will first address the recent environmental impact statement regarding oyster restoration in the Chesapeake Bay, which was triggered by the National Environmental Policy Act (NEPA). This is an excellent example of how the NEPA environmental impact statement process works. Afterwards, specific restoration strategies will be examined, including introduction of the nonnative Suminoe oyster, establishing a harvest moratorium and expanding aquaculture. With the exception of introducing a nonnative oyster, the other policies are likely to result in long-term sustainability if they are used in combination.

1. Proposed Policy in Maryland and Virginia

a. The Programmatic Environmental Impact Statement for Oyster Restoration in Chesapeake Bay Including Use of a Native and/or Nonnative Oyster

Recently oyster restoration efforts in Maryland and Virginia focused on evaluating the feasibility of nonnative oyster introduction and improving restoration of Eastern oysters.[212] The Draft Programmatic Environmental Impact Statement (DPEIS) was developed by the United States Army Corps of Engineers (ACE), the Maryland Department of Natural Resources (MD DNR), and the Virginia Marine Resources Commission (VA MRC) to comply with the National Environmental Policy Act.[213] The National Environmental Policy Act[214] process was "triggered by the proposed action, which is to introduce the nonnative Suminoe oyster to the Chesapeake Bay while continuing to restore the native oyster."[215] When the DPEIS was published, the drafters avoided establishing a preferred alternative so that public comment could be considered in making that determination.[216] After the public comment period ended on December 15, 2008, the agencies responded to the public comments received and issued a Final Programmatic

212. U.S. Army Corps of Engineers, *supra* note 2, § 1, at 1.
213. *Id.*
214. National Environmental Policy Act of 1969, 42 USC §§ 4321 *et. seq.* (2009).
215. U.S. Army Corps of Engineers, *supra* note 2, § ES, at 2.
216. *Id* § 1, at 1-2; U.S. ARMY CORPS OF ENGINEERS, MD. DEP'T OF NATURAL RES. & VA. MARINE RES. COMM'N, RECORD OF DECISION—FINAL PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT FOR OYSTER RESTORATION IN CHESAPEAKE BAY INCLUDING THE USE OF A NATIVE AND/OR NONNATIVE OYSTER (2009), *available at* http://www.nao.usace.army.mil/OysterEIS/ [hereinafter Record of Decision].

Environmental Impact Statement (FPEIS) in August 2009.[217] The FPEIS is now being used to provide a broad framework for more specific restoration efforts in the future, as well to promote cooperation among the federal government and the States of Maryland and Virginia.

The National Environmental Policy Act process requires identification and evaluation of the proposed action and alternatives the proposed action to provide a context for evaluating the proposed action.[218] The DPEIS proposed restoration of the oyster population to that existing from 1920 to 1970, as the population appeared to be stable then.[219] This is equivalent to a population consisting of approximately twelve billion market-sized oysters.[220] However, some commentators have noted that there is little evidence that the 1920 to 1970 population restoration goal is appropriate, as there is little evidence that this population was truly stable.[221]

The DPEIS proposed eight alternatives to introducing Suminoe oysters to the Chesapeake Bay and continuing to restore the Chesapeake Bay. The first alternative was to take no action and for oyster restoration programs to continue at current levels.[222] The second alternative was to enhance Eastern oyster restoration, including doubling the number of acres of oyster habitat, constructing artificial reefs, and increasing oyster seed-planting efforts.[223] The third alternative was to implement a temporary harvest moratorium by either establishing a buy-out program or offering displaced oystermen on-water work in restoration programs.[224] The fourth alternative was to implement aquaculture of diploid and triploid Eastern oysters.[225] The fifth alternative was implementing aquaculture of Suminoe triploid oysters, in an effort to avoid establishing a wild population of nonnative oysters and triploids are more efficient for aquaculture due to their more rapid growth rates.[226] The sixth alternative was to introduce another nonnative oyster species to the Chesapeake Bay; however, this alternative was abandoned.[227] Preliminary studies ruled out other species as good candidates for

217. *See* U.S. Army Corps of Engineers, *supra* note 216; *see also* Karl Blankenship, *Use of Nonnative Oyster Officially Ruled Out*, 19 BAY J., Sept. 2009, at 13.
218. U.S. Army Corps of Engineers, *supra* note 2, § 1, at 2.
219. *Id.* § 2, at 1.
220. *Id.*
221. OYSTER ADVISORY PANEL, FINAL REVIEW OF PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT FOR OYSTER RESTORATION IN CHESAPEAKE BAY 14 (2008), http://www.nao.usace.army.mil/OysterEIS/documents/OAP_Comments_full_10-20.pdf.
222. U.S. Army Corps of Engineers, *supra* note 2, § 2, at 5.
223. *Id.*
224. *Id.* § 2, at 7.
225. *Id.* § 2, at 8.
226. *Id.* § 2, at 7.
227. U.S. Army Corps of Engineers, *supra* note 2, § 2, at 10, 12.

introduction due to low survivability and poor marketability.[228] The seventh alternative was to introduce Suminoe oysters and to stop restoring Eastern oysters; however, this alternative also was abandoned due to its similarity to the proposed alternative.[229]

The eighth alternative consisted of three combinations of the other alternatives.[230] The first combination was to restore only the Eastern oyster by enhancing restoration efforts, imposing a temporary harvest moratorium, and establishing Eastern oyster aquaculture.[231] The second combination was to restore the Eastern oyster and establish triploid Suminoe oyster aquaculture by enhancing restoration efforts, imposing a temporary harvest moratorium, and establishing Eastern oyster and triploid Suminoe aquaculture.[232] The third combination was to restore Eastern oysters, introduce diploid Suminoe oysters into the wild population, and establish Eastern oyster and Suminoe oyster aquaculture.[233]

The FPEIS adopted the eighth alternative, specifically the first combination: restore only the Eastern oyster by enhancing restoration efforts, imposing a temporary harvest moratorium, and establishing Eastern oyster aquaculture.[234] When the FPEIS was completed the NEPA process ended.[235]

b. Life After the NEPA Process

On May 12, 2009, President Barack Obama issued Executive Order 13508 on Chesapeake Bay Restoration and Protection; this was the first ever executive directive targeting the Chesapeake Bay.[236] The Executive Order calls for increasing research on the Chesapeake Bay ecosystem, increasing public access to the Bay, and improving the Chesapeake Bay's water quality by strengthening storm water management, utilizing tools provided for in the Clean Water Act, and extending land conversation and best management practices in farming.[237] While the Executive Order does not directly target oysters, its success will impact and be at least partially dependent on the oyster population since oysters

228. *Id.*
229. *Id.* § 2, at 15.
230. *Id.* § 2, at 10.
231. *Id.*
232. U.S. Army Corps of Engineers, *supra* note 2, § 2, at 10.
233. *Id.*
234. Record of Decision, *supra* note 216.
235. *Id.* at ROD-4.
236. Executive Order 13508, 74 Fed. Reg. 23,099 (May 12, 2009); *see also* Karl Blankenship, *Executive Order Calls on Federal Agencies to Lead Bay Cleanup*, 19 BAY J., June 2009, at 18.
237. Executive Order 13508, 74 Fed. Reg. 23,099 (May 12, 2009).

are a keystone species in the Chesapeake Bay.[238] Furthermore, it could lead to increased funding for oyster research and restoration, as ecosystem research is one of its goals.[239]

On November 9, 2009, the Federal Leadership Committee for the Chesapeake Bay released its Draft Strategy for Protecting and Restoring the Bay.[240] The Draft Strategy proposes to restore clean water, conserve treasured places and habitat, and adapt to climate change, as its primary goals.[241] These goals are to be met by promoting local efforts, especially through stewardship; emphasizing decision-making through science by facilitating information sharing among all involved agencies; and ushering in a new era of federal leadership based on collaboration and transparency.[242] The Draft Strategy was open for public comment until January 8, 2010.[243] After taking the public comments into consideration, the Final Strategy was released May 12, 2010.[244]

Maryland has expanded efforts to restore the Eastern oyster in the Chesapeake Bay. On May 7, 2009, Governor Martin O'Malley accepted Maryland Senate Bill 271, which eases restrictions on aquaculture and shellfish leasing in Maryland's portion of the Bay.[245] The Maryland Department of Natural Resources announced that it will be expanding its Marylanders Grow Oysters program beginning in 2010.[246] In December 2009, Governor Martin O'Malley unveiled his ten-point plan for oyster restoration and aquaculture development.[247] The plan includes

238. *See supra* Part II.B.

239. Executive Order 13508, 74 Fed. Reg. 23,099 (May 12, 2009).

240. Federal Leadership Committee for the Chesapeake Bay, *Executive Order 13508: Draft Strategy for Protecting and Restoring the Chesapeake Bay*, Nov. 9, 2009, http://executiveorder.chesapeakebay.net/.

241. *Id.*

242. *Id.*

243. Executive Order 13508 Chesapeake Bay Protection and Restoration Section 203 Draft Strategy and Section 202 Federal Agency Reports, 74 Fed. Reg. 57,675 (Nov. 9, 2009); Executive Order 13508 Chesapeake Bay Protection and Restoration Section 202 Federal Agency Reports, 74 Fed. Reg. 63,752 (December 4, 2009).

244. Executive Order 13508 Chesapeake Bay Protection and Restoration Section 203 Final Coordinated Implementation Strategy, 75 Fed. Reg. 26,226 (May 11, 2010); *see also* Karl Blankenship, *7 Federal Reports Direct Federal Agencies to Take Lead in Bay Cleanup*, 19 BAY J., October 2009, at 1, 9-10.

245. News in Brief, *O'Malley Signs Aquaculture Bill*, 19 BAY J., June 2009, at 21; *see* 2009 Md. Laws 173.

246. In the Marylanders Grow Oysters Program, "[t]he Maryland Department of Natural Resources provides spat—young oysters—free to residents to raise at their docks with the understanding that they return them after 10-12 months for deposit on sanctuaries." Len Zuza, *Thinking Outside the Box and into the BOCS Aids Oyster Restoration*, 19 Bay J., Sept. 2009, at 21. Maryland Department of Natural Resources, Marylanders Grow Oysters Program, http://www.oysters.maryland.gov/ (last accessed Mar. 31, 2010).

247. Maryland Department of Natural Resources, Maryland's Vision for Oysters, http://dnr.maryland.gov/fisheries/oysters/pdfs/GovernorsOfficeSlidesFinal.pdf (last

increasing the oyster sanctuary program, shifting from wild harvest to an aquaculture based industry, rehabilitating oyster bar habitat, enhancing law enforcement against poachers, and increasing hatchery production to support expanded aquaculture.[248]

Virginia is also expanding its Eastern oyster restoration efforts. The Virginia oyster industry is in the process of basing its production on aquaculture, rather than wild harvest and, as a result, aquaculture is a growing industry.[249] However, budget shortfalls have temporarily led to decreases in public restoration programs overall.[250]

2. Introduction of the Suminoe Oyster (*Crassostrea Ariakensis*)

Previous proposals regarding nonnative oyster introduction were based around introduction of the Pacific oyster (*Crassostrea gigas*).[251] The Pacific oyster exhibits tolerance to MSX and Dermo; however, it also suffers severe mud-blistering[252] on its shell due to mud worms commonly found in the Chesapeake Bay.[253] Mud blisters reduce the marketability of oysters and weaken shells making predation more likely.[254] As a result, the Pacific oyster has been largely abandoned as a candidate for introduction to the Chesapeake Bay.[255]

More recent proposals have centered on introduction of the Suminoe oyster (*C. ariakensis*).[256] The DPEIS[257] was based on the introduction of an aquaculture strain known as "Oregon Stock" which is grown commercially in the Northwest United States and has been used in experimental trials in Maryland, Virginia and North Carolina.[258]

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visited Mar. 31, 2010); *see also* Maryland Department of Natural Resources, Open House Presentation, http://dnr.maryland.gov/fisheries/oysters/pdfs/GovernorsOfficeSlides Final.pdf (last visited Mar. 31, 2010).

248. *Id.*

249. *See* CHESAPEAKE BAY FOUNDATION, VIRGINIA OYSTER RESTORATION CENTER 2008 YEAR END SUMMARY 1 (2008), http://www.cbf.org/Document.Doc?id=333.

250. *Id.* at 2.

251. U.S. Army Corps of Engineers, *supra* note 2, § 1, at 20.

252. Mud blisters in Chesapeake Bay oysters are caused by mud worms of the genus *Polydora*. The mudworms bore into an oyster's shell, the hole fills with mud, and the oyster covers mud with more shell. Mud worms don't kill the oyster but mud worms do negatively impact the oyster's condition. When an oyster has to expend energy fixing its shell, it has less energy to expend on growth, reproduction or fending off pathogens and predators. Low mud worm infection rates reduce oyster marketability, while high rates of infection lead to increased oyster mortality by other sources. Mud blisters occur most commonly at low and moderate salinities. *Id.* § 4, at 17.

253. *Id.* § 1, at 20.

254. *Id.*

255. *Id.*

256. *Id.*

257. *See supra* Part III.C.1.a.

258. *Id.* § 1, at 20, 21.

Introduction proposals have included introduction of triploid[259] Suminoe oysters for aquaculture and/or introduction of diploid[260] Suminoe oysters into the wild.[261]

Any introductions of nonnative species must be done with extreme caution, as nonnative species generally have unexpected negative effects on the ecosystem.[262] Introducing a nonnative species to open aquatic environments is especially risky because such introductions are irreversible.[263] Generally, nonnative species compete with native species for food and space.[264] They may also hybridize with native species causing genetic deterioration of the native species.[265] Nonnative species may introduce foreign pathogens and often expand their population into unintended areas.[266] To mitigate these risks, careful assessment must be made before Suminoe oysters are introduced to the Chesapeake Bay. The following paragraphs will evaluate the positives and negatives associated with Suminoe oyster introduction.

Suminoe oyster introduction may be advantageous for a number of reasons. First, Suminoe oysters experience low mortality when exposed to Dermo and MSX.[267] Suminoe oysters are tolerant to Dermo, as they may be infected by the parasite, but it does not cause mortality.[268] Suminoe oysters are resistant to MSX infection at all salinities.[269] Second, Suminoe oysters grow much more rapidly than Eastern oysters[270] and reach sexual maturity before Eastern oysters.[271] Also, Suminoe oyster growth rates increase with salinity, making them prime for Virginia's higher salinity waters.[272] Third, Suminoe oyster spat appear to experience lower mortality than Eastern oyster spat under the same conditions.[273] Fourth, Suminoe oysters appear to survive well in

259. Triploids have three sets of chromosomes, which should render them sterile. Lori H. Peoples, *A Call for Uniform Regulation of Intentional Introductions of Non-Indigenous Species: The Suminoe Oyster*, 81 N.C. L. Rev. 2433, 2438 n.30 (2003). Triploids grow much faster than diploids of the same species because all of their energy can go to growth. U.S. Army Corps of Engineers, *supra* note 2, § 2, at 9.

260. Diploids have two sets of chromosomes and are able to reproduce. Peoples, *supra* note 259, at 2438 n.30.

261. U.S. Army Corps of Engineers, *supra* note 2, § 1, at 20.

262. *Id.* § 1, at 21.

263. *Id.*

264. Peoples, *supra* note 259, at 2435.

265. *Id.*

266. *Id.*

267. U.S. Army Corps of Engineers, *supra* note 2, § 4, at 4-5.

268. *Id.*

269. *Id.*

270. Peoples, *supra* note 259, at 2438.

271. U.S. Army Corps of Engineers, *supra* note 2, § 4, at 4-6.

272. *Id.* § 4, at 7.

273. *Id.* § 4, at 8.

the same salinity and temperature ranges as Eastern oysters in the Chesapeake Bay, indicating that they could successfully colonize the Bay.[274]

One of the largest problems with introducing Suminoe oysters to the Chesapeake Bay region is the lack of knowledge regarding their effect on Eastern oysters.[275] Research so far has indicated that the risk is moderate to high that Suminoe Oysters will interact and compete with Eastern oysters for habitat and food.[276] The species are likely to coexist; however, coexistence could consist of anything from local extinction of one species to creation of reefs containing both species.[277] The following are likely to be drawbacks to introducing the Suminoe oyster to the Chesapeake Bay.[278] First, it is unclear that the Suminoe oyster will be able to survive in the full range of habitats that the Eastern oyster inhabits. The Chesapeake Bay is subject to periods of anoxia or hypoxia in deeper water during the summer.[279] The Eastern oyster has largely adapted to this phenomenon, while the Suminoe oyster has not.[280] For example, in one study juvenile Suminoe and Eastern oysters were exposed to prolonged periods of anoxic conditions.[281] After prolonged exposure to anoxia, all of the juvenile Suminoe oysters died, compared to only fifty-one percent of juvenile Eastern oysters.[282] It appears that Suminoe oysters are unable to colonize the deeper Bay waters where hypoxia is common and would suffer high mortality if the hypoxic layer in the Bay expands.[283]

In addition to low tolerance to anoxia, Suminoe oysters are not very tolerant of intertidal habitats, an area customarily inhabited by Eastern oysters.[284] Suminoe oysters have low survivability in intertidal habitats evidenced by their depressed growth rates, higher mortality, and the fact that they do not inhabit the intertidal zone in their native China.[285]

Second, introduction of aquaculture stock into the wild, such as the "Oregon Stock," could result in a genetic bottleneck.[286] Aquaculture stock has been inbred over numerous variations, so it has much lower

274. *Id.*
275. *Id.* § 4, at 57.
276. U.S. Army Corps of Engineers, *supra* note 2, § 4, at 57.
277. *Id.*
278. *Id.*
279. *See supra* Part II.C.2.
280. U.S. Army Corps of Engineers, *supra* note 2, § 4, at 10.
281. *Id.*
282. *Id.*
283. *Id.* § 4, at 11.
284. U.S. Army Corps of Engineers, *supra* note 2, § 4, at 11.
285. *Id.*
286. *Id.* § 4, at 10.

genetic variability than a wild population.[287] A genetic bottleneck results when there is reduced genetic diversity among members of the population, meaning that the individuals within a population are genetically similar.[288] When there is little genetic variability within the population, the population is less likely to adapt to changes in the environment such as changes in salinity, diseases, or predation.[289] A general rule of population genetics is that the more genetically varied a population is, the more likely the population is able to withstand changes in its environment.[290] The likelihood of a genetic bottleneck would be decreased if wild Suminoe oysters were introduced in addition to, or instead of, the "Oregon Stock." However, doing so would increase the likelihood of transmitting harmful nonnative pathogens into the Chesapeake Bay.[291]

Third, introduction of Sumino oysters could cause reproductive and food interference with Eastern oysters.[292] The species spawn within the same time span and each species can induce the other to spawn.[293] This increases the risk of gametes of each species fusing and forming hybrids.[294] The hybrids are not viable and die within ten days of forming, resulting in net gamete loss for both species.[295] Research indicates that the species with the highest population on the reef will be reproductively advantaged.[296] Suminoe oysters could potentially out-compete Eastern oysters because Suminoe oysters reach sexual maturity more quickly.[297] Also, there could be competition for food and habitat since both species consume the same sized particles as they filter feed.[298] This would probably not be an issue now since there is an abundance of plankton in the Chesapeake Bay, but it could become problematic in the future if oysters become more prevalent.[299]

Fourth, Suminoe oysters may not survive well in the Chesapeake Bay due to conditions that negatively impact spat survival. Suminoe oyster spat are negatively impacted by common algal blooms that do not affect Eastern oysters.[300] Oyster spawning coincides with the periods

287. *Id.* § 2, at 14.
288. *Id.*
289. U.S. Army Corps of Engineers, *supra* note 2, § 2, at 14.
290. *Id.*
291. *Id.* § 4, at 10.
292. *Id.* § 4, at 12.
293. *Id.*
294. U.S. Army Corps of Engineers, *supra* note 2, § 4, at 12.
295. *Id.*
296. *Id.*
297. *Id.*
298. *Id.* § 4, at 13.
299. U.S. Army Corps of Engineers, *supra* note 2, § 4, at 13.
300. *Id.*

when there is high abundance of two species of bloom algae, *Karlodinium veneficum* and *Prorocentrum minimum*.[301] Suminoe oyster spat exhibit reduced growth rates and larvae exhibit altered swimming behavior in the presence of these algae.[302] Juvenile Suminoe oysters are also subject to higher rates of predation by crabs and ctenophores than Eastern oysters due to the Suminoe oyster's weaker shell.[303] However, no one has studied whether the Suminoe oyster's higher growth rates are sufficient to balance the negative effects of higher early predation.[304]

Fifth, the Suminoe oyster is more susceptible than the Eastern oyster to diseases that could spread to the Chesapeake Bay.[305] Suminoe oysters are extremely susceptible to the blood parasite *Bonamia*.[306] For example, one study found that forty-seven percent of Suminoe oysters were infected with *Bonamia*, while no Eastern oysters in the same area were infected.[307] Spread of *Bonamia* into the Chesapeake Bay is a legitimate concern if Suminoe oysters are introduced, as the disease is found in other parts of North America, including Cape Hatteras, North Carolina.[308] *Bonamia* is especially virulent in eighteen to thirty parts per thousand salinity, which could prevent Suminoe oyster colonization or survival in most of Virginia's waters.[309]

Also, Suminoe oysters elsewhere have been stricken by unknown protozoan parasites.[310] Since 1992, oyster aquaculture facilities in Pearl River Valley, China have experienced eighty to ninety percent oyster mortality from February to May every year, but the pathogen has not been identified.[311] France considered introducing Suminoe oysters into its aquaculture industry, but abandoned the idea when many of their experimental oysters died and appeared to have been stricken by a protozoan parasite not seen before.[312] Since these pathogens remain unidentified, their effect on the Eastern oyster is unknown.

Sixth, Suminoe oysters are very susceptible to mud blisters, which affect the oyster's survival and marketability.[313] Suminoe oysters suffer higher infection of mud worms than Eastern oysters, most likely related

301. *Id.* § 4, at 14.
302. *Id.*
303. *Id.*
304. U.S. Army Corps of Engineers, *supra* note 2, § 4, at 15.
305. *See id.* § 4, at 15-17.
306. *Id.* § 4, at 15.
307. *Id.*
308. *Id.*
309. U.S. Army Corps of Engineers, *supra* note 2, § 4, at 16.
310. Leffler, *supra* note 46, at 9.
311. *Id.*
312. *Id.*
313. U.S. Army Corps of Engineers, *supra* note 2, § 4, at 17.

to the Suminoe oyster's thinner, less dense shell.[314] This higher rate of infection depresses Suminoe growth rates and increases their susceptibility to predation.[315]

Seventh, it is unclear how the Suminoe oyster will accumulate harmful toxins in its tissues, which could raise public health issues.[316] Since oysters are filter feeders they can accumulate contaminants in their tissues, especially heavy metals and bacteria.[317] It is unclear whether Suminoe oysters metabolize these things in the same way that Eastern oysters do, so more research is needed.[318]

The eighth drawback to introducing Suminoe oysters to the Chesapeake Bay region is the likelihood that Suminoe oysters will spread to other ecosystems.[319] Eastern oysters are present throughout the eastern seaboard[320] and the habitat requirements of the Eastern oyster and the Suminoe oyster are similar.[321] Therefore, it is likely that if Suminoe oysters are introduced to the Chesapeake Bay, their range will spread up and down the east coast and may negatively impact Eastern oyster fisheries elsewhere.[322]

Finally, even if the Suminoe oyster is only introduced for aquaculture, there are a number of negatives associated with its introduction.[323] The primary risk is that triploid oysters may not be sterile or they may revert to being diploid oysters, creating the possibility of unintentionally establishing a breeding population of Suminoe oysters in the Chesapeake Bay.[324] Triploid oysters sometimes produce gametes allowing them to breed with diploids of the opposite sex and produce diploid offspring.[325] Because of the inconsistency in sterility of triploid Suminoe oysters, biosecure aquaculture facilities would be required to avoid Suminoe oyster introduction into the wild.[326] Biosecure facilities are expensive and are not failsafe, further decreasing the feasibility of triploid Suminoe oyster aquaculture.[327]

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314. *Id.*
315. *Id.*
316. *Id.* § 3, at 59.
317. *Id.*
318. U.S. Army Corps of Engineers, *supra* note 2, § 3, at 59.
319. Peoples, *supra* note 259, at 2438-2439; Oyster Advisory Panel, *supra* note 221, at 14.
320. *See supra* Part II.
321. *See supra* Part III.C.2.
322. Peoples, *supra* note 259, at 2438-2439; Oyster Advisory Panel, *supra* note 221, at 14.
323. U.S. Army Corps of Engineers, *supra* note 2, § 3, at 61-62.
324. Leffler, *supra* note 46 at 6; Peoples, *supra* note 259, at 2438-2439.
325. U.S. Army Corps of Engineers, *supra* note 2, § 4, at 44.
326. *Id.* § 2, at 9.
327. *Id.*

3. Alterations to Oyster Harvest

a. Temporary Moratorium on Oyster Harvest

It seems clear that a moratorium on oyster harvesting alone would not result in a restored Eastern oyster population; however, it could be effective if combined with other restoration efforts.[328] One benefit of a harvest moratorium is that it would eliminate loss in oyster population due to by-catch. It is estimated that ten percent of oysters on a reef are incidentally destroyed during each harvesting event on each reef due to shell destruction by harvesting gear.[329] Another benefit is that a moratorium eliminates the major impediment to natural disease resistance development in the oyster population. This is because a moratorium prevents harvest of the largest, most fertile, and most disease resistant oysters in the population.[330] Finally a moratorium would be beneficial because it would relieve at least one of the environmental pressures on the oyster population.[331]

While there may be ecological benefits and long-term economic benefits to enacting a temporary harvest moratorium on oysters, one cannot ignore the short-term economic and cultural detriments to such action. Many watermen reside in communities where there are few alternative employment opportunities, so a harvest moratorium would severely impact their communities, their families, and the seafood packing industry.[332]

If a moratorium was imposed, it should be the state and federal governments' responsibility to mitigate damage to watermen and the packing industry. Benefits should be provided to give watermen and packers as many employment options as possible and fair compensation. Possibilities include implementing a "buy-out" program to buy packers and watermen out of the business.[333] Individuals could also be given the opportunity and support to transition their livelihoods from harvesting wild oysters to oyster aquaculture.[334] Watermen and packers could be employed in oyster restoration programs, which would be beneficial to those individuals, as well as the programs.[335] Individuals would be employed, and the restoration programs would benefit from their

328. *See id.* § 2, at 7.
329. *Id.* § 4, at 28.
330. U.S. Army Corps of Engineers, *supra* note 2, § 4, at 61.
331. *See supra* discussion Part II.C.
332. Santopiertro, *supra* note 131, at 414.
333. U.S. Army Corps of Engineers, *supra* note 2, § 4, at 114.
334. *Id.* § 4, at 116.
335. *Id.* § 2, at 7.

expertise including familiarity with oysters, knowledge of local waterways, and experience in operating boats and other equipment. Even if a moratorium is not established, many of these opportunities could be offered to packers and watermen to relieve some harvest pressure on the population and to provide these individuals with steadier employment than the current, declining oyster population does.

While not adopting a full harvest moratorium, Virginia has established programs to provide watermen with alternative or supplemental employment.[336] One such program was instituted by the Virginia Marine Resources Commission and the non-profit Chesapeake Bay foundation to train watermen in oyster aquaculture techniques.[337]

b. Harvest Restrictions

There are a number of alterations that could be made to current harvest regulations that would aid in Eastern oyster restoration. First of all, public and private harvest areas can be rotated so that the same beds are not constantly depleted year after year, maximizing oyster survivability and harvest yields.[338] Secondly, maximum harvest size regulations should be enacted Bay-wide to preserve older oysters in the breeding population that may have developed disease resistance through natural selection.[339] Third, total allowable landing limits should be implemented for the oyster season each year based on current population data.[340] Currently, watermen are limited in when they may harvest, for how long and how many bushels per day; however, there are no restrictions on how many oysters total may be harvested by everyone during an oyster season.[341] Implementing total allowable landing limits would help ensure that there is not overharvest of an already decimated population.[342] Finally, both states need to establish stronger enforcement mechanisms and stricter punishment for violators of harvest regulations to deter violation of the rules and ensure fair competition among watermen.[343]

336. CHESAPEAKE BAY FOUNDATION, VIRGINIA OYSTER RESTORATION CENTER 2008 YEAR END SUMMARY 7 (2008), http://www.cbf.org/Document.Doc?id=333.
337. *Id.*
338. Blue Ribbon Oyster Panel, *supra* note 86, at 6.
339. *Id.* at 7.
340. Oyster Advisory Panel, *supra* note 221, at 12.
341. *Id.*
342. *Id.*
343. Blue Ribbon Oyster Panel, *supra* note 86, at 8.

4. Commercial Aquaculture and Privatization of Oyster Grounds

Expanding aquaculture within the Chesapeake Bay could involve use of both diploid and triploid Eastern oysters. Oyster farming has been used in many other regions following decline of their natural oyster populations.[344] It should be noted that expanding aquaculture will not completely restore the Eastern oyster, especially its ecological benefits.[345] Siltation and pollution remain a threat and the ecological niche oyster reefs provide still need to be restored.[346] Furthermore, widespread use of aquaculture could result in a genetic bottleneck,[347] which could be avoided by use of different Eastern oyster aquaculture stock and continued restoration of wild populations of the Eastern oyster.

There are three primary methods of oyster aquaculture, all of which are suitable for use in the Chesapeake Bay.[348] Depending on the characteristics of the individual oyster farms, some methods may be better suited to specific locations.[349] Historically, the most common aquaculture method is on-bottom culture, where oyster shells or other substrate are placed on the estuary bottom, wild spat settle there and are either left there to reach harvestable size or are transferred to private grounds.[350] Currently the most common form of oyster aquaculture is off-bottom culture, where oyster spat are placed in racks, floats or bags that are suspended above the waterway's bottom.[351] Off-bottom culture is beneficial because it makes harvest easier, reduces predation, results in greater yields, and reduces disease mortality.[352] The third method, seed culture, is generally used in combination with on-bottom or off-bottom culture.[353] In seed culture, spawning and spat settlement occur in an oyster hatchery and the spat are either used in reef restoration or sold to aquaculture facilities.[354]

To improve aquaculture yields, some oyster farmers may want to consider using triploid Eastern oysters.[355] Triploid Eastern oysters reach market size in eighteen to twenty-eight months, compared to twenty-four

344. Kennedy, *supra* note 29, at 141.
345. *See supra* Part II.D.1.
346. Power, *supra* note 47, at 244.
347. *See supra* Part III.C.2.
348. Kennedy, *supra* note 29, at 142.
349. *Id.*
350. *Id.*
351. U.S. Army Corps of Engineers, *supra* note 2, § 3, at 40.
352. Kennedy, *supra* note 29, at 142; U.S. Army Corps of Engineers, *supra* note 2, § 4, at 33.
353. Kennedy, *supra* note 29, at 143.
354. *Id.*
355. U.S. Army Corps of Engineers, *supra* note 2, § 4, at 35.

to thirty-six months for diploid Eastern oysters.[356] However, since triploid oysters are generally sterile, this would not contribute to a sustainable wild population.

Another alternative is to utilize MSX-resistant hatchery stock like DEBY and CROSSBreed in aquaculture facilities where prevalence of MSX can be high.[357] Growers should be cautious when considering introducing DEBY and CROSSBreed to private oyster beds because these strains are not resistant to Dermo, it is not clear that resistance is maintained in offspring with the wild population, and such introduction could result in a genetic bottleneck.[358]

In order to ensure success of an expanded aquaculture industry and to meet the growing needs of restoration efforts, public and private hatchery capacity in Maryland and Virginia needs to increase.[359] Also, in order to build support for aquaculture among watermen, Maryland should implement[360] and Virginia should expand programs that train commercial fishermen in aquaculture techniques.[361]

Other regions have used oyster aquaculture with extensive success. Holland and France have used oyster aquaculture since the 1800s.[362] Long Island Sound also provides a good model.[363] There the commercial oyster industry is based primarily on aquaculture.[364] Annually, farmers spread new shells on settling beds, control predators by harvest methods, and decrease siltation by altering seed transplantation timetables.[365] These rather simple farming methods have lead to drastic increases in harvests.[366] For example, yields in Connecticut in 1972 were eight-five times the yields in 1966.[367]

5. Habitat Restoration

In addition to the overall decline in the condition of the Chesapeake Bay, habitat loss is one of the major hindrances to large-scale restoration of the Eastern oyster population.[368] Currently, there is a high rate of loss of oyster habitat and disappearance of oyster shell supply due to natural

356. *Id.*
357. *Id.* at 22.
358. *Id.*
359. Blue Ribbon Oyster Panel, *supra* note 86, at 4.
360. Maryland recently eased restrictions on aquaculture. *See* 2009 Md. Laws 173.
361. Blue Ribbon Oyster Panel, *supra* note 86, at 4.
362. Kennedy, *supra* note 29, at 141.
363. *Id.* at 122.
364. *Id.*
365. *Id.*
366. *Id.*
367. Kennedy, *supra* note 29, at 139.
368. U.S. Army Corps of Engineers, *supra* note 2, § 1, at 18.

shell disintegration.[369] Shell stocks have not been replenished due to the depressed oyster population's diminished reef building.[370] Sedimentation and shell deterioration are reducing hard bottom habitat available; it is estimated that only one percent of Maryland's historic oyster grounds are clean or lightly sedimented shell.[371] Since there is a shortage of oyster shells, restoration efforts should concentrate on those oyster grounds with the highest spat settlement and survivability to avoid wasting valuable shell and economic resources.[372] Programs have been implemented in the Chesapeake Bay region to recover oyster shells from the food service industry and private citizens to use in reef restoration.[373] Other substrates like concrete and granite may prove to be good reef substrate, although further research is needed.[374]

The size and number of oyster sanctuaries should be increased, especially near harvest grounds.[375] This would create higher spat settlement in nearby harvest areas.[376] Within the sanctuary areas, artificial reefs should be constructed to improve oyster survival and more rapidly restore the ecological niche oyster reefs provide to other species.[377]

Finally, water quality must improve.[378] Any further degradation of water quality may undermine all oyster restoration efforts.[379] Therefore, there must be a long-term commitment among stakeholders to mitigate or decrease pollution in Chesapeake Bay waters.[380]

IV. CONCLUSION

Restoration of the Chesapeake Bay oyster population is going to be difficult. Success will require a multi-faceted approach including cooperation among stakeholders and long-term commitment to establishing a sustainable population. It is clear that none of the policies discussed here is singularly capable of restoring the ecological and

369. *Id.* § 1, at 18.
370. *Id.*
371. *Id.* § 4, at 9.
372. Blue Ribbon Oyster Panel, *supra* note 86, at 5;
373. Maryland's oyster shell recycling program is operated by the non-profit Oyster Recovery Partnership. Shells are collected weekly from participating restaurants and catering facilities and delivered to Horn Pointe Laboratory in Cambridge, Maryland. *See* Oyster Recovery Partnership, Shell Recycling Alliance, http://www.oysterrecovery.org/Content/ContentDisplay.aspx?ContentID=88 (last visited Mar. 31, 2010).
374. Blue Ribbon Oyster Panel, *supra* note 86, at 5.
375. *Id.* at 7.
376. *Id.*
377. *Id.*
378. Blue Ribbon Oyster Panel, *supra* note 86, at 2.
379. *Id.*
380. *Id.*

economic functions of the Eastern oyster. However, if restoration polices are applied in a coordinated manner, the Eastern oyster population will increase. If these policies are coordinated into a long-term plan, there is even greater likelihood that the Eastern oyster population will become sustainable.

It appears that Virginia's efforts to expand its aquaculture and Maryland's Oyster Plan are excellent steps toward a multi-faceted long-term approach. Success may be possible with the support of nonprofit organizations like the Chesapeake Bay Foundation and individuals who participate in the homegrown oyster programs operated by Maryland Department of Natural Resources and Virginia Marine Resources Commission. Further efforts to improve the overall health of the Chesapeake Bay by the surrounding states and federal government will assist in restoring the keystone species, the Eastern oyster, to the Chesapeake Bay.