Section 1. Oyster Management

I. Introduction

The native oyster, *Crassostrea virginica*, is currently estimated at less than 1 percent of its historic abundance. The decline in its abundance can be attributed to many factors, including fishing, habitat destruction, disease mortality, reduced water quality and the interactions among these factors. The role of degraded water quality and its impact on the oyster resource has a dual nature. Oysters are negatively impacted by sedimentation, turbidity and anoxic conditions, thereby limiting oyster restoration. Oysters also have the potential to improve water clarity and remove algae from the water through their suspension-feeding activities; thereby having a positive effect on water quality. However, at current low abundance their positive effects are minimal.

Fishery managers in the Chesapeake Bay have been addressing these issues through fishery management plans. A *Chesapeake Bay Oyster Management Plan* was adopted in 1989 and revised in 1994. Oyster restoration efforts were addressed in the *Chesapeake Bay Aquatic Reef Habitat Plan*, also completed in 1994. The *Oyster Management Plan* (*OMP*) combines these past efforts in one document and includes additional considerations. The individual jurisdictions also have developed statewide plans to manage and restore the oyster resource. The Maryland Action Plan was adopted in 1993 and reflects a collaborative approach to management. Similarly, the Virginia Restoration Plan coordinates restoration, monitoring efforts and the management of private and public grounds. The state plans provide the specific measures for implementing the *OMP* strategies and actions. In addition, a separate but coordinated effort addresses the issue of poor water quality in the Bay. Water quality criteria, such as levels of dissolved oxygen (DO), chlorophyll *a*, nitrogen and phosphorous, have been set to delist the Bay as an impaired body of water. The Chesapeake Bay Program has led the effort to determine water quality criteria, and the states are working to develop tributary strategies to meet the criteria in all of the Bay's tributaries. Improved water quality is a critical factor in supporting a vibrant oyster resource**.**

The purpose of the *OMP* is to provide both a general framework and specific guidance for implementing a strategic, coordinated, multipartner management effort. Representatives from state and federal agencies, academia, environmental groups and the oyster industry developed the plan (for a complete list and description of the oyster partners, refer to Section 1.VIII). Part of this renewed effort to rebuild the Bay's native oyster resource came from a keystone commitment in the *Chesapeake 2000* agreement. The *OMP* defines several strategies for rebuilding and managing native oyster populations. They are: evaluating the use of sanctuaries and harvest reserves to obtain optimum ecological and economic benefits; rebuilding habitat; managing harvest; increasing hatchery production; evaluating the impediments to aquaculture; improving coordination among the oyster partners; and developing a baywide database to track restoration projects. The *OMP* endeavors to improve and complement the ongoing efforts of multiple oyster partners toward restoration in the Chesapeake Bay. Currently, the major impediments to rebuilding the oyster resource are the impact of diseases and the degraded condition of oyster habitat. The magnitude of these impediments cannot be over-emphasized and is a common theme throughout the document.

A programmatic Environmental Impact Statement (EIS) is in progress to evaluate alternative approaches to increasing oysters in the Chesapeake Bay. The action to be evaluated is a proposal to introduce a non-native oyster, *C. ariakensis*. Alternatives to the introduction will also be considered and include taking no action and continuing the current management policies; expanding the native oyster restoration program; implementing a harvest moratorium; establishing and/or expanding aquaculture operations for either the native or non-native species; and introducing and propagating an alternative oyster species. Upon completion of the EIS, the *OMP* will be reviewed to determine whether any management actions need to be added or amended.

Vision

A restored oyster resource can be described as abundant, self-sustaining, occurring over a wide range throughout the Chesapeake Bay, performing important ecological roles and supporting an oyster fishery. In order to attain both ecological and socioeconomic objectives, compromises will be necessary, since these two objectives often work in opposition to one another.

It is unknown how large the Bay's oyster population must be to attain a restored oyster resource and deliver the desired ecological and economic benefits. Although the objective of a tenfold increase in oysters has been propagated by the *Chesapeake 2000* commitment, a tenfold increase would represent only a fraction of historic levels. Since the Chesapeake Bay ecosystem and its watershed have been drastically altered by human activities over the past centuries, it is not possible to restore oysters to historic levels. With the increase in disease and its recent expansion, more challenges have arisen with regard to oyster restoration and harvest. Given the limiting factors of disease, degraded habitat and low abundance, achieving a tenfold increase in oyster biomass by 2010 is unlikely. To date, small-scale projects have shown that oyster biomass has increased at project sites. The challenge is to expand these projects to a larger scale and contribute to increases in biomass at the baywide scale.

DESIRED BENEFITS

A restored oyster resource will:

- Produce more oysters than are removed each year by natural mortality and harvest;
- Improve water clarity by filtering phytoplankton and sediment from the water;
- Provide ecologically valuable reef habitat for crabs, fish and other organisms;
- Provide income for water-dependent families and communities; and
- Generate additional revenue from processing, shipping and secondary sales of oyster products.

Objective 1.

Increase oyster populations to levels that restore important ecological functions, including water filtration and nutrient cycling; aquatic reef community structure; and adequate broodstock to sustain regional populations.

1a): Rehabilitate habitat by utilizing appropriate bottom type; consider the influence of environmental conditions; and increase oyster biomass.

1b): Conserve/protect oyster grounds as sanctuaries.

1c): Achieve a tenfold increase in oyster biomass by 2010, relative to a 1994 baseline.

Objective 2.
Achieve a sustainable oyster fishery through a combination of harvest from public oyster grounds and private aquaculture.

Objective 3.
Reduce the impacts of disease on oyster populations.

Objective 4.
Increase hatchery production and develop disease-resistant strains.

Perspectives

It is widely recognized that oysters and oyster reefs are vital components of the Chesapeake Bay ecosystem and that their restoration is an essential element in the ecological rehabilitation of the Bay. Oyster reefs, as they occurred historically, no longer exist in the Chesapeake Bay. Sediment-free shell is one of the most important components of quality oyster habitat (MacKenzie 1983; Smith et al. 2001). New techniques for surveying the bottom suggest that as little as 1 to 2 percent of Maryland's historic oyster grounds can be classified as clean or lightly covered with sediment (Smith, unpublished data). Based on limited data, the best estimate of potentially restorable habitat in Maryland is 10,000 to 20,000 acres**.** Based on Virginia's Restoration Plan, there are approximately 28,500 acres of potentially restorable oyster habitat in the Virginia portion of the Chesapeake Bay.

Oyster shell, either new (shucked) or from buried deposits, is the predominant and preferred cultch for oyster habitat projects in both Maryland and Virginia. Improving degraded oyster habitat across large areas will require more shell than is available from traditional shell deposits. The dominant source of shells for oyster restoration since 1960 has been dredged shells from buried shell deposits in the upper Bay. In Maryland, there are two large deposits remaining in the upper Bay, and more deposits exist in the upper Potomac River. Access to these areas will likely be limited or even prohibited because of environmental and other issues surrounding dredging. Virginia has identified several potential shell deposits in the James River system. Permits to dredge buried shell have been acquired for two sites. Enough shell is available in these two sites to allow a significant oyster restoration effort over the next 10 years.

Another source of shell is the shell already present on an oyster bar. Most of this *in situ* shell is covered by sediment ranging from a thin layer of silt to thicker deposits of sand or mud and could be extracted and recycled in place to rehabilitate local habitat. This process would require permits and involve environmental issues such as suspended sediment and impacts to the benthic community. Before degraded bottom habitat can be efficiently utilized, potential sites need to be located. Alternative substrates should also be considered. Currently, the most feasible function of alternative substrates is to provide a base for constructed oyster bars, which reduces the amount of natural shell necessary to create an oyster bar. Alternate materials that replace the need for natural shell and can be economically manufactured in large quantities have not yet been identified.

The combined threats of disease in high-salinity areas and freshets in low-salinity areas also have significantly reduced the amount of potentially restorable oyster habitat. In some areas such as the Potomac River, the frequency, severity and immediacy of freshets have risen with the hardening of the basin through urban development and suburban sprawl. Currently, using wild, native stock**,** the highest probability of success for establishing stable, multi-year class, reproductive oyster populations lies in areas between the spatial boundaries set by disease and freshets. There are few places where stable oyster populations might realistically be re-established because these boundaries shift in both space and time. There are no areas in Bay waters that are absolutely inviolate to freshets, poor water quality or disease. In very dry years, the disease limit can extend upstream as far as the freshet limit will extend downstream in wet years and from time to time overlap. Increasing the number of oysters depends on the cumulative probability of several factors: 1) the location of effort in regions of lowest susceptibility to disease and/or freshet impact; 2) the location of effort in regions of historically high recruitment that remain in proximity to extant broodstock populations; 3) the ability to improve population structure by encouraging multiple rather than single-year classes that could lead to increased recruitment; and 4) the development of disease resistance (refer to p.11 for description of terms). While items (2) and (3) have the potential to improve the resource by strategically placing habitat rehabilitation efforts, the underlying drivers for item (1) are random variables beyond human control. It is important to point out, however, that even small gains driven by favorable environmental conditions and the prospect of disease-resistant strains of the native oyster (4) could shift the probability function in a more positive direction.

Tracking Progress

A collaborative project was initiated between researchers in Maryland and Virginia to quantify a baseline oyster population in the Bay, standardize population monitoring efforts and measure progress toward the objective of increasing oyster biomass (Mann et al. 2003). Estimating the oyster population in terms of biomass rather than abundance (absolute number) eliminates misleading results due to the large and variable number of spat. Using oyster biomass is also a more useful barometer of population size and ecological function (Mann et al. 2003).

Oyster biomass data are obtained from designated sentinel sites in Maryland and Virginia. The term ‘sentinel site’ describes a monitoring station that has a long-term monitoring data set. Mean oyster densities are estimated from these sites and then extrapolated over an estimated habitat area. The most critical issue for estimating the baywide abundance of oysters is to accurately assess the productive bottom areas and areas of marginal production (Mann et al. 2003). The total biomass estimate relies heavily on estimates of oyster habitat, and an incorrect estimate of habitat can result in an over- or underestimation of oyster population size. As the number of sanctuaries and reserves increases, the number of sentinel sites may need to be adjusted to provide a more accurate population estimate.

Data for estimating the Chesapeake Bay oyster populations include fishery independent and dependent data, restoration efforts and aquaculture. The Maryland population estimate for 2002 was 184 million grams or 205 million oysters. The Maryland estimate does not include oysters from restoration efforts (sanctuaries) or from replenishment areas. The Virginia population estimate for 2002 was 920 million grams or 4.6 billion oysters.

The methodology to estimate biomass needs refinements. Several research proposals have been developed to improve the biomass estimates and develop quantitative population models. The information generated from these projects will provide the basis for managing the stock using biological reference points, i.e., appropriate mortality rates and biomass thresholds and targets.

Oyster Management Plan Content

The main components to rebuilding and managing the native oyster population in the Chesapeake Bay are: 1) to evaluate the use of sanctuaries and harvest reserves to obtain optimum ecological and economic benefits using the results of the demographic modeling project, retrospective analyses, salinity zones and natural mortality (especially disease); 2) to rebuild oyster habitat; 3) to implement harvest strategies; 4) to increase hatchery production; 5) to evaluate aquaculture; 6) to improve coordination among the oyster partners; and 7) to develop a database to track oyster restoration projects and monitoring results. All strategies consider the impacts and limiting factors associated with disease. The *OMP* provides guidance on restoration areas and a standardized approach to implementing restoration projects. Special management areas will be implemented to enhance ecological functions and obtain better market values for the oyster industry. An information network will be established to assess the status of the oyster resource, track restoration efforts and evaluate management strategies and actions. A database will be developed that will allow the oyster partners to interact in a timely manner, contribute research results and exchange monitoring information. The first section concludes with a list of oyster partners and a description of their functions. There is also an implementation table that summarizes all the strategies and actions and indicates which oyster partners are responsible for implementing the actions.

The second section of the plan provides guidance on implementing oyster restoration projects, including plan content, monitoring, review and evaluation. The guidance applies to any restoration project including but not limited to sanctuaries, harvest reserves and repletion programs. It includes site selection and site suitability criteria. The third section also includes a glossary of terms and an appendix that identifies the links to other Chesapeake Bay Program activities.

A supporting document that provides the biological background for oysters including life history, a historic view of the oyster fishery and habitat requirements, is under development. The document will follow the guidelines of the Chesapeake Bay Fisheries Ecosystem Plan and build an ecosystem-based management approach for oysters. A draft of the supporting document may be completed by December 2005.

II. Zonal Approach to Management

Recognizing that disease is the dominant factor in all restoration and repletion activities and that disease is correlated with salinity, management strategies will be defined according to three salinity regions; high, moderate and low. The boundaries of the low- and high-salinity zones are relatively well-defined, except in extreme climatic events (e.g., drought, freshets), while the boundaries of the moderate zone fluctuate annually. In order to produce visual representations, e.g., maps of each salinity zone, the following methodology was used. Salinity data from the

Chesapeake Bay Program was averaged from 1990-1999 at depth between 10-20 feet. Two seasons are represented, spring (April-June) and summer (July-September). Different management actions pertaining to the three strategy components will be considered for each zone (Figure 1, 2). As estuarine organisms, oysters exist under a wide range of environmental conditions. In any given area, a particular oyster bar, river system or region is subject to change, especially due to rainfall patterns. During periods of abnormal rainfall, characteristics of the zones, as defined in this document, may be dramatically altered. Actions outlined for individual zones are based on long-term salinity patterns and are subject to modifications as environmental conditions dictate.

Zone 1

Zone 1 is the lower salinity water of the Chesapeake Bay, between 5ppt and <12ppt. This zone generally encompasses the portion of the Bay above the Bay Bridge in Maryland, and the upper reaches of the Potomac, Choptank, Chester, Patuxent and other tributaries in Maryland. Virginia has virtually no *public oyster grounds* designated within the lower salinity zone.

Relative to the other zones, Zone 1 is characterized by lower levels of disease and better survival, but low reproductive capability. It is subject to intermittent freshets that can result in substantial mortality, particularly in the upper reaches of the zone. Restoration efforts will depend on *seed plantings* to increase populations. Disease exists in this zone, but low salinity reduces the impact of disease. There is less mortality and oysters live longer. However, because of the decreased salinity, *spat settlement* is very low, often nonexistent. To increase the oyster population, this area is dependent on either natural or *hatchery seed*. Expectations are that oysters in this zone will contribute significantly to the short- term, tenfold objective and long-term biomass accumulation.

Zone 2

Zone 2 is generally classified as 12-14 ppt and has fluctuating boundaries based on climatic variation between wet and dry years. Although Zone 2 appears to be a rather narrow salinity range, it actually encompasses a broad geographic area. This zone experiences a range of spat settlement from low to moderate to high due to fluctuating environment parameters. Disease mortality also fluctuates, generally increasing during drought years and decreasing during wetter periods. When disease mortality lessens, this zone can experience rapid recovery of populations and biomass due to increased survival in combination with successful *recruitment*. The reverse can also happen just as quickly. Public oyster grounds and restoration activities that occur within this area will have varying results depending on environmental and disease conditions. Any oyster projects in this zone should be carefully considered on an annual basis.

Zone 3

Zone 3 is the highest salinity region of the Chesapeake Bay with greater than 14ppt. This zone comprises a large portion of the Bay and most Virginia waters. There is continuous disease pressure from parasites. As a result, there is generally heavy disease-related mortality and few oysters survive to market size. Those oysters that do survive beyond 3-4 years in this region may presumptively be *disease-resistant (*refer to page 11 for definition*)*. This zone favors spat settlement. There is a higher probability of yearly spat settlement events that provide a fairly constant influx of new oysters. This zone does not experience the dramatic rebounds that are possible in Zone 2 because of constant, high levels of disease mortality. Augmenting biomass will be a challenge in Zone 3. More aggressive restoration techniques involving stock enhancement with selectively bred oysters will be required. Restoration sites will require adaptive management and extensive maintenance. This zone may or may not significantly contribute to the tenfold increase baywide, but it may contribute to developing disease resistance in native oysters.

Adaptive Management

Considerations of oyster biology, potential for project success and contribution to overarching objectives will form the basis for decisions about where and how to invest limited resources. Oyster restoration and management strategies will differ by salinity zone. The extent of disease mortality and the results of activities in special management areas (sanctuaries and harvest reserves) will determine the type of habitat restoration efforts and fishery management measures that take place in a particular zone. The Bay jurisdictions and oyster partners will focus their activities in selected geographic areas to increase the possibility of success, optimize monitoring and optimize funding resources. Electronic synthesis (GIS) of relevant data – salinity, bottom, environmental conditions, spat settlement history, disease and biomass estimates, etc., will aid in the decision-making process. Spatially explicit population dynamic models that include the major factors influencing mortality and recruitment rates across multiple salinity regimes could help to develop appropriate management strategies.

The oyster partners have practiced and will continue to practice a policy of adaptive management. Before any oyster project is implemented in the Chesapeake Bay, the results of previous efforts will be considered to formulate the best approach for each project. With the adoption of the *OMP*, the partners agree to use the best available data to obtain the greatest level of success from each project and from all the projects collectively. The essential elements of adaptive management that will be practiced are briefly described below.

Project Design. The oyster partners will provide as much information as possible about the performance of methods used in each project.

Measurable Objectives. Project objectives must relate directly to one or more of the baywide objectives for oyster restoration; be compatible with the standards set for monitoring biomass; and provide input into oyster stock estimates.

Project Review Process. Partners and stakeholders will participate in the review of proposed project plans and site designations through an ongoing review process. Current review processes for Maryland and Virginia are detailed in Section 2.

Monitoring. Each project must specify an adequate monitoring protocol and funding to implement the monitoring. Data will be collected in a standardized format and each state will maintain oyster data in compatible databases.

Evaluation. Results of projects will be shared among the restoration partners through the ongoing project review process and through the development of information management systems.

III. Oyster Disease

Introduction

The biggest challenge to oyster restoration in the Chesapeake Bay is to overcome the effects of disease. Two oyster protozoan (single-celled) parasites, *Perkinsus marinus* (Dermo) and *Haplosporidium nelsoni* (MSX), are currently the major sources of oyster mortality in the Chesapeake Bay. Environmental conditions, especially temperature and salinity, affect the distribution and abundance of the parasites (Burreson & Ragone Calvo 1996). In addition, they affect how parasites are transmitted, their prevalence (how many hosts are infected) and their intensity (how severe the infection) (Andrews & Wood 1967; Reece et al. 2001). Environmental conditions that affect temperature and salinity, especially climatic and seasonal changes, make it particularly difficult to manage oyster restoration efforts in the presence of disease. The best management practices can be negated by naturally occurring events. The opposite results also are possible. Environmental conditions can favor oyster growth and reproduction, and disease can abate. During the late 1980s and early 1990s, significant changes in the distribution of pathogens in the Chesapeake Bay occurred as a result of four years of drought conditions and warm winters (Burreson & Ragone Calvo 1996). Currently, *P. marinus* is present on all productive oyster grounds in the Bay. Successful management strategies for rebuilding the oyster population in the Chesapeake Bay must consider the life history of the pathogens, the effects of environmental conditions and methods to increase recruitment.

Impacts of Disease

Generally in low-salinity areas (<12 ppt), some individuals survive to adulthood (i.e., reproductive maturity = about 1 ½ inches) and reach or exceed market size (3 inches and larger). However, these low-salinity areas also have low population recruitment rates because salinity affects the production of gametes, larval growth and settlement (Ford & Tripp1996). In mid-salinity areas (12-14 ppt), oyster survival and growth are variable depending on climatic fluctuations – in wet years survival is generally higher but spat settlement and growth are poor, and in dry years the opposite is true. Higher salinity areas (>14 ppt) tend to have large numbers of small oysters because population recruitment rates are higher but fewer individuals survive to large size. This general pattern is further modified in portions of Maryland, Virginia and the upper Potomac by periodic, often lethal, freshets that occur in the lower salinity reaches of the upper tidal tributaries. Record levels of disease prevalence and geographic extent have recently occurred (2002). Since disease impacts on the oyster resource are closely associated with salinity, the last few years (1999-2002) of drought conditions have caused sharp increases in mortality especially in the higher salinity tributaries.

Although an annual cycle of disease-induced mortality can be discerned in the Chesapeake Bay, disease mortality is compounded in consecutive years because *P. marinus* can overwinter. Consequently, for any given year class, disease mortality can have significant cumulative effects over several years. There is currently no direct method to distinguish between the effects of each of the diseases, but the relative effects of *P. marinus* and *H. nelsoni* can be inferred from population data, disease diagnostics and salinity. Adopting a management strategy based on salinity zones will help to emphasize the regional differences associated with disease and oyster life history parameters. However, there are other factors, such as growth, oyster density and the transplanting of seed oysters, which can affect population structure and do not follow the usual geographic trends associated with salinity (Jordan 1995). Salinity zones are not static, but change seasonally and interannually; therefore, management strategies have to be adaptive to reflect environmental parameters.

Disease Tolerance and Resistance

In the research literature, the terms ‘tolerance’ and ‘resistance’ are often used interchangeably and generally refer to the ability of some oysters to withstand disease infection. In this document, the term ‘tolerance’ will not be used and ‘resistance’ will refer to the ability of an oyster to become infected by either parasite and live longer than the average lifespan under disease conditions. The term does not imply that disease-resistant oysters *never* get infected with disease. From an evolutionary perspective, natural selection due to disease mortality would lead to a resistant stock of oysters. Oyster life history parameters have complicated the process of developing resistance to oyster parasites. Oysters mature and spawn after one year of growth and may survive more than one exposure to parasites (especially *P. marinus*). Oysters with relatively low resistance may contribute offspring to the Bay’s oyster population before succumbing to the effects of disease. This may slow the development of resistance within a given population.

Another factor that complicates the development of resistance is larval dispersion. Oyster larvae can be transported from lower salinity areas where disease (i.e., selective) pressure is low, to areas with higher salinity and a higher incidence of disease. These larvae, when imported from lower salinity areas, possess little resistance to parasites and contribute very little to the development of resistance in higher salinity areas. The reverse situation may also occur. To date, data have not been collected to quantify these effects on localized populations.

Research efforts artificially to breed strains of native oysters with greater disease resistance have been underway for a number of years. Several strains of oysters possessing varying degrees of disease resistance are currently available for commercial aquaculture, restoration and repletion projects. Research is currently in progress to understand what role selectively bred strains of oysters could contribute to restoration efforts on a large scale (e.g., tributary or greater scale). Whether these strains can effectively infuse local oyster populations with greater resistance to parasites is unknown. Alternatively, the selectively bred strains could serve as a means of starting new populations of oysters in areas where local populations are depleted. Ideally, a strain (or several strains) of native oysters could be developed that possess enough resistance to parasites to allow oyster populations to develop an age structure that mirrors oyster populations unaffected by diseases. An aggressive research and monitoring program is needed to better understand the dynamics of using disease-resistant strains of oysters.

Disease Management

Maryland and Virginia confront different problems concerning disease. Virginia is faced with constant disease pressure. Under these circumstances, VMRC does not move infected seed or only small quantities of seed. Maryland’s situation is more variable and dependent on climatic influences. Maryland DNR has the option to reduce disease mortality for a year class in a particular area by moving natural seed away from high disease areas and managing harvest. However, under drought conditions, Maryland is more like Virginia, and disease management options are very limited. The challenge of rebuilding the oyster population is increasing oyster survival. Oyster restoration is intricately associated with how to manage activities in the presence of disease. Cleaning bars of infected oysters prior to planting, limiting the distribution of infected seed, avoiding disease areas when planting stock and using specific pathogen-free (SPF) seed are site-specific activities that have been successful on a small scale. Planting disease-resistant strains of *C. virginica* is another option for disease management. These activities reduce pathogen density and increase survival and productivity. The challenge is to extend the site-specific effects to a baywide scale.

Guidelines for Disease Management

Strategies that address disease have been in place for several decades and have been reevaluated as environmental changes have occurred. Disease management should continue to:

- Promote and utilize research on the development of disease-resistant oysters, which is critically important for the long-term recovery of the oyster resource;
- Evaluate the use of disease-resistant native strains;
- Move infected stocks only under suitable conditions using adopted criteria;
- Enhance hatchery production;
- Monitor for parasite abundance and distribution; and
- Monitor the effects of disease and environmental parameters on the oyster stock.

Disease Strategy

3.1.A

Guided by retrospective analyses, utilize disease management actions in all aspects of restoration activities and harvest to minimize the possibility of spreading disease**.**

3.1.B

Develop and implement disease management strategies within the three different salinity zones for each oyster activity, i.e., special management areas; harvest practices; use of hatchery-produced seed; and aquaculture activities (refer to each chapter for specific actions that should minimize disease impacts).

In addition, the following specific actions will enhance management practices directed at reducing and minimizing the effects of disease.

Action 3.1

Conduct an analysis of how other disease management strategies might affect overall survival and productivity. Answer the following question: What additional management strategies will help increase oyster biomass over a large scale and the long term?

Action 3.2

Increase hatchery production to supplement natural recruitment and mitigate the prevalence of *P. marinus* (see Chapter VI, Hatchery Production).

Action 3.3
Establish special broodstock sanctuaries in heavily infected areas to produce disease-resistant seed (see Chapter IV, Sanctuaries).

Action 3.4
Develop, implement and maintain a seed policy to reduce and minimize disease impacts.

Action 3.5
Implement oyster surveys as necessary to obtain the best estimates of oyster population data.

a) Increase the frequency and spatial intensity of sampling for disease prevalence and intensity in Maryland and Virginia; and

b) Seek additional funding to meet the additional monitoring requirements.

IV. Oyster Sanctuaries

In 1999, a meeting of oyster experts from Maryland, Virginia and North Carolina recommended that 10 percent of traditional oyster bars be set aside and restored as sanctuaries. Since sanctuaries are a management tool in oyster restoration, the Bay Program Partners will continue to refine the recommendation, utilizing the demographic modeling effort and other applicable scientific findings to evaluate the appropriate number, size and distribution of sanctuaries and probabilities of achieving increased biomass.

The creation of sanctuaries will protect the complex biological interactions of oyster bar communities and resident fish populations. Currently, shellfish harvest is prohibited in sanctuaries, and habitat has been improved to facilitate oyster growth and survival. By protecting oysters from harvest and rehabilitating habitat (e.g., bar cleaning, addition of cultch) there is the potential to increase oyster biomass, i.e., broodstock (spawning adults) and larval production. Factors such as salinity, temperature and disease mortality will significantly affect the success of oyster sanctuaries and the increase in oyster biomass. Sanctuaries in disease-endemic areas may have the added benefit of encouraging selection for disease tolerance by providing protection from harvest.

Habitat Restoration Strategy

- Facilitate the establishment of self-sustaining oyster populations;
- Rehabilitate degraded habitat;
- Develop a protocol for using limited shell resources and evaluate alternative substrates for habitat rehabilitation; and
- Remove or minimize controllable causes of habitat degradation.

Strategy 4.1
A network of clearly marked oyster sanctuaries will be established throughout the Chesapeake Bay and its tributaries.

A) Sanctuaries will be used in sufficient size and distribution to enhance oyster production.

B) Sanctuaries will contribute to an increase in oyster biomass and may contribute to the development of disease-resistant broodstocks over the long term (a century or more).

C) Sanctuaries will be managed based on defined and measurable criteria. The criteria should include a description of the scope of restoration and the results. Scope should include whether the sanctuary has met the criteria on a project level, a tributary level and at a regional level or baywide.

Establishing Sanctuaries

The task of determining where to designate sanctuaries is multidimensional and extends over a broad geographic area. Salinity patterns, disease prevalence and intensity, bottom type, historical productivity, stock abundance, currents and water depth are all factors that affect oyster production. Resources that are necessary for restoration activities within sanctuaries are limited—especially cultch, disease-free seed and funding. Selecting priority areas, effectively using resources and coordinating restoration activities among the various oyster partners are primary considerations for successfully establishing oyster sanctuaries.

In order to guide, focus and coordinate the multiple partners that participate in oyster restoration, the following strategies and actions are necessary.

Strategy 4.2

The following steps will be taken for establishing oyster sanctuaries throughout the Chesapeake Bay:

A) Identify appropriate oyster bottom (see Site Suitability Criteria, Section 3);

B) Establish quality habitat with suitable cultch material and deploy (plant) substrate as appropriate;

C) Prohibit shellfish harvest and enforce restrictions;

D) Maintain suitable bottom conditions and oyster production in the face of sedimentation and disease, if necessary; and

E) Monitor and evaluate success.

Action 4.2.1

Decisions regarding where to locate sanctuaries will be guided by the Virginia Oyster Restoration Plan, developed by VIMS and VMRC, and by Maryland's Priority Restoration Areas, developed by MDNR and the Maryland Oyster Roundtable Steering Committee. The maps will be used as a preliminary tool to focus restoration activities.

Virginia Oyster Restoration Plan

The Virginia Oyster Restoration Plan identifies optimum sites for restoration projects based on suitable bottom habitat. The plan consists of a series of maps and text that describe historical and current data relevant to oyster distribution and current and projected habitat options for all Virginia waters of the Bay. The maps are categorized by region, or in the case of large watersheds, as part of a series that comprise a single region. They provide details on substrate, including delineation of public and leased oyster grounds, and bathymetry relevant to operating vessels and barges in restoration areas. They also identify past restoration projects and their designations. Accompanying each individual map is a commentary on seasonal salinity changes; effects of storm-induced freshwater flows; and disease incursion from downstream, higher salinity water. An example of a map from the Virginia Oyster Restoration plan including the plan index can be found at the website **www.chesapeakebay.net/cop.htm: Insert hyperlink for VA Oyster Restoration Plan**

Maryland Priority Restoration Areas

The Maryland Priority Restoration Areas consist of 11 regions throughout the Maryland waters of the Bay. These areas were delineated based on average total oyster mortality, disease prevalence, annual spat settlement patterns and the potential to meet restoration objectives. In addition to the maps delineating restoration regions, there are maps identifying the legal boundaries of natural oyster grounds and the locations of past restoration efforts, including sanctuaries and reserves. The sanctuary and reserve maps include the size and amount of seed oysters used in their creation. A sample map of one Maryland Priority Restoration area can be found at the website: **www.chesapeakebay.net/cop.htm: Insert hyperlink for MD Oyster Restoration Plan**. There will be a process to determine priorities within the 11 regions in Maryland, developed through the Maryland Oyster Scientific Committee.

Action 4.2.2

Use existing protocols and standard operating procedures for recording or charting GPS coordinates for oyster sanctuaries in order to verify locations and track restoration progress.

Action 4.2.3

Evaluate the use of alternative cultch material, because all restoration efforts depend on the availability of suitable habitat, and traditional shell dredging cannot support the scale of the current and future sanctuary initiatives.

Action 4.2.4

Develop and implement techniques to locate and recover buried shell or shell with layers of sedimentation using vacuuming, bar cleaning or other innovative methods.

Action 4.2.5

Increase hatchery production to support restoration needs. Current seed levels are too low to effectively stock sanctuaries (see Chapter VI, Hatchery and Aquaculture).

Action 4.2.6

Monitor areas to evaluate oyster population status and measure progress toward the commitment to increase oyster biomass tenfold. Provide results in a compatible format to generate quantitative estimates of oyster biomass. As the number of sanctuaries and reserves increases, evaluate the need to increase the number of sentinel sites currently used in the monitoring program.

Strategy 4.3

Management actions within sanctuaries are primarily based on salinity zones and focus on three key factors: growth, reproduction and disease. It is important to note that the salinity maps (figures 1 and 2) depict long-term averages. The zonal approach to management provides general guidelines for selecting project objectives and anticipating project results in each area. However, since salinity patterns vary annually and zonal boundaries shift, a close examination of current environmental parameters is essential.

Strategy 4.3.A
Zone 1 (5ppt to <12ppt) Increase biomass and enhance reef habitat
Enhance reef and bottom habitat to increase oyster biomass and promote the development of living oyster reefs with broad size/age class structure that support a diverse reef community. Zone 1 sanctuaries are expected to contribute to an increase in oyster biomass because of good survival in this zone.

Action 4.3.A.1
Identify priority areas within Zone 1 that would have the most success at reaching the defined project objectives.

Action 4.3.A.2
Rehabilitate and maintain oyster bottom habitat to provide planting substrate for seed oysters and optimal conditions for larval settlement.

Action 4.3.A.3
Plant hatchery-produced, SPF seed, if necessary over several years, to establish an oyster population with a diverse age class structure.

Maryland waters have the potential to contribute significantly to an increase in biomass because certain regions are less affected by disease. The potential for establishing Zone 1 sanctuaries in Virginia is limited and restricted to the upper reaches of tributaries in which disease pressure is minimal. During sustained drought years the low salinity regions are far upriver and suitable habitat does not exist. Increases in biomass could occur during ‘wet’ years, when disease pressure is reduced

The following table considers different project objectives and site characteristics that should be considered when determining placement of a sanctuary in low salinity zones.

Zone 1 Project Objectives	**Site/Project Characteristics**
Long-term survival	Salinity $\leq$10 ppt Limit the placement of oysters on bottom that may contain residual diseased oyster population

Zone 1 Project Objectives	Site/Project Characteristics
High oyster density	Seed at high densities (≥1million spat/acre) Use non-infected seed
Sustained population recruitment	Occasional episodes of local spat settlement augmented by repeated stocking with wild or hatchery seed
Reef growth outpaces sedimentation rate	Low sedimentation rates

Strategy 4.3.B

Zone 2 (12-14 ppt) Transition Area

The boundaries of Zone 2 shift because of variations in rainfall and resulting salinity changes. Consequently, Zone 2 will exhibit fluctuations in spat settlement and disease mortality. These types of fluctuations make it difficult to plan a project and predict the outcome. Projects planned in this zone must use current environmental data. In Virginia, areas for consideration under Zone 2 sanctuaries include Nomini Bay, Lower Machoadoc Creek, and the Glebe, Coan and Yeocomico rivers.

Action 4.3.B.1

Critically examine long-term environmental conditions and develop relevant project objectives for sanctuaries in Zone 2.

Action 4.3.B.2

In areas that have predominantly Zone 1 characteristics, use Zone 1 guidelines, and in areas that have predominantly Zone 3 characteristics, use Zone 3 guidelines.

Strategy 4.3.C

Zone 3 (>14 ppt) Develop Disease Resistance

Oyster populations have been under constant disease pressure for decades. It is not certain that disease resistance in resident populations can develop using a management approach in Zone 3. Increasing biomass will be more difficult in Zone 3 than in any other zone. The strategy in Zone 3 will be to promote the development of disease resistance where disease mortality is high.

- Encourage the long-term development of disease-resistance through natural selection.
- Use field exposure of oysters to naturally occurring disease as the best large-scale method to encourage the development of disease-resistant broodstocks.
- Develop disease-resistant oysters as a long-term project.
- To the extent possible, add to biomass.

Action 4.3.C.1

Reestablish and maintain bottom habitat for oyster spat settlement and growth of disease-resistant adults.

Action 4.3.C.2

Monitor Zone 3 sanctuaries to determine the effects of disease mortality.

Action 4.3.C.3
Use Zone 3 as an area to test laboratory strains of disease-resistant oysters

Action 4.3.C.4
Limit the use of natural seed to sanctuaries in Zone 3. The use of natural seed in repletion areas is allowed as long as disease protocols are followed (Section 1.III).

The following table considers different project objectives and site characteristics that should be considered when determining placement of a sanctuary in the high salinity Zone 3.

Zone 3 Project Objectives	Site/Project Characteristics
Strong disease-dependent selection	Salinity (≥15 ppt) High disease mortality
Reproduction and spat settlement	History of reoccurring spat settlement
Large numbers of individuals with potential disease resistance	Plant at high densities Use disease-resistant strains.
Local larval retention (ideal for test location)	Hydrography – retentive system Use models to explore potential larval retention

Strategy 4.4
The jurisdictions will establish oyster sanctuaries to promote maximum ecological value.

Action 4.4.1
Identify areas of special interest throughout the Bay, especially areas that may retain larvae (maybe through auto-recruiting), and protect them using the sanctuary status.

Disease Management in Sanctuaries

Strategy 4.5
Implement the actions described in Chapter III to address disease problems. In addition, the jurisdictions will take further action to minimize the spread of disease.

Action 4.5.1
Use only SPF hatchery seed in sanctuaries designated for oyster biomass accumulation, Zone 1 and Zone 2.

Action 4.5.2
Place hatchery seed on newly created sanctuary bottom and not on top of infected oyster populations in order to prevent rapid infection of the disease-free seed.

Action 4.5.3
Continue to prohibit the movement of infected oysters from higher salinity waters onto newly or previously created sanctuaries in Zone 1.

Enforcement

Sanctuaries are closed to harvest in order to reduce harvest pressure, to protect reef habitat and to promote ecological benefits. Since closures are part of the harvest management, enforcement problems are discussed in Section 1.V, Managing Harvest, Enforcement of Harvest Regulations (see below). Additional enforcement options can be found under Strategy 5.6 and Action 5.6.1.

Strategy 4.6
To facilitate the enforcement of closed areas, especially sanctuaries, the following actions will be implemented.

Action 4.6.1
Sanctuaries will be placed in geographically distinct areas with enough space to create a buffer zone between harvest and sanctuary areas to enable enforcement.

Action 4.6.2
Sanctuaries will be buoyed and marked. The public will be encouraged to report any violations.

Action 4.6.3
The public and judiciary will be notified about sanctuary areas through educational initiatives, public announcements and stakeholder meetings.

Action 4.6.4
New enforcement measures will be identified and implemented. Additional manpower will be recommended if necessary.

V. Managing Harvest

Fishery Management

The main strategy for regulating harvest and enhancing harvest potential is to establish sanctuaries and special management areas throughout the Bay. By establishing areas that are protected from harvest, fishing mortality rates (F) in managed areas and the overall F for the population will decrease. Currently, the methods for regulating harvest include controlling the size and amount of oysters harvested through daily bushel limits, size restrictions, gear restrictions, time limits, seasons, limited entry and area closures.

Management Strategies

- Evaluate F at a level that does not compromise progress toward restoration objectives.
- Develop appropriate biological reference points for managing the resource.
- Enforce harvest prohibitions.

Fishing Mortality Rate (F)
Fishery management strategies traditionally include a definition for overfishing and biological reference points that

describe fishing mortality targets and thresholds. The ideal situation is to estimate the amount of oysters that can be taken safely from the population while maintaining a sustainable population size and age structure. For the oyster resource, the term ‘population’ can be used in two ways. It can refer to the whole baywide population of oysters or to the population on discrete reefs or bars. The term ‘population’ in this document refers to the baywide population of oysters. When referring to discrete reefs or bars, the term ‘bar-specific populations’ will be used.

Beginning in the late 1980s, disease became a major cause of size-selective mortality in adult oysters. Consequently, harvest pressure has decreased, with fewer watermen reporting landings and fewer harvest days (see Section 2). Under current conditions, the effects of adjusting F on stock size must be better understood. A major challenge is to determine whether a reduction in F will allow the oyster population to rebuild to a more productive level, and, at the same time, to determine what level of exploitation is appropriate and will not compromise restoration efforts. The effect of no harvest, or F = 0 on oyster population dynamics, should also be considered. Sanctuaries are areas where F = 0. Their overall effect on the total population needs to be evaluated.

In order to establish the appropriate level of F, it is necessary to better understand the interactions between disease and harvest. By age 3 it is estimated that 80 percent or more of a year class will die due to disease in high disease areas (>14 ppt, Zone 3). Reducing F on the surviving 20 percent could affect population size and reproduction but may only have short-term benefits because of disease pressure. In lower disease mortality areas (zones 1 and 2) where survival is higher, decreasing F may be more beneficial and lead to increases in biomass over time. Understanding the interaction between F and disease is crucial, especially how the interaction impacts achieving the tenfold increase in biomass. Important questions include:

- Can adjusting F increase oyster standing stocks in the presence of disease? Are there areas where disease mortality plays a greater role than F?
- What would be the effects of a harvest moratorium on increasing oyster biomass?
- What are the genetic considerations of removing large and/or disease tolerant individuals?

Strategy 5.1
Establish sanctuaries and special management areas throughout the Bay, thereby reducing fishing mortality (F), and develop appropriate biological reference points to manage the resource.

Action 5.1.1
Establish a network of oyster sanctuaries (see Section 1.IV) and special management areas throughout the Bay to limit harvest and increase oyster production

Action 5.1.2
Define appropriate biological reference points for the oyster resource based on the results of the baywide stock assessment using the following steps:

a) Determine the current level and spatial distribution of F.

b) Evaluate whether adjusting F could significantly contribute to progress toward the tenfold increase in biomass.

c) Determine the appropriate level of F.

d) Incorporate the F into the *OMP*.

e) Adopt harvest controls to attain the F.

Fishing mortality varies among salinity regions. Establishing the process for determining F is the first step in developing targets and thresholds for the oyster population. There will be additional input from the scientific community, stakeholders and interest groups on the appropriate methods to implement harvest controls.

Action 5.1.3
Use the disease guidelines and actions presented in Section 1.III in handling all aspects of special management areas and the fishery.

Controlling Fishing Effort

Management strategies for the Maryland oyster fishery are considered by a number of advisory groups working with MD DNR. The Maryland Oyster Roundtable Scientific Advisory Committee (ORTSAC) will be charged with reviewing the biological reference points defined for the oyster stock during the Programmatic EIS for the Proposed Introduction of the Oyster Species, *Crassostrea ariakensis*. The EIS will also provide stock assessment analyses of native oysters, a necessary component for developing management recommendations. Depending on the biological reference points adopted through the ORTSAC and discussed through the public review process, additional controls on fishing effort and regulatory changes may be necessary. If Virginia's situation improves, the committee that reviews and develops management strategies for the fishery should be expanded to include Virginia representatives.

Action 5.1.4
Control oyster harvest through one or more of the following methods to reach an appropriate fishing mortality rate (F) determined by the oyster scientific committee.

a) Limit entry into the fishery (expand on current policies);

b) Establish time limits;

c) Alter size limits, either >3 inches or adopting a slot limit and gear restrictions;

d) Set bushel limits;

e) Set seasonal restrictions on public grounds (October through March);

f) Establish area restrictions (e.g., sanctuaries and reserves);

g) Establish partial or a full moratorium with or without a license 'buy-out'; and

h) Establish a total allowable catch (TAC) based on current environmental conditions. (This action may require compensation to harvesters. If a conservative F and TAC are implemented, there would be losses to the fishery until the stocks could rebuild.) This may be less expensive than other restoration approaches.

Alternate methods for controlling harvest or effort can be considered through the committee and public discussion. Methods for regulating harvest are not limited to those listed. Strategies for controlling fishing mortality will require input from the stakeholders and possibly changes in regulations.

Special Management Areas

Currently, there is a minimal public fishery in Virginia, and the Maryland Repletion Program supports approximately 80 percent of the commercial oyster harvest (MD DNR Shellfish Program, personal communication). Areas established by the Repletion Program are open for harvest as specified in current laws and regulations. Harvest will be enhanced by a relatively new initiative, i.e., by establishing open and closed areas throughout the Bay. Harvest will be allowed from these areas on a rotational basis. This strategy will delay harvest beyond the current minimum size of 3 inches. The rationale for this approach is that larger oysters (> 4 inches) have greater meat yield and market value and are expected to contribute more to population biomass, reproductive potential and ecological functions.

Harvest Reserves (Maryland)

To date, Maryland has designated 19 areas as harvest reserves in Zone 2. The most recently designated reserves were selected based on ‘good’ bottom and low-to-moderate disease mortality. Since the best grow-out sites can change from year to year, designating new harvest reserves will be based on the best available information. Criteria for managing harvest reserves have been drafted, and regulations and legislation are being developed. Tentatively, the draft guidelines are to delay harvest beyond 3 inches until 50 percent of the population in a reserve has reached 4 inches. Opening and closing areas would be based on size, disease prevalence and intensity, mortality thresholds and target rates, and biomass thresholds and targets (biological reference points). MD DNR has authority to regulate harvest within the allowed open season, but new regulations are being considered to harvest oysters outside the season. There are a limited number of resources—i.e., hatchery seed, shell and funding—to support the establishment of harvest reserves. The same resources are needed to establish sanctuaries. It will be necessary to decide formally how to allocate the limited resources between sanctuaries and harvest reserves.

Open and Closed Areas (Virginia)

Most of Virginia’s oyster bars were closed in 1994. Since then, oyster harvest has been managed on a bar-specific basis. Areas are closed for at least three years to allow oysters to grow undisturbed and then opened to support a modest fishery. Virginia has a standing stock criterion, which can be used to close an area to harvest. When the standing stock of oysters is depleted by 50 percent or more, the commissioner of the marine resources can close an area to harvest. The initial estimate of standing stock for each area is determined by the oyster replenishment officer and is the volume of oysters as of October 1st each year. The procedure for opening areas is as follows:

- The replenishment officer requests areas to be opened at the monthly Virginia commission meeting.

- A 30-day comment period begins at the time of the request, and interested parties have the opportunity to comment in writing or by attending the next commission meeting.
- After the 30-day comment period, the nine Virginia commissioners decide if the area under consideration should be opened or modified based on the comments they have received.

Strategy 5.2

Develop guidelines for managing fishing effort and monitoring oysters in open and closed areas:

Action 5.2.1

a) Determine the criteria for opening and closing areas. Criteria may vary depending on regional differences or new management objectives. The options concerned with when to open areas to harvest, and how to regulate fishing effort, include:

1. When 50 percent of the bar-specific population reaches a certain minimum size (such as 4 inches or larger);
2. For a limited period, for example, for one week at a time, special times when market demands are highest, i.e., prior to Thanksgiving or Christmas:
3. Under a particular disease scenario, i.e., if high disease mortality is imminent allow harvest before natural mortality occurs.

b) Monitor the population size, age structure and disease prevalence and intensity on a particular bar or in a particular area.

c) Determine the level of acceptable exploitation by determining harvest rate depending on oyster size and abundance, and establishing a decision-making protocol for harvesting under different disease conditions and at different size limits.

d) Regulate harvest and gear type, by limiting participation, establishing daily limits, establishing time and seasonal limits, limiting or reducing fishing impacts due to harvest gear that can affect shellfish habitat and benthic populations, and using a predetermined harvest limit or total allowable catch (TAC) based on abundance estimates and population and size/age structure.

e) Develop additional monitoring efforts depending on criteria for opening or closing an area.

f) Close an area when harvest criteria are met.

Action 5.2.2
Use the site-selection criteria set forth in this plan to select special management areas (see Section 3).

Action 5.2.3

a) Maryland DNR will ask the ORT Science Advisory Committee to review and make recommendations on where to locate harvest reserve areas. Maryland DNR, the Maryland Watermen's Association (MWA) and the Oyster Restoration Partnership (ORP) will be responsible for implementing the recommendations.

b) Virginia will use their current system to review and make recommendations on open and closed areas.

Action 5.2.4
Identify and implement regulatory and legislative changes needed for managing open and closed harvest areas.

Action 5.2.5

a) Evaluate how rotating open and closed areas contributes to reproduction, oyster biomass and harvest.

b) Based on the harvest reserve biological data, reevaluate the criteria (Action 5.2.1) for opening and closing areas and modify actions, as necessary.

Repletion Program

The Maryland Repletion Program is the major source of harvestable oysters because of the effects of disease throughout the Chesapeake Bay. The program has focused on increasing the size of the oyster harvest by planting shell and transplanting seed oysters. Oyster shell is planted in areas with high natural spat settlement, usually in waters of the mid- to lower Eastern Shore and the lower Bay. Seed oysters are transported to oyster bars in grow-out regions where survival rates are higher than their original location. Generally, the Maryland Repletion Program plants approximately 2 million bushels of shell and between 150,000 and 500,000 bushels of seed depending on spat settlement levels. In the future, the amount of shell and seed will vary from year to year, depending on availability. A new limitation may be the supply of shell from the upper Bay shell deposits. Acquiring new permits is difficult and may end the dredged shell program, which is the backbone of the Maryland program and the fishery.

The Virginia Repletion Program is similar to Maryland's program except that it focuses on moving shell. It no longer has an active seed component because of disease. Since the 1990s, the movement of seed has been at a minimum. Virginia depends on the availability of dredged shell and shucked shell to continue their program.

The repletion programs track the exact coordinates, depth, bottom type, salinity, bushels planted, numbers of seed planted, acres planted and survival rates for each planting. Through the repletion programs' efforts, oyster habitat, recruitment, growth and survival are potentially enhanced. To date, the repletion programs have not been evaluated in terms of baywide oyster population dynamics. Evidence suggests that in the past, when the programs moved seed to lower salinity areas, pathogens may have spread and possibly extended their range. The scope of this problem has decreased with increased awareness and new disease management strategies. The repletion programs are limited by natural reproduction (spat settlement), disease infection and funding. Disease has been the greatest limitation over the past 15 years. Disease mortality has severely compromised planted areas (shell and seed), reducing bar-specific populations and harvest to record low levels.

Annual Work Plan

The repletion programs develop an annual work plan in the following manner. The Maryland Fall Dredge Survey provides data on spat settlement, disease and mortality. Maryland DNR Shellfish Program staff use data from the annual survey in combination with data on bottom type, site surveys, salinity, harvest trends and legal mandates to draft a work plan at the beginning of each calendar year. In general, seed planting areas are selected to maximize survival to market size, and shell planting areas are selected to capture natural spat settlement. The draft work plan is further developed with the county oyster committees, where specific bars are listed for planting. The work plan follows the guidelines established by the Maryland Oyster Roundtable Action Plan and is reviewed by the Oyster Roundtable Steering Committee. The work plan estimates the amount of seed and shell available and describes the planting sites that have been selected. The steering committee provides comments on the work plan and appropriate changes are made if needed.

The Virginia Repletion Program follows a similar process. A work plan is developed and determines the placement of shell. Virginia fall survey data are used to determine the appropriate areas. The Virginia Commission reviews the draft work plan and, if appropriate, adopts it as a guideline for the following year's work.

Strategy 5.3

A) Follow project guidance criteria specified in Section 3 when developing repletion program work plans.

B) Maintain the Maryland work plan review process as follows:

1. DNR drafts the annual work plan;
2. County oyster committees review the work plan;
3. Detailed list of planting sites are added to the work plan based on county recommendations and included for consideration;
4. The Oyster Roundtable Steering Committee reviews the revised work plan; and

5. Additional changes are made to the annual work plan if necessary.

Action 5.3.1
Modify the Maryland repletion program through the established Oyster Roundtable Steering and Scientific Committee to reduce and minimize the force of disease:

a) Establish criteria to limit or restrict seed movement to certain regions depending on environmental conditions and disease levels.

b) Avoid transplanting older year classes that have higher levels of disease than young spat.

c) Rotate or clean seed areas to produce seed supplies that have a single year-class (single year-classes will have lower disease levels than older, multi-year classes). Since geographic areas have become more limited, track the use of seed areas.

d) Allow old seed areas to lie fallow or be harvested to reduce the number of infected oysters on the site before using the site again as a seed area.

e) Use the disease results from the fall survey to determine in the fall, rather than in the spring, where and when diseased seed will be moved, using the criteria developed above.

f) Transplant wild seed as soon as possible after set to minimize disease levels. Implement this action based on disease analysis and risks associated with moving fragile, young spat.

Action 5.3.2
Maryland will evaluate the effects of the repletion program on oyster population dynamics and habitat; and document how it contributes to an increase in oyster biomass and habitat.

Enforcement of Harvest Regulations

Sanctuaries and special management areas represent significant investments of money, shell and seed for rebuilding oyster biomass. Effective enforcement of closed areas is crucial for protecting oyster habitat and ecological functions; for protecting ongoing scientific investigations in these areas; and to protect the potential increases in biomass. Funding for additional restoration projects depends on adequate enforcement levels. Since oyster sanctuaries will be closed to harvest and other areas will alternately be opened and closed to harvest, poaching becomes a concern. As the number of protected areas increase, the task of protecting these sites will become increasingly difficult. To facilitate enforcement, all special management areas are marked with permanent buoys. Maryland has increased the fines for poaching and is undertaking an educational outreach program. In addition, it is possible that fines and penalties for harvesting from protected sites may be increased.

Virginia generally builds three-dimensional sanctuary reefs that differ from the surrounding two-dimensional harvest areas. Under this configuration, sanctuary reefs are interspersed within harvest areas. All areas are marked, and harvest is prohibited from the sanctuary reef areas. The three-dimensional reefs act as natural deterrents to harvest. Watermen and the public have accepted the reef concept, and poaching has not been a significant problem. If conditions change, additional law enforcement measures will be adopted.

Strategy 5.4:
Strengthen the enforcement of oyster closures in sanctuaries and special management areas.

Action 5.4.1
Evaluate and implement the appropriate enforcement measures. Consider, but do not limit to, the following options:

a) Increase enforcement staff (marine patrols);
b) Establish more severe penalties;
c) Increase fines;
d) Add points to the license system for violations;
e) Buoy all sites;
f) Place physical deterrents in sanctuaries (such as boulders);
g) Use innovative techniques to identify oysters that have been harvested from sanctuaries (such as foreign cultch materials or wire tagging);
h) Educate the general public, landowners, members of the judicial system and watermen;
i) Implement a citizen hotline for reporting violations; and
j) Educate the judiciary system.

Action 5.4.2
Prohibit the culling of oysters while underway (i.e., moving from one oyster bar to the next) to minimize the movement of infected oysters, especially adults.

VI: Hatchery and Aquaculture Considerations

In the Chesapeake Bay, state agencies and private planters have practiced oyster culture in a variety of ways for more than a century. Traditional methods involved the placement of oyster shell in areas of high larval settlement and the subsequent transplanting of newly settled spat for grow-out in areas favoring oyster growth to market size. Most recently, hatcheries have been used artificially to produce seed oysters for a variety of purposes, ranging from recreational and commercial oyster aquaculture to broodstock enhancement and support of commercial fisheries. Private aquaculture was once productive in Maryland and Virginia (and in Virginia was a major fishery) until disease became virulent. Although numerous constraints on aquaculture practices exist, the impact of disease is currently the major impediment.

Oyster hatcheries can produce seed oysters with potentially improved quality. Hatchery seed can be free of endemic oyster parasites that may provide some advantage when placed in the natural environment. In areas of low natural spat settlement, the use of hatchery seed provides an initial, dense population of oysters that otherwise would not be available. Hatchery production also can be used artificially to select for genetic traits that may lead to increased survival (e.g., tolerance to MSX and Dermo). Currently, demands for hatchery seed exceed production.

The magnitude of spat settlement and early survival varies both spatially and temporally. Comparisons of historic and current spat settlement data indicate that the overall magnitude of spat settlement has decreased over the past century (Meritt 1977; Krantz 1995). Using hatchery-produced oysters to enhance broodstock could be a critical component in augmenting larval production and recruitment when natural spat settlement is low and could play a key role in rejuvenating oyster populations. However, the overall number of oysters that hatcheries can generate on an annual basis cannot compare with the numbers of larvae produced baywide by wild stocks in most years. To date, hatchery produced seed has been used for a variety of projects, including stock enhancement on sanctuaries, public oyster bars, community restoration sites, oyster gardening and commercial aquaculture.

Hatchery Production

Strategy 6.1

Use hatchery-produced seed to augment natural reproduction, reduce disease effects and increase biomass.

Action 6.1.1
Develop an interlab certification program for oyster diseases. Use the molecular diagnostic protocols for certifying SPF oyster seed developed by the Virginia Institute of Marine Science (VIMS) Shellfish Pathology Laboratory (the Office International des Epizooties [OIE] laboratory for diseases caused by *Perkinsus* spp. and *Haplosporidium* spp.).

Action 6.1.2
Maryland will increase hatchery production of specific pathogen-free (SPF) seed to support the tenfold increase in oyster biomass.

a) Increase and maintain, as necessary, the operating funds for each Maryland hatchery facility.

b) Evaluate and optimize the efficiency of each facility in order to ensure maximum production of spat.

Action 6.1.3
Continue the protocol for certifying and using specific pathogen-free (SPF) seed.

a) Establish standards and refine criteria.

b) Use only SPF seed in sanctuaries located in Zone 1 (<12ppt).

Action 6.1.4
The U.S. Army Corps of Engineers (COE) will conduct an analysis of hatchery production in relationship to environmental benefits as part of its long-term restoration planning and determine whether augmenting or building new hatcheries is warranted.

Action 6.1.5
Virginia will increase hatchery production of disease-resistant seed to support the tenfold increase in oyster biomass.

a) Increase and maintain, as necessary, the operating funds for oyster breeding in Virginia.

b) Evaluate the feasibility of a public or public/private hatchery.

Action 6.1.6
Virginia will develop strategies for effective seeding of reefs and study their effects on recruitment, especially in relation to the spread of disease resistance in the wild population.

Future use of hatchery seed by the commercial aquaculture industry is contingent on emerging technologies and the survivability of disease-resistant oyster seed. Hatcheries are currently underused for commercial oyster culture but may gain prominence if significant gains are made in disease resistance. The use of hatchery seed may be the only way to circumvent the high disease pressures in the lower Bay.

Genetic Concerns of Hatchery Production

It is widely recognized that conserving genetic diversity in exploited resources and in populations that are being restored ensures the highest level of overall fitness within those populations. The genetic diversity of oyster populations in the Bay is currently unknown, but has likely been altered by a variety of activities over the past century or more, including the movement of oysters between sites in the Chesapeake Bay and the transplanting of oysters into the Bay from other coastal areas. The use of hatchery-produced oysters for restoration, repletion or commercial aquaculture also has the potential to affect genetic diversity, though the exact magnitude of these effects is unknown.

Hatchery operators recognize the need to maintain genetic diversity while ensuring high levels of production for commercial and restoration purposes, and have begun to implement protocols designed to minimize undesirable genetic effects of hatchery-produced oysters on remnant oyster populations. Some practices now being employed include careful tracking of hatchery stocks used for restoration projects; maximizing the number of broodstock oysters used in a given spawn; co-mingling larvae from different spawns of the same strain; and using a variety of different stocks over time to maximize variation within a given transplanting site. Additional research is needed to better characterize the 'natural' genetic variation within oyster populations and to define the effective population size for oyster populations throughout the Bay. As new information becomes available, the development of more formal protocols may be necessary to help maximize genetic diversity while protecting the Bay's oyster population from MSX and Dermo.

Strategy 6.2

Continue to track the genetic background of broodstocks used in hatcheries for restoration or replenishment activities.

Disease-Resistant Oysters and their Role in Restoration

The use of selectively bred, disease-resistant strains of oysters is less extensive in Maryland than in Virginia. Using selected strains of oysters in the wild has the potential to improve survival, may lead to increased reproduction (adults live longer and have the opportunity to spawn more than once) and increased recruitment, and result in increased abundance. Large-scale experiments using genetically enhanced oysters are just beginning and may be limited because of financial restraints. Rutgers University, VIMS, the University of Maryland and the University of Delaware comprise a consortium that has developed various strains of oysters, such as DEBY and CROSBreed, which are less susceptible to oyster pathogens. Other disease-resistant strains have been developed at the VIMS hatchery and were originally bred for aquaculture. The best use of disease-resistant strains has not been determined. Efforts to use selectively bred oyster strains to infuse more desirable traits into the wild population are just getting underway, and ongoing research should help to define how these strains are used. A current research project is observing the gene flow from restored reefs stocked with disease-resistant oysters to surrounding areas of recruitment (S. Allen, personal communication). The ultimate aim of this research is to document the spread of disease-resistant genes among wild oysters.

Virginia will begin a new strategy to construct three-dimensional reefs and seed them at high densities with large disease-resistant strains of oysters (e.g., CROSBreed and DEBY). Construction will take place in 'trap' estuaries (small tributaries where larvae have a better chance of being retained in the same system). Reefs will also be built in high disease areas to field test various strains of disease-resistant stocks and assess their effectiveness in the wild.

Strategy 6.3

Develop recommendations for using disease-resistant strains of native oysters for restoration in the Chesapeake Bay. Selectively bred oyster strains should be used for restoration only in areas where native oysters are locally depleted (Allen and Hilbish 2000)

Action 6.3.1

Assess and evaluate the use of disease-resistant stocks as a tool for increasing disease resistance in the native oyster population in the Bay.

Action 6.3.2

Monitor restoration activities to clarify the interaction between selectively bred strains and wild stocks of oysters.

Aquaculture

Production of oysters by private-sector aquaculture has the potential to contribute to the overall increase in oyster biomass, ecological value and economic benefits to the Bay. To date, the Bay's oyster aquaculture industry has involved two approaches: leased-bottom aquaculture and off-bottom aquaculture.

Leased-Bottom Aquaculture

The cultivation of oysters on leased bottom has a long history in the Chesapeake Bay. Leases issued by the states give leaseholders exclusive rights to cultivate, hold and harvest oysters in specific areas. In Maryland, total acreage under leased bottom peaked in 1990 at approximately 10,000 acres and has decreased since then to approximately 7,500 acres. Approximately 800 leases, controlled by about 300 individuals are responsible for the leased ground acreage. Based on reported data, production from leased bottom in Maryland has averaged about 2 percent of the total harvest (Jordan et al. 2002). In Virginia, approximately 100,000 acres are available for leased-bottom production through about 3,000 leases. Before pathogens arrived in the Chesapeake Bay, oyster production on leased bottom exceeded the Virginia's public fishery. Current production has been reduced to approximately 20,000 bushels (Jordan et al. 2002).

Off-Bottom Aquaculture

Large-scale, off-bottom aquaculture is minimally developed in the Bay. In Maryland, there are 26 experimental aquaculture permits for oysters in use. Estimated oyster production from experimental culture was approximately 120,000 oysters in 2001. One of the most developed off-bottom aquaculture approaches in the Bay is oyster gardening. This process involves citizens in cultivating oysters, usually using floats tied to private docks. It is practiced in both Maryland and Virginia. Oyster gardeners have several different objectives for their activities, including personal consumption, improving local water quality and providing oysters for restoration activities. Although oyster gardening is popular with environmental groups and citizens, it does not significantly contribute to increasing biomass in the Bay. A potential benefit of off-bottom aquaculture that should be more closely investigated is its role in helping to remove excess nitrogen and phosphorus from the water column.

Environmental Effects of Aquaculture

Bivalve culture has the potential to affect the ecosystem in a number of ways. These include the effects of wastes (including nutrient and organic matter); the use of chemicals (pesticides, drugs and antifoulants); the use of particulate food resources and competition between farmed and wild species; and the removal of minerals from the system. Most effects are site-specific and influenced by environmental conditions. There are few quantitative measures of aquaculture effects on the ecosystem, and more ecologically relevant studies are needed to assess these effects. Besides biological ecosystem interactions, there are also potential conflicts due to navigational hazards.

Constraints on Further Growth of the Aquaculture Industry

The availability of a consistent supply of disease-resistant seed oysters is a significant constraint on the growth of the industry. Collection of natural seed by commercial oyster producers is not cost-effective at the present time, due to the inconsistency of spat set in any one area. In a 'chicken-and-egg' dilemma, capital investments necessary for growth in the industry are not likely until more seed is available, and investments in seed production are not likely until cost-effective market production from the seed is demonstrated.

Before 1999, there was no commercial off-bottom aquaculture in Maryland. Although approximately 95 percent of Maryland's waters are classified as approved for shellfish harvesting by the Maryland Department of the Environment (MDE), the sites chosen by off-bottom aquaculturists, and permitted by MDNR, are in shallow areas where tidal flushing is minimal and where there is the potential for polluted runoff. Often these areas are denied permits because of water quality and unsafe conditions for harvesting oysters for human consumption. The biggest impediment to aquaculture is disease, and this is a major deterrent for active or new leasing activity. Leasing of Bay bottom by corporate entities is prohibited by the state, thereby excluding many large investments in bottom culture. For the small operator, extensive state and federal permit requirements may inhibit efforts to develop off-bottom aquaculture. In Maryland, there is a need for new regulations specific to aquaculture activities and new resources for regulatory oversight. Both Maryland and Virginia have a well-coordinated outreach program to stimulate private production of shellfish. These programs have been active for decades and network with national and international networks. Finally, the challenge of managing around disease is a significant constraint on the development of the aquaculture industry. At this time, there is limited interest, especially in Maryland, in using hatchery-produced native oysters because of increased operating costs associated with intensive aquaculture and low survival associated with disease pressure.

Recommendations for Supporting the Growth of the Aquaculture Industry

An interim objective to achieve an increase in native oyster production by the aquaculture industry should also be considered, consistent with the overall objective to achieve a tenfold increase in native oysters in the Bay by 2010. One advantage of this approach is the investment of private funds versus government funds. The following actions will support the achievement of this objective:

1. Increase the availability of disease-resistant or specific pathogen-free native seed oysters. This initiative is addressed above in the section on hatcheries.

2. Create aquaculture policies that protect the environment and are responsive to the needs of the industry. This could include a time-sensitive permitting process, simplifying permit conditions, and removing or modifying restrictions on corporate participation.

    - In Virginia, reevaluate the recommendations brought forth in 1996 in "An Analysis of Organic Statutes and Regulations which Inhibit Shellfish Aquaculture Operations" and fulfill the remaining recommendations, if appropriate.

    - In Maryland, use the recommendations of the 2002-2003 Task Force on Aquaculture to improve development. Promulgate new regulations and provide resources for regulatory oversight. Clarify a procedure to assure consistency with National Shellfish Sanitation Program requirements, fisheries and wetland laws.

3. Continue to provide education and training to lease-holders and other aquaculture operators through the Sea Grant Program.

4. Develop and distribute a positive public communication message concerning the benefits of native oyster aquaculture to the Bay (e.g., biofiltration, living resources habitat, water quality and public health issues).

In 2002, the Maryland governor created a task force to study the economic development of the Maryland Seafood and Aquaculture Industries. The task force has been directed to:

- Assess the status, economic viability and potential of the Maryland aquaculture industry;

- Assess the economic, technical and educational requirements for enhancement of the Maryland aquaculture industry;

- Develop mechanisms to enhance coordination among agencies and the University of Maryland to strengthen the aquaculture industry;

- Study and recommend innovative methods for aquaculture to target commercial production and restoration of critical species;

- Review methods undertaken in other states to develop their aquaculture industries;

- Consider and include, as appropriate in a report, the findings of any other task force or work group engaged in a study that affects the economic development of the aquaculture industry; and

- Review and evaluate legislative and regulatory issues and permitting procedures to facilitate sustainable development of the industry. The task force will prepare a report with its findings and recommendations by September 2004.

Strategy 6.4
The members of the *OMP* drafting team will review the Maryland task force report and recommend changes to the OMP, as appropriate, regarding aquaculture strategies and actions.

Action 6.4.1
Amend the *OMP* as necessary to incorporate new strategies and actions regarding aquaculture.

VII. Monitoring and Information Management

An important part of the planning process is coordinating how the oyster partners will monitor their projects, process the data and make the data available to each other and other interested groups. This process is necessary for assessing the status of the oyster resource, tracking the restoration effort and evaluating management strategies and actions. There are several steps in coordinating data management. The first step is to define the critical data elements and to collect the data. The second step is to maintain a centralized database or databases and identify the people and organizations responsible for maintaining the data. The next step is to analyze the data and integrate the various project results into a comprehensive view. The last step is to make the data and results accessible to the oyster partners, the scientific community and the general public.

Oyster monitoring programs already exist in Maryland and Virginia. Monitoring results (e.g., mortality; disease prevalence and intensity; and spat settlement) are currently used to guide restoration and repletion activities. Efforts to improve the existing monitoring programs have occurred throughout the history of oyster management in the Bay (see Site Suitability Criteria, Section 3). The development of an integrated monitoring program by Maryland and Virginia is in progress as a part of the stock assessment project (CBSAC Report, 2003). With the proposed scope of restoration activities over the next decade, monitoring needs will increase. Over time, monitoring programs should periodically be reviewed and adapted to the changing needs of restoration and assessment. Monitoring the oyster stock and oyster restoration projects requires at least two different spatial considerations, a baywide approach and a site-specific approach. The general framework for monitoring is based on standard scientific methodology. Each oyster project must state its purpose or hypothesis and have a statistically valid monitoring design to address the hypothesis. In addition, each project should identify how it will contribute to the overall objective of increasing oyster biomass. All oyster projects and sites will be tracked, but at different levels of intensity and for varying lengths of time. As oyster populations in sanctuaries and open/closed areas change over time, the level of monitoring may also change over time.

Measuring Stock Status

The Chesapeake Bay Stock Assessment Committee (CBSAC) has funded a research effort to estimate the size of the Bay's oyster population. This research endeavor is in progress and has, to date, collected the data and determined a method for estimating. The results of this effort will provide the means to track progress toward the tenfold objective; establish a quantitative standard for managing the commercial harvest; and track the results of habitat restoration efforts. The 1994 oyster population estimate (which includes the 1993/1994 commercial harvest season in Maryland) will be used as the baseline for estimating progress toward the tenfold objective. Since the oyster population will naturally change in abundance from year to year, determining the effects of fishing, disease, reproductive success and environmental factors such as temperature and salinity are important for developing commercial harvest strategies. As sanctuaries and special management areas increase in size and number over time, it will be important to integrate project-specific monitoring results with those of the large-scale oyster surveys. The large-scale state surveys may not reflect oyster increases within these special management areas. The CBSAC oyster stock assessment project is developing methods for integrating baywide data and will develop monitoring recommendations for the special management areas.

Strategy 7.1

A) Use the results of the oyster stock assessment as an estimate of oyster abundance in the Bay.

B) Use the 1994 biomass value as a baseline to track progress toward the tenfold objective.

Action 7.1.1
Conduct monitoring programs consistent in terms of sampling procedure, timing of sampling, types of data collected and analysis, and provide the results to a central database or databases.

Action 7.1.2
Establish a Technical Committee to develop data management guidelines for handling the oyster data. The following topics will be included: document each jurisdictions databases; determine what parameters will be in centralized form; what data questions/queries will be needed on a routine basis; what are the data responsibilities of each oyster partner; what are the analytical needs; and how will the data be distributed.

Action 7.1.3
Develop and maintain a database to track oyster restoration projects and provide web-based access. Examples of the types of information to be included in the centralized database(s) are:

- A summary of past and current projects, locations (maps) and contacts;
- Online access to the Project Tracking Database, with query function so that viewers can search for relevant information;
- Online access to data, similar to other living resources data currently available through the CBP web site; and
- Oyster Stakeholders Network (OSN), containing:
    - Subscription options;
    - Submission of information to be disseminated through the network; and
    - An archive of previous OSN bulletins or notices.

Stakeholder inclusion is an important component of this plan because the success will depend on the support and involvement of all oyster constituencies. In addition to resource agencies and academia, the following stakeholder groups have been identified for specific attention: watermen, growers, processors, retailers, sportfishermen and environmental volunteers.

Action 7.1.4

The Chesapeake Bay Program will conduct an annual oyster symposium in order to:

- Review of results from projects and monitoring conducted in the previous year;
- Recap plans for the upcoming year; and
- Reevaluate and revise the *OMP* in light of new knowledge

The annual review symposium will be a forum for partners to exchange ideas and come to consensus on restoration strategies and methods. The format of the meeting will include both plenary sessions for presentations and discussions, as well as break-out sessions for state-level planning. Partners and stakeholders invited to the symposium will include, at a minimum, those groups listed as partners and stakeholders. The symposium will be organized and hosted by the Chesapeake Bay Program and funded by one or more of the federal partners.

Action 7.1.5
Promote the research recommendations listed in Section 2.

Conclusion

The *OMP* is a guide to focus and coordinate the multiple oyster partners in rebuilding the native oyster population in Chesapeake Bay. The objectives defined in the plan to increase oyster biomass and rebuild habitat are broad in scope and ambition. The obstacles and limitations to achieving the objectives are immense, especially in relation to disease. There are no easy and quick answers to the disease problem. Environmental factors, over which the oyster partners have very little control, will play a major role in the success of the rebuilding effort. Section 1 of the *OMP* describes the problems, strategies and actions that the oyster partners will use to protect and restore oysters in the Bay.

Section 2 of the *OMP* provides guidance on specific steps that should be taken to implement any type of oyster restoration project within the Chesapeake Bay. The purpose of this section is to standardize the project planning, project site evaluation and reporting processes. This guidance applies to any oyster restoration project including but not limited to sanctuaries, open and closed areas (harvest reserves) and state repletion programs. The lead agencies responsible for ensuring compliance with these procedures are the Maryland Department of Natural Resources and the Virginia Marine Resources Commission. This guidance applies to the oyster partners listed below and any other group proposing oyster restoration activities:

- Community associations or watershed groups;
- Non-government organizations, such as the Chesapeake Bay Foundation, the Oyster Recovery Partnership, the Potomac River Fisheries Commission, the Maryland Watermen's Association, the Living Classrooms Foundation, Virginia Institute of Marine Science, the University of Maryland and other academic institutions; and

- Government agencies, such as the Virginia Marine Resources Commission, the Virginia Department of Environmental Quality, the Maryland Department of Natural Resources, the U.S. Army Corps of Engineers and the National Oceanic and Atmospheric Administration.

In addition to the *OMP*, a background document on oyster life history, the historical fishery, food web interactions and habitat is being developed. This source document will provide the basis for developing management strategies and actions that specifically consider species interactions and functions within the Bay ecosystem. A draft source document is scheduled for completion by December 2005. Ultimately, the *OMP* will be amended to include ecosystem-based management strategies and actions that will protect and enhance predator-prey interactions and essential fish/shellfish habitat.

VIII. Identification of All Relevant Jurisdictions and User Groups

Projects that restore and enhance oyster biomass in the Bay are conducted by a number of different groups. Most groups have distinctive roles but there are overlapping objectives and projects that need to be coordinated among the oyster partners. In order to understand each group's function and role, the following descriptions were formulated.

Federal Agencies

U.S. Army Corps of Engineers (ACOE)

The U.S. Army Corps of Engineers is a service organization that provides engineering and construction support to the Army, other defense elements and the American people. The environmental restoration mission of ACOE includes examining the condition of existing ecosystems, or portions thereof, and determining the feasibility of restoring degraded structure and function to a less degraded, natural condition. This includes identifying a plan, or plans, that create the maximum amount of environmental benefits by the most cost-effective means and then implementing the chosen plan.

The ACOE's restoration plan focuses on contributing to the goals of restoring 10 percent of the Bay's historically productive public oyster grounds as oyster sanctuaries and increasing the biomass of oysters tenfold by 2010 from a 1994 baseline. The role of the Corps will be centered on cost-effective planning, followed by construction and rehabilitation of oyster reef habitat of various heights and types in cooperation with a local sponsor. The Corps' recommended plan will be determined by the best available scientific and economic information and focused primarily on achieving the restoration of native oysters by the most cost-effective means.

The Norfolk District, Army Corps of Engineers has developed a strategy for restoration implementation in partnership with the Virginia Marine Resources Commission, the Virginia Institute of Marine Science and the Chesapeake Bay Foundation. The demonstration project to test this new strategy is the Great Wicomico project. The strategy, referred to as genetic rehabilitation, is to achieve disease resistance at the population level in all river basins throughout the Virginia portion of the Chesapeake Bay using the following approach:

- Construct new oyster reefs in trapped river basins;
- Seed newly constructed reefs with selectively bred disease-resistant strains of native oyster broodstock;
- Scale efforts to achieve critical oyster biomass for target river basins;
- Monitor project sites;
- Using adaptive management, plan for additional broodstock and spat on shell seedings through the project life (five years), as needed; and
- Develop breeder reef systems that will produce disease-resistant broodstock and spat on shell oysters of sufficient quantity for restoration projects.

Environmental Protection Agency (EPA)

The EPA is the lead federal agency representing the federal government in the Chesapeake Bay Program. The agency provides funding for staff for the Living Resources Subcommittee and for baywide fisheries management planning and coordination, as well as for research, habitat restoration, ecosystem modeling and ecosystem monitoring, data management and public communication. The EPA has the ultimate responsibility for implementing and enforcing the Clean Water Act, including oversight of state and federal programs that regulate pollution discharge. They also play a key role in the environmental review of federal project plans (e.g., ACOE plans) and federal permits (e.g., shell dredging and discharge permits) for consistency with the National Environmental Policy Act.

National Oceanic and Atmospheric Administration (NOAA)

NOAA's involvement in oyster restoration activities is anchored by technical staff at the NOAA Chesapeake Bay Office (NCBO). This office provides restoration planning, coordination, funding and technical assistance to entities in each state. NOAA funds oyster population and habitat restoration and has funded restoration projects ranging from local community-based activities, to large-scale, multi-river efforts to restore both oyster habitat and oysters for harvest, which employ various strategies to further the science of oyster restoration. NOAA also funds initiatives to increase hatchery efficiency and capacity and oyster disease research including development of specific pathogen-free oyster strains. Technical assistance is also provided through cooperative projects for monitoring and project result validation. They also provide ship-based charting technology, which may be used for large-scale, baywide bottom substrate mapping to aid in oyster restoration objectives.

NOAA/National Marine Fisheries Service (NMFS)

The Oxford office reviews permit applications for restoration activities to ensure compliance with federal mandates such as the National Environmental Protection Act (NEPA) and the Rivers and Harbors Act, among others. Restoration activities include shell dredging, bar cleaning and placement of shell. The Oxford office also evaluates the impacts of proposed restoration activities on essential fish habitat (EFH) and provides recommendations.

United States Fish and Wildlife Service (USFWS)

The USFWS reviews project proposals and comments on impacts to endangered or threatened species. They are interested in protecting the ecosystem as a whole and provide comments accordingly.

State Agencies

State agencies in both Maryland and Virginia are responsible for regulating the use of the bottom resource and for managing the public oyster grounds on behalf of the citizens of each state. The various state agencies are responsible for a wide range of actions regarding oysters, including fishery management (season, daily limits, licensing, gear and cull size, etc.); resource restoration, including the establishment of special management areas (shell and seed programs, bottom cleaning, etc.); the regulation of bottom uses; permitting and leasing for restoration projects and aquaculture; the protection of public health; monitoring oyster populations and water quality; disease analysis; the coordination of restoration partners; and providing technical assistance to other agencies and organizations. The states also issue permits and contracts for the dredging of buried shell, and thus control access to this resource.

Maryland Department of Natural Resources (MDNR)

M DNR is the state agency responsible for oyster restoration and management. Maryland law authorizes the department to "…take measures which in its judgment seem best calculated to increase the productivity or utility of any part of the natural oyster bars of the state." To fulfill this mission, M DNR's Shellfish Division conducts two programs to increase the economic and ecological benefits of oysters. The Oyster Restoration Program restores oysters for ecological benefits, and the Oyster Repletion Program restores oysters to enhance the fishery. M DNR regulates harvest, establishes sanctuaries and reserves, manages the acquisition of buried and fresh (i.e., shucking house) shell, conducts reef restoration within sanctuary areas, surveys and monitors the oyster population, maps bottom types and maintains a GIS of oyster grounds, bottom types and environmental conditions. Partners include federal, state and nongovernment agencies. M DNR establishes and works closely with various committees, including county oyster committees, statewide oyster committees, and the Tidal Fisheries Advisory Commission. In addition, M DNR spearheads the Maryland Oyster Roundtable Steering Committee.

Maryland Department of the Environment (MDE)

The Maryland Department of the Environment is the state agency responsible for protecting public health by regulating the Shellfish Harvesting Areas in Maryland waters. MDE conducts monitoring to determine whether shellfish areas are contaminated with disease-causing bacteria, and identifies approved, restricted or conditional growing areas according to protective criteria for human consumption. The agency periodically monitors to ensure that open harvest areas are free of disease-causing bacteria. In addition to monitoring for bacteria, the agency also triennially monitors shellfish for levels of metal and pesticides.

Virginia Marine Resources Commission (VMRC)

The Department of Conservation and Replenishment within VMRC is tasked with managing and replenishing the public oyster grounds in Virginia. Along with an advisory committee, the department chief develops strategies to improve and restore the public oyster grounds. Restoration activities include spreading cultch as oyster substrate, rejuvenating old oyster beds using dredges, creating oyster reefs for optimal oyster habitat and moving oysters from seed areas to grow-out areas. VMRC is also one of the main partners in the Virginia Oyster Heritage Program and supports their mission of creating broodstock sanctuaries, enhanced harvest areas and oyster monitoring activities. The department systematically and scientifically monitors all the restoration activities to determine their success.

VMRC develops strategies and promulgates regulations to conserve the oyster resources using season and time limits, catch limits and gear restrictions. Conservation and replenishment personnel also coordinate all shellfish relaying information to ensure compliance with the Code of Virginia and FDA guidelines for handling shellfish taken from condemned shellfish areas.

Virginia Department of Environmental Quality (VDEQ)

VDEQ is one of the lead agencies in the Virginia Oyster Heritage Program. Please see the Multi-Partner Groups section below for a description of that program.

Multi-Partner Groups

Several bodies have been formed to facilitate collaboration among multiple partners.

Chesapeake Bay Program (CBP)

Created in 1983, the Chesapeake Bay Program is a regional, multi-agency partnership that direct and conducts the restoration of the Chesapeake Bay. Bay Program partners include the states of Maryland, Pennsylvania and Virginia; the District of Columbia; the Chesapeake Bay Commission; the U.S. Environmental Protection Agency; and numerous advisory groups. In June 2000, the Chesapeake Bay Program partners signed the *Chesapeake 2000* Agreement, which set goals for restoring and protecting the Bay and its watershed over the next decade. The oyster goal established by the new agreement is to achieve, at a minimum, a tenfold increase in native oysters in the Chesapeake Bay by 2010 based upon a 1994 baseline

The CBP's Living Resources Subcommittee serves as a forum for all the partners to collaborate in the planning and implementation of oyster restoration activities throughout the Chesapeake Bay. The staff of the Living Resources Subcommittee coordinates these efforts baywide and will ensure interagency cooperation in achieving the tenfold goal, including organizing and hosting an annual review to evaluate progress. CBP staff also will be responsible for tracking cumulative progress toward the tenfold goal.

Virginia Oyster Heritage Program (VOHP)

The Virginia Oyster Heritage Program is a partnership among state and federal agencies, nonprofit organizations, watermen and business groups. This partnership is administered by VDEQ's Coastal Management Program and VMRC. Major partners within the program include NOAA's Office of Ocean and Coastal Resource Management, ACOE's Norfolk District, VIMS, Virginia Sea Grant, the Virginia Environmental Endowment, the Virginia Seafood Council and the Chesapeake Bay Foundation. The program is a forum for integrating the activities of the various partners in order to undertake large-scale oyster restoration work in Virginia. To date, VOHP's activities have focused on the Rappahannock River, Lynnhaven River and Tangier Sound.

The program has four major objectives: to establish sanctuaries; enhance harvest areas near established sanctuaries; monitor newly created reefs for success in increasing oysters, water clarity, and biodiversity; and to train and provide educational materials to volunteers interested in oyster gardening.

As an outgrowth of the program, a non-profit organization – the Virginia Oyster Reef Heritage Foundation (see Non-profit Organizations) – was created to conduct private fundraising to support the program's goals.

Potomac River Fisheries Commission (PRFC)

The Potomac River Fisheries Commission, consisting of four members from Virginia and four from Maryland, works to conserve and improve the seafood resources of the Potomac River. The commission is a semi-autonomous agency, but its work and policies are coordinated closely with the Fisheries Service of the MD DNR and the Marine Resources Commission of Virginia. Fishery agencies of both states provide law enforcement on the Potomac River for the commission. The commission regulates and licenses fisheries and the dredging of soft-shell clams in the Potomac River.

Maryland Oyster Roundtable and Steering Committee (MD ORT)

The Maryland Oyster Roundtable was convened by the State of Maryland in 1993 to address how to bring oyster stocks back to economically and ecologically healthy levels. It consists of 40 members representing commercial waterman, aquaculturists, environmentalists, legislators, scientists and senior staff from the Maryland departments of Agriculture, Environment, Natural Resources and the Governor's Office.

Representatives from the processing industry, commercial waterman, state agencies, environmentalists and scientists formed a steering committee to serve as the implementation branch of the roundtable. The steering committee has multiple roles, which include serving as a forum to discuss and resolve pertinent oyster management issues and provide guidance to Maryland's oyster restoration efforts in a consensus process among stakeholders. The committee meets three to six times a year.

Chesapeake Bay Commission (CBC)

The Chesapeake Bay Commission is a tri-state legislative body that advises the general assemblies of Virginia, Maryland and Pennsylvania in cooperatively managing the Chesapeake Bay. The commission is available to provide information and advice on Chesapeake Bay issues to any member of the three general assemblies. The commission is also a signatory to the *Chesapeake 2000* agreement. As a signatory, the commission serves as the legislative arm of the Chesapeake Bay Program and is fully involved in all Bay Program policy and implementation decisions.

Nonprofit Organizations

Chesapeake Bay Foundation (CBF)

The Chesapeake Bay Foundation is a nonprofit conservation organization with more than 93,000 members and offices in Maryland, Virginia and Pennsylvania. CBF's mission is "…to restore and sustain the Bay's ecosystem by substantially improving the water quality and productivity of the watershed, with respect to water clarity, resilience of the system and diversity and abundance of living resources, and to maintain a high quality of life for the people of the Chesapeake Bay region."

CBF considers oysters to be a key element of any strategy to restore the Bay. The foundation has been involved in oyster protection efforts for 20 years and has been actively engaged in oyster restoration for 10 years. CBF plays a multifaceted role in oyster restoration. It serves as an advocate with special emphasis on lobbying for state and federal support for restoration. CBF also serves as an educator, annually teaching tens of thousands of students about oyster ecology and empowering them to contribute to restoration. CBF also facilitates citizen involvement in restoration through its oyster gardening and volunteer programs. Finally, CBF is a catalyst for restoration through its creative partnering, targeted fundraising and innovative aquaculture and reef-building work. In these ways, the foundation attempts to clear roadblocks to restoration and develops new approaches that help achieve the collective oyster goals for the Bay.

Oyster Recovery Partnership

The Oyster Recovery Partnership's mission is to help bring back the health of the Chesapeake Bay by restoring critical oyster resources. The partnership was formed in 1994 by a mandate of the Maryland Oyster Roundtable, and its role is to implement the Roundtable Action Plan's initiatives.

The partnership works with regional interest groups to create oyster sanctuaries and to enhance and manage reserve areas that can be opened periodically to harvest. It relies heavily on cooperative relationships to provide specific pathogen-free seed oysters produced by the University of Maryland's Center for Environmental Science; provide information on bottom conditions for proper site selection; and to provide monitoring services. The partnership's small staff depends on citizen volunteers, environmental groups and watermen to complete restoration projects and thus integrates outreach and education with restoration work. The partnership also works to strengthen ties with watermen through groups such as the Maryland Watermen's Association.

Funding is provided by cooperative agreements with Maryland state agencies, contracts with the Army Corp of Engineers; grants from NOAA's Chesapeake Bay Office, the Chesapeake Bay Foundation, the Chesapeake Bay Trust, the Campbell Foundation for the Environment, Mirant Mid-Atlantic Corporation, the World Wildlife Fund, the National Fish and Wildlife Foundation, numerous local community groups and individual donations.

Virginia Oyster Reef Heritage Foundation

The Virginia Oyster Reef Heritage Foundation was created to undertake private fundraising to support the goals of the Virginia Oyster Heritage Program. The foundation's overarching purpose is to receive private contributions in support of oyster restoration in Virginia. The Virginia Environmental Endowment is a major contributor to the foundation. It has provided a matching grant designed to encourage private business involvement by requiring a match of two dollars from the private sector for every dollar awarded from the grant.

Academic and Research Institutions

Academic and research institutions play key roles in helping to restore the Chesapeake Bay and its oyster resource. Their three main contributions are:

- Conducting research to gain a fuller understanding of oyster biology and to develop improved methods and technologies for oyster restoration;
- Collecting scientific data by monitoring the results of many restoration projects; and
- Communicating information to other partners to provide a sound scientific basis for management and policy decisions.

Numerous institutions contribute to the oyster effort. The two largest are the Virginia Institute of Marine Science and the University of Maryland.

Virginia Institute of Marine Science (VIMS)

VIMS conducts interdisciplinary research in coastal ocean and estuarine science, educates students and citizens and provides advisory service to policy makers, industry and the public. In all of their activities they seek to understand the biological, ecological and fishery impacts on oysters and apply that knowledge toward restoration, management and educational issues and provide research-based advisory service to the Commonwealth of Virginia. VIMS supports Virginia's oyster restoration objectives by providing spatfall, dredge and patent tong surveys and is developing, in cooperation with other universities, an oyster that is less susceptible to the oyster diseases MSX and Dermo.

University of Maryland (UMD)

The University of Maryland provides scientific guidance and monitoring services for many of the oyster restoration projects in the state of Maryland. Researchers at UMD also investigate various aspects of oyster physiology, population dynamics, diseases and oyster reef ecology. The hatchery at the UMD Center for Environmental Studies (UMCES) Horn Point Laboratory is an important producer of spat for restoration activities. Almost all spat available for restoration projects in Maryland come from the Horn Point hatchery. The hatchery is part of the UMD Cooperative Extension Program, which conducts research and environmental education and outreach regarding oyster aquaculture.

Other Academic and Research Institutions

Other research institutions, including the Academy of Natural Science Estuarine Research Center, conduct research and monitoring related to oyster reef ecology, oyster population dynamics and oyster disease. They also participate in Maryland and Chesapeake Bay committees charged with oyster restoration and management and provide public education and outreach related to oyster restoration.

Private Stakeholders

Watermen and Private Leaseholders

This group includes individual watermen working public oyster beds and private groups or individuals holding leases for on-bottom oyster aquaculture. They are represented by groups such as the county oyster commissions and the Maryland Watermen's Association.

Seafood Industry

This stakeholder group includes private (for-profit) hatcheries, oyster processing houses, packers, shippers, retailers and industry associations such as the Virginia Seafood Council and the Chesapeake Bay Seafood Industries Association.

Citizens

Citizens play important roles by providing public support for restoring the oyster resource, serving as volunteers on restoration projects and organizing community groups that work to restore oysters and improve the quality of their local waters. One activity in which citizens are becoming increasingly engaged is oyster gardening.

Off-Bottom Aquaculturists

The largest movement of off-bottom culture in the Bay is oyster gardening conducted by private citizens to further restoration objectives or for private consumption. Commercial off-bottom culture occurs in a limited capacity in both Maryland and Virginia.

Section 2: Project Planning Guidelines

Note: State and federal projects currently incorporate these guidelines. Any new groups sponsored by groups that are independent from state agencies must follow the guidelines listed in this section.

I. Project Plan Content

A written project plan will be required for all proposed projects, regardless of whether they are conducted by state, federal, non-profit or private groups. Proposed projects can include multiple sites in the project plan. In preparing the plan, project proponents should follow the actions and recommendations laid out in this chapter and elsewhere in the *OMP* and provide justification if the recommendations are not followed. The types of information that should be included in project plans are listed below.

Required Information

- Project objective(s);
- Project design;
- Site location (latitude and longitude);
- Designation status (i.e., sanctuary, reserve);
- Criteria used to assess site suitability;
- Construction specifications and methods;
- Source of live oysters to be planted, planting density and post-planting target density;
- Disease management protocols;

- Success criteria and monitoring protocols;
- Data management including communication with Data Management Technical Committee;
- Primary contact person with contact information;
- Other partners involved; and
- Estimated cost.

Additional Information

As part of the planning phase, these projects must compile spatial data in a Geographic Information System (GIS) and perform an assessment of site suitability. Relevant data layers may include but are not limited to bathymetry, substrate type, subsurface bottom structure, previous shell or oyster plantings, charted oyster grounds, harvest areas, other projects in the area, water quality and disease prevalence. Projects should focus on the identified priority regions (Action 4.2.1) to conduct oyster restoration activities, and the centralized database, constructed by the Database Management Technical team (Action 7.1.2 & 7.1.3), should be used to convey this information to interested parties. Additionally, the project plan should include a brief description of the GIS maps and a mechanism should be in place to keep these maps current to reflect changes made to the project plan.

II. Project Site Monitoring

Monitoring the oyster stock and oyster restoration projects requires at least two different spatial considerations: a baywide approach and a site-specific approach. The general framework for monitoring is based on standard scientific methodology. Each oyster project must state its purpose or hypothesis, followed by a statistically valid monitoring design to address the hypothesis. In addition, each project should identify how it will contribute to the overall objective of increasing oyster biomass. All oyster projects/sites will be tracked but at different levels of intensity and for varying lengths of time. As oyster populations in sanctuaries and open/closed areas change over time, the level of monitoring may also change over time.

Baseline Monitoring

Sample once per year – October/November
The number of samples depends upon the variability of samples.
Parameters:

- Abundance;
- Mortality;
- Disease (Dermo only) – prevalence and intensity;
- Size;
- Salinity;
- Temperature;
- DO; and
- Additional parameters, as needed, to evaluate project (i.e., success criteria listed in the project plan).

Standard Monitoring

This applies to most oyster sanctuaries and open/closed areas.
Sample two times per year – October/November and April/May.
The number of samples is dependent upon the variability of samples.
Parameters:

- Abundance, density and size distribution;
- Mortality;
- Disease (Dermo only) – prevalence and intensity; archive for MSX/other;
- Spat settlement;
- Salinity;
- Temperature;
- DO;
- Additional parameters as needed to evaluate project (i.e., success criteria listed in the project plan); and
- Videography (optional).

Enhanced Monitoring

This applies to selected oyster sanctuary and open/closed project sites.
Three times per year – October/November, April/May and July/August.
The number of samples is dependent upon the variability of samples.
Parameters:

- Abundance and size distribution;
- Mortality;
- Disease (Dermo only) – prevalence and intensity; archive for MSX/other;
- Spat settlement;
- Salinity;
- Temperature;
- DO;
- Additional parameters as needed to evaluate project (i.e., success criteria listed in the project plan);
- Videography (if available);
- Fouling organisms;
- Benthic community diversity;
- Finfish abundances;
- Sedimentation; and
- Larval production (only during appropriate seasons).

III. Project Review Process

The project review process is intended to:

- Facilitate coordination among groups by informing all partners about projects in advance of project implementation;
- Provide the opportunity for partners to share information, suggest changes to improve proposed projects and identify opportunities for collaboration and cost-sharing; and

- Review the logistical and technical competence of proposed projects to ensure the best use of limited resources and materials.

The review processes for Maryland and Virginia differ slightly. Project proponents should adhere to the process for the state in which the project will take place.

Maryland

1. Establish initial contact with the MDNR Shellfish Program in order to 1) notify them of the proposed project and 2) receive assistance and advice on topics such as project location, available data and potential collaboration with other partners. It is vital that the Shellfish Program be aware of every project conducted in Maryland waters, even if MDNR is not a partner in the project. Contact: MDNR Shellfish Program

2. Submit project plan to MDNR Shellfish Program and the Maryland Oyster Roundtable Steering and Scientific Committee for review. The Shellfish Program reviews projects for technical competence, regulatory and legal issues, user conflicts and bottom access issues. The Steering and Scientific Committee provides a technical review of projects and assesses them for scientific validity to ensure that the objectives, site selection, methods and monitoring, etc., are consistent with the Oyster Management Plan, the Maryland Action Plan and prevailing science.

3. Submit permit applications to the appropriate agencies, if needed. Permits are required for:
   - Any use of non-shell material (alternative materials);
   - All medium- to high-relief reef base construction projects that create an obstruction in the water column and may impact navigation;
   - Water column (off-bottom) aquaculture; and
   - Invasion or excavation of the bottom.

   Permitting agencies include the Maryland Wetlands Administration and the Baltimore District of the Army Corps of Engineers (COE). The Maryland Department of the Environment (MDE) handles the permits for the state, but they are issued through the Wetlands Administration. To apply for a permit, contact MDE or the COE. The Maryland Historical Trust, U.S. Fish and Wildlife Service, MDNR, EPA and NOAA provide technical input and advice to guide the permit agencies. Maryland Historical Trust addresses archeological concerns, and NOAA, USFWS, MDNR and EPA evaluate potential impacts to fish, SAV and other resources. EPA addresses impacts on the physical, chemical and biological integrity of the waters.

   The permitting process generally takes four to six months and potentially longer if environmental or archeological surveys are required. Permit applications should be submitted to the permitting agencies as early as possible to avoid delays. All permits must be obtained before project implementation can occur.

4. Revise the project plan based on comments from the MDNR Shellfish Program and Maryland Oyster Roundtable Steering and Scientific Committee.

Virginia

1. Establish initial contact with the VMRC Conservation and Replenishment Division in order to 1) notify them of the proposed project and 2) receive assistance and advice on topics such as project location, available data and potential collaboration with other partners. It is vital that the Conservation and Replenishment Division be aware of every project conducted in Virginia waters even if VMRC is not a partner in the project. Contact: VMRC, Conservation and Replenishment Division

2. Submit project plan to VMRC for review in cooperation with Virginia Institute of Marine Science, Department of Environmental Quality and Army Corp of Engineers, Norfolk District. VMRC, DEQ and ACOE review each project for technical competence, regulatory and legal issues, user conflicts and bottom access issues. VIMS provides a technical review of projects and assesses them for scientific validity to ensure that the objectives, site selection, methods and monitoring, etc., are consistent with the Oyster Management Plan and prevailing science.

3. Submit permit applications to VMRC, if needed. Virginia has a Joint Process Permit, in which VMRC acts as a clearinghouse and circulates permit applications to DEQ and ACOE for review and approval. The request for a permit should be submitted four to six months in advance to prevent construction delays.

4. Revise the project plan based on comments from the four reviewing agencies

IV. Site Selection

Proper site selection is essential to project success, and without proper evaluation project objectives may not be met. A series of steps should be followed when evaluating a location as a potential site for an oyster project. The preliminary step in identifying a potential restoration site is to consult either the Maryland Priority Restoration Area maps or the Virginia Oyster Restoration Plan, each detailed in Section 1.IV, for determination of suitable habitat in a given area. The next step of the process is to "know" the bottom of the site being considered. A bottom survey will provide the necessary information and should be done in a manner that enables determination of whether a site is suitable to achieve the desired project objectives and meets the Site-Suitability Criteria detailed below. The final step is to assess the information gathered in the site survey to make a final determination of whether the site complies with the Site-Suitability Criteria and the project's objectives.

Site-Suitability Criteria

All projects in sanctuaries, special management areas and repletion areas need to use the site-suitability criteria when determining the site location of an oyster project. The following are minimal criteria that must be met for a given oyster project, unless justification otherwise is provided in the project plan.

1. <u>Hard Bottom</u>, preferably with at least some shell. A bottom that will support single shells should support oysters. Firm sandy muds and muddy sands are good; it is even better if they

contain 10 percent shell and/or rocky material. Soft mud (>80 percent silt and/or clay) or shifting sand (>80 percent sand) are not suitable. These unsuitable bottoms will generally remain so even if shells are planted because the shells sink into the mud or are buried by the shifting sand.

2. Presence of Shell. The presence of shell in the top several inches of sediment indicates that oysters once lived there, and thus is a good indication that the location may be suitable. If oysters have never lived there (and there is no evidence that they did) the site will be considered unsuitable. Exceptions could be considered based on project objectives and justification. For example, hard bottom may be considered for special disease projects when trying to establish disease-free area.

3. History of Wild Spat Settlements. Projects will be placed in areas of high or low spat settlement depending upon project objectives. Optimal locations will have sufficient spat settlement to facilitate the development of a self-sustaining population. Even low to moderate occasional spat settlements may build up an area over time, but areas with no history of spat settlement are not suitable since a population put there would probably not be self-sustaining.

4. Adequate Water Flow. Water flow is critical to bringing food and oxygen to the oysters and removing silt, feces and pseudofeces that can smother the oysters.

5. Sedimentation Rate. An area is unsuitable if the rate of sedimentation outpaces oyster growth. If sedimentation occurs too rapidly, an oyster population cannot be sustainable due to degraded habitat and lack of substrate for oyster larval settlement.

6. Water Depth. Projects should occur in areas <20ft (7.6 m) but not in areas impacted frequently by low dissolved oxygen (DO) events. No projects should occur in waters >30 ft as these areas have increased chances of low DO events. All projects should refer to the Dissolved Oxygen Criteria as documented in the Water Quality Criteria under development.

7. Salinity. The project objectives as identified in the project plan will determine at what salinity a specific project will be placed. Due to disease pressure, there are strategies in Section 1- III, IV and V for determining what the salinity ranges for sanctuary, special management and repletion projects should be.

Evaluation

Evaluating the data collected during the bottom survey to assure compliance with the Site-Suitability Criteria is the final step of the site-selection process. This evaluation needs to be detailed in the Project Plan. The assessment is critical to proper site location, and without proper evaluation the project objectives may not be met. An analogy to this process can be thought of in terms of a surveyor assessing whether a building can be put on a site; the surveyor must provide plans, statistics and drawings. Similarly, the project proponent must perform an assessment and evaluation. Given the present technology, knowledge and resource limitations, oyster projects should not be placed in suboptimal locations due to lack of a proper site assessment or poor site selection.

V. Glossary

Development of a common language is fundamental to any collaborative undertaking. Terms such as oyster reef, bar and ground or restoration, rehabilitation, repletion and replenishment have been used interchangeably in the past. The purpose of this section is to clarify common terms used by the oyster restoration partners in order to avoid confusion in the future.

Key Management Terms

Restoration. Returning to a former, normal or unimpaired condition (adapted from Luckenbach et al., in press; Webster's New World Dictionary 1982). In its literal sense, restoration would imply bringing something back to its original state. In the context of oyster reef habitats and oyster populations in the Chesapeake Bay, a return to the original or historical state is probably not feasible. In this document, restoration is used in a general sense to encompass the suite of objectives presented in this *Oyster Management Plan*. As a general term, restoration does not refer to any specific management activity.

Protection. The reduction or management of anthropogenic disturbance (Luckenbach et al., in press). In the Chesapeake Bay, the level of protection for oysters and oyster habitat depends upon the formal designation of a given site.

Rehabilitation. Repair of damage caused by some disturbance (usually anthropogenic, but may also include natural disturbance) to recover desired ecosystem services (modified from Luckenbach et al., in press.).

Enhancement. Intervention to increase specific human or ecosystem services associated with shellfish habitat (Luckenbach et al., in press.).

Other Terms

Aquaculture. The propagation and rearing of aquatic organisms in controlled or selected aquatic environments for any commercial, recreational or public purpose. Specifically, oyster aquaculture is the cultivation of oysters and can be classified according to whether it occurs on or off the bottom:

> *On-bottom*. Cultivation that involves planting directly on the bottom without containment and requires a lease issued by the state
>
> *Off-bottom*. Cultivation that involves the use of structures (e.g., floats or racks), and often requires both federal and state permits.

Baylor oyster bar/ground. Historic oyster bar/ground in Virginia charted by the Baylor surveys of 1894 and revised periodically by the General Assembly.

Biomass. The total weight or volume of a species. The current method of estimating oyster biomass organizes Chesapeake Bay tributaries into designated areas or basins. Within a basin, oyster population data are used to estimate total numbers and calculate biomass. Population data are obtained from fishery-dependant and fishery-independent surveys, public/commercial fishery and restoration efforts (replenishment areas and reefs). Virginia also uses data from oyster aquaculture programs.

Bottom rehabilitation. (Also called oyster habitat rehabilitation.) Repairing damage to bottom habitats within oyster grounds caused by disturbances such as harvest and increased sedimentation rates. In the Chesapeake Bay, this type of rehabilitation is focused on increasing the amount and quality of substrate suitable for oyster settlement, survival and/or growth.

Broodstock. The group of adult (reproductively mature) oysters. Oysters in the Chesapeake Bay typically become reproductive at 1 ½ inches (this varies with location), which is below the current minimum market size of 3 inches. Larger oysters (3 to 5 inches) are typically more fecund than smaller oysters.

Commercial aquaculture. The propagation, rearing and/or grow out of animals to be sold, traded, bartered, offered for sale or marketed to others for financial considerations or remuneration.

Cultch. Any material, especially oyster shell, which serves as a settlement substrate for oyster larvae.

Disease-resistant strain. An artificially selected genetic unit that has been developed to resist disease. Under laboratory conditions, disease-resistant strains become more genetically distinct and less genetically variable. Examples include strains of the native oyster called CROSBreed and DEBY.

Enhancement. Intervention to increase specific human or ecosystem services associated with shellfish habitat (Luckenbach et al., in press.).

Fecundity. Reproductive potential; specifically, the quantity of gametes, especially eggs, produced per individual over some time period. In oysters there is a strong positive relationship between oyster size and fecundity, with larger individuals producing more gametes than smaller individuals.

Harvest area. A general term, not a formal designation, referring to an area where public harvest is allowed (see Oyster Harvest Reserve and Public Oyster Ground).

Harvest reserve. (Maryland only.) A formally designated area that is managed to maximize oyster production for both commercial harvest and ecological services by opening the reserve to harvest on a rotational basis. Protection is afforded through site-specific controls on the amount (i.e., catch size), methods (i.e., gear) and timing of harvest.

Hatchery production. The production of spat by private, state or nonprofit hatcheries to provide seed for commercial or public oyster aquaculture.

Historic oyster bar/ground. General areas where oysters once occurred, charted by historic surveys of the late 1800s and early 1900s.

Historically productive oyster bar/ground. The fraction of historic oyster ground that is believed to have been occupied by oysters. Productive grounds amounted to less than 100 percent of the total area charted because the historic oyster reefs were not continuous, but were interspersed with areas of sand and mud.

Intertidal oyster reef. An oyster reef that extends from the sea bottom to the intertidal zone, the top of which occasionally breaks the water surface during low tide. Intertidal reefs can occur along the shoreline, or as high relief (6' to 8' height) structures in deeper water. Historically, intertidal oyster reefs in Chesapeake Bay occurred primarily in Virginia waters.

Leased oyster bottom. A formally designated area that has been leased by the state to a private interest for on-bottom commercial oyster aquaculture. In Maryland, these areas are restricted to areas outside charted oyster bars or lacking commercially harvestable quantities of clam (i.e., usually barren bottom). In Virginia, these areas can include barren bottom or historic oyster grounds.

Market oyster. An oyster 3 inches or more in length available for legal harvest by the public commercial and recreational fishery.

Natural oyster bar (NOB). (Also, charted oyster bar.) In Maryland this term has a legal definition, which is generally similar to the definition given here for oyster bar/ground, and is used in a regulatory context. This term is not used in Virginia.

Noncommercial aquaculture. Grow out of animals strictly for personal or private consumption or use, specifically for oysters, cultivation by the state or nonprofit groups to enhance the public resource.

Oyster bar/ground. General areas where oysters once occurred (see historic oyster bar/ground) or currently occur. These areas are represented on charts maintained by the states of Maryland and Virginia for the purposes of management and enforcement of fishery regulations; they may or may not be a true delineation of current oyster habitat.

Oyster gardening. The cultivation of oysters by private citizens for personal consumption or restoration purposes. This activity is distinctly smaller in scale than commercial aquaculture and is typically conducted at private docks.

Oyster planting. (Also, oyster stocking, oyster seeding.) Placing live oysters (usually seed, but sometimes adults) on a suitable substrate.

Oyster reef. A biogenic structure created and stabilized by an aggregation of living oysters and other sessile (permanently attached) organisms, which provides habitat for a variety of other organisms. Living oysters reefs typically have average densities of $\geq$100 oysters/m^2, although a truly 'healthy' oyster reef would have densities of $\geq$400 oysters/ m^2 covering at least 50 percent of the reef surface. A biologically important aspect of oyster reef architecture is the amount and nature of interstitial space. Formation and continued existence of an oyster reef requires conditions favorable for oyster recruitment, survival and growth, as well as the absence physical disturbances to the integrity of the reef structure. Oyster reefs are not defined by any particular shape or size, but can be classified by certain gross morphological features such as vertical relief (height or elevation) relative to the sea bottom and the water surface:

Protection. Reduction or management of anthropogenic disturbance (Luckenbach et al., in preparation). In the Chesapeake Bay, the level of protection for oysters and oyster habitat depends upon the formal designation of a given site.

Public oyster ground. Virginia designation for oyster grounds open to the public fishery, generally including all charted oyster grounds except areas designated as oyster sanctuary, oyster harvest reserve or leased bottom. Harvest on public oyster grounds is regulated through traditional state fishery regulations.

Recruitment. Addition of new individuals to some group. In the context of oysters, two interpretations are relevant:

> *Ecological*. Survival beyond the larval and spat stages, at which point individuals become ecologically functional (e.g., water-filtering, reef-building) members of the oyster population.
>
> *Population*. Survival to reproduction (i.e., typically at 1 ½ inches in size), at which point individuals become genetically functional members of the oyster population.

Reef base. A foundation of material (e.g., shell or alternative materials) placed in such a manner and location, and typically accompanied by other management activities (e.g., oyster planting), as to encourage the formation of an oyster reef.

Rehabilitation. Repair of damage caused by some disturbance (usually anthropogenic, but may also include natural disturbance) to recover desired ecosystem services (modified from Luckenbach et al., in press.).

Repletion. Oyster planting in specific areas for commercial harvest.

Resistance. The relative ability of an organism to avoid infection or to withstand the effects of disease (Ford and Tripp 1996).

Restoration. Returning to a former, normal or unimpaired condition (adapted from Luckenbach et al., in press; Webster's New World Dictionary 1982). In its literal sense, restoration would imply bringing something back to its original state. In the context of oyster reef habitats and oyster populations in the Chesapeake Bay, a return to the original or historical state is probably not feasible. For the purposes of this document, the term restoration is used in a general sense to encompass the suite of objectives presented in this *Oyster Management Plan*. As a general term, restoration does not refer to any specific management activity (see definitions under protection, rehabilitation and enhancement for terms related to specific management activities).

Sanctuary. A formally designated and marked area that is permanently protected by a complete prohibition on the harvest of shellfish species (clams and oysters).

Seed (noun). Oysters usually less than one year of age (spat) used in oyster planting. Size at planting is typically less than 1 inch, but if older year classes are used as seed, then they may be up to 1.5 inches. Seed may be classified according to its source of production.

> *Hatchery seed.* Seed oysters produced by a hatchery. Hatchery seed can be produced from a variety of broodstock sources. Hatchery seed are very young when planted, usually less than four weeks, and they are usually less than 1 inch in size.

> *Wild seed.* Seed oysters produced by natural reproduction of wild populations. Spat settle upon dredged shells that are planted for the purpose of creating the seed, within areas known as seed areas. Spat comprise the majority of the wild seed used in Maryland and are between .5 inches to 1 inch, although some may be smaller or larger.

Seed (verb). See oyster planting.

Shell planting. Placing clean oyster shell on the bottom.

Spat. Juvenile (not yet reproductive) oysters, less than one year old, typically ranging in size up to 30 mm. Oysters typically become reproductive in their second year of life, at which time they are usually 1 ½ inches in size and are predominantly males.

Spat settlement. (Also spatfall, spatset.) Metamorphosis of planktonic oyster larvae into juvenile oysters (spat), during which the larvae permanently attach to the settlement substrate (cultch).

Specific Pathogen Free (SPF). Refers to oysters that have been tested and found to be free of certain specific pathogens, namely MSX and Dermo.

Stock. The natural genetic unit of a population determined by its isolation from other populations. Stocks are an evolutionarily determined entity. For example, oyster (*Crassostrea virginica*) stocks from northern New England, the mid-Atlantic region and the Gulf Coast vary genetically from one another. For the purpose of this document, we consider all Chesapeake Bay oysters to be one stock.

Subtidal oyster reef. An oyster reef that extends some height above the surrounding bottom, but does not reach the intertidal zone. Subtidal oyster reefs can be further categorized as:

Low relief. From >0 to 1 foot in height.

Medium relief. From 1.5 to 6 feet in height.

High relief. Over 6 feet in height. High relief subtidal oyster reefs probably did not historically occur in Maryland waters.

Transplantation. Moving live oysters from one location to another.

Yates oyster bar/ground. Historic oyster bar/ground in Maryland charted by the Yates Oyster Survey of 1906-1912, and its amendments.

Wild stock. Oysters that are genetically unchanged from their natural state. Oysters in the Chesapeake Bay are more or less wild because of several human activities: movement of oysters within the Bay; movement of oysters into the Bay from other areas (e.g., Louisiana); and the introduction of disease-resistant strains.

VI. References

Book and Periodical References

Allen, S. K. Jr., and T. J. Hilbish. 2000. Genetic considerations for hatchery-based restoration of oyster reefs. A summary from the September 2000 workshop, Virginia Institute of Marine Science and Aquaculture Genetics and Breeding Technology Center.

Andrews, J. D. 1968. Oyster mortality studies in Virginia. VII. Review of epizootiology and origin of *Minchinia nelsoni*. Proceedings of National Shellfish Association. 58:23-36.

Andrews, J. D. 1988. Epizootiology of the disease caused by the oyster pathogen *Perkinsus marinus* and its effect on the oyster industry. American Fishery Society Special Publication.18:47-63 .

Andrews, J. D. and J. L. Wood. 1967. Oyster mortality studies in Virginia. VA. History and distribution of *Minchinia nelsoni*, a pathogen of oysters, in Virginia. Chesapeake Science 8:1-13

Bender, M. E., W. J. Hargis, Jr., R. J. Hegget and M. H. Roberts, Jr. 1988. Effects of polynuclear aromatic hydrocarbons on fishes and shellfish: An overview of research in Virginia. Marine Environmental Research 24: 237-241.

Burreson, E. M. and J. D. Andrews. 1988. Unusual intensification of Chesapeake Bay oyster diseases during recent drought conditions. Pages 799-802 in Oceans '88 Proceedings. IEEE Service Center, Piscataway, New Jersey.

Burreson, E. M. and L. M. Ragone Calvo. 1996. Epizootiology of *Perkinsus marinus* disease of oysters in Chesapeake Bay, with emphasis on data since 1985. Journal of Shellfish Research. Vol. 15 (1):17-34.

Burreson, E. M., N. A. Strokes and C. S. Friedman. 2000. Increased virulence in an introduced pathogen: *Haplosporidian nelsoni* (MSX) in the eastern oyster *Crassostrea virginica.* Journal of Aquatic Health 12:1-8

Butler, P. A. 1954. Summary of our knowledge of the oyster in the Gulf of Mexico. Fishery Bulletin. 55:479-489.

Calvo, G. W., M. W. Luckenbach, S. K. Allen, Jr. and E. M. Burreson. 2001. A comparative field study of *Crassostrea ariakensis* (Fujita 1913) and *Crassostrea virginica* (Gmelin 1791) in relation to salinity in Virginia. Journal of Shellfish Research. 20:221-229.

Capuzzo, J. M. "The Bioaccumulation and Biological Effects of Lipophilic Organic Contaminants" in The Eastern Oyster *Crassostrea virginica*. Kennedy, V. S., R. . Newell and A.F. Eble, eds. 1996. Ch 15: 539-553.

Chesapeake Bay Program. 1989. Chesapeake Bay Oyster Management Plan. Annapolis, MD.

Chesapeake Bay Program. 1991. Habitat Requirements for Chesapeake Bay Living Resources. Funderbunk, S. L., S. J. Jordan, J. A. Mihursky and D. Riley, eds. Annapolis, MD.

Chesapeake Bay Program. 1994. Aquatic Reef Habitat Plan. Annapolis, MD.

Chu, F.-L.E., and R. C. Hale. 1994. Relationship between pollution and susceptibility to infectious disease in the eastern oyster, *Crassostrea virginica*. Marine Environmental Research. 38:243-256.

Castagna, M., M. C. Gibbons and K. Kurkowski. 1996. Culture Application in The Eastern Oyster Crassostrea virginica. Kennedy, V., R. Newell and A. Eble. (eds.) Maryland Sea Grant Book, College Park, Maryland.

Galtsoff, P. S. 1964. The American oyster *Crassostrea virginica* (Gmelin). U. S. Fish and Wildlife Service Bulletin. 64:1-480.

Hargis, W. J., Jr. and D. S. Haven. 1995. The precarious state of the Chesapeake public oyster resource. Pp. 559-584 In Hill, P. L. and S. Nelson. (eds.). Toward a sustainable coastal watershed: The Chesapeake Experiment. Proceedings of a Conference, Jun 1-3, 1994. Norfolk, VA. Chesapeake Research Consortium Publication No. 149, Solomons, MD.

Haskin, H. H. and J. D. Andrews. 1988. Uncertainties and speculations about the life cycle of the eastern oyster pathogen *Haplosporidian nelsoni* (MSX). Pages 5-22 in Disease Processes in Marine Bivalve Molluscs, W. S. Fisher (ed.). American Fishery. Society Special Publication. 18. Bethesda, Maryland.

Jordan, S. J. 1995. Population and disease dynamics of Maryland oyster bars: A multivariate classification analysis. Journal of Shellfish Research Vol. 14 (2):459-468.

Jordan, S., K. Paynter, J. Wesson, R. Mann, J. Harding, M. Southworth and A. Bohannon. 2002. Oyster population estimation in support of the 10-year goal for oyster restoration in the Chesapeake Bay: Estimation of Virginia stocks. Chesapeake Bay Stock Assessment Committee Workshop Report 2001. NOAA publication.

Kennedy, V. S. and L. L. Breisch. 1981. Maryland's oysters: Research and Management. University of Maryland Sea Grant Publication No. UM-SG-7S-81-04. 286p.

Krantz, G. E. and J. F. Chamberlain. 1978. Blue crab predation of cultchless oyster spat. Proceedings of National Shellfish Association. 68: 38-41.

Krantz, G. 1995. Maryland oyster population status 1993 and 1994 biological seasons. CBRM-OX-95-1, Fisheries Division & Chesapeake Bay Research and Monitoring Division, Oxford, Md.

Landers, W. S. and E. W. Rhodes, Jr. 1970. Some factors influencing predation by the flatworm, *Stylochus ellipticus* (Girard), on oysters. Chesapeake Science. 11:55-60.

Luckenbach, M., B. Dumbald, R. Mann and R. Newell. In press. Habitat Restoration, In: Bivalve Shellfish—A National Assessment. S. Shumway, J. Kraeuter, D. Leonard and K. McGraw (eds.) NOAA/NMFS Office of Habitat Conservation.

MacKenzie, Clyde L., Jr. 1970. Causes of oyster spat mortality, conditions of oyster setting beds, and recommendations for oyster bed management. Proceedings of National Shellfish Association. 60:59-67.

Meritt, D. 1977. Oyster spat set on natural cultch in the Maryland portion of the Chesapeake Bay (1939-1975). UMCEES Special Report No. 7, Cambridge, Maryland. (What's the problem with this one? I double-checked and that's the correct spelling of Don's last name.

Powell, E. N., J. M. Klinck, E. E. Hofmann and S. M. Ray. 1994. Modeling oyster populations IV. Rates of mortality, population crashes, and management. Fishery. Bulletin. 92:347-373.

Reece, K. S., D. Bushek, K. L. Hudson and J. E. Graves. 2001. Geographic distribution of *Perkinsus marinus* genetic strains along the Atlantic and Gulf coasts of the USA. Marine Biology. 139:1047-1055.

Roesijadi, G. "Environmental Factors: Response to Metals" in The Eastern Oyster *Crassostrea virginica*, Kennedy, V. S., R. . Newell [elsewhere referred to as R. Newell?] and A. F. Eble (eds.) 1996. 14:515-532.

Shumway, S. E. "Natural Environmental factors" in The Eastern Oyster *Crassostrea virginica*, Kennedy, V. S., R.. Newell and A. F. Eble (eds.) 1996. 13:497-499, 500-502.

Smith, G. F. 2001. Cooperative Oxford Laboratory—Mapping and Analysis Project Activities Report: Initiatives toward oyster restoration. Oxford, MD

Smith, G. F., K. N. Greenhawk, D. G. Bruce, E. B. Roach and S. J. Jordan. 2001. A digital presentation of the Maryland oyster habitat and associated bottom types in the Chesapeake Bay (1974-1983). Journal of Shellfish Research 20 (1):197-206

White, M. E. and E. A.Wilson. "Predators, Pests, and Competitors" in The Eastern Oyster *Crassostrea virginica*, Kennedy, V. S., R. Newell and A. F. Eble (eds.) 1996. 16:559-563.

Zachary, A. and D. S. Haven. 1973. Survival and activity of the oyster drill *Urosalpinx cinerea* under conditions of fluctuating salinity. Marine Biology. 22:45-52.

Website References:

Chesapeake Bay Program Webpage: www.chesapeakebay.net

www.eNature.com

http://coastwatch.noaa.gov/seanettles/sn_habitat.html

http://chem.unep.ch/pops/POPs_Inc/proceedings/stpetbrg/milyaev.htm

Appendix 1: Chesapeake Bay Program-Related Projects

Suspension Feeders

Currently, there is an ongoing initiative as set forth in the *Chesapeake 2000* agreement to, "…by 2004, assess the effects of different population levels of filter feeders such as menhaden, oysters and clams on Bay water quality and habitat." In March 2002, a workshop was convened to determine the best approaches to fulfill this commitment. It is recognized that the impact of suspension feeders on water quality depends on population levels and distributions of species in space and time, which ultimately can be altered by management actions and natural variation in physical and biological factors.

In response to this commitment the workshop had three goals: 1) to assess current understanding of the biological and physical characteristics of the Chesapeake ecosystem needed to estimate suspension feeder effects, 2) to assess the utility of currently existing models and 3) to identify critical features (process, organisms, model capabilities) to include in future models designed to predict effects of suspension feeders on phytoplankton and sediment in Bay waters. Stemming from these goals, a four-pronged approach was developed calling for monitoring and research, development of consumption estimates, the use of numerical models to predict the fate of consumed nitrogen and suspended sediments and the use of models that incorporate the relative complexity of the food web.

Three different groups were formed to represent the various suspension feeders, including menhaden, benthic suspension feeders and zooplankton. Each group was tasked with making three recommendations, including: 1) how to estimate/model the effect of each taxa of suspension feeders on Chesapeake Bay phytoplankton, given no funding or information constraints; 2) how to predict the effect of their group of suspension feeders on phytoplankton in the best way possible, given funding and time constraints; and 3) to develop a short list of highest priority areas of research and model development needed to reach the suggested recommendations in number 2.

The following recommendations were identified by the workshop participants for each of the three focus areas.

Data

Data that are needed to help fulfill the commitment include additional data for Atlantic menhaden, epibenthic invertebrates other than oysters, and soft-bodied microzooplankton, with the highest priority to obtain information for Atlantic menhaden.

Modeling

Consumption estimates are needed for each of the above identified groups. Additional analysis, synthesis and evaluation of monitoring and relevant data sets on abundance and spatial and temporal distributions of relevant organisms and review of scientific literature to develop consumption rates needs to occur for all three groups. [please punctuate previous sentence according to its proper sense—I wasn't sure where to begin—RB.]In addition, there should be development of targeted models that include nutrient cycling and consumption for benthic suspension feeders and zooplankton.

Water Quality Protection and Restoration: An Innovative Approach

The *Chesapeake 2000* agreement considers improvement of water quality to be one of the most critical elements in the overall protection and restoration of the Bay and its tributaries. A seven-jurisdiction cooperative partnership, consisting of Maryland, Pennsylvania, Virginia, the District of Columbia, West Virginia, New York and Delaware, is currently developing a new process for setting and achieving the nutrient and sediment load reductions necessary to restore Bay water quality. This new process requires the partners to establish and meet specific water quality standards instead of traditional broad percentage reduction goals.

New water quality standards will be based on three criteria: dissolved oxygen, water clarity and chlorophyll *a*. Additionally, the criteria will differ from one region of the Bay to another in order to account for the diversity in differing habitats; however, similar habitats throughout the jurisdictions will have the same criteria to ensure consistency throughout the watershed. The habitat zones that will define the criteria include shallow water, open water, spawning and nursery areas, deep water and deep channel.

The proposed schedule for completion of the criteria and adoption of new water quality standards by the jurisdictions is as follows:

April 2003	Completion of Bay criteria and tidal waters designated uses.
Summer 2003	Maryland, Virginia, Delaware and the District of Columbia will propose new water quality standards.
2004	Completion of tributary strategies by each of the jurisdictions.
2005	Jurisdictions will finalize the adoption of water quality standards.

Watershed initiatives supported by the Bay Program that help to further the commitment of restored water quality include:

- Watershed management planning in two-thirds of the Bay's watershed;
- Restoration of 25,000 acres of tidal and non-tidal wetlands;
- Conservation of forests along streams and shorelines;
- Expansion and connection of contiguous forests;
- Creation of riparian forest buffer; and
- Development and promotion of sound use practices.