Zebra Mussels (*Dreissena polymorpha*) in the Chesapeake Bay Watershed: A Regional Management Plan

Final Draft

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Executive Summary

The zebra mussel, *Dreissena polymorpha*, is a shellfish native to the Caspian and Black Seas in Eastern Europe (Stegemann, 1992). In 1988, the first zebra mussel was found in North America in Lake St. Clair, which had most likely been introduced to the lake a couple years earlier via ballast water from a European ship (Marsden, 1992). By 1989, zebra mussels were well established in the Great Lakes, and as early as 1991, they had found their way into the major waterways of North Eastern America and Canada. Many factors have contributed to the dramatic and rapid spread of zebra mussels. As with most introduced species, the invaded environment lacks natural ecological controls, such as predators and disease, which manage species population (Ludyanskiy et al., 1993). Furthermore, the combined effect of zebra mussels' extensive physiological adaptive abilities and genetic plasticity, and the human activity-mediated dispersal and transportation has added to this species' rapid and broad invasion of North American waters. Zebra mussels are a great concern not only because of their ability to spread so quickly but also because of their capacity to both directly and indirectly alter their invaded environment. The most visible and dramatic effects of zebra mussels have been on industrial and municipal structure. Zebra mussels are major biofouling organisms (Rosell et al., 1999). Large zebra mussel colonies foul boat hulls, sink buoys, and clog pipes that provide cooling water to power plants, processing water to industrial plants, and raw water for municipal water treatment facilities resulting in high clean up costs (Marsden, 1992). The removal of established zebra mussel colonies is a temporary solution to control biofouling in industrial and municipal facilities. Treatments often must be repeated because recolonization is quick to occur. Eradication of zebra mussels is relatively impossible in most cases once a population becomes established in large bodies of water. This reaffirms the importance of prevention efforts in areas like the Chesapeake Bay watershed, where there has been little colonization thus far.

In Spring 2001, the Chesapeake Bay Program's Invasive Species Workgroup (ISW) began to address the following two goals of the Chesapeake 2002 Agreement: "By 2001, identify and rank non-native aquatic and terrestrial species which are causing or have the potential to cause significant negative impacts to the Bay's aquatic ecosystem. By 2003, develop and implement management plans for those species deemed problematic to the restoration and integrity of the Bay's ecosystem." In September 2001, the ISW developed and distributed a questionnaire to obtain from the Chesapeake Bay Program jurisdictions and federal partners a consensus list identifying the top six aquatic nuisance species currently adversely affecting or with the potential to adversely affect the Bay ecosystem. Despite the zebra mussels' lack of widespread presence within the Chesapeake Bay watershed, the potential threat of a zebra mussel invasion warranted a high classification, and thus zebra mussels were ranked a top priority species by the signatory jurisdictions and federal partners. In May 2002, the Chesapeake Bay Program in partnership with Maryland Sea Grant College sponsored a workshop to develop draft regional management plans for each of the six priority species. In December 2002, the Chesapeake Bay Program appointed the Regional *Dreissena polymorpha* Working Group, to begin developing a final regional management plan. The Working Group was comprised of Chesapeake Bay Program signatory jurisdictional representative and federal partners, as well as other resource managers and interested parties

The goal of this management plan is to stop the further spread of zebra mussels by identifying strategies and partnerships necessary to control the mussels and where possible eradicate zebra mussel colonies in the Chesapeake Bay watershed. The management plan recommends public outreach programs, monitoring programs, rapid response strategies, and possible eradication methods as well as actions and funding needs to implement each of the recommendations.

Implementation tables were developed to include a time line for each action, as well as the identification of lead agencies, partner involvement, funding/cost share, and funding sources.

The final plan will be submitted to the Chesapeake Bay Program's ISW and the Living Resources Subcommittee for comprehensive review. These comments will be collected and incorporated for final submission to the Chesapeake Bay Program's Implementation Committee. Upon approval, the Chesapeake Bay Program signatory jurisdictions will adopt the management plan and implement the recommended actions with the intended goal of slowing or halting further the spread of zebra mussels into the Chesapeake Bay watershed.

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I. Introduction

Zebra mussels, *Dreissena polymorpha*, are temperate freshwater bivalve mollusks related to oysters, clams, and freshwater mussels. The native species originated in the Caspian and Black Seas regions of Eastern Europe (Stegemann, 1992). In 1988, the first zebra mussel was found in North America in Lake St. Clair. The individual mussel most likely had been transported to the lake a couple years earlier via ballast water from a European ship (Marsden, 1992). By 1989, zebra mussels were well established in the Great Lakes, and as early as 1991, they had found their way into the major waterways of eastern North America and Canada. Zebra mussels can grow to 5 cm in length but adults typically range from 0.5 cm to 3.5 cm. External coloration of the shell is variable, though most individuals exhibit dark and light concentric bands, which look like stripes, consequently giving the zebra mussel its name (Moser, 2002). The anterior side of the shell is reduced and the posterior is inflated giving the shell an elongated shape. Zebra mussels are the only freshwater bivalves to retain more than one byssal thread which the mussel uses to attach to various substrates (Zebra Mussel Research Program ACOE, 1992). The threads, which are secreted from a gland at the base of its muscular foot, are extremely adhesive and make removal of the mussel very difficult.

Since the zebra mussel first appeared in the North American Great Lakes in 1988, it has rapidly spread and has significantly impacted its invaded environment. These impacts include the severe fouling of man-made structures, changes in fish populations, increases in water clarity, and alterations of the plankton and benthic communities (Rosell, et al., 1999). While zebra mussels have spread in many major waterways of central and eastern North America since their first introduction, they had not been found in the Chesapeake Bay watershed until recently. The mussels' arrival in the watershed presents a major threat to the health of the Chesapeake Bay ecosystem. On account of the zebra mussels' adaptive abilities and rapid spread, it was declared a high priority nuisance species in the watershed and as a result the following management plan was drafted to identify strategies for prevention and control. The introduction briefly outlines the following components: species biology, ecological impacts, economic impacts, methods of introduction, population status and distribution, management efforts in the Chesapeake Bay watershed, methods for control, and existing federal and state regulations. The detailed management plan addresses the following sections: Section 1, Leadership, Coordination, and Regulatory Authority; Section 2, Prevention; Section 3, Early Detection and Rapid Response; Section 4, Control and Management; and Section 5, Communication and Information Access. Implementation tables designate the appropriate lead agency to implement each of the specific strategies and indicate funding needs, potential sources of funding and a time line to accomplish each strategy.

A. Biology/Life History

Zebra mussels, *Dreissena polymorpha*, are bivalve mollusks that belong to the Dreissenidae family and have a typical life span of 3 to 5 years with some living up to 15 years (Ludyanskiy, 1993). Adult zebra mussels are sessile and are generally found in clumps or layers on hard substrate. These aggregations exhibit an equal ratio of males to females (Ram et al., 1996). Zebra mussels are dioecious spawners and exhibit external fertilization and reach sexual maturity in their first or second year when they are about 1 cm in length (Ludyanskiy, 1993). Optimal conditions for spawning occur when water temperature exceeds 12°C. During one reproductive cycle, an individual female may release over 30,000 eggs, and over an entire spawning season, more than one million eggs (Moser, 2002). The resulting larvae have a velum or ciliated swimming organ and are referred to as veliger larvae. The veliger larvae are free-swimming and

planktonic and can live in the water column for about five days to 3 months as long as the water temperature stays from 10 to 25°C. However, since veligers are unprotected by a hard shell, this stage of the mussel's life cycle is the most vulnerable to environmental fluctuations (Hincks and Mackie, 1997). During this time, water currents can easily transport the veligers from one body of water to another.

Once the zebra mussel larvae settle to the bottom, their survival depends on attachment to a hard or firm substrate (Moser, 2002). Byssal threads are secreted from a gland at the base of the mussel's muscular foot to securely attach the mussel to a hard substrate. They are extremely adhesive and make the removal of the mussels from an object very difficult. Because zebra mussels are epifaunal - unlike most other freshwater bivalves - and not overly selective, they will colonize almost any solid, submerged surface such as buoys, water intake pipes, rocks, pier pilings, rooted aquatic plants, boat hulls, and the shells of other mollusks (Claudi and Mackie, 1994). They often settle with the younger zebra mussels attaching to the top of older, bigger mussels resulting in large colonies, called druses (Ram et al., 1996). Druses have reached densities as high as 800,000/m^2 in North America and 1,700,000/m^2 in Europe. A zebra mussel's growth rate depends greatly on water quality and temperature and a single individual can grow at a rate of anywhere from 1.0 cm to 1.6 cm/ year (Zebra Mussel Research Program ACOE, 1992). A single population of zebra mussels may have an annual production rate as high as 29.8 grams of dry tissue/ sq meter/ year (Zebra Mussel Research Program ACOE, 1992). This production rate is one of the highest among freshwater or marine bivalves.

Zebra mussels tend to be found in temperate freshwater lakes, embayments, rivers, canals, and reservoirs. Primary environmental requirements depend on temperature and water quality, pH levels, calcium concentrations, dissolved oxygen content, turbidity and salinity (Ludyanskiy et al, 1993). Zebra mussels prefer waters where salinity levels are less than 4 parts per thousand, a summer water temperature range between 17 to 23°C, pH levels between 7.4 to 9.0, calcium concentration between 20 to 125 ppm, turbidity between 40 to 200 NTU, and a dissolved oxygen range between 8 to 10 ppm. Secondary environmental requirements include a water velocity of 0.2 to 1.2 meters/second and the presence of solid substrate. However, zebra mussels have been found in waters with less than optimal conditions. Zebra mussels are characterized by high genetic plasticity and have been known to adapt to systems with ecological parameters that lie outside their ideal ranges. This may allow the mussels to spread to brackish estuaries where salinity levels are as high as 10 to 14 ppt or to sub-tropical waters where summer temperatures exceed 30°C. They also can tolerate low levels of food, desiccation, and variable dissolved oxygen levels (Claudi and Mackie, 1994). Zebra mussels' most limiting factors are pH and calcium concentration. Laboratory experiments have shown evidence that a pH as low as 7.4 will sterilize a mussel population and low calcium concentration has a dramatic effect on the mussels' external morphology (Ludyanskiy et al, 1993). The availability of substratum has an effect on zebra mussels' ability to colonize.

Zebra mussels are filter feeders, filtering on average between 1 to 2 liters of water per individual per day (O'Neill and MacNeill, 1991). They remove large quantities of particulate matter from the water column. Filtered particle sizes are reported to range from 0.4 to 750 μm with reports of up to 1200 μm. Filtered particles are sorted, and either consumed, or rejected (Karatayev et al., 2002). Zebra mussels filter the water for both feeding and respiration (Karatayev et al., 2002). Water is constantly circulated through their siphons and over their gills. Ensuing water currents result from the steady beating of cilia on the gills of the mussels. Particulate matter is continually removed from the water in an unselective fashion. Zebra mussels are selective about what they

consume. Unconsumed particles are rejected as mucus-bound psuedofeces, which prevents the particles from being resuspended in the water column.

Natural predators include freshwater drum, yellow perch, sturgeon, crayfish, and diving ducks (Marsden, 1992).

B. Biological and Ecological Impacts

Most of the biological and ecological impacts of zebra mussels in North America are unknown. However, the limited research in North America supports the findings in Europe, which imply that zebra mussels have a severe impact on their invaded environment.

Changes to Environment Caused by Zebra Mussel Functioning

Zebra mussels are extremely efficient water filterers. Their prolific filter-feeding enables them to filter 1 to 2 liters of water per day per individual and remove a significant amount of particles from the water column (O'Neill and MacNeill, 1991). This efficient filtering behavior increases water clarity because large amounts of both plankton and inorganic particulates are removed. Enhanced water clarity increases the total lake volume available for photosynthesis, extending the depth of the photic zone, thus augmenting primary productivity of submerged plants.

Zebra mussels' filtration activity increases deposition of organic and inorganic matter in the water body, altering the benthic taxonomic assemblage, trophic structure, and biomass. The mollusks' subsequent psuedofeces and feces production increases the sedimentation of suspended matter - resulting in reduced levels of phytoplankton and increased numbers of benthic species that feed on the deposited organic matter (Karatayev et al., 2002). In this way, zebra mussels create benthic-pelagic coupling by building a direct connection between the plankton and the benthos. Although the number of deposit feeders greatly increases after zebra mussel introduction, zebra mussels end up dominating the benthos in terms of biomass, which can reach 10-50 times more than the total mass of all other benthic invertebrates combined (Karatayev et al., 2002). They also out-compete the native filter feeders, reducing population abundance of native species. Zebra mussels are a biofouling organism and have been found encrusting other benthic organisms such as native mussels and crayfish. This dramatic shift in the benthic community only occurs where there are druses or large colonies of zebra mussels. The presence of a solitary mussel does not appear to alter the quantitative or qualitative composition of the benthic community.

Zebra mussels also have a dramatic effect on interspecies interactions (Karatayev et al., 2002). Since they consume phytoplankton, they compete with zooplankton for microalgal foods. As indicated above, zebra mussels compete with native filter feeders for plankton. In addition, there is evidence that zebra mussels compete with fish for benthic space by encrusting and covering fish spawning and nursery habitat. Increased density and body size of benthic invertebrates attracts more benthic feeding fishes, which in turn will increase the number of piscivorous fish. Planktivorous fish abundance will most likely be negatively affected since the zebra mussels tend to decrease the abundance of zooplankton. The increases in phytoplankton and detritus, major food sources for pelagic fish, increase the abundance of pelagic fish, possibly impacting local fisheries (O'Neill and MacNeill, 1991).

Changes to the Environment Caused by Zebra Mussel Structure

Zebra mussels possess hard, calcium carbonate shells that provide additional substrate available for other species that live attached to substratum, including other zebra mussels (Karatayev et al.,

2002). The colonies of sessile animals create three-dimensional structures that provide habitat for a variety of species that would otherwise not be common in the water body. Zebra mussel shells do not decompose quickly and, therefore collect on the bottom, forming reef-like structures. These structures provide additional surface area for organisms to live under and attach to, transforming the bottom habitat from a soft sediment environment to one covered in hard substrate.

C. Economic Impacts

Zebra mussels are major biofouling organisms (Moser, 2002). Huge zebra mussel colonies can grow on any firm, submerged substrate or structures (Marsden, 1992). The most visible and dramatic biofouling effects of zebra mussels have been on industrial and municipal facilities. Intake pipes and screens of facilities that withdraw water - such as power plants (cooling water), factories (manufacturing process water), and municipal utilities (drinking water) - become clogged with large clumps of mussels. In the Great Lakes region, industrial plants and public utilities have been shut down many times costing the region millions of dollars in damages and lost production due to zebra mussel cleanup. Zebra mussels may seriously impact both commercial navigation and commercial boating by infesting boat hulls, buoys, ropes, piers, and docks. Zebra mussels also negatively affect public recreation by littering beaches and swimming areas with dead mussel shells and the air can be polluted with the smell of decaying mussels (Ludyanskiy et al., 1993). As a result, the tourism economy has begun to suffer in the Great Lakes region (Ludyanskiy et al., 1993).

Furthermore, zebra mussels may have socioeconomic impacts on commercial and sports fisheries (Ludyanskiy et al. 1993). The entire benthic-pelagic energy balance may become altered due to declining primary productivity, increases in the number of benthic species, biodeposition of most nutrients, and reductions in biomass along with the shift in zooplankton and fish production. However, scientific studies yielding clear data to support this claim have yet to be conducted.

D. Methods of Introduction

The advent of boat traffic between water bodies facilitated the transportation of exotic species and caused more frequent introductions (Marsden, 1992). Organisms such as zebra mussels that were able to attach to the bottom of boats and others that were carried as part of cargo were accidentally transported from one country to another. In the late 1800s when ships began to use ballast water, the transfers of large volumes of water were possible. This ballast water frequently harbored exotic species and it is most likely that zebra mussels were introduced into the North American Great Lakes in this manner. Large-scale habitat alterations such as the construction of navigable waterways and canals have created pathways for the fast and easy spread of exotic species into surrounding water bodies. Bait buckets, bilge water, and live tanks on boats also pose as potential vehicles for species introduction. SCUBA diving may be a possible vector for species transfer and distribution between water bodies within a country as well as between countries. Zebra mussel larvae mortality can be high in the water current and those that survive can only reproduce if they settle near to other mussels, therefore dispersal mechanisms that deliver many individuals to the same area increase the probability of invasion (Baker et al., 1993).

Natural dispersal within an invaded watershed occurs as veligers are passively transported from colonized lakes through connected outflowing streams (Horvath et al, 1996; Schneider et al, 1996). This lake-stream dispersal allows zebra mussels to colonize all downstream waters directly connected with the outflowing streams. However, adult mussel populations in these

smaller outflowing streams do not appear to be very large, and they appear to be mostly restricted to within a few kilometers of the immediate lake outlets (Horvath and Lamberti, 1999).

E. Population Status and Distribution

Europe

Dreissena polymorpha is native to lakes, slow-moving rivers, and low salinity areas of the Black, Azov, and Caspian Sea regions in Eastern Europe (Minchin et al., 2002). As a result of the widespread construction of canal systems, pathways were created and by the late 18th and 19th centuries, zebra mussels had appeared in almost every major drainage ways in Europe (Moser, 2002). Zebra mussel populations are now well established all across Europe, from Finland to England and Ireland.

North America (Figure 1)

Zebra mussels were first discovered in North America in June of 1988 in Lake St. Clair – a water boundary between Michigan and Ontario, Canada. It is widely accepted that ballast water from a European vessel is the most likely vector responsible for the introduction of zebra mussels into North American waters. Extensive colonies of up to 30,000 to 40,000 individuals per square meter were reported in Lake Erie only one year after the species' discovery (O'Neill and MacNeill, 1991) and by late 1989, zebra mussels had been found in all the Great Lakes and in the St. Lawrence River in western New York (Stegemann, 1992). By the end of 1993, zebra mussels were well established in all the Great Lakes, 18 states, and two provinces (Moser, 2002). By 2000, zebra mussels had made their way into most stretches of the Mississippi, Illinois, Ohio, Mohawk, Hudson, St. Lawrence, Cumberland, Tennessee and Arkansas, Missouri, Allegheny, Monongahela, Wabash and St. Croix rivers. Zebra mussels have colonized New York's Finger Lakes, Lake Champlain, Wisconsin's Lake Winnebago, Kentucky Lake and nearly 100 smaller inland lakes in seven of the eight states bordering the Great Lakes.

Chesapeake Bay Watershed (Figure 2)

<u>New York</u>

Zebra mussels first appeared in the New York waters of Lake Erie in the fall of 1989. They moved eastward through the Erie Canal into the Finger Lakes region of central New York. At the same time, they moved down the Niagara River into Lake Ontario. In the early 1990s, zebra mussels were detected in the Hudson River. They did not reach the Hudson by coming down the Erie Canal, rather, there was a separate introduction incident. It is not known whether they entered the Hudson River as a separate ballast water discharge from transoceanic, commercial vessel traffic or from recreational boating. Over the next several years, zebra mussels consolidated their colonization by "filling in" connected waterways. Only in the past five or six years have there been many introductions into non-connected waters that are most likely attributable to recreational boating. Also in 1992, zebra mussels first appeared in the Susquehanna River at Goudy Station in Endicott, NY. Based on the size/age of the veligers, and flow velocities in the Susquehanna/Tioghnioga river systems, it was speculated that the adult zebra mussels were possibly in the Whitney Point flood control reservoir. However, the adults were never found, and the density of veligers decreased over the next three years and then disappeared entirely. In the mid 1990s, zebra mussels hitchhiked, probably on barge traffic, from the Hudson into Lake Champlain via the Champlain canal.

Zebra mussels appeared in Lake George, in the southern Adirondacks for a short time. The Lake George Commission organized divers to hand pick the zebra mussels out, because they appeared to be a small population at a single site near the site of a discharge that had much higher calcium in its effluent than the normal lake water. The effort appears to have been successful, although others speculate that they died out because the water chemistry was unsuitable.

In the fall of 2000, a zebra mussel population was identified in the Chesapeake Bay watershed at Eaton Brook reservoir in Madison County, New York, on the upper Chenango River of the Susquehanna basin. Eaton Brook is a 238-acre reservoir primarily used for recreation. The mussel has colonized the out-flowing creek, but is limited to a few hundred meters from the outlet. However, veligers have been detected throughout the out-flowing creek and even into the Chenango River. The larval stage of the mussel does not do well in turbulent conditions.

In Otsego County, NY, an established and reproducing population of zebra mussels was found in August 2002 in Canadarago Lake - a 2,000-acre lake that has a well-maintained public launch site and receives heavy recreational boat traffic. The population was very small ($<1/m^2$), but the lake is well suited, chemically and physically, for zebra mussels. Judging by shell lengths of a few mussel samples found in the lake, it was predicted that the population had been established in the lake for at least one year and probably since 2000. There is no known physical barrier that could be placed at the outlet of Canadarago Lake that would prevent veligers from heading downstream to Oaks Creek, which connects Canadarago Lake to the Susquehanna River and veligers have been detected thoughout Oaks Creek and into the Susquehanna River.

Pennsylvania

For most of Pennsylvania's monitoring program history, zebra mussel distribution was limited to Lake Erie and its tributaries, the Ohio River mainstem, and the lower Monongahela and Allegheny River mainstems. In 2000, zebra mussels were found outside of their known, established northwestern Pennsylvanian range for the first time in Edinboro Lake. This was followed by specimens discovered in Edinboro Lake's outlet stream, two northwestern inland lakes, the upper Conewago Creek, and two quarries in eastern Pennsylvania, Dutch Springs and Richland. Only Richland Quarry is in the Chesapeake Bay drainage area. Of these recent sightings, only Edinboro Lake, its outlet stream, and Dutch Spring Quarry have established populations. Repeated visits to the other locations have not yielded any live individual zebra mussels. The status of the Richland quarry population has not been determined.

Virginia

In late 2002, Virginia's Department of Game and Inland Fisheries documented the state's first zebra mussel population in Millbrook Quarry located in Prince William Country. Millbrook Quarry is a fairly popular location for SCUBA. There is no outflow from Millbrook Quarry but Broad Run flows adjacent to the quarry and is within approximately 300 feet. This has led to subsequent surveys in Broad Run and in Lake Manassas, which is fed by Broad Run and is about 6 miles downstream of the quarry. Additionally, Fishersville Quarry and Lake Rawlings were surveyed given their use as dive sites and anecdotal reports that divers were introducing mussels to these bodies of water. To date, no zebra mussels have been found in any of these water bodies.

Maryland

To date, zebra mussels have not been found in Maryland waters. Periodic calls from the public to the Department of Natural Resources (DNR) about zebra mussel sightings have all been negative. Samples of suspected zebra mussel specimens examined by DNR staff have been positively identified as the dark false mussel, *Mytilopsis leucophaeata*.

F. Management Efforts in the Chesapeake Bay Watershed

Pennsylvania

Pennsylvania has an active program with approximately 50 monitored stations and 175 stations where annual monitoring reports are no longer submitted. Original monitoring stations concentrated on large river mainstems, popular public access lakes, and waters associated with power and water companies. Most active monitors consist of state agency field personnel, COE Districts, and power and water company representatives. Several reports are received from surrounding states (NY, MD, NJ). The annual reports vary from monitoring report sheets submitted periodically throughout the monitoring season (May-Oct) to a single letter mailing at the end of the year. Pennsylvania did not allocate any funding for zebra mussel monitoring activities by the public sector; early monitors were volunteers and government staff who "piggy-backed" monitoring onto their existing field duties. However, the Coastal Zone Management Program initiated a low-cost pilot volunteer program in 2003 that could easily be adapted for statewide use.

Pennsylvania's monitoring program was initially set up in 1990 to detect the spread of zebra mussels and act as a notification tool to warn downstream water users of upstream zebra mussel threats. Once notified, it was the water users' responsibility to monitor their intakes and take protective measures, as deemed necessary.

Originally, Pennsylvania's monitoring was based on the deployment of artificial substrate boxes with removable slides that allow for several samplings per season. Straining water pumped from facility intakes was recommended. Both methods were designed for veliger detection. However, these methods were labor intensive and required in-lab microscopic examination. Many volunteers and some companies stopped this type of monitoring because of the time and expense. Further, the artificial substrate boxes were prone to damage, loss, and vandalism. After several years, most of these boxes were out of commission. Monitoring for microscopic veligers converted to monitoring for juveniles or adults by "naked eye" inspection of simple submerged substrates suspended from docks or other near shore structures.

For most of the monitoring program's early years, zero zebra mussel spread was detected beyond their early established range in Pennsylvania (Lake Erie and tributaries, Ohio and lower Monogahela and Allegheny River mainstems). While this was good news, monitoring efforts declined as no new zebra mussel infestations were found and zebra mussel interest waned. Many of the early volunteers' monitors stopped or reduced their annual activities to one visit per monitoring site. As a result, several zebra mussel sightings in northwestern lakes were reported in the last two years. In most cases, the zebra mussel population appeared to be at least 2+ years old.

Virginia

Virginia currently does not have an active zebra mussel monitoring program. Since no populations were known within the state before August 2002, Department of Game and Inland Fisheries has relied on reports from the public.

Maryland

Currently, there are 11 sites in Maryland waters where monitoring is focused on detecting the presence of zebra mussels- specifically the settle life stages: juveniles and adults. No zebra mussel monitoring is focused on detecting veligers.

The Baltimore City Department of Public Works has monitored eight sites since 1992 in three water supply reservoirs (Loch Raven, Prettyboy, and Liberty) and in the Conowingo Pool portion of the lower Susquehanna River. Baltimore City adopted a proactive approach to the zebra mussel threat that also includes a plan to control any infestation by using potassium permanganate as the primary chemical, with chlorine as an emergency back-up. To protect the trout population downstream from Prettyboy Reservoir, a thermal control system would be used instead of chemical controls.

Zebra mussel monitoring is continuing at one site in Jennings Randolph Lake, a large impoundment on the North Branch Potomac River near Bloomington, MD. The U.S. Army Corps of Engineers conducts the monitoring.

Two sites are being monitored for zebra mussel presence in Deep Creek Lake, a reservoir located on a tributary to the Youghiogheny River, near Oakland, MD. Reliant Energy monitors one site near their hydroelectric plant. Maryland's Department of Natural Resources (DNR) monitors the other site at the boat dock in the State Park. Deep Creek Lake is located in western Maryland and used by boaters from Pennsylvania and other states. Thus, there is a real possibility that zebra mussels could be inadvertently transported to Deep Creek Lake from an infested water body outside of Maryland.

For several years prior to 2001, Pepco (now Mirant) staff monitored for zebra mussels at two power plant sites in the Potomac River- one near Dickerson, MD, and the other near Alexandria, VA. According to Ann Wearmouth, a Mirant biologist, the company does not have the staff to re-establish a zebra mussel monitoring program.

In the late 1990's, DNR discontinued a 24-station monitoring program directed at juvenile and adult zebra mussels. However, monitoring programs that collect hundreds of samples of other benthic macroinvertebrates are currently being conducted by DNR, other state agencies, and local jurisdictions in streams and rivers across Maryland. Most of these programs could detect zebra mussels if they were present. In addition, colleges, universities, consultants, and volunteers annually sample benthos at hundreds of stream and river sites in the state. Although totally complete, the level of monitoring activity in Maryland that should be able to detect the presence of juvenile and adult zebra mussels is extensive. So far, no zebra mussel infestations have been detected.

G. Methods for Control

The need to control zebra mussels has led to the creation of a multi-million dollar industry. Chemical options have been most commonly used in both North America and Europe to treat internal and closed systems where zebra mussel biofouling has occurred (Sprecher and Getsinger, 2002). The removal of established zebra mussel colonies is a temporary solution to control biofouling in industrial and municipal facilities. Treatments need to be repeated often because, despite treatment efforts, recolonization is quick to occur. Control options identified for zebra mussels in the open water system are limited to hand harvesting and dredging (Tim Sinnott, written communication). Once a population becomes established on large bodies of water, eradication of zebra mussels is relatively impossible in most cases.

Although describing methods for control in great detail is beyond the scope of this management plan, the following is a brief description of a few successful methods for minimizing the effects of zebra mussel biofouling (Marsden, 1992):

- Chemical controls
  - Use of chlorine, bromine, ozone, and molluscicides on incoming water.
- Biological controls
  - Introduction of species-specific parasites or diseases.
  - Local enhancement of predator populations.
- Oxygen deprivation
  - De-oxygenate to deplete dissolved oxygen supply to a lethal level.
- Thermal treatment
  - Heat recirculation to increase internal temperatures above lethal levels.
  - Heat wrap small, vulnerable areas, such as small-diameter pipes.
- Exposure and desiccation
  - De-watering of pipes to desiccate the mussels.
  - Drawdowns in small lakes or reservoirs.
- Radiation
- Manual scraping
  - Periodic physical removal of mussels.
- High-pressure jets
- Mechanical filtration
  - Use of closed water systems or heat exchangers.
- Removable substrates
  - Use of removable or disposable elements.
- Design
  - Re-design to reduce vulerability of critical areas.

For in depth information regarding the control of zebra mussels, please see the bibliographic database on the Sea Grant National Aquatic Nuisance Species website: http://www.cce.cornell.edu/aquaticinvaders/. The US Army Corps Of Engineers 2002 "Zebra Mussel Chemical Control Guide" can be accessed at the following website: http://www.wes.army.mil/el/zebra/pdf/trel00-1.pdf.

H. Federal Laws and Regulations

The Non-Indigenous Aquatic Nuisance Prevention and Control Act (NANPCA) of 1990 amended the Lacey Act to include the zebra mussel on the list of injurious fish, mollusks and crustaceans. In 1996, Congress reauthorized and expanded the Non-Indigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA). The new legislation, titled the National Invasive Species Act of 1996 (PL 104-332) (NISA), established a national ballast management program targeted at all U.S. coastal regions, continues the mandatory Great Lakes ballast water management requirements, and expanded invasive species management programs within the Department of Interior and the National Oceanic and Atmospheric Administration (NOAA). However, NISA expired in 2001, although funding will continue though fiscal year 2002, and is currently pending reauthorization as the National Aquatic Invasive Species Act (NAISA) of 2003. NISA established a federal interagency Aquatic Nuisance Species Task Force (ANSTF), co-chaired by the United State's Fish and Wildlife Service (USFWS) and NOAA, responsible for coordinating governmental efforts related to aquatic nuisance species in the United States. ANSTF is charged with developing an Aquatic Nuisance Species Program, describing the responsibilities of individual agencies, and recommending necessary funding levels. NISA also directed States to develop Aquatic Nuisance Species Management Plans. NISA provides the opportunity for Federal cost–share support for a Plan's implementation once it has been approved by the ANSTF.

In the early 1990s, USFWS amended its regulations to include the zebra mussel. Effective December 9, 1991, the importation of live zebra mussels, veligers or viable eggs into the United

States, or transportation between the continental United States, the District of Columbia, Hawaii, the Commonwealth of Puerto Rico, or any territory or possession of the United States by any means is prohibited except by permit for zoological, educational, medical or scientific purposes. This prohibition includes any live species of the genus *Dreissena.* Under the amended regulation, viable eggs or progeny may not be sold, donated, traded, loaned, or transferred to any other person unless USFWS issues a permit.

I. State Regulations

Zebra mussel regulations vary from state to state across the Chesapeake Bay Watershed. For a listing of state regulations and permit requirements, contact one of the following specific state information sources.

Pennsylvania

In Pennsylvania, the primary regulatory control over aquatic invasive animal species resides with the Pennsylvania Fish & Boat Commission. PFBC regulations regarding zebra mussels restrict the release of zebra mussels into waters of the Commonwealth. Furthermore, the PFBC had recently imposed regulations controlling snakehead fish species and, as a result also many other aquatic species invasions (several carp and goby species). In the summer of 2003, the PFBC expanded the regulations to include live zebra mussels and quagga mussels. These expanded regulations make it illegal to possess, purchase, sell, barter, import, or transport live zebra mussels - as well as several other aquatic invasive fish species.

For the further details on these regulations and associated penalties pertaining to zebra mussels, please contact:

Pennsylvania Fish & Boat Commission
1601 Elmerton Avenue
P.O. Box 67000
Harrisburg, PA 17106-7000
telephone: 717-705-7800
http://www.fish.state.pa.us/

Virginia

In Virginia, the primary regulatory control over aquatic invasive animal species resides with the Department of Game and Inland Fisheries (VDGIF). The current regulation (4 VAC15-30-40: Importation requirements, possession and sale of nonnative (exotic) animals) states that "A special permit is required and may be issued by the department, if consistent with the department's fish and wildlife management program, to import, possess, or sell those nonnative animals listed below that the board finds and declares to be predatory or undesirable within the meaning and intent of 29.1-542 of the Code of Virginia, in that their introduction into the Commonwealth will be detrimental to the native fish and wildlife resources of Virginia." The referenced list is generated by the VDGIF and approved by the agencies' Board of Trustees. *Dreissena polymorpha* is included on this list. Additionally, through VDGIF's scientific collection permit review process, collections made in zebra mussel infested waters (in state and out-of-state) are highly scrutinized and possession of any aquatic specimens from these water bodies is currently not permitted. All sampling gear permitted for use in zebra mussel infested waters must be decontaminated according to accepted agency guidelines.

In addition to VDGIF's regulation, the Code of Virginia was amended on March 16, 2003 to include the Aquatic Nuisance Species Act (HB 2752). This newly enacted piece of legislation gives VDGIF the authority to "…conduct operations and measures to control, suppress, eradicate, prevent, or retard the spread of any non-indigenous aquatic nuisance species." Animals currently considered aquatic nuisance species under this law include snakehead fishes, quagga mussels, and zebra mussels. VDGIF also has been granted the authority to conduct reasonable inspections of any property in Virginia to determine if an aquatic nuisance species is present, either through cooperation with the landowner or through a warrant. It also is illegal for any person to knowingly import, possess, sell, purchase, give, receive, or introduce any designated aquatic nuisance species into the Commonwealth. Any person who violates any provision of this law or knowingly obstructs VDGIF may be subject to a civil penalty of no more than $25,000, and be liable for the costs of investigation, control, and eradication incurred by any political entity or authority.

For the current status and further details on these regulations and associated penalties pertaining to zebra mussels, please contact:

Virginia Department of Game and Inland Fisheries
4010 West Broad Street
P.O. Box 11104
Richmond, VA 23230-1104
(808) 367-9147
http://www.dgif.state.va.us

Maryland

The Maryland Department of Natural Resources (DNR) has primary regulatory authority over aquatic and terrestrial exotic (non-native) species. One law that pertains specifically to zebra and quagga mussels states that except as permitted by the Secretary of DNR, a person may not import into the MD or possess any living life stage or reproductive products of mussels of the genus *Dreissena*. DNR also administers and enforces a regulation to ensure that live aquatic bait grown in an aquaculture operation and purchased from certified dealers is free of zebra mussels. For shellfish in general (i.e., live oysters, seed oysters, oyster shells, live hard-shell clams, live soft-shell clams, and clam shells), a person may not import or possess within the MD shellfish taken from waters outside the waters of the MD for planting in the waters of the MD, unless they first obtain a permit from DNR. A person may not introduce, or import and possess for introduction, any live fish species not indigenous to the nontidal waters of MD.

For further details on these and other regulations and associated penalties pertaining to zebra mussels, please contact:

Maryland Department of Natural Resources
580 Taylor Avenue, E-1
Annapolis, MD 21401
Phone: 410-260-8540
http://www.dnr.state.md.us/

II. Management Plan

Goal: To stop the further spread of zebra mussels, *Dreissena polymorpha,* in the Chesapeake Bay watershed.

A. Leadership, Coordination, & Regulatory Authority

Needs: Following the recent discoveries of zebra mussels at the headwaters to the Susquehanna river (NY) and Millbrook Quarry (VA), workshop participants and regional workgroup members identified a need for better coordination among federal, state, and local authorities for rapid response to new infestations.

Objective 1: Develop Coordinated Action Plan for Rapid Response to New Infestations in the Chesapeake Bay Watershed.

Actions:

1.1 Establish a rapid response panel with members representing the Chesapeake Bay Program, signatory states, academia, scientific experts, federal agencies, Sea Grant programs, and interested non-governmental agencies (NGOs).

1.2 Compile and summarize Federal and state regulations related to zebra mussel occurrence, movement, and transport.

1.3 Develop Rapid Response Action Plan for New Zebra Mussel Infestations in the Chesapeake Bay Watershed based on several tasks that include:

- Identifying different zebra mussel infestation scenarios (e.g. lake, stream, quarry) and all known and potential introduction and dispersal pathways;
- Ranking high risk waterways based on potential for introduction, proximity to current populations and utilization;
- Reviewing existing eradication plans (i.e., Millbrook Quarry);
- Development and implementation of the Rapid Response Plan will require coordination with appropriate federal and regional organizations; i.e., federal rapid response teams and regional ANS Panels.

B. Prevention

Needs: Due to significant gaps in state monitoring programs at private lakes, public access sites, and waterways adjacent to known infestations, as well as diminished budgets for long-term monitoring and outreach programs, the regional workgroup recommends enhancing the regional monitoring network to provide for early detection and rapid response and providing targeted outreach programs to raise awareness about the zebra mussel's ecological and economic impacts, help limit their spread, and gain community support for rapid response.

Objective 1: Educate recreational users and natural resource managers to prevent future introductions

Actions:

1.1 Design and implement outreach activities to educate target audiences on how to prevent introduction of zebra mussels and how to reduce their spread from already infested areas.

Examples: For recreational boaters, distribute posters at marinas and boat launches, operate boat washing demonstrations, mail out zebra mussel ID cards with boat registration and fishing licenses. For scuba divers, distribute posters and ID cards at popular quarry sites and gear shops. For aquaculturists and fish hatchery personnel, incorporate zebra mussel prevention and control in existing Aquatic Nuisance Species (ANS) Hazard Analysis and Critical Control Points (HACCP) programs, coordinate with Sea Grant and USFWS ANS-HACCP training programs. (HACCP is a process initially developed by the seafood industry that has been tailored to identify pathways through which ANS and non-target aquatic species could enter aquaculture and baitfish operations.)

1.2 Develop plans for a Bay-wide awareness day, with specific activities targeted to different segments of the population. This could be a one-time event, or a series of events held in areas in the Bay region that are at high risk of zebra mussel introduction or spread.

1.3 As described earlier, the CBP zebra mussel website can serve as a focal point for information dissemination to all target audiences.

Objective 2: Educate Chesapeake Bay Region Policymakers and Communities about Rapid Response.

Actions:

2.1 Link existing state regulations on zebra mussels to CBP website to provide easy access to any ongoing rapid response initiatives and state contacts.

2.2 Develop and implement a workshop for Chesapeake Bay region natural resource agency personnel, municipal water supply and private lake managers to provide information on existing rapid response models from other areas.

2.3 Provide information on rapid response models on website.

2.4 Collaborate with Susquehanna River Basin Commission and Northeast-Midwest Institute to develop and implement an environmental workshop for legislators on rapid response.

Objective 3: Encourage local government and municipalities to take a proactive role in zebra mussel prevention.

Actions:

3.1 Develop information items and tools for local government implementation. This would involve:

- Assessing management or regulatory tools available to local municipalities,
- Developing a Best Management Practices (BMP) manual to distribute to lake associations, marinas, boat launches, etc., and
- Developing a sample decontamination protocol for newly infested sites. See Appendix 1, Millbrook Quarry Decontamination Case Study for examples.

C. Early Detection & Rapid Response

Needs: Due to significant gaps in state monitoring programs at private lakes, public access sites, and waterways adjacent to known infestations, as well as diminished budgets for long-term monitoring and outreach programs, the regional workgroup recommends enhancing the regional monitoring network to provide for early detection in order to trigger the Rapid Response Panel's action plan.

Objective 1: Expand capacity and coordination of zebra mussel monitoring programs.

Actions:

1.1 Review zebra mussel monitoring needs in the Chesapeake Bay watershed. This Action will require each state to:

- Review the status zebra mussel monitoring plans in their state;
- Identify gaps in existing state monitoring networks (i.e. unknown populations or high sensitivity areas that may be a management priority;
- Identify priority sites for placement of long-term monitoring stations;
- Evaluate and communicate existing sampling of protocols.

1.2 Improve monitoring efforts based on identified needs. Completing this Action may result in:

- Expand the number of monitoring stations throughout the region by enlisting the aid of state natural resource agency monitoring programs, volunteer programs, or other organizations like the Susquehanna River Basin Commission, SCUBA clubs, and Boy and Girl Scout programs;
- Target goals should be established, such as monitoring all of priority sites by 200X;
- Providing for regional coordination of state monitoring programs through the Chesapeake Bay Program website and GIS maps (see sections E1 and E4).

1.3 Expand or initiate web-based reporting process.

Objective 2: Identify threshold decision criteria defining when Rapid Response Panel is notified.

D. Control & Management

Needs: With the increasing risk of zebra mussel introduction, it is important to be aware of and provide up-to-date information to the public and water-based stakeholders on the threat potential, waterway vulnerability, and approved methods to control this invasive species.

Objective 1. Define probable pathways of introduction, dispersal, and associated risk of zebra mussel invasions in the Chesapeake Bay Watershed (Pathway Analysis & Prevention).

Actions:

1.1 Conduct a Pathway Analysis to identify all known and potential introduction and dispersal pathways applicable to the Chesapeake Bay Watershed. This should be accomplished by:

- Conducting studies of dive shops to determine their potential for the introduction and/or spread of zebra mussels. Must include surveys of divers who reside outside of the Chesapeake Bay Watershed and locations where Chesapeake Bay Watershed residents dive outside of the watershed boundaries;

- Conducting studies of boating activities to determine their potential for introduction and/or spread of zebra mussels. Must include surveys of boaters who reside outside of the Chesapeake Bay Watershed and locations where Chesapeake Bay Watershed residents boat outside of the watershed boundaries;

- Identifying high risk waterways based on potential for introduction, proximity to current populations, and utilization - Rank high risk water bodies to determine potential control measures. (This also serves in the development of the Rapid Response Plan in Action A.1.3);

- Coordinate with the Outreach subcommittee to direct educational materials at the appropriate target audiences.

1.2 Conduct a Risk Analysis to determine the vulnerability and potential biological and economical impacts of a zebra mussel invasion. This Risk Analysis should be based on:

- Conducting an assessment to determine the suitability of Chesapeake Bay Watershed waters to invasion by the zebra mussel;

- Conducting a comprehensive literature review to determine the potential biological and ecological impacts to Chesapeake Bay Watershed and surrounding non-infested areas;

- Conducting an assessment to determine the potential economic impacts to Chesapeake Bay Watershed and surrounding non-infested areas.

Objective 2. Review Eradication and Control measures that are currently available and determine which measures could be implemented in the Chesapeake Bay Watershed.

Actions:

2.1 Determine the feasibility of eradication and control measures that are practical for the Chesapeake Bay Watershed by:

- Conducting an extensive review of chemical and non-chemical eradication and control methods evaluated in laboratory and/or field (literature and professionals);
- Consulting with state and federal agencies (including EPA) for obtaining status compliance, and potential eradication and control measures;
- Reviewing relevant current and pending legislation and local regulations that contain provisions for access to affected properties for surveys, containment, control, and eradication.

Objective 3. Once they are identified, implement eradication and control measures

Actions:

3.1 Develop a work plan that tailors eradication and control measures for the targeted infestation. Plan development tasks should include:

- Assess the site invaded by zebra mussels and determine whether eradication or control is the best option;
- Develop a work plan to determine the needed information to implement an eradication or control protocol;
- Apply for rapid response funding through the USFWS/Aquatic Nuisance Species Task Force.

3.2 Implement a work plan.

- Determine and implement the most appropriate eradication or control method;
- Conduct follow up surveys to determine if eradication or control measures have been effective.

E. Communication & Information Access

Needs: Interstate communication and public and school outreach programs could be greatly enhanced through a coordinated suite of web-based and printed materials. A central contact needs to be established to report new zebra mussel sightings for each state and update range maps for the Chesapeake Bay watershed.

Objective 1: Create website on Aquatic Nuisance Species in the Chesapeake Bay.

Actions:

1.1. It is recommended that the Chesapeake Bay Program as part of their existing website framework host a dedicated aquatic nuisance species website. Wherever the website is

housed, the host site should have the capability to quickly update information. The species that are included in the website should be those identified as high-risk. Lower-risk species could be added as time and resources allow. Using the zebra mussel as the first example, the website should include at a minimum:

- General introduction to the zebra mussel and its impacts;
- Fact sheet (PDF) that is updated when appropriate;
- Map of zebra mussel infestations in Chesapeake Bay watershed, updated as necessary. It is recommended that each Bay state establish a contact person who reports GPS-referenced data on the sites and dates of confirmed zebra mussel sightings, introductions, and established populations. Building on the current zebra mussel monitoring and mapping program in Pennsylvania, this information could be compiled by the Pennsylvania Department of Environmental Protection, where updated maps would be produced and transferred to the Chesapeake Bay Program office for posting to the website;
- Links to each Chesapeake Bay state's regulatory information on zebra mussels;
- Links to SRBC and states early warning websites;
- Links to additional sources of current, scientifically accurate information, i.e. Zebra Mussel Clearinghouse (NY Sea Grant/Cornell); USGS Non-Indigenous Aquatic Species maps, 100th Meridian Initiative, U.S. Army Corps of Engineers Zebra Mussel Information System, the ANS Task Force's "Protect your Waters Campaign," Sea Grant Non-indigenous Species website (SGNIS), etc.
- Guidelines on how individuals should report a zebra mussel sighting:
    - photographs and drawings of zebra mussels and native mussels to help with accurate identification;
    - descriptive content on physical characteristics and range of zebra mussels vs. native mussels;
    - contact information for each state for reporting a zebra mussel sighting
- Links to contacts for zebra mussel volunteer monitoring programs;
- Audience-specific sections:
    - press page with media releases and contact information for each state;
    - educators page with links and listings of resources and curriculum materials;
    - resource managers' page with content and links on risk factors, monitoring strategies, rapid response models, control options, fact sheets, regional contacts, etc.
- Streaming video illustrating impacts of zebra mussels, particularly underwater footage showing how zebra mussels encrust and obscure dive features.

Objective 2: Produce and distribute new posters and ID cards.

Actions:

2.1. Prepare a single poster displaying images and information about several Chesapeake Bay aquatic invasive species, including zebra mussels. One poster

design will help create a consistent message and image, as well as lower costs to agencies. Posters should be distributed to marinas, boat launches, bait and tackle shops, etc. Contact information on the poster can be made specific to each jurisdiction.

2.2. Develop a new zebra mussel identification card, based on cards produced in Great Lakes region, Virginia and Maryland. Like the poster, the basic information on the ID card can be identical for all Bay jurisdictions, but contact information on the back of the card should be specific to each state.

Objective 3: Identify and disseminate existing science education programs.

Actions:

3.1. A regional workgroup should be established to develop an invasive species/zebra mussel instructional module specific to the Chesapeake Bay region, or compile existing resources if sufficient. This module should be made available to classroom teachers as well as to educators in science museums, aquariums, summer enrichment for inclusion in environmental curricula, or for incorporation into educational programs offered by Virginia Marine Science museum, or Wallops Island Marine Science Consortium, Chesapeake Bay Program, 4H Centers, etc. It could be produced in hard copy and posted on the zebra mussel website.

3.2. Compile a list of educational materials and post it on the zebra mussel website (create links to and from the Chesapeake Bay Program's Chesapeake Science on the Internet for Educators "ChesSIE" website).

Objective 4: Establish a Zebra Mussel Mapping Program.

Actions:

4.1. Each Bay State should identify a central contact person who compiles confirmed reports of zebra mussel sightings. This information should be relayed to the Pennsylvania Department of Environmental Protection, where a regional map will be produced, archived, and updated. The updated maps will be provided to the Chesapeake Bay Program for inclusion on the website (see Website Section A above). Each new confirmed zebra mussel sighting in the Bay region should be reported by PA to the Zebra Mussel Clearinghouse (NY Sea Grant/Cornell) for incorporation into the national range map.

III. Implementation Table

An implementation table is provided for each of the five management components. For each action identified under the components, we have identified a time frame for completing the actions, identification of agencies responsible for leading actions, the partners that should be involved, the funding/cost share, and the source of funding.

A. LEADERSHIP, COORDINATION, & REGULATORY AUTHORITY

Objective/Action	Tasks	Task Description	Task Duration	Cost	Funding Source	Lead Agency	Partners
Objective 1. Develop Coordinated Action Plan for Rapid Response							
1.1) Establish Rapid Response Panel	1.1.a	Identify potential candidates for Panel membership and participation to represent each CBP jurisdiction	1 week	$0		EPA's Chesapeake Bay Program Office	State agencies (PA DEP, VA DGIF, MD DNR, NYSDEC)
	1.1.b	Contact and confirm Panel membership and commitment	1 month	$0		EPA's Chesapeake Bay Program Office	Stakeholders, Assistant Secretaries of natural resource agencies
	1.1.c	Convene Organizational Meeting for Panel to define and review its rapid response mission	3 months	$1000		EPA's Chesapeake Bay Program Office	VDGIF, MDNR, PADEP, NYDEC, USFWS, academia, scientific experts, Sea Grant programs, and interested non-governmental agencies (NGOs).
1.2) Compile and summarize Federal and state regulations applicable zebra mussel issues	1.2.a	Define current regulations that pose limitations on zebra mussel occurrence, movement, and transport for each signatory state.	3 months	$500		EPA's Chesapeake Bay Program Office	Same as 1.1.c
	1.2.b	Track regulation promulgation, changes, and revisions	Ongoing			EPA's Chesapeake Bay Program Office	Same as 1.1.c
1.3) Develop Rapid Response Action Plan for New Zebra Mussel Infestations	1.3.a	Identify different zebra mussel infestation scenarios (e.g. lake, stream, quarry)	3 months	$1000		Rapid Response Panel (RRP)	Same as 1.1.c
	1.3.b	Identify all known and potential introduction and dispersal pathways	6 months	$3000		RRP	Same as 1.1.c

	1.3.c	Identify and rank high risk waterways based on potential for introduction, proximity to current populations and utilization	1 month	$1000		EPA's Chesapeake Bay Program Office /State Agencies	Same as 1.1.c
	1.3.d	Compile and review existing eradication plans, (i.e. Millbrook Quarry and other states affected by zebra mussels	6 months	$3000		EPA's Chesapeake Bay Program Office /State Agencies	Same as 1.1.c
	1.3.e	Define response options and feasibility for each jurisdiction	3 months	$1000		EPA's Chesapeake Bay Program Office /State Agencies	Same as 1.1.c
	1.3.f	Coordinate rapid response planning and implementation with appropriate federal and regional organizations; i.e. federal rapid response teams and regional ANS Panels.	1 year	$5000		RRP/ EPA's Chesapeake Bay Program Office	Same as 1.1.c

B. PREVENTION

Objective/Action	Tasks	Task Description	Task Duration	Cost	Funding Source	Lead Agency	Partners
Objective 1. Educate recreational users and natural resource managers							
1.1) Design and implement outreach to prevent introduction of zebra mussels and reduce their spread to infested areas	1.1.a	Target recreational boaters by distributing posters at marinas and boat launches, holding boat washing demonstrations, mailing out zebra mussel ID cards with registration cards and licenses	1 year	$5,000		EPA's Chesapeake Bay Program Office	PFBC, VDGIF, MDDNR, NYSDEC, marina owners, lake associations, Sea Grant
	1.1.b	Target scuba divers by distributing posters and ID cards at popular quarry sites and gear shops; contributing articles in trade magazines	Ongoing	$5,000		EPA's Chesapeake Bay Program Office	Sea Grant, Project AWARE
	1.1.c	Minimize risk by offering regional HACCP workshops to aquaculturists and fish hatchery personnel	Ongoing	$10,000		Sea Grant	USFWS, State agencies, State aquaculture associations
1.2) Bay-wide awareness day about aquatic invasive species	1.2.a	Plan and implement awareness day, or series of events in regions at high risk of zebra mussel introductions	1 year	$8,000		EPA's Chesapeake Bay Program Office	Sea Grant, NOAA, State agencies, B4B
1.3) Raise public awareness through web-based media	1.3.a	Maintain Chesapeake Bay Zebra Mussel website	1 year	$6270		EPA's Chesapeake Bay Program Office	PA DEP, VA DGIF, MD DNR, NYSDEC, Sea Grant, NOAA Chesapeake Bay Program
Objective 2. Educate Chesapeake Bay Region Policymakers and Communities about Rapid Response							
2.1) Link existing state regulations on zebra mussels to CBP website	2.1.a	Link zebra mussel regulations on to CBP website in order to provide easy access to any ongoing rapid response initiatives and state contacts.	3 months	$1500		EPA's Chesapeake Bay Program Office	
2.2) Develop and	2.2.a	Develop and implement a	1 year	$18,000		EPA's	Sea Grant, USFWS, State

implement a workshop for Chesapeake Bay Region		workshop for natural resource agency personnel, municipal water supply and private lake managers to provide information on existing rapid response models from other areas.				Chesapeake Bay Program Office	agencies, lake associations, NWR's Great Lakes ANS Panel, USCG, NPS
2.3) Provide information on rapid response models	2.3.a	Provide information on rapid response models on CBP zebra mussel website	6 months	$1000		EPA's Chesapeake Bay Program Office	SRBC, NEMW Institute, Sea Grant Programs, National Governor's Association
2.4) Develop and implement an environmental workshop for legislators on rapid response	2.4.a	Collaborate with SRBC and Northeast-Midwest Institute to develop and implement an environmental workshop for legislators on rapid response.	1.5 years	$10,000		EPA's Chesapeake Bay Program Office	SRBC, NEMW Institute, Sea Grant Programs, National Governor's Association
Objective 3. Encourage local governments to take a proactive role in zebra mussel prevention							
3.1) Develop information items and tools for local government implementation	3.1.a	Assessing management or regulatory tools available to local municipalities				EPA's Chesapeake Bay Program Office	
		Developing a Best Management Practices (BMP) manual to distribute to lake associations, marinas, boat launches				EPA's Chesapeake Bay Program Office	
		Developing a sample decontamination protocol for newly infested sites.				EPA's Chesapeake Bay Program Office	

C. EARLY DETECTION & RAPID RESPONSE

Objective/Action	Tasks	Task Description	Task Duration	Cost	Funding Source	Lead Agency	Partners
Objective 1. Expand capacity and coordination of zebra mussel monitoring programs							
1.1) Review zebra mussel monitoring needs in the Chesapeake Bay Watershed	1.1.a	Review existing monitoring plans and deficiencies in signatory state waters.	6 months	$2000		State agencies (PA DEP, VA DGIF, MD DNR, NYSDEC)	
	1.1.b	Identify gaps in existing state monitoring networks, i.e. unknown populations or high sensitivity areas that may be a management priority.	6 months	$0 (Included in 1.1.a)		Same as 1.1a	
	1.1.c	Each state identifies priority sites for placement of long-term monitoring stations	1 year	$0 (Included in 1.1.a)		Same as 1.1a	
	1.1.d	Evaluate and communicate sampling protocols	3 months	$1000		Zebra Mussel Clearinghouse	CBP
1.2) Improve monitoring efforts based on identified needs	1.2.a	Expand the number of monitoring stations throughout the region based on Action1 findings	Ongoing?	$20000+ (this is a SWAG – too many uncertainties)		Same as 1.1a	State natural resource agency monitoring programs, volunteer programs, or other organizations (e.g. SRBC, SCUBA clubs, and Boy and Girl Scout programs)
	1.2.b	Provide for regional coordination of state monitoring programs through the Chesapeake Bay Program website and GIS maps (see sections E1. and E4.)	Ongoing	$6270		EPA's Chesapeake Bay Program Office	
1.3) Expand or initiate web-based reporting process	1.3.a	Develop web-based reporting site for public zebra mussel sightings	1 year	$4200		EPA's Chesapeake Bay Program Office (build into	Volunteer organizations (Alliance for Bay, etc.)

						existing website)	

D. CONTROL & MANAGEMENT

Objective/Action	Tasks	Task Description	Task Duration	Cost	Funding Source	Lead Agency	Partners
Objective 1. Define probable pathways of introduction, dispersal, and associated risk of zebra mussel invasions							
1.1) Conduct a Pathway Analysis to identify all known and potential introduction and dispersal pathways applicable to the Chesapeake Bay Watershed	1.1.a	Conduct studies of dive shops to determine their potential for the introduction and/or spread of zebra mussels (Must include surveys of divers who reside outside of the Watershed and locations where Chesapeake Bay Watershed residents dive outside of the watershed boundaries)	1 year			EPA's Chesapeake Bay Program Office	State agencies (PA DEP, VA DGIF, MD DNR, NYSDEC), USFWS
	1.1.b	Conduct studies of boating activities to determine their potential for the introduction and/or spread of zebra mussels (Must include surveys of divers who reside outside of the Chesapeake Bay Watershed and locations where Chesapeake Bay Watershed residents dive outside of the watershed boundaries)	1 year			EPA's Chesapeake Bay Program Office	Same as 1.1.a
	1.3	Coordinate with the Outreach Subcommittee to direct educational materials at the appropriate audiences	Ongoing			EPA's Chesapeake Bay Program Office	Same as 1.1.a
1.2) Conduct a Risk Analysis to determine the vulnerability and potential biological	1.2.a	Conduct assessment to determine the suitability of Chesapeake Bay watershed waters to invasion by the zebra mussels	1 year			VCU	Same as 1.1.a

and economical impacts of a zebra mussel invasion.							
	1.2.b	Conduct a comprehensive literature review to determine the potential biological and ecological impacts to the Chesapeake Bay watershed	1 year			EPA's Chesapeake Bay Program Office	Same as 1.1.a
	1.2.c	Conduct an assessment to determine the potential economic impacts to the Chesapeake Bay watershed	1 year			EPA's Chesapeake Bay Program Office	Same as 1.1.a
Objective 2. Define probable pathways of introduction, dispersal, and associated risk of zebra mussel invasions							
2.1) Determine potential Eradication and Control Methods that are most practical for the Chesapeake Bay Watershed	2.1.a	Conduct extensive literature review of chemical and non-chemical eradication and control methods evaluated in laboratory and/or field; contact all relevant professionals to determine eradication/control strategies	6 months/ ongoing			VA DGIF	Same as 1.1.a, CBP
	2.1.b	Consult with state and federal agencies (including EPA) for obtaining status, compliance, and permits applicable to potential eradication and control measures	6 months			EPA's Chesapeake Bay Program Office	Same as 1.1.a
	2.1.c	Identify and be familiar with the relevant current and pending legislation and local regulations that contain provisions for access to affected properties for surveys, containment, control, and eradication	Ongoing			EPA's Chesapeake Bay Program Office	Same as 1.1.a
Objective 3. Implement appropriate eradication and control measures							
3.1) Develop an Eradication and	3.1.a	Assess the site invaded by zebra mussels and determine whether	1 month			State agencies (PA DEP, VA DGIF,	USFWS, CBP

Control work plan as appropriate		eradication or control is the best option				MD DNR, NYSDEC)	
	3.1.b	Develop a work plan to determine the needed information to implement an eradication or control protocol	2 months			State agencies (PA DEP, VA DGIF, MD DNR, NYSDEC)	USFWS, CBP
	3.1.c	Apply for rapid response funding through the USFWS/Aquatic Nuisance Species Task Force					
3.2) Implement work plan	3.2.a	Carry out work plan, and determine and implement the most appropriate eradication or control methods	9 months			State agencies (PA DEP, VA DGIF, MD DNR, NYSDEC)	USFWS, CBP
	3.2b	Conduct follow up surveys to determine if eradication or control measures have been effective	Ongoing			State agencies (PA DEP, VA DGIF, MD DNR, NYSDEC)	USFWS, CBP

E. COMMUNICATIONS & INFORMATION ACCESS

Objective/Action	Tasks	Task Description	Task Duration	Cost	Funding Source	Lead Agency	Partners
Objective 1. Create website on Aquatic Nuisance Species in the Chesapeake Bay							
1.1) Enhance Chesapeake Bay Program Website on Invasive Species by developing zebra mussel pages	1.1.a	Develop general fact sheet	1 year	$2000		EPA's Chesapeake Bay Program	PA DEP, VA DGIF, MD DNR, NYSDEC, Sea Grant, NOAA Chesapeake Bay Office
	1.1.b	Create watershed map of zebra mussel infestations; update as needed	Ongoing	$2000		EPA's Chesapeake Bay Program	State agencies (PA DEP, VA DGIF, MD DNR, NYSDEC)
	1.1.c	Provide links to state regulatory information	6 months	$3400		EPA's Chesapeake Bay Program	PA DEP, VA DGIF, MD DNR, NYSDEC
	1.1.d	Provide links to scientifically accurate resources	6 months	$3400		EPA's Chesapeake Bay Program	Cornell University, Sea Grant
	1.1.e	Provide guidelines on reporting new zebra mussel sightings	1 month	$3400		EPA's Chesapeake Bay Program	PA DEP, VA DGIF, MD DNR, NYSDEC
	1.1.f	Develop audience-specific sections, i.e. press page, educators page, natural resource managers page	1 year	$3400		EPA's Chesapeake Bay Program	State agencies (PA DEP, VA DGIF, MD DNR, NYSDEC), Regional press media
Objective 2. Update and distribute new educational materials							
2.1) Produce new posters	2.1.a	Prepare poster displaying images and information about Chesapeake Bay aquatic invasive species, including zebra mussels	1 year	$10,000		EPA's Chesapeake Bay Program	PA DEP, VA DGIF, MD DNR, NYSDEC, USFWS, Sea Grant
	2.1.b	Distribute posters to marinas, boat launches, bait and tackle shops, etc.	Ongoing	$0			State agencies (PA DEP, VA DGIF, MD DNR, NYSDEC), Sea Grant
2.2) Produce new ID	2.2	Develop a new zebra mussel	3 months	$10,000		Sea Grant	

cards		identification card with contact information tailored to individual states (160,000 copies)					
Objective 3. Identify and disseminate existing science education programs							
3.1) Identify and Disseminate existing education programs	3.1.a	Create regional workgroup to develop an invasive species/ zebra mussel instructional module specific to the Chesapeake Bay region, or compile existing resources if sufficient (1 month @ $25/hr for educator to author module)	1 year	$4,000		EPA's Chesapeake Bay Program Office	Sea Grant, NOAA Chesapeake Bay Office, State Departments of Education
	3.1.b	Produce, print, and distribute instructional module to classroom teachers, aquatic educators, educational programs at museums or nature centers (2500 hard copies)	Ongoing	$8,000		Sea Grant	Mid-Atlantic Sea Grant Programs, VA Marine Science Museum, Wallops Island Marine Science Consortium, Chesapeake Bay Program, 4H Centers, DE Teacher's Estuary Institute; Centers for Watershed Protection, NERRS, NWRs
3.2) Post a list of recommended educational materials on website	3.2.a	Compile list of educational materials and post on CBP zebra mussel website	1 month	$3400		EPA's Chesapeake Bay Program Office	Mid-Atlantic Sea Grant Programs
Objective 4. Initiate a Zebra Mussel Mapping Program							
4.1) Zebra Mussel Mapping Program	4.1.a	Establish state contacts for new sightings information	1 month	$0		EPA's Chesapeake Bay Program Office	PA DEP, PFBC, VA DGIF, MD DNR, NYSDEC
	4.1.b	Submit new sightings to PA DEP to update regional maps and incorporate into CBP website	Ongoing	$3400		PA DEP, PFBC, VA DGIF, MD DNR, NYSDEC	
	4.1.c	Share sightings data with Zebra	Ongoing	$0		PA DEP	New York Sea Grant

		Mussel Clearinghouse for incorporation into the national range map					

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Figure 1
***Dreissena polymorpha* Distribution in the Mid Atlantic United States**
Map Source: http://nas.er.usgs.gov/mollusks/maps/current_zm_map.jpg

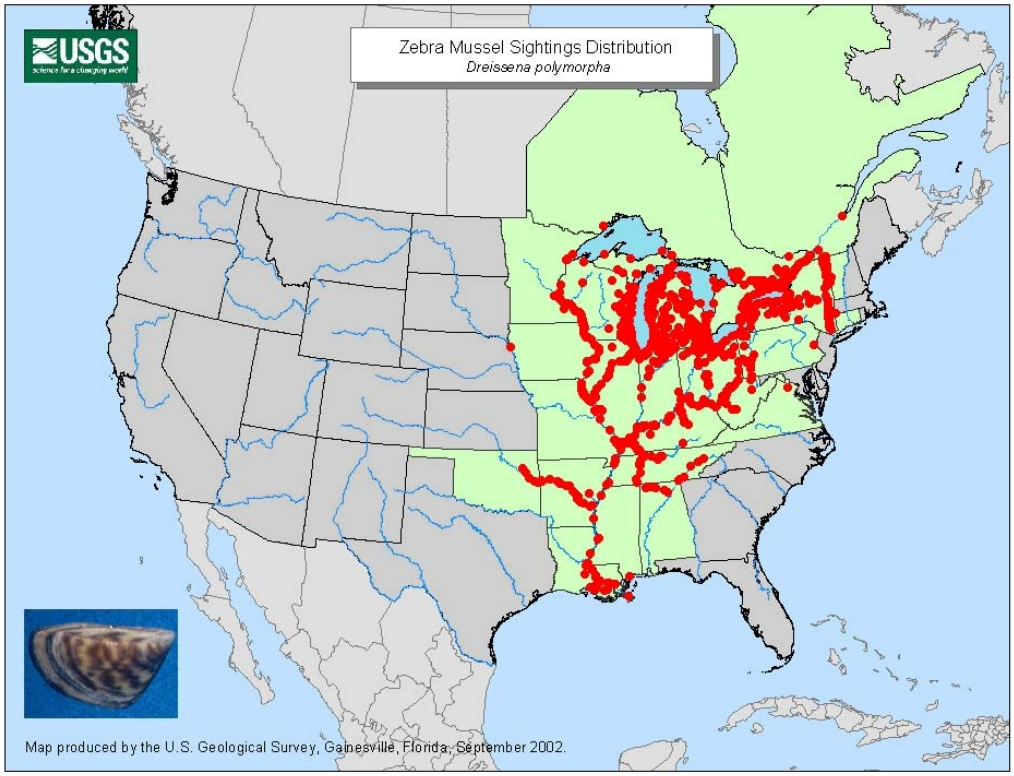

Figure 2
***Dreissena polymorpha* Distribution in the Chesapeake Bay Watershed**
Map Source: Chesapeake Bay Program