2 Description of the Proposed Action and Alternatives

2.1 DEVELOPMENT OF THE PROPOSED ACTION AND ALTERNATIVES

2.1.1 Estimating a Benchmark Population Based on the Statement of Purpose

The size of the Bay-wide oyster population between 1920 and 1970 cited in the statement of purpose defined for this PEIS (Section 1.1.2) was never documented; therefore, the population during that time had to be estimated to establish a benchmark for evaluating the extent to which the proposed action or alternatives might be capable of meeting the stated goal. The numerous assumptions that were required to estimate the historical benchmark population, which are discussed below, illustrate the deficiencies in knowledge about the dynamics of the Eastern oyster population in Chesapeake Bay. The uncertainties created by those deficiencies are noted and their consequences are addressed in the analyses presented in Section 4.

Recorded commercial landings were the only historical data available from which to estimate the average abundance of oysters between 1920 and 1970; therefore, the size of the benchmark population had to be estimated in terms of the number of market-size oysters (more than 3 inches long). The average annual harvest between 1920 and 1970 was on the order of 35 million pounds (Figure 1-1), which is roughly equivalent to five million bushels. Applying the estimate of 275 market-size oysters per bushel used in the economics analyses for this PEIS (Section 4.6.2), 5 million bushels would contain 1.4×10^9 market-size oysters.[7] No estimates of annual exploitation rates[8] are available for 1920 through 1970. Annual exploitation rates in Maryland from 1994 to 2007 have been estimated to range from 8% to 18% (Table 7 in Attachment 7 of Appendix A). As discussed in Section 4.1.4, oyster populations are unlikely to be able to sustain harvest rates greater than about 20% per year (E. Powell, Rutgers University, pers. comm.). If historical exploitation rates between 1920 and 1970 ranged from 8% to the 20% considered to be the maximum sustainable range, the number of market-size oysters in any given year needed to support an average annual harvest of 5 million bushels over several decades would range between 6.9×10^9 and 1.7×10^{10}. The midpoint of this range (i.e., 12 billion market-size oysters), therefore, affords a roughly estimated goal that is consistent with the

[7] The number of oysters in a bushel varies depending on the size distribution of the oysters being harvested. It also differs between Maryland and Virginia: a "Virginia bushel" is 7% larger in volume than a "Maryland bushel." The value of 275 oysters per bushel was used as the standard unit in all analyses reported in this Draft PEIS.

[8] The term "annual exploitation rate" refers to the percentage of the population of market-size oysters that is removed from the population in a year.

statement of purpose defined for this PEIS.[9] The outcomes of the proposed action and alternatives were evaluated against that benchmark.

Many analyses in Section 4 (Environmental Consequences) as well as the estimated size of the oyster population shown in Figure 1-3, are discussed in terms of the biomass of the total oyster population; however, the benchmark goal could not be expressed in those terms for two reasons. First, it is not possible to estimate the number of oysters smaller than market size that would be required to maintain a population of 12 billion market-size oysters. When conditions favor settlement and survival of oyster spat, even a small number of oysters can quickly increase into a large population because of the species' enormous reproductive potential (Section 1.3.1); furthermore, in the absence of virulent diseases, oysters are long-lived. A single year of very successful spawning, therefore, could result in a large number of market-size oysters being available to harvesters for several years if the intensity of fishing effort remained fairly constant, while during those same years the number of small oysters might decrease as a result of poor spawning conditions (i.e., large volume of fresh-water inflow). Second, the benchmark estimate of 12 billion market-size oysters, which was calculated using exploitation rates and annual harvests, is based on the premise that landings from 1920 to 1970 all were from public bars that were open to oystering. This assumption probably was true for harvests from Maryland but is not likely to have been true for harvests from Virginia. About two-thirds of Virginia's oyster harvest historically has been supported by private investment on leased grounds (J. Wesson, VMRC, pers. comm.). This system of aquaculture produces landings that would not occur independently of the manipulation of shell and seed by growers and, therefore, that are not totally dependent on the health and status of the wild oyster stock. Depending on the proportion of harvest between 1920 and 1970 that was supported by private investment in Virginia, which is unknown, the size of the wild stock required to support average annual landings of 5 million bushels over several decades could be considerably smaller than the estimated benchmark of 12 billion market-size oysters.

In fact, if taken to its logical conclusion, expanding aquaculture to produce 5 million bushels of oysters a year could achieve one element of the stated goal in the absence of any wild stock in the Bay. The statement of need for the actions being evaluated in this PEIS clearly indicates, however, that "a need exists to restore the ecological role of oysters in the Bay and the economic benefits…." Although large-scale aquaculture of oysters in Chesapeake Bay probably would produce local ecological benefits (e.g., improvements in water quality), cultivated oysters would not be capable of providing the magnitude and kinds of ecological services throughout the Bay that a fully restored stock of wild oysters would produce (Sections 4.2.5 and 4.2.6). Furthermore, natural oyster reefs expected to be created by a fully restored stock of wild oysters that could provide the desired ecological benefits could not withstand many of the methods currently used to harvest oysters. Any kind of dredging or tonging would result in breaking up the "clusters" of oysters that are the foundation of a developing reef. Such methods would have

[9] Some stakeholders contend that even though harvest remained relatively constant over the specified period, that level of harvest was, in fact, not sustainable. If that contention is correct, then excessive harvesting in preceding decades could have been substantially responsible for the declines in population and harvest observed since the 1970s. Available data and information are insufficient to assess the relative importance of harvest, disease, and other factors (e.g., water quality) in contributing to the decline in oyster stocks and their inability to recover despite interventions to date.

to be prohibited to promote and preserve reef structures, thus constraining the potential magnitude of harvests of a restored stock.

These factors and the analyses presented in Section 4.1 illustrate a significant contradiction inherent in the statement of purpose for oyster restoration between the goals of restoring the ecological services of an abundant wild stock of oysters and restoring the economic contributions of the oyster fishery when the proposed action or alternatives are considered individually as potential means of reaching those goals. Several stakeholders who commented on the Draft PEIS recommended restating the purpose to establish two distinct goals, one economic and one ecological, and re-evaluating the proposed action and all alternatives (or additional alternatives) for their potentials to achieve each of those separate goals. Given the limited data and information available, however, the analyses of the broad, general actions described in this programmatic EIS provide considerable insight concerning how a wide range of possible actions might contribute to achieving economic and ecological objectives; consequently, restating the purpose and restructuring the analyses was deemed to be unnecessary. In lieu of redefining the goals of restoration individually, the lead agencies defined combinations of alternatives that could address both goals. All three of the combinations of alternatives include aquaculture of one or both species of oysters together with enhanced restoration actions; therefore, each combination provides a viable means of resolving the contradiction inherent in the statement of purpose.

2.1.2 Defining the Proposed Action

Maryland and Virginia proposed to introduce the disease-resistant Suminoe oyster into the Bay because oyster diseases appear to be a major factor inhibiting the recovery of the Eastern oyster population (Section 1.4). Proponents of the proposed action reasoned that introducing a disease-resistant oyster might be a cost-effective means of restoring the Bay's oyster population if the species is able to survive, reproduce, and colonize the large portions of the Bay where the Eastern oyster is currently depleted. A population capable of sustaining itself in Chesapeake Bay could supplement the stock of Eastern oysters that is being augmented (i.e., by planting seed oysters) through current restoration programs and also might increase the amount of shell in the Bay. Introducing a nonnative species, however, might also result in introducing devastating new diseases to which native organisms might be vulnerable. The wording of the proposed action developed by the PDT with public input obtained during scoping accounts for that concern as follows:

> ***The State of Maryland and Commonwealth of Virginia propose to introduce the nonnative Suminoe oyster into the tidal waters of Maryland and Virginia for the purpose of establishing a naturalized, reproducing, and self-sustaining population of this Asian species. Diploid Suminoe oysters would be propagated from existing third or later generations of the Oregon stock of this species, in accordance with the ICES Code of Practices on the Introductions and Transfers of Marine Organisms 1994 (ICES 1995). Diploid Suminoe oysters produced in hatcheries would be deployed first on State-designated sanctuaries (separate from native oyster restoration projects), where harvesting would be prohibited permanently, then on harvest reserves and special management areas, where selective harvesting would be allowed. The States further propose***

to continue efforts to restore the native Eastern oyster throughout the Chesapeake Bay by using the best available restoration strategies and stock assessment techniques, including maintaining and expanding the existing network of sanctuaries and harvest reserves, enhancing the brood stock, and supplementing natural recruitment of the species with hatchery-produced spat.

The use of the Oregon stock and ICES protocols to introduce the Suminoe oyster were proposed to minimize the risk of introducing new diseases (Section 4.1.1 and Appendix B - Section 4.2.3). DNR, VMRC, and PRFC developed a representative plan for implementing the proposed action to serve as input to analyses for the PEIS; that plan is described in detail in Section 4.1.1. The representative implementation plan was designed to be reasonably realistic but not to be a specific recommendation for an introduction, if the proposed action were to be selected as the preferred alternative. The plan simply represents the kinds of actions that might be taken to implement the broad programmatic proposal being evaluated. The agencies did not consider cost specifically when developing the representative implementation plan. The kind and level of effort included in the plan represent realistic expectations of increases in funding that the agencies believe might be available. The scope of the representative introduction plan was intended to be sufficient to produce a significant increase in the oyster population, and that potential outcome was investigated in this PEIS. The PDT intended the cost of the representative introduction plan to be estimated as part of the economic analysis of the proposed action.

2.1.3 Defining the Alternatives

The PDT defined the alternatives to the proposed action after extensive discussion and debate. Alternative 1 is the "no action" alternative. All environmental impact statements must include a "no action" alternative to represent the baseline conditions against which to evaluate the proposed action and other alternatives. The "no action" alternative for this PEIS is simply a continuation of oyster restoration programs implementing traditional restoration measures at the level of effort expended during 2004.[10] The expected outcomes of continuing restoration programs at the 2004 level, therefore, provide the benchmark for comparison with the outcomes of the proposed action and all other alternatives.

The PDT defined the seven additional alternatives described in the Notice of Intent to represent a variety of distinct strategies for attempting to achieve the stated purpose for action. They reasoned that considering a wide range of alternatives would increase the likelihood that analyses might reveal clear differences in outcomes. The alternatives represent the major approaches being advocated by different agencies or stakeholders in Chesapeake Bay oyster restoration. The scope of the alternatives is appropriately broad because this is a Programmatic EIS. Each of the broadly defined strategies for restoring oysters could be implemented in a variety of ways. PEIS analyses are not intended or designed to identify optimal implementation plans; however, as described earlier, a reasonable representative implementation plan was identified for each alternative to provide a basis for evaluating the potential outcomes of the alternatives. The PDT chose to define two somewhat different approaches for implementing Alternative 2 to reflect the range of current hypotheses about how best to distribute effort to increase the population of the native oyster (Section 2.2.2).

[10] PEIS preparation began in 2004.

As in the case of the proposed action, the PDT did not consider cost while developing the alternatives. Each alternative and its representative implementation plan were developed based on knowledge of past and current oyster management and restoration programs in the Bay and on actions and programs that the PDT believes could reasonably be expected to be feasible for implementation in the future. Estimating the cost of implementing the alternatives according to the representative plans was among the analyses performed to prepare this PEIS (Section 4.6.2). The estimated costs differ substantially. The outcome of an alternative probably would change if the level of effort and amount of funding were significantly different than is described for the representative plans, but such relationships were not investigated for the individual alternatives evaluated in this PEIS.

Alternative 8 in this PEIS is called "Combination of Alternatives." The lead agencies defined combinations of alternatives near the completion of the Draft PEIS. Based on the analyses of the individual alternatives available at that time, several combinations were defined to explore how the distinctly different approaches represented by the individual alternatives might be combined to improve the likelihood of achieving oyster restoration goals. Analyses of Alternative 8 are based on the outcomes of the analyses of the individual alternatives.

After initial evaluations and analyses, the PDT concluded that two of the eight alternatives listed in the Notice of Intent, Alternatives 6 and 7, did not merit detailed analysis in this PEIS. The basis for those decisions is presented in Section 2.2 Alternatives Evaluated but Eliminated from Detailed Analysis.

2.1.4 Alternative 1: No Action

Alternative 1 is: ***No Action—Not taking the proposed action: Continue Maryland's present oyster restoration and repletion programs, and Virginia's oyster restoration program under current program and resource management policies and available funding using the best available restoration strategies and stock assessment techniques.***

This alternative maintains the status quo and assumes that funding and resources for oyster restoration programs would continue as they were during 2004. Details of the States' restoration activities during 2004 are presented in Attachment 5 of Appendix A. One element of those activities, the dredged-shell planting component of Maryland's repletion program, ended in 2006. Maryland has designed and will be implementing a "shell reclamation" program that involves retrieving previously planted shell that has since been covered with silt and replanting it on other bars. That effort is expected to allow the State to continue rehabilitating habitat at the level achieved previously with the dredged-shell program. Maryland also is applying for a new permit to resume the dredged-shell program. If the State obtains that permit, dredging might provide shell resources that would allow for an increase in the level of habitat restoration; however, analyses for Alternative 1 assumed that habitat rehabilitation efforts will be maintained at the 2004 level into the future.

2.1.5 Alternative 2: Enhance Efforts to Restore the Native Oyster

Alternative 2 is: ***Expand Native Oyster Restoration Program: Expand, improve, and accelerate Maryland's oyster restoration and repletion programs, and Virginia's oyster***

restoration program in collaboration with Federal and private partners. This work would include but would not be limited to an assessment of clutch limitations and long-term solutions for this problem and the development, production, and deployment of large quantities of disease resistant strain(s) of C. virginica (Eastern oyster) for brood stock enhancement.

Alternative 2 was intended to provide a basis for investigating if increasing oyster restoration activities significantly beyond the level during 2004 would result in a substantial increase in the oyster population. As described in Section 4.1.3 and Attachment 5 of Appendix A, this alternative includes roughly doubling the number of acres of habitat to be rehabilitated over a 10-year period and increasing the number of seed oysters to be planted by a factor of 4.5 over 10 years. The method of rehabilitation would be the same as is being used currently: placing thin layers of clean shell on selected bars.

In developing Alternative 2, the PDT determined that two different approaches for implementing this increased effort should be considered. The 2004 Chesapeake Bay OMP recommends that Maryland focus most of its effort in low-salinity areas where disease pressure is low, and the survival rate is maximized, but the rate of reproduction is low. Some stakeholders believe that increasing restoration on sanctuaries in areas of moderate and high salinity would produce better outcomes because the rate of reproduction is greater in saltier areas and because oysters that survive and reproduce in high-salinity areas, where disease pressure is great, might contribute to the development of disease resistance within the population. Alternative 2a, consequently, would focus enhanced restoration efforts in areas of low salinity, whereas Alternative 2b would shift a significant portion of effort into areas of moderate and high salinity. Whereas all of the seed would be planted in low-salinity areas (<10 ppt) under Alternative 2a, only 55% of the sites that would be seeded in Alternative 2b would be in low-salinity areas.

During development of the Draft PEIS, peer reviewers noted that the results of restoration programs might be enhanced if all restoration resources (i.e., shell and seed) were deployed only on “best bars” in order to ensure the greatest return in oyster abundance for investments in restoration. DNR compiled statistics based on the findings of its oyster bar surveys conducted from 2003 to 2007 to identify and rank the best bars in Maryland waters. The metrics used to rank the productivity of bars included consistency of spat set, mortality rate, and number of oysters in a sample (C. Judy, DNR, pers. comm.). DNR considers these data when selecting bars for its restoration efforts, and the data were used to select the bars included in the representative implementation plans for Alternatives 2a and 2b. Virginia has used similar information in planning its restoration programs (J. Wesson, VMRC, pers. comm.). No data are available from which to determine if increases in the number of oysters in the Bay since 1994 would have been greater than those shown in Figure 1-3 if all restoration resources had been deployed on the highest-ranked best bars (e.g., if all shell and seed were allocated to only the top 10 bars instead of being distributed over the top 20). The best-bar approach probably would result in greater oyster abundance on the best bars but would contribute to Bay-wide restoration only if those best bars served as "impact bars" that could generate increases in the number of oysters consistently over time on bars far afield from the enhanced bars (C. Judy, DNR, pers. comm.). Detecting any beneficial far-field effects that could be attributed specifically to best-bar enhancements probably would be difficult; consequently, many years would be required to achieve a reliable test of the

efficacy of the best-bar approach. Both Maryland and Virginia are considering best bars in their current and future implementation plans, and that concept is inherent in the representative implementation plans defined for Alternative 2.

All of the expanded habitat rehabilitation included in the representative implementation plan for Alternative 2 was assumed to be of the conventional kind used in 2004 (Attachment 5 of Appendix A). Another approach for increasing the amount of suitable habitat for oyster settlement and growth is to enhance existing oyster bars in ways that would mimic the three-dimensional characteristics of historical oyster reefs. Section 1.3.1 summarizes recent and past efforts to construct three-dimensional reefs in Chesapeake Bay and the outcomes of those efforts. The PDT did not include large-scale construction of three-dimensional reefs in the representative implementation plan for evaluating Alternative 2 because of the significantly greater cost of that approach and its inconsistent performance in the past. Mann and Powell (2007) suggested that the potentially feasible scope of development of three-dimensional reefs is not likely to be sufficient to counteract the effect of the continuing loss of hard-bottom habitat throughout the Bay. However, Schulte et al. (2009) reported that three-dimensional reefs constructed recently using different techniques than those employed in the past have produced increases in local oyster populations at specific sites. These reefs have produced more than 20 liters of new shell material for each square-meter of constructed reef since they were installed in 2004 and have achieved a population density of more than 1,000 oysters/m^2 via natural recruitment. Important questions to be considered include whether these promising early results at relatively young three-dimensional reefs will be sustained into the future and the extent to which such local enhancements can contribute to natural increases in oyster populations in other locations that do not receive significant habitat enhancements. The continuing loss of hard-bottom habitat is highlighted as a major obstacle to oyster restoration throughout this PEIS, and no attempt has yet been made to determine the level of habitat restoration that might be required to achieve the PEIS benchmark oyster population.

This alternative calls for deploying disease-resistant strains of the Eastern oyster to enhance the wild brood stock in the Bay. Potential use of those strains was investigated in conducting preliminary analyses for this PEIS. That element of the alternative was dismissed during initial stages of analysis based on a general consensus among oyster researchers that using disease-resistant strains of oysters produced in hatcheries to supplement the wild brood stock is inadvisable because of the potential for adverse genetic consequences (Section 4.1.3). Numerous stakeholders commented on an alternative approach known as “revolving brood stock hatchery production” that uses wild oysters from areas in which disease resistance appears to be developing as brood stock in the hatchery instead of domesticated strains. The brood stock would be replaced each year with new brood stock from those locations. Analyses for Alternative 2 assume the use of offspring of brood stocks of wild Eastern oysters spawned in hatcheries each year in Maryland and Virginia.

2.1.6 Alternative 3: Harvest Moratorium

Alternative 3 is: ***Harvest Moratorium: Implement a temporary harvest moratorium on native oysters and an oyster industry compensation (buy-out) program in Maryland and Virginia or a program under which displaced oystermen are offered on-water work in a restoration program.***

The premise of this alternative is that if harvest is a major factor precluding recovery of the stock of Eastern oysters in the Bay, eliminating harvest for some period of time might allow the stock to rebuild to a level that would provide significant ecological services and also support a sustainable harvest in the future. The lead agencies did not specify how long the temporary moratorium might be in effect or the level of stock restoration at which harvesting might be allowed to resume. The representative implementation plan for this alternative (Section 4.1.4) assumes that a moratorium would be in place for 10 years, which was adopted as a reasonable milestone for comparing the outcomes of the alternatives. The representative implementation plan also assumes that the cost of an industry-compensation program would be no more than the income that watermen earn from their oyster harvests and that current restoration programs would continue as described for Alternative 1. Alternative 3, therefore, is similar to Alternative 1, except that harvest of wild oysters would cease for an assumed period of 10 years. One important point reflected in the evaluation of this alternative (Section 4.1.4) is that most of the oyster population that is influenced by current restoration and management is on sanctuaries and harvest reserves, where harvest is prohibited or significantly restricted. Only the portion of the Bay-wide oyster population that is on unrestricted bars that are exposed to harvest would be affected by a moratorium.

During development of the alternatives, the members of the PDT discussed the potential benefits of different strategies for managing the oyster harvest as an element of the analysis of Alternative 3. Initial PEIS analyses suggested that the outcomes would be insensitive to the kinds of management actions that might be possible, at least relative to the goals established for the PEIS; therefore, alternative management strategies were not evaluated further. In response to a substantial number of stakeholders' comments on Alternative 3 as presented in the Draft PEIS, the lead agencies revised their concept for this alternative as a component of the combinations considered in Alternative 8 to represent substantially revised management programs rather than a complete moratorium on the harvest of wild oysters.

2.1.7 Alternative 4: Cultivate Eastern Oysters

Alternative 4 is: ***Aquaculture: Establish and/or expand State-assisted, managed or regulated aquaculture operations in Maryland and Virginia using the native oyster species.***

After considering several possible approaches for developing a representative implementation plan for this alternative, the PDT concluded that economic feasibility should be the primary consideration. An economic demand model developed for use in analyses for this Final PEIS (Section 4.6.2) was used to explore how the value of oyster harvests would change in response to changes in the number of oysters entering the market. Additional analyses evaluated the economic viability of aquaculture operations as a function of the price paid for the oysters produced. Outputs of those analyses were used to determine the maximum number of oysters that could be produced annually in an economically viable (i.e., profitable) aquaculture industry in the Chesapeake Bay area (Section 4.1.5). Analyses of the environmental consequences of this alternative assumed the existence of the maximum viable aquaculture industry. Section 4.1.5 identifies the numerous factors that could preclude the development of the maximum industry but does not estimate the probability of attaining that level. Assuming the maximum industry as

a basis for evaluating the consequences of Alternative 4 is a protective approach because it resulted in characterizing the greatest potential benefits and the worst potential adverse effects.

Information about current aquaculture operations in Maryland and Virginia supplied by operators, managers, and regulators of those operations was used to construct a representation of where and how large-scale aquaculture might become established in the Bay (Section 4.1.5). The representative plan considers using both diploid and triploid Eastern oysters because triploids of both species grow faster than diploids. The term "State-assisted" was assumed to involve technical support, not financial incentives. The economic analyses assumed that private investors would establish and expand aquaculture operations if they were profitable. In considering this alternative at the programmatic level, the lead agencies chose not to evaluate the efficiency or cost of different methods of oyster aquaculture currently being used in Chesapeake Bay or elsewhere in North America or the world. Analyses designed to identify the economically optimal methods of cultivating oysters in Chesapeake Bay may be appropriate in developing a specific implementation plan for the preferred alternative.

2.1.8 Alternative 5: Cultivate a Nonnative Oyster

Alternative 5 is: ***Aquaculture: Establish State-assisted, managed or regulated aquaculture operations in Maryland and Virginia using suitable triploid, nonnative oyster species.***

This alternative specifies the use of a triploid nonnative species but is not limited to the Suminoe oyster. Some initial studies indicated that the Suminoe oyster survives better and grows faster in Chesapeake Bay than the Eastern oyster does and, therefore, is a good candidate for aquaculture in the bay. Several oyster growers in Virginia who participated in field trials with triploid Suminoe oysters found such operations to be profitable (Section 4.6.2.6); therefore, the PDT included this alternative in this PEIS to provide a basis for comparing the pros and cons of aquaculture using the native oyster with those of using a nonnative oyster. A review of studies of nonnative species other than the Suminoe oyster that have been considered for use in aquaculture in Chesapeake Bay was performed as a preliminary assessment of Alternative 6. Based on that review, which is described in Section 2.3.1, the Suminoe oyster was determined to be the only nonnative species considered to date that has suitable environmental tolerances and could be economically viable for aquaculture in the Bay, and for which available information would support an acceptable level of analysis of the potential environmental consequences of growing the species in Chesapeake Bay. Evaluations for this alternative, therefore, considered only the use of triploid Suminoe oysters in nonnative aquaculture.

The alternative specifies the use of triploids for two reasons. First and most importantly, many stakeholders are concerned that using a nonnative species in aquaculture could result in accidentally introducing a potentially reproductive population into the Bay, as has occurred elsewhere throughout the world (e.g., the invasion of the Wadden Sea in the Netherlands by Pacific oysters brought to the area for use in aquaculture). Genetically altered triploid oysters generally have been believed to be incapable of reproducing and, therefore, to be unlikely to contribute to an accidental introduction. The probability that producing and using triploid Suminoe oysters in aquaculture would result in an unintended introduction of reproductively

capable diploids is explored in detail in Section 4.3 of Appendix B and discussed in Section 4.1.6 of this PEIS. One commenter on the Draft PEIS identified several errors in the calculations made to estimate the numbers of diploids that might arise as a result of large-scale aquaculture of triploid Suminoe oysters. Those errors have been corrected and several additional revisions suggested by VIMS oyster researchers have been incorporated into revised calculations presented in this Final PEIS. A second reason for considering aquaculture using triploids is that triploids of any species grow faster than diploids of the same species because their energy is devoted to growth instead of to reproduction; therefore, using triploids enhances the potential production and economic return of an operation.

Producing triploid oyster spat and constructing and operating the biosecure facilities that would be required to cultivate a nonnative species and minimize the risk of an unintentional introduction are likely to cost more than producing diploid spat and building and operating hatcheries that do not require biosecurity measures. Furthermore, evaluations of this alternative assume that nonnative triploids would be contained in bags or cages when deployed to further reduce the risk of releasing them into the Bay. Section 4.6.2.6 discusses the economic consequences of those factors for aquaculture production of triploid Suminoe oysters.

The same approach used to define a representative implementation plan for Alternative 4 was used in developing the plan for this alternative. The discussion presented in Section 4.6.2.6 addresses the fact that Suminoe oysters may have different economic value than Eastern oysters, depending on the composition of the oyster market, and that the differing value could influence how these two aquaculture alternatives might evolve over time. Oysters for the half-shell market draw higher prices than oysters for the shucking market, and some attributes of the Suminoe oyster appear to make it less suitable for the half-shell market than the Eastern oyster. That issue and its implications for the success of aquaculture operations using triploid Suminoe oysters are discussed in the economic analyses presented in Section 4.6.2.6. The representative implementation plan for this alternative was developed assuming that methods of cultivation to be used in the future would be the same as those currently in use in Chesapeake Bay. The analysis of this alternative was not designed or intended to identify the economically optimal methods of cultivating triploid Suminoe oysters in Chesapeake Bay.

2.1.9 Alternative 8: Combination of Alternatives

This alternative includes three combinations of oyster restoration activities included among those evaluated in this Final PEIS. The lead agencies defined these combinations near the completion of analyses for the Draft PEIS in an effort to resolve the contradiction between economic and ecological objectives discussed earlier to achieve the greatest potential to restore the economic, cultural, and ecological benefits of oysters in Chesapeake Bay. The combinations were presented in the Draft PEIS to provide stakeholders with the opportunity to consider and comment on options that would include the most promising elements of the proposed action and other alternatives. In considering the potential benefits and risks of each of these combinations, the lead agencies recognized that financial and physical constraints (e.g. oyster hatchery capacity, shell resources) might require some activities included as part of a combination to be implemented on smaller scales than were considered in evaluating the individual alternatives and the proposed action. The lead agencies will identify management actions that would best meet

restoration objectives of the States of Maryland and Virginia in future plans for implementing the preferred alternative. The combinations of alternatives that were evaluated include:

- **Combination 8a – Eastern oysters only**
  - Alternative 2: Enhance efforts to restore Eastern oysters
  - Alternative 3: Impose a temporary harvest moratorium and a compensation program for the oyster industries
  - Alternative 4: Cultivate Eastern oysters

- **Combination 8b – Eastern oysters and triploid Suminoe oysters**
  - Alternative 2: Enhance efforts to restore Eastern oysters
  - Alternative 3: Impose a temporary harvest moratorium and a compensation program for the oyster industries
  - Alternative 4: Cultivate Eastern oysters
  - Alternative 5: Cultivate triploid Suminoe oysters

- **Combination 8c – Eastern oysters and both diploid and triploid Suminoe oysters.**
  - Proposed action: Introduce diploid Suminoe oyster and continue native oyster restoration
  - Alternative 2: Enhance efforts to restore native oysters
  - Alternative 3: Impose a temporary harvest moratorium and a compensation program for the oyster industries
  - Alternative 4: Cultivate Eastern oysters
  - Alternative 5: Cultivate triploid Suminoe oysters

Table 2-1 is an overview of the definitions of the proposed action and all alternatives evaluated in this Final PEIS.

2.2 ALTERNATIVES CONSIDERED BUT ELIMINATED FROM DETAILED ANALYSIS

2.2.1 Alternative 6: Introduce Another Nonnative Oyster Species

Alternative 6 is: ***Introduce and propagate in the State sponsored, managed or regulated oyster restoration programs in Maryland and Virginia, a disease resistant oyster species other than C. ariakensis, or an alternative strain of C. ariakensis, from waters outside the United States in accordance with the ICES 1994 Code of Practices on the Introductions and Transfers of Marine Organisms.***

The suitability of nonnative oyster species other than the Suminoe oyster for propagation in the Chesapeake Bay was reviewed in two studies. Mann et al. (1991) reviewed ranges of temperature and salinity for growth of larvae and adults and for optimal spawning of various species of oysters of the genera *Crassostrea* and *Ostrea*. Carriker and Gaffney (1996) reviewed the native ranges and areas of successful naturalization of several species of oysters as well as the maximum sizes they attain. Results of these two studies are summarized in Table 2-2.

Table 2-1. Overview of proposed action and alternatives evaluated in the PEIS for Oyster Restoration in Chesapeake Bay; Xs indicate expected conditions for each of the alternatives.

Alternative # / Description	**Funding for Effort to Restore the Native Oyster**		**Harvest Restrictions***		**Aquaculture**		**Deployment of Nonnative Oyster**		
	Status Quo	**High**	**As Is**	**Moratorium**	**As Is**	**Increased**	**None**	**Diploid (Fertile)**	**Triploid (Sterile)**
Proposed Action – Introduce Suminoe Oyster and Continue Effort to Restore Eastern Oyster	X		X		X			X	
1 – No Action	X		X		X		X		
2a – Enhance Native Restoration (100% in low salinity)		X	X		X		X		
2b – Enhance Native Restoration (55% in low salinity)		X	X		X		X		
3 – Harvest Moratorium	X			X	X		X		
4 – Cultivate Eastern Oysters	X		X			X	X		
5 – Cultivate a Nonnative Oyster	X		X			X			X
8a – Combination (Alts. 2, 3, and 4)		X		X		X	X		
8b – Combination (Alts. 2, 3, 4, and 5)		X		X		X			X
8c – Combination (PA and Alts. 2, 3, 4, and 5)		X		X		X		X	X

* For evaluations of the proposed action and alternatives, harvest restrictions were limited to either "as is" or "moratorium." Implementation of the preferred alternative is likely to involve regulatory changes other than those presented in this table.

Table 2-2. Comparison of environmental preferences and tolerances of nonnative oysters considered for use in Chesapeake Bay

General Characteristics				Adults				Larvae	
				Temp. (°C)		Salinity (ppt)		Temp. (C)	Salinity (ppt)
Species	**Native Range**	**Introduced**	**Max. Size (cm)**	**Growth**	**Spawning**	**Growth**	**Spawning**		
Crassostrea angulata	Southern Europe, Portugal	France	18	20-30	7-40 (30-40)*	21-43	< 32		21-43 (28-35)
C. gasar	Central Western Africa, Senegal to Angola		large	25-30	5-34	14-20			
C. gigas	Indo-West Pacific to Pakistan to Japan, Korea, Philippine Islands; Borneo, and Sumatra; along the Chinese coast	Western Coasts of Canada, U.S., Mexico; Chile, Korea, Taiwan, New Zealand, Australia, coastal European countries	40-45	3-35 (11-34)	16-30 (20-25)	10-42 (35)	10-30 (20-30)	18-35 (30)	19-35
C. gryphoides	NW coast of India		17	19-33	27-31	4-40 (30-40)	13-29		
C. iredalei	Philippines, Southwest Asia		Large	30-33	< 45	> 15			
C. madrasensis	India, China, Pakistan		21	26 (30)	1-40 (8-25)	17-35 (20-35)			
C. rhizophore	Gulf of Mexico, Caribbean, Brazil	Maine, Eastern Canada. Japan	15			22-40 (26-37)		< 30 (25)	20-40 (28)
Ostrea edulis (= O. taurica)	From Norway and British Isles to Morocco; Mediterranean, Black, Aegean, and Marble Seas		11	3-28	17-18				

* Values in parentheses are average ranges. For example, *C. angulata* can spawn at temperatures ranging from 7°C to 40°C, but the average temperature for spawning is between 30°C and 40°C.

Of the species examined by Mann et al. (1991), only the Pacific oyster (*C. gigas*)[11] has growth and spawning ranges similar to those of the Eastern oyster. *O. edulis* has a similar temperature range for growth but a very narrow temperature range for spawning. All other species seem to prefer temperature and salinity in higher ranges than those that are optimal for the Eastern oyster. The Pacific oyster accounts for 80% of the world's commercial oyster harvest (Ayer 1991). The Pacific oyster has been introduced successfully in many areas of the world including France, Oregon and Washington (United States), Western Canada, Australia, and New Zealand (Shatkin 1997). The Pacific oyster is more tolerant of Dermo and MSX than the Eastern oyster (Calvo et al. 1999; Gottlieb and Schweighofer 1996; Mann et al. 1991; Barber and Mann 1994) and can co-exist with the Eastern oyster, as observed in British Columbia (Bourne 1979).

Of the species reviewed, only the Pacific oyster has been studied in the Bay and other East Coast waters. Several studies examined the potential for survival and growth of Pacific oysters in Chesapeake Bay and North Carolina. Barber and Mann (1994) compared the growth and survival of Eastern and Pacific oysters in the presence of the parasite that causes Dermo by holding specimens in quarantined flumes that received water from the York River, Virginia. Although many Pacific oysters in that study accumulated parasites within their tissue (i.e., high prevalence), the rate of mortality due to Dermo disease was not great (i.e., low disease intensity). In contrast, Eastern oysters in the study showed high parasite prevalence and high intensity of Dermo disease. Mortality was great among Pacific oysters in the experiment, but the researchers attributed it to an extended period of exposure to salinity less than 20 ppt. The prevalence of the Dermo parasite in Pacific oysters was not high during the episode of mortality. Calvo et al. (1999) determined that triploid Pacific oysters "out-performed" triploid Eastern oysters only at salinities greater than 25 ppt in the Virginia portion of Chesapeake Bay. At salinities less than 15 ppt, Eastern oysters grew significantly faster and experienced less mortality than Pacific oysters. At medium salinities (15-25 ppt), the rates of growth and mortality of Eastern and Pacific oysters were not significantly different. At low and medium salinities, Pacific oysters in the study showed heavy infestations of the parasite *Polydora*, which produces mud-filled blisters on the inner surfaces of the shell. The Pacific oyster was deemed a poor candidate for aquaculture in Chesapeake Bay because of its relatively poor performance at low salinity and greater susceptibility to mud blisters (NRC 2004). At sites in North Carolina with salinities of 25 to 36 ppt, rates of growth and mortality among Pacific oysters were significantly greater than those among Eastern oysters; however, Eastern oysters "out-performed" Pacific oysters in areas with salinities between 15 and 25 ppt (Grabowski et al. 2004).

Anecdotal evidence of several unsuccessful attempts to introduce the Pacific oyster into Chesapeake Bay and surrounding areas has been recorded (NRC 2004). In the early 1930s, a couple of bushels of Pacific oysters were planted in Barnegat Bay (Andrews 1980). Those oysters failed to grow and died within two years, possibly due to low salinity (12-20 ppt) and insufficient DO (NRC 2004). A couple of trays of Pacific oysters were kept in Rehoboth Bay for several years without significant mortality or successful reproduction (Andrews 1980). During the 1970s, a Maryland seafood dealer obtained some Pacific oysters from the West Coast and planted them in the Maryland portion of Chesapeake Bay (Andrews 1980). The oysters were recovered by scuba divers, and a law specifically prohibiting the introduction of Pacific oysters

[11] The Pacific oyster is sometimes called the Japanese oyster.

was passed to discourage similar attempts. Carlton (1992) reported that sometime between 1988 and 1990, thousands of bushels of Pacific oysters were introduced illegally into the Chesapeake Bay; however, no population appears to have become established as a result of that introduction. Based on this information and the findings of the reviews summarized above, it was concluded that no nonnative oyster considered to date other than the Suminoe oyster appears to have significant potential for successful reproduction or propagation in Chesapeake Bay.

Alternative 6 also refers to introducing a strain of the Suminoe oyster other than the Oregon stock. Proponents of this suggestion reasoned that reduced genetic variability in the Oregon stock could limit the ability of Suminoe oysters descended from that stock to survive and propagate in a new environment. Studies using molecular techniques have shown that all current hatchery stocks of the Suminoe oyster in the United States exhibit reduced genetic variability compared with wild populations and little differentiation from each other (Cordes and Reece 2007). Many generations of inbreeding within a small starting population can limit the genetic diversity of the population, which can reduce its resilience to selective pressures such as disease, predators, and extreme weather. In a genetically diverse population, if a strong selective pressure kills a large portion of the population, some genetic variants will be able to withstand the selective pressure and continue to produce offspring. The more genetically varied the population is, the greater the variety of selective pressures it can withstand. Introducing a strain of Suminoe oysters obtained from a population outside the United States that has greater genetic variability than the Oregon stock, therefore, might increase the likelihood of establishing a self-sustaining population in Chesapeake Bay.

Researchers at VIMS have imported other strains of the Suminoe oyster from the Yellow River estuary (Northern China *ariakensis*) and from the Guanxi Province (Southern China *ariakensis*) for comparative studies (NRC 2004). Some researchers, including Zhou and Allen (2003), have observed that the taxonomy of *C. ariakensis* has been confused in Asia with several other *Crassostrea* species. Zhang et al. (2005) recently provided more precise taxonomic clarification of *C. ariakensis* in its native range as well as in hatcheries in the United States. Oyster samples were taken from northern and southern China, from southern Japan, from four groups of *C. ariakensis* at the VIMS hatchery, and from oysters at the Taylor Hatchery in Washington State. Significant genetic variation was found between the oysters from northern and southern China. The southern oysters that were thought to be *C. ariakensis* were re-classified as *C. hongkongensis* based on genetic evidence; the northern oysters were determined to be *C. ariakensis*. The VIMS Aquatic Genetics and Breeding Technology Center currently maintains two other strains of the Suminoe oyster besides the Oregon stock (which has been labeled WCA). One was imported from the Yellow River area and labeled NCA for northern China *ariakensis*. The NCA are genetically very similar to the WCA, which originated from Japan, and the two have been cross-bred. The offspring were labeled WNA. WNA is not another strain, but rather, is a derivative with genetic characteristics of the two parent populations. One additional strain was obtained from southern China and has been labeled SCA. SCA are genetically distinct from either NCA or WCA, are kept separately, and have not been hybridized. All tests of the Suminoe oyster in the Chesapeake Bay area, both in the lab and in the field, have used WCA (i.e., the Oregon stock) to ensure consistency over all studies and all study years. The WNA population is likely to offer greater genetic diversity than the WCA strain; however, no field or comparative studies using the hybrid have been conducted to date.

As a result, no information is available for use in assessing the merits of an introduction using the WNA strain.

This alternative was dismissed from detailed analysis in this PEIS due to the lack of information about a suitable alternative nonnative species and the lack of information about the probable behavior of other strains of the Suminoe oyster in Chesapeake Bay.

2.2.2 Alternative 7: Introduce the Suminoe Oyster and Discontinue Efforts to Restore the Eastern Oyster

The Notice of Intent presented Alternative 7 as the "combination of alternatives." Following scoping meetings and further discussion among the lead agencies and other members of the PDT, one additional alternative was created, and the "combination of alternatives" became Alternative 8. Alternative 7 as defined after scoping is: ***Introduce the oyster species, Crassostrea ariakensis, into the tidal waters of Maryland and Virginia for the purpose of establishing a naturalized, reproducing, and self-sustaining population of this oyster species. Diploid C. ariakensis would be propagated from existing 3rd or later generation of the Oregon stock of this species, in accordance with the International Council for the Exploration of the Sea's (ICES) 2003 Code of Practices on the Introductions and Transfers of Marine Organisms. Deployment of diploid C. ariakensis from hatcheries is proposed to occur first on State designated sanctuaries where harvesting would be prohibited permanently, and then on harvest reserve and special management areas where only selective harvesting would be allowed***.

Biologically, this alternative is similar to the proposed action, except that any benefits (or costs) of current restoration activities for the Eastern oyster would not be realized. Section 2.1.2 noted that a population of Suminoe oysters capable of sustaining itself in the Bay would significantly supplement the Eastern oyster population being augmented (i.e., by planting seed oysters) through restoration programs. The concept underlying Alternative 7 was that if the introduction of the Suminoe oyster were to result in an oyster population that grows and disperses throughout the Bay, the need for efforts to restore the Eastern oyster might decrease, potentially resulting in significant cost savings.

When considered individually, the potential outcomes of the proposed action and Alternative 1 suggested that the size of the total Bay-wide oyster population expected to result from implementing Alternative 7 would be similar to the population that might result from implementing the proposed action, although some geographical differences in any changes in oyster abundance are possible. Preliminary economic analysis of costs of the proposed action and Alternative 7 revealed that costs for Alternative 7 were only about 2% less than costs for the proposed action (Appendix D, p. 15). The primary explanation for the minimal savings is that the representative implementation plans for both strategies include habitat rehabilitation only for the continuing effort to restore the Eastern oyster; Suminoe oyster seed would be planted in areas that are assumed not to need rehabilitation. Assuming that the environmental consequences of this alternative would not differ significantly from those of the proposed action and that the difference in cost between them would be minimal, this alternative was dismissed from detailed analysis in this PEIS.

2.3 COMPARISON OF ALTERNATIVES

Tables 2-3 and 2-4 provide summaries of potential effects of the proposed action and all alternatives drawn from the detailed analyses presented in PEIS Section 4 and the supporting appendices. The outcomes of each of the three combinations of alternatives (Table 2-4) represent the additive effects of each of the individual alternatives included in the combinations. Deliberations among the lead agencies leading to the designation of a preferred alternative focused solely on the three combinations of alternatives.

2.4 PROCESS FOR SELECTING THE PREFERRED ALTERNATIVE

At the initiation of this PEIS, the PDT and EC discussed possible approaches for selecting a preferred alternative from among the proposed action and alternatives. The initial outcome of these discussions was a matrix of decision criteria that listed all of the ecological, environmental, social, and economic factors to be considered in selecting the most appropriate means of restoring oysters in Chesapeake Bay. The EC and PDT considered using the matrix in a multiple-criteria decision analysis (MCDA) process. MCDA involves scoring and weighting the various decision criteria to create a quantitative basis for a final decision. Given the complexity of the issues addressed in the PEIS, the level of uncertainty associated with projected outcomes, and the subjectivity involved in scoring and weighting outcomes, the EC decided against using MCDA. They retained the matrix of decision criteria, however, as the basis for relative comparisons of the projected outcomes of the proposed action and the alternatives. A form of that matrix appears in Table 2-3 as the structure for comparing the risks and benefits of the alternatives based on summaries of the projected outcomes of the proposed action and each alternative analyzed.

The members of the EC carefully reviewed the summaries of projected outcomes and evaluated the benefits and risks associated with the proposed action and each of the alternatives for each of the decision criteria. Each of the lead agencies conducted its review from its own management perspective. CENAO took the lead in building consensus among the lead agencies on a preferred alternative through development and application of a decision-making framework and a series of meetings and conference calls. Developing a framework for selecting the appropriate management alternative and making decisions in the field of environmental management poses a significant challenge because of the uncertainty and variability associated with the data and information available. The same data and information can be interpreted differently by different stakeholders involved in the decision-making process, and stakeholders tend to respond to complex challenges by using intuition and personal experience while adapting the policies of their organizations to arrive at the solution considered optimal from their own perspective. Transparent decision-making tools are required to structure the decision making process and organize all relevant information in the most effective manner in order to overcome such challenges.

Decision analysis is a process that systematically considers all information resulting from scientific studies, risk assessments, economic analysis, socio-political factors, and professional judgments and values. CENAO selected the Analytical Hierarchy Process (AHP) and the Multi-Attribute Value Theory (MAVT) as the best means of organizing the diverse and complex universe of information that had to be considered (Anninos 2009 in Appendix G). These tools

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Table 2-3. Summary of potential effects of the proposed action and Alternatives 1 through 5

Components of the Affected Environment	Proposed Action Introduce Suminoe Oyster	Alt. 1 No Action	Alt. 2 Expand Native Restoration	Alt. 3 Harvest Moratorium	Alt. 4 Aquaculture (native)	Alt. 5 Aquaculture (nonnative)
Total Bay-wide Oyster Population (attainment of PEIS goal)	Disease resistance and rapid growth of the Suminoe oyster could contribute to a substantial increase in the Bay-wide oyster population and the potential to attain the restoration goal; continuing habitat loss, vulnerability to predation, and competition with the Eastern oyster are some of the factors that could constrain or preclude such an increase; the time frame of any increase can not be predicted.	A small increase in oyster abundance in lower salinity waters in Maryland associated primarily with planting hatchery seed is likely; continuing loss of hard-bottom habitat is likely to preclude increases elsewhere in the Bay; development of disease resistance that could enhance population growth is possible but the time required is unknown and cannot be predicted; no chance of meeting PEIS goal within 10 years.	An increase in abundance may be possible in lower salinity waters in Maryland if reefs are sustained continually with hatchery raised seed. In high salinity waters, evidence of substantial increased abundance, development of disease resistance, and growing populations via natural recruitment has been documented using non-traditional methods (e.g., three dimensional reefs) on sanctuaries; shell accretion is outpacing shell degradation and loss. The time required for increased disease resistance to result in an increase in the Bay-wide oyster population is unknown. Continuing loss of hard-bottom habitat may limit increases elsewhere in the Bay, assuming only traditional restoration activities are implemented. Reaching the PEIS goal is unlikely within 10 years or after a longer period.	Greater increase than Alt. 1 and less than Alt. 2, primarily in lower salinity waters and closely associated with planting hatchery seed; factors that could not be accounted for in population projections (e.g., continuing loss of hard-bottom habitat) could preclude the increase; no chance of meeting PEIS goal within 10 years; development of disease resistance that could enhance population growth is possible but time required for increased disease resistance to result in an increase in the Bay-wide oyster population is unknown	Maximum annual production could be several times the current Bay-wide population of market-size oysters but only about half the PEIS harvest goal; the wild population is distributed through-out the Bay, whereas aquaculture probably would be concentrated in certain areas; the estimated maximum industry is unlikely to be attained.	Maximum annual production could be several times the current Bay-wide population of market-size oysters but only about half the PEIS harvest goal; the current population of native oysters is distributed throughout Bay, whereas aquaculture would be concentrated in certain areas; the maximum industry is unlikely to be attained; fewer oysters would be in the Bay than under Alt. 4 because of faster growth rate of triploid Suminoe oysters.
Native Oyster	High potential for competition with Suminoe oyster; occurrence of Suminoe oyster in mixed-species reefs in its native range suggests that coexistence is likely, but could range from local extinction to mixed-species reefs; possible benefit to the native oyster from increased shell provided by Suminoe oyster.	Effects as described for Total Bay-wide Oyster Population.	Effects as described for Total Bay-wide Oyster Population.	Effects as described for Total Bay-wide Oyster Population.	Effects as described for Total Bay-wide Oyster Population.	Potential effect if diploid Suminoe oysters introduced due to triploid aquaculture establish a reproductive population; the probability of such an introduction cannot be calculated but is considered to be likely over a long period
Other Ecosystem Components	Suminoe oyster is likely to provide ecosystem services similar to those provided by the Eastern oyster. If an introduction were successful, a large positive influence would be expected for reef-dependent fish; small potential negative influences for phytoplankton in local areas of high oyster abundance (via increased consumption by oysters), the benthic soft-bottom community (via reduction in the amount of organic matter from phytoplankton that reaches the sediment), zooplankton (via competition with oysters for phy-toplankton food in local areas of high oyster abundance), planktivorous fish (via reduction in phytoplankton food), and avian soft-bottom feeders (via indirect effects of potential reduction	Small potential negative influences for phytoplankton (via increased consumption by oysters), the benthic soft-bottom community (via reductions in the amount of organic matter from phytoplankton that reaches the sediment), zooplankton (via competition with oysters for phytoplankton food), planktivorous fish (via reduction in phytoplankton food), and avian soft-bottom feeders (via indirect effects of potential reduction in the soft-bottom community) as a result of increased oyster abundance in low-salinity zone in MD; small positive influences for all other receptor groups in zones with increased oyster biomass; most negative influences would occur in high salinity zones in VA; magnitude	Small influences, but larger than under Alt.1, given likely patterns of increase in oyster biomass over the state/salinity zones; small negative influences on phytoplankton and animals that depend on it, primarily in low-salinity areas in MD; small negative influence in higher salinity zones on species that depend on oysters for food or habitat or that are affected indirectly through changes in water quality; implementation of recently developed restoration methods (e.g., three-dimensional reefs) could result in positive influences in higher salinity areas.	Small positive influence in low-salinity areas in both states on species affected indirectly through changes in water quality (e.g., SAV); small negative influences on phytoplankton and animals that depend on it in those areas; small negative influence likely on species that depend on oysters for food or habitat in higher salinity zones in VA.	Minimal effect; some temporary beneficial influence if on-bottom techniques are used; positive influence through effects on water quality and habitat or food could be magnified if aquaculture is concentrated in restricted areas.	Minimal effects because confined culture is likely to be required; positive influence, particularly through effects on water quality, could be magnified if aquaculture is concentrated in restricted areas. Unquantifiable potential for unintended introduction of a diploid, reproducing stock of Suminoe oysters but expected to occur over a long period; effects on other ecosystem components would be as described for the proposed action but would take longer to be realized.

Table 2-3. (Continued)

Components of the Affected Environment	Proposed Action Introduce Suminoe Oyster	Alt. 1 No Action	Alt. 2 Expand Native Restoration	Alt. 3 Harvest Moratorium	Alt. 4 Aquaculture (native)	Alt. 5 Aquaculture (nonnative)
	in soft-bottom community); positive influences for all other receptor groups that benefit from increases in oyster biomass either directly as a source of food or habitat, or indirectly through changes in water quality (e.g., SAV benefits from increased water clarity). If an introduction is not successful, none of these effects would occur.	of effects would be small based on small changes in oyster abundance.				
Water Quality	If an introduction were successful, slight increases in dissolved oxygen (a few tenths of a milligram per liter) at the large scale of state/salinity zones; reductions in TSS of less than 6% on the large geographical scale; greater effects likely on smaller scales, which could result in local,(tributary) increases in SAV. No effects if an introduction were not successful.	No measurable effect.	Slight improvement in low-salinity areas in MD.	No measurable effect.	No change at the large scale of state/salinity zones; greater effects likely if aquaculture operations are concentrated in restricted areas.	No change at the large scale of state/salinity zones; greater effects likely if aquaculture operations are concentrated in restricted areas; effects might be greater than for Alt. 4 due to greater magnitude of filtering on a local basis; but potentially lower overall effects than Alt. 4 if few oysters were in the water.
Rare, Threatened, and Endangered Species	If an introduction were successful, potential slight negative effect on sturgeon due to reduction in soft-bottom habitat; potential positive effect for bald eagles and peregrine falcons due to increase in forage; potential minor negative effect for black skimmer, brown pelican, terns, and plovers if additional hatcheries are constructed; potential mixed effects on turtles through food chain interactions.	No effect on most species; potential small positive effect via food web for species that use low-salinity areas.	No effect on most species; potential small positive effect via food web for species that use low-salinity areas.	No effect on most species; potential small positive effect via food web for species that use low-salinity areas.	Construction of support facilities and operation and maintenance of aquaculture equipment could affect bald eagles and other birds and insects that nest along the shoreline; potential interference in foraging of black skimmer and terns; potential for entangling turtles if off-bottom techniques are used; effects would be limited to restricted areas.	Construction of support facil-ities and operation and main-tenance of aquaculture equip-ment could affect bald eagles and other birds and insects that nest along the shoreline; potential interference in forag-ing of black skimmer and terns; potential for entangling turtles if off-bottom tech-niques are used, slightly greater than Alt. 4 because confined aquaculture probably would be required; effects limited to restricted areas.
Essential Fish Habitat	Portions of Chesapeake Bay provide essential habitat for 21 species; if an introduction were successful, possible negative effects on early life stages of 2 species through indirect competi-tion with oysters for food; possible positive effects on 9 piscivorous species due to increase in forage fish; possible positive effects on 10 species considered to be reef-oriented. No effects with unsuccessful introduction	Small positive effects for species that use low-salinity areas; small negative effects for species that use higher salinity areas.	Small positive effects for species that use low-salinity areas; small negative effects for species that use higher salinity areas.	Small positive effects for species that use low-salinity areas; small negative effects for species that use higher salinity areas.	Some temporary positive benefit for reef-oriented species if on-bottom techniques are used.	Minimal effects on any species.

Table 2-3. (Continued)

Components of the Affected Environment	Proposed Action Introduce Suminoe Oyster	Alt. 1 No Action	Alt. 2 Expand Native Restoration	Alt. 3 Harvest Moratorium	Alt. 4 Aquaculture (native)	Alt. 5 Aquaculture (nonnative)
Culture	If an introduction were successful, potential to accomplish stakeholders' shared goal to restore oysters for multiple purposes; lack of success would preclude achieving multiple purposes. Stakeholders are uncertain about using a nonnative oyster for restoration.	Highly unlikely to achieve oyster restoration for multiple purposes; continued, slow decline in accomplishing ecological, economic and cultural/ community goals expected.	Highly unlikely to achieve oyster restoration for multiple purposes for most oyster stakeholders; localized successes in low-salinity areas may result in achieving goals for a few stakeholders in a few areas; implementation of recently developed restoration methods (e.g., three-dimensional reefs) could result in increased benefits in higher salinity areas.	Multiple benefits of oyster restoration would not be realized; significant numbers of watermen would leave the fishery, and business for most growers and processors would not increase.	Does not accomplish goals of cultural model of oyster restoration; localized ecological benefits dependent on private-enterprise decision-making; watermen not able to participate without consideration of economic constraints; any economic benefits realized only for private-sector growers and processors; results inconsistent with the stakeholders' goal of a sustainable population of oysters in the Bay.	Does not accomplish goals of cultural model of oyster restoration; localized ecological benefits dependent on private-enterprise decision-making; watermen not able to participate without consideration of economic constraints; any economic benefits realized only for private-sector growers and processors; results inconsistent with the stakeholders' goal of a sustainable population of oysters in the Bay.
Economics	Estimated present value cost to implement hypothetical introduction program over 10 years is $257.1M; estimation of fishery, processor and indirect benefits (e.g., enhanced recreational fishing) not possible due to uncertainty concerning possibility and rate of Suminoe oyster population growth; fishery and processor benefits of a successful introduction not likely to be realized for an extended period of time because a substantial proportion of introduced Suminoe oyster spat would be on unharvestable bars; unsuccessful introduction would produce no fishery, processor or indirect benefits.	Estimated present value cost to implement current restoration programs over 10 years is $95.2M; assuming future harvests are similar to those in recent years, present value revenues from fisheries over 10 years would be $9.6M; estimated net present value of revenues for processors at the wholesale level for oysters harvested in Maryland would be $39.3M; no positive indirect effects are likely.	Estimated present value cost to implement expanded restoration programs over 10 years is $345.5M; fishery and processor benefits likely to be greater than for Alt. 1; if the population of legal oysters on harvestable bars increased by a factor of five, fishery benefits would be on the order of $48 M; some positive indirect benefits (e.g., improved recreational fishing), greater than under Alt. 1.	Restoration costs the same as for Alt. 1 ($95.2M); compensation program assumed to equal the foregone net income to watermen of $9.6M, for total cost of $104.8M; no direct fisheries benefits over an assumed 10-year moratorium, but potential benefits if fishery is reopened in the future; some positive indirect benefits (e.g., improved recreational fishing), greater than under Alt. 1. Although eliminating harvest would result in some decrease in benefits for processors and consumers, the effect would be limited because imported oysters dominate the current market.	Analysis assumed no direct government investment in implementing expanded aquaculture (indirect costs for technical support were not estimated); assuming growth to maximum size within 10 years, expanded industry would contribute about $10.4M, net present value (ranging from $6M to $15M); net present value could be higher with triploids, but available data were insufficient to estimate the difference; minimal indirect benefits.	Analysis assumed no direct government investment in implementing expanded aquaculture (indirect costs for technical support were not estimated); assuming growth to maximum size within 10 years, expanded industry would contribute about $16.2M, net present value (ranging from $9M to $23M), a substantial economic advantage over Alt. 4; unsuitability for half-shell market could reduce or eliminate the advantage, as could higher cost for biosecurity and production of triploid spat; would support more firms and create more employment opportunities for watermen and others; minimal positive indirect benefits and potential for negative indirect benefits due to interference with activities like recreational boating.
Visual & Aesthetic Resources	If an introduction were successful, some visual benefits might increase (e.g., increased activity by skipjacks and watermen; support to retain aesthetic shoreline facilities such as shucking houses). No benefits with unsuccessful introduction.	Possible decline in visual benefits (e.g., decline in working oystermen).	Limited benefit to visual resources such as working oystermen and skipjacks because most increased oyster stock would be on sanctuaries and reserves.	Decrease in visual benefits from loss of working oystermen and aesthetic shoreline facilities.	Limited visual and aesthetic effects of shoreline facilities if on-bottom techniques are used; potential visual effects of buoys and floats used with off-bottom techniques.	Limited visual and aesthetic effects of shoreline facilities; greater potential visual effects of buoys and floats than for Alt. 4 because confined methods probably required.

Table 2-3. (Continued)

Components of the Affected Environment	Proposed Action Introduce Suminoe Oyster	Alt. 1 No Action	Alt. 2 Expand Native Restoration	Alt. 3 Harvest Moratorium	Alt. 4 Aquaculture (native)	Alt. 5 Aquaculture (nonnative)
Recreation	If an introduction were successful, Bay-wide benefit to recreational fishing for reef-oriented fish and waterfowl hunting for diving ducks; little to no effect on recreational swimming and boating; minor, temporary disruption of wildlife viewing, boating, and fishing during seed and shell planting. No benefits with unsuccessful introduction	No effect on recreational boating, swimming, hunting or wildlife viewing except for minor, temporary disruption of wildlife viewing, boating, and fishing during seed and shell planting.	Modest benefits to recreational fishing for reef-oriented fish and waterfowl hunting where oysters increase; minor, temporary disruption of wildlife viewing, boating, and fishing during seed and shell planting.	Modest benefits to recreational fishing for reef-oriented fish and waterfowl hunting where oysters increase; minor, temporary disruption of wild-life viewing, boating, and fishing during seed and shell planting; elimination of minimal conflicts between recreational boaters and watermen activities.	Minor temporary benefits to recreational fishing if on-bottom techniques are used; potential interference with boating, fishing, wildlife viewing, hunting, and swimming due to buoys, floats, and other operations if off-bottom techniques are used.	Greater potential for interference with boating, fishing, wildlife viewing, hunting, and swimming from buoys and floats because confined methods probably would be required; also potential negative effects on similar activities due to cultivation operations and activities.
Historic & Archaeological Resources	If an introduction were successful and if exploitation increased, potential effects on underwater resources present on or adjacent to existing oyster beds, depending on the harvest method (e.g., greatest potential with dredging, least with diver harvest); increased boat activity could affect shoreline resources. No effects with unsuccessful introduction.	Minimal change in current status of archeological resources; assumes no new dredging of buried shell deposits.	Minimal change in current status of archeological resources; assumes no new dredging of shell deposits and no new methods of shell cleaning	Reduced potential to affect archeological resources in or adjacent to existing oyster beds; assumes no new dredging of shell deposits and no new methods of shell cleaning	High potential for wide range of cultural resources in many potential aquaculture locations; submerged resources exposed to potential effects of bar preparation and harvest, assuming on-bottom methods; submerged resources exposed to effects of anchors or other mooring structures and disturbances of bottom when equipment is retrieved, assuming off-bottom methods; potential effects on terrestrial resources from any required construction of shoreline facilities; more extensive boat traffic in confined waters could increase wave action and cumulative disturbance of submerged or shoreline resources; overall, potential for effects is greater than for the proposed action and other non-aquaculture alternatives	High potential for wide range of cultural resources in many potential aquaculture locations; submerged resources exposed to potential effects of bar preparation and harvest, assuming on-bottom methods; submerged resources exposed to effects of anchors or other mooring structures and disturbances of bottom when equipment is retrieved, assuming off-bottom methods; potential effects on terrestrial resources from any required construction of shoreline facilities; more extensive boat traffic in confined waters could increase wave action and cumulative disturbance of submerged or shoreline resources; slightly less potential for effects than Alt. 4.
Wetlands	If an introduction were successful, possible indirect benefits to wetlands due to local improvements in water clarity or dampening of wave action, only in localized areas of high oyster abundance. No benefits with unsuccessful introduction	No measurable effect.	Minimal indirect benefits to wetlands as a result of improvements in water clarity or dampening of wave action in low-salinity waters in MD, but only in localized areas of high oyster abundance.	Minimal indirect benefits to wetlands as a result of improvements in water clarity or dampening of wave action in low-salinity waters in MD, but only in localized areas of high oyster abundance.	Potential for adverse effects if construction of shoreline facilities is required; use of floats could dampen wave action in restricted waters, reducing shoreline erosion and increasing accretion to the benefit of wetlands.	Potential for adverse effects if construction of any shoreline facilities is required; use of floats could dampen wave action in restricted waters, reducing shoreline erosion and increasing accretion to the benefit of wetlands.

Table 2-3. (Continued)

Components of the Affected Environment	Proposed Action Introduce Suminoe Oyster	Alt. 1 No Action	Alt. 2 Expand Native Restoration	Alt. 3 Harvest Moratorium	Alt. 4 Aquaculture (native)	Alt. 5 Aquaculture (nonnative)
Sanctuaries & Refuges	If an introduction were successful, no effects on freshwater sites, where oysters would not occur; increases in oysters in the vicinity of sites in higher salinity waters could benefit some species that use the sites. No benefits with unsuccessful introduction	No measurable effect.	Increase in oysters in low-salinity zones in MD might benefit the Eastern Neck refuge by reducing wave action and erosion and promoting small, localized improvements in water clarity; however, effects likely to be dispersed and minimal at any single location.	Increase in oysters in low-salinity zones in MD might benefit the Eastern Neck refuge by reducing wave action and erosion and promoting small, localized improvements in water clarity; however, effects likely to be dispersed and minimal at any single location.	Aquaculture unlikely to be sited adjacent to a sanctuary or refuge.	Aquaculture unlikely to be sited adjacent to a sanctuary or refuge.
Environmental Justice	If an introduction were successful, possible benefit to minorities or low-income individuals to the extent that they become involved in an expanded fishery. No benefits with unsuccessful introduction	No effect.	No effect.	No effect.	Possible benefit to minorities or low-income individuals to the extent that they become involved in an expanded industry.	Possible benefit to minorities or low-income individuals to the extent that they become involved in an expanded industry.
Air Quality	Slight localized decreases in air quality with increased boat operation for introduction programs and increased harvesting activity.	No effect.	Slight localized decrease in air quality due to increased operation of boats used in restoration programs.	Slight benefit to local air quality due to absence of operation of oystering vessels.	Slight localized decrease in air quality in the vicinity of concentrated aquaculture operations resulting from boat and truck traffic for deployment, maintenance, harvest, and transport of oysters.	Slight localized decrease in air quality in the vicinity of concentrated aquaculture operations resulting from boat and truck traffic for deployment, maintenance, harvest, and transport of oysters.
Public Safety and Fouling	If an introduction were successful, increased oyster populations could contribute to increase in stinging sea nettles, adversely affecting swimmers; Suminoe oysters may bioconcentrate contaminants to greater levels than Eastern oysters; potential for greater fouling of artificial surfaces by the Suminoe oyster. No such effects with an unsuccessful introduction.	No effect.	Slight potential for boating accidents associated with restoration activities.	Slight decrease in potential for boating accidents associated with oystermen activities.	Possible local effects on public safety factors such as emergency services, law enforcement, and fire protection, to the extent that a large-scale aquaculture industry with a significant staff and infrastructure develops; increased risk of accidents due to boat and truck traffic involved in deployment, maintenance, harvest, and transport of oysters.	Possible local effects on public safety factors such as emergency services, law enforcement, and fire protection, to the extent that a large-scale aquaculture industry with a significant staff and infrastructure develops; increased risk of accidents due to boat and truck traffic involved in deployment, maintenance, harvest, and transport of oysters. Possibility of a diploid Suminoe oyster population becoming established; consequences would be the same as for the proposed action..
Commercial Navigation	If an introduction were successful, creation of three-dimensional reefs in shallow waters could create new navigational hazards for shallow-draft commercial vessels that transit small inlets and tributaries in the Bay; no such effect if an introduction were unsuccessful	No effect.	Minor interference with commercial traffic during increased restoration activities.	Minor decrease in interference with commercial traffic with decrease in oystermen boating.	No effect.	No effect on commercial navigation; possibility for introduction of a diploid population of Suminoe oyster; consequences would be the same as for the proposed action.

Table 2-3. (Continued)

Components of the Affected Environment	Proposed Action Introduce Suminoe Oyster	Alt. 1 No Action	Alt. 2 Expand Native Restoration	Alt. 3 Harvest Moratorium	Alt. 4 Aquaculture (native)	Alt. 5 Aquaculture (nonnative)
Resources Outside Chesapeake Bay	A successful introduction in the Chesapeake Bay carries a high probability of dispersal of Suminoe oyster into adjacent coastal waters; expansion of species is more probable to the north than to the south; colonization of subtidal habitat is more likely than of intertidal habitat; influences on other components of adjacent ecosystems expected to be similar to those predicted for representative species of Chesapeake Bay; coexistence with Eastern oyster is likely, but ranging potentially from local dominance of one species or the other to mixed species reefs of different proportions.	No effect.	No effect.	No effect.	No effect.	Possibility of unintended introduction of a diploid, reproducing stock of Suminoe oysters; probability high that free diploids would be dispersed to coastal waters; effects on coastal ecosystems would be the same for the proposed action.

Table 2-4. Summary of environmental consequences of the combinations of alternatives

Components of the Affected Environment	Alt. 8a Eastern Oyster Only (Alternatives 2,3,&4)	Alt. 8b Eastern Oyster and Triploid Suminoe Oysters (Alternatives 2,3,4,&5)	Alt. 8c Eastern Oyster and Diploid and Triploid Suminoe Oysters (Proposed Action + Alternatives 2,3,4,&5)
Total Bay-wide Oyster Population (attainment of PEIS goal)	Abundance likely to increase in low-salinity waters and remain constant or continue to decline in higher salinity waters if traditional restoration methods are employed; greater population growth in higher salinities is possible if disease resistance develops in the population and with enhanced restoration techniques (e.g., construction of elevated reefs, rotating wild brood stock); local increases in areas where aquaculture operations are developed, but not likely to reach maximum economically viable size.	Abundance likely to increase in low-salinity waters and remain constant or continue to decline in high-salinity waters if traditional restoration methods are employed; some population growth possible in higher salinities if disease resistance develops in the population and with enhanced restoration techniques (e.g., construction of elevated reefs, rotating wild brood stock); local increases in abundance possible where aquaculture operations develop, but many constraints could limit ability to achieve maximum economically viable size; size of operations less than under 8a because use of triploid Suminoe oysters would require fewer oysters and less area; likely to result in an eventual introduction of reproductively viable Suminoe oysters	Greatest potential to significantly increase oyster abundance throughout the Chesapeake Bay but high uncertainty of realization due to many potentially constraining factors; localized increases in oyster abundance likely where aquaculture operations were established and expanded, but many constraints could limit ability to achieve maximum economically viable size; size of operations may be less than under 8a because use of triploid Suminoe oysters would require fewer oysters and less area.
Native Oyster	Same as described for Bay-wide oyster population.	Increases in native oyster likely in low-salinity waters in response to restoration programs (e.g., seed planting); some population growth possible in higher salinities if disease resistance develops in the population and with enhanced restoration techniques (e.g., construction of elevated reefs, rotating wild brood stock); potential adverse effects if diploid Suminoe oysters released due to triploid aquaculture were able to establish a reproductive population; accidental introduction considered to be likely.	If the introduction of the Suminoe oyster were successful, the probability of competition with the native oyster would be high; occurrence of Suminoe oyster in mixed-species reefs in its native range suggest coexistence is likely, but could range from local extinction to mixed-species reefs; possible benefit to the native oyster from increased shell provided by Suminoe oyster; failure of an introduction would result in no effect on the native oyster.
Other Ecosystem Components	Small negative influence on phytoplankton and receptors that depend on it in restricted areas with high oyster density; small positive influence expected for other receptors in low-salinity areas	Small negative influence on phytoplankton and receptors that depend on it in restricted areas with high oyster density; small positive influence expected for other receptors in low-salinity areas; possible minimal direct effects of aquaculture using off-bottom floats or cages through provision of habitat and food; small influence of aquaculture on other ecological receptors in areas where aquaculture is pursued; potential for some adverse effects on water quality, sediment, and benthos from concentrated shellfish aquaculture; risk of inadvertently releasing diploid Suminoe oysters into the Bay, which might establish a reproducing population of the species.	Suminoe oysters and native oysters would provide similar ecological services; greatest potential for positive influences on other ecological receptors that depend on oysters if introduction were successful; slight negative influences in localized areas due to reductions in the biomass of algae for species that rely on planktonic algae for food; an unsuccessful introduction would result in ecological services similar to those of Combination 8b
Water Quality	Local improvements in water quality in lower salinity waters in Maryland and higher salinity locations where concentrated aquaculture operations would be established.	Similar to 8a but addition of triploid Suminoe aquaculture increases potential for local water quality improvements in high-salinity waters in Virginia	Successful introduction of the Suminoe oyster could result in local improvements in water quality in high-salinity areas in Maryland and Virginia; some improvements at local and possibly tributary levels in low-salinity areas as a result of expanded native oyster restoration and in specific tributaries where aquaculture develops
Rare, Threatened, and Endangered Species	Refer to Table ES-1 for summary of effects for Alts. 2, 3 and 4; cumulative effects of all three alternatives likely to be greater than impacts of any individual alternative.	Refer to Table ES-1 for summary of effects for Alts. 2, 3, 4 and 5; cumulative effects of all four alternatives likely to be greater than effects of any individual alternative.	Refer to Table ES-1 for summary of effects of the proposed action and Alts. 2, 3, 4 and 5; cumulative effects of all five actions likely to be greater than effects of any individual action
Essential Fish Habitat	Potential effects likely to be negative for planktivorous fish, skates and flounders and positive for piscivorous fish and most reef-oriented fish; declines in oyster abundance could positively influence planktivorous fish, skates and flounders, and negatively influence the remaining species; local effects of aquaculture expected to be positive for reef-oriented fish, negative for skates and flounders, and to have no large-scale effect for the remaining species	Negative influence likely on planktivorous fish, skates, and flounders; positive influence on piscivorous fish and most reef-oriented fish in low-salinity areas; in high-salinity areas where oyster abundance would continue to decline, positive effects expected for planktivorous fish, skates, and flounders and negative effects other Federally managed species with EFH in the Bay; effects of aquaculture locally positive for reef-oriented fish and negative for skates and flounders	Greatest potential for both positive and negative effects on EFH if an introduction were successful; widespread increases in oyster abundance could adversely affect planktivorous fish and skates and flounder and positively affect piscivorous fish and most reef-oriented species; failure of introduction would result in no change in EFH.
Culture	Least likely to meet the goals shared by all stakeholders, at least with regard to size of the oyster stock and oyster fisheries, but least risk of incurring any adverse effects of a non-native oyster; a total moratorium on wild harvest would have significant adverse impacts on watermen and their communities	Unlikely to meet the goals shared by all stakeholders but includes some risk of incurring potential adverse effects of a non-native oyster; a total moratorium on wild harvest would have significant adverse impacts on watermen and their communities	Greatest potential for accomplishing the stakeholders' shared objectives of restoring the ecological, cultural, and economic benefits of oysters in Chesapeake Bay; but stakeholders expressed concerns about a nonnative oyster; a total moratorium on wild harvest would have significant adverse impacts on watermen and their communities

Table 2-4. (Continued)

Components of the Affected Environment	Alt. 8a Eastern Oyster Only	Alt. 8b Eastern Oyster and Triploid Suminoe Oysters	Alt. 8c Eastern Oyster and Diploid and Triploid Suminoe Oysters
Economics	Assuming restoration under Alt. 2 is in addition to that under Alt. 1 and buy-out cost of watermen is included, the present value 10-year cost of this combination would be $450.3 M; benefits cannot be quantified but would likely exceed $68M (sum of benefits of the three alternatives); indirect benefits likely to be minimal but not quantifiable.	Assuming restoration under Alt. 2 is in addition to that under Alt. 1, buy-out cost of watermen is included, and no state funding for aquaculture, present value,10-year cost of this combination would be the same as 8a ($450.3 M) but fishery benefits would be greater ($73.8M) due to inclusion of triploid Suminoe aquaculture.	Implementation cost for the proposed action includes the cost of Alt. 1; thus present value 10-year cost of this alternative, assuming no State funding for aquaculture, would be $612.2M; fishery, processor, and indirect benefits probably would be much higher than for 8a and 8b but cannot be quantified.
Visual & Aesthetic Resources and Recreation	Temporary negative effects on visual and aesthetic resources during periods when oyster spat are planted, and shell or other substrate is replenished; no direct effect on visual or aesthetic resources from native oyster aquaculture; decrease in visual benefits of activity of skipjacks and watermen under a moratorium.	Temporary negative effects on visual and aesthetic resources during periods when oyster spat are planted, and shell or other substrate is replenished; some direct effect on visual or aesthetic resources as well as on fishing, boating and hunting from Suminoe oyster aquaculture due to buoys and floats; decrease in visual benefits of activity of skipjacks and watermen under a moratorium.	Temporary negative effects on visual and aesthetic resources greater than under 8a and 8b during periods when greater quantities of oyster spat are planted, and shell or other substrate is replenished; some direct effect on visual or aesthetic resources as well as on fishing, boating, and hunting from Suminoe oyster aquaculture due to buoys and floats; decrease in visual benefits of activity of skipjacks and watermen under a moratorium.
Historic & Archaeological Resources	Expanded culture of the native oyster creates greatest potential to adversely affect historic and archeological resources; increased boat traffic from restoration activities as well as aquaculture maintenance, which could increase wave action, shore erosion and impact to shoreline historic and archeological resources..	Expanded cultivation of the native oyster offers greatest potential to adversely affect historic and archeological resources; cultivation of triploid Suminoe oysters may reduce the spatial extent of aquaculture areas to less than under 8a but could require constructing new shoreline hatcheries; increased boat traffic from restoration activities and aquaculture maintenance could increase wave action, shore erosion, and effects on shoreline historic and archeological resources	Expanded cultivation of the native oyster would offer the greatest potential to adversely affect historic and archeological resources; cultivation of triploid Suminoe oysters may reduce the spatial extent of aquaculture areas to less than under 8a but could require constructing new shoreline hatcheries; increased boat traffic from restoration activities and aquaculture maintenance could increase wave action, shore erosion, and effects on shoreline historic and archeological resources
Wetlands	Least potential for formation of new oyster reefs that could have beneficial effects on wetlands by reducing the erosive force of wave action.	Minimal potential for formation of new oyster reefs that could have beneficial effects on wetlands by reducing the erosive force of wave action; floats or buoys associated with Suminoe oyster aquaculture could reduce wave action and enhance wetland growth.	Greatest potential for formation of new oyster reefs that could have beneficial effects on wetlands by reducing the erosive force of wave action; floats or buoys associated with Suminoe oyster aquaculture could reduce wave action and enhance wetland growth.
Sanctuaries & Refuges	Potential but minimal benefits to local NERRS sites in low-salinity waters.	Potential minimal benefits to local NERRS sites in low-salinity waters.	Greatest potential for benefit to several NERRS sites by enhancing ecological services associated with oysters, if an introduction were successful.
Environmental Justice	No effects.	Minimal effects with potential benefits from increased aquaculture.	Minimal effects with potential benefits from increased aquaculture.
Air Quality	Truck and boat emissions are unlikely to result in an increase that would exceed the threshold that requires a Clean Air Act conformity statement	Truck and boat emissions are unlikely to result in an increase that would exceed the threshold that requires a Clean Air Act conformity statement	Truck and boat emissions are unlikely to result in an increase that would exceed the threshold that requires a Clean Air Act conformity statement
Public Safety and Fouling	Minimal change in public safety risk and no fouling risk.	Increased safety risks due to increased aquaculture operations.	Potential risk from diploid Suminoe oysters that may cause fouling or bioconcentrate contaminants; increased safety risks from increased aquaculture operations.
Commercial Navigation	No effect.	No effect.	Minimal effect if significant reefs were to develop.
Resources Outside Chesapeake Bay	No effect.	Any potential effects would arise from an accidental diploid introduction from triploid Suminoe aquaculture; if effects occurred they would be the same as the proposed action.	Same as the proposed action, as described in Table ES-1
Cumulative Effects	Increases in oyster populations in lower salinity sections of the Bay could result in local ecosystem changes that would counteract some of the cumulative effects of watershed development and pollutant loading to the Bay, although the effects are likely to be small	Same as 8a, except that because triploid Suminoe oysters are resistant to MSX and Dermo, they could be cultivated over a larger portion of the Bay than the native oyster; as a result, benefits could be realized over a greater geographical area throughout the Bay; because large-scale use of triploids in aquaculture over an extended period of time is likely to result in an unintended introduction of a reproducing population of Suminoe oysters in the Bay, over the long term the outcomes of this alternative would likely be similar to those of Alternative 8c	Highest potential to increase oyster abundance because it includes the proposed action; however, many factors could preclude that potential from being realized; could contribute significantly to local improvements in water quality; counteract the effects of such factors as watershed development and nutrient and sediment runoff; help to counteract the loss of hard-bottom habitat; contribute to enhancing populations of species that depend on oyster-reef habitat; reverse the decline in the Bay's oyster fishery and create a means of sustaining the watermen's culture in the Bay, exacerbate changes in the Bay's biodiversity, and contribute to further decline of the native oyster. A failed introduction would not contribute to any cumulative impacts on the Bay.

work by reducing the decision-making process into smaller parts and judging all possible pairs of alternatives (based on science, public comments, observations and professional opinion) on their relative effects on each of the evaluation criteria listed in the matrix presented in Section 2.3. These pair-wise judgments are then aggregated into larger categories that reflect stakeholders' priorities. The four priority categories established to select the preferred alternative were Environment and Ecological, Economic, Regulatory, and Social Effects. Applying this decision-making process resulted in ranking the category of Environment and Ecological as the highest priority and the category of Social Effects as the lowest priority. Ecosystem effects were ranked the most important of the specific decision criteria and visual and aesthetic effects were ranked the least important. The proposed action and the alternatives then were evaluated according to their effect on each individual criterion (i.e., very strong, strong, or moderate effect; positive or negative effect; very strong, strong or moderate uncertainty) within each of the priority categories. The details of the approach are presented in detail in a letter from Colonel Anninos of CENAO that is reproduced in Appendix G.

Implementing these decision-making tools resulted in ranking Alternative 8a the highest in three of the four priority categories. Alternative 8b was ranked highest in the Economic category. CENAO (Anninos 2009) acknowledged considerable uncertainty regarding the likelihood that Alternative 8a will result in establishing a sustainable Bay-wide oyster population and the possibility that the Bay-wide population of Eastern oysters will continue to decline in the future; however, CENAO considered Alternative 8a to be a conservative choice given the ecological uncertainties associated with implementing Alternative 8c and the strong opposition of most stakeholders to that alternative. CENAO considered the ecological uncertainties associated with Alternative 8b to be somewhat less than those associated with Alternative 8c, but those uncertainties could not be resolved with the data and information available for preparing the PEIS. CENAO has expressed the view that scientific research and scientifically monitored projects that focus on addressing and resolving the uncertainties associated with cultivating triploid Suminoe oysters would be valuable in future decision making. CENAO will consider proposals for such studies only when they are part of a framework of scientific research. The research framework must be reviewed and approved by the lead and cooperating agencies for this PEIS and PRFC. A key criterion for approving any such proposal will be to demonstrate that the proposal will not pose unacceptable ecological and socioeconomic risks. This criterion is consistent with the principles established in the Chesapeake Bay Program's 1993 *Policy for the Introduction of Non-Indigenous Aquatic Species*, to which the states of Maryland and Virginia are signatories. According to established regulatory processes, the review of any such proposal will include consultation with the Atlantic States Marine Fisheries Commission and a process agreed to by the partner agencies to obtain scientific advice and peer review similar to that used in developing this PEIS. If findings of such research were to reduce uncertainties and delineate a means of reducing the probability of unintended consequences, such information could be addressed in a Supplemental PEIS in which the option of triploid Suminoe oyster aquaculture could be revisited.

The State of Maryland (Griffin 2009) provided additional perspectives on the selection of a slightly modified version of Alternative 8a as the preferred alternative. Several key points from Maryland's perspective are presented here:

- Not all strategies for native oyster restoration have yet been exhausted; past native oyster restoration efforts were limited in scope (i.e., scale, lacked an ecological focus, and precluded a regional, large-scale response).

- The State of Maryland has adopted a "zero-risk" policy regarding the nonnative Suminoe oyster based upon the precautionary principle, the potential for significant negative ecological consequences, and the irreversible nature of an introduction of the species, whether intended or unintended.

- Preliminary evidence of the development of disease resistance among native oysters suggests the potential for enhancing that attribute through more restrictive management of the fishery.

- Every local and regional scientific organization and local, State, and Federal governmental body that commented on the Draft PEIS strongly opposed any use of the Suminoe oyster.

- An emphasis on cultivating triploid Suminoe oysters (e.g., Alternative 8b) would focus public attention on an aquaculture-specific strategy that, by definition, is expected to yield little benefit to the large task of restoring the oyster population in Chesapeake Bay.

2.5 PREFERRED ALTERNATIVE

Based on the current state of the science and extensive public discourse, the use of nonnative oysters in Chesapeake Bay, its tidal tributaries, and the coastal bays and waters of Maryland and Virginia poses unacceptable ecological risks; therefore, it is prudent for the U.S. Army Corps of Engineers, the State of Maryland, the Commonwealth of Virginia and Potomac River Fisheries Commission (PRFC) to adopt a native-oyster-only preferred alternative for the purposes of this PEIS.[12] In selecting the native-oyster alternative, the Corps, together with the cooperating Federal agencies, the State of Maryland, the Commonwealth of Virginia, and PRFC will remain fully committed to using only the native oyster to work towards revitalizing oyster restoration and aquaculture to meet commercial and ecological goals. Furthermore, the State of Maryland, the Commonwealth of Virginia, and PRFC will work towards implementing biologically and economically sustainable harvesting measures for the public oyster fishery. Finally, the Corps, together with the cooperating Federal agencies, the State of Maryland, the Commonwealth of Virginia, and PRFC will pursue the establishment of realistic metrics, accountability measures, and a performance-based adaptive management protocol for all efforts to revitalize the native oyster for purposes of achieving commercial and ecological goals. The selection of Alternative 8a as the preferred alternative is consistent with *Chesapeake Bay Policy for the Introduction of Non-Indigenous Aquatic Species* (CBP 1993), which requires that jurisdictions in the Chesapeake Bay basin oppose the first-time introduction of any non-

[12] Although the Executive Committee approved the phrase "for the purposes of this PEIS" as part of its joint statement to identify a preferred alternative, the members of the Committee acknowledge that none of the actions evaluated for this PEIS may be able to achieve the population goal defined in the statement of purpose for action (i.e., an oyster population that reaches a level of abundance in Chesapeake Bay that would support sustainable harvest comparable to harvest levels during the period 1920-1970).

indigenous aquatic species into the unconfined waters of the Chesapeake Bay and its tributaries unless environmental and economic evaluations confirm that risks associated with the first-time introduction are acceptably low.

Alternative 8a, as presented in the Draft PEIS, is a combination of Alternative 2 (enhancement of existing native oyster restoration efforts), Alternative 3 (harvest moratorium), and Alternative 4 (expanded native oyster aquaculture). The preferred alternative established by the lead agencies is Alternative 8a with some modifications. The modifications of the individual alternatives are based on relevant findings of analyses conducted during the preparation of this PEIS as well as input from stakeholders delivered in written correspondence and oral presentations at public meetings. Revisions of the components of Alternative 8a are as follows:

Alternative 2 – The conceptual implementation plans for enhanced native oyster restoration activities evaluated in the Draft PEIS consisted of "traditional" restoration activities conducted on a larger scale than any efforts to date. Recent restoration programs using non-traditional restoration methods were described in Section 1.3.1 (e.g., creation of elevated reefs; revolving brood stock hatchery operations to increase the rate of development of disease resistance; large-scale restoration in target tributaries). The promising findings of these recent programs suggest that the form of future restoration activities will differ substantially from the traditional restoration in both states. Although the kinds of future restoration activity may differ from those evaluated in some detail in the Draft PEIS, the level of activity will be substantially greater than past levels.

Alternative 3 – The conceptual implementation plan for this alternative evaluated in the Draft PEIS was a total moratorium on the harvest of wild oysters throughout the Bay. A key potential benefit of a harvest moratorium would be the enhancement of rate of development of disease resistance by reducing the removal of large oysters that may have developed some level of disease resistance and that have much greater reproductive potential than smaller, younger oysters. Although the premise of this alternative is that a transition to aquaculture would ameliorate the socio-cultural effects of a harvest moratorium, the rate at which such a transition might occur is uncertain, and the short-term effects on communities of watermen throughout the region would be substantial. In lieu of a total moratorium, the lead agencies envision implementing more restrictive oyster harvesting management regimes (e.g., annual harvest quotas, closed and open harvesting areas) that would be biologically and economically sustainable, that would include accountability measures, and that would minimize the effects of harvest on the potential development of disease resistance.

Alternative 4 –The Draft PEIS evaluated the expansion of oyster aquaculture as a private endeavor, whose magnitude would be limited only by the economic viability of the expanded operations. The State of Maryland has recognized the regulatory constraints that currently limit aquaculture operations in the state and is drafting legislation to remove those constraints. Both states may expand technical support programs for oyster aquaculture, particularly in the training of watermen who may be interested in transitioning from wild harvest to aquaculture. State expenditures to support aquaculture expansion may increase in the future and, thus, would be greater than those considered in this PEIS.

The slight modifications of the individual alternatives included in Preferred Alternative 8a are all based on and supported by the data and analyses included in this Final PEIS. All of the agencies recognize that the scale of implementation of Preferred Alternative 8a may be constrained by financial resources available for Bay-wide oyster restoration. The findings of this PEIS provide a basis for establishing priorities among the various actions that would be taken to ensure that all available funds are used as effectively as possible. The Baltimore and Norfolk Districts of the USACE are currently working with Maryland and Virginia to develop a master plan for restoring native oysters in Chesapeake Bay. That plan will be based upon information, data, and analyses developed for and presented in this PEIS. Development of that plan will enable the USACE to seek $50 million that was authorized through a 2007 amendment of the Water Resources Development Act, a first step in large-scale oyster restoration in the Bay. The native oyster master plan will serve as the road map for implementing Preferred Alternative 8a.

2.6 REGULATORY COMPLIANCE[13]

As an element of a Programmatic EIS, Preferred Alternative 8a establishes only a broad outline of the approach that the lead agencies will take in future actions to restore the Bay-wide oyster population. The representative implementation plans for each of the elements of this combination of alternatives that were created to facilitate the assessments required for the PEIS are conceptual; they do not represent planned, site-specific measures endorsed by the management agencies. Such measures will be specified in oyster management plans to be developed in response to findings of the Final PEIS. The selection of Alternative 8a as the preferred alternative eliminates the requirement to comply with some of the federal statutes that were listed in the Draft PEIS. The regulations and policies applicable solely to actions involving nonnative species are no longer relevant. All kinds of restoration activities involving the native oyster that are likely to be considered in the future involve placing various kinds of substrate on the bottom of the Bay, manipulating existing Bay substrate, or both. In addition, large-scale programs may require on-shore development of various kinds, such as building hatcheries or support facilities for expanded aquaculture operations. Regulatory requirements are likely to differ among projects, depending on their scope, magnitude, and location, but the potentially applicable statutes include the following:

- **NEPA of 1969**, as amended, 42 U.S.C. 432 et seq. - Federally funded projects must comply with NEPA. As noted in Section 1, subsequent to a PEIS, further NEPA analyses may be required in tiers (40 C.F.R. § 1508.28) upon definition of site-specific plans for implementing a preferred alternative. The findings of this PEIS will be used in subsequent NEPA analyses and decisions regarding site-specific plans for implementing the preferred alternative. The follow-on analyses are most likely to be presented in the form of relatively brief Environmental Assessments (EAs) and Findings of No Significant Impact (FONSIs).

[13] The descriptions of potentially applicable regulations are provided as a summary for the convenience of the reader. These descriptions are not complete statements of applicable law nor do they define the full requirements of any regulatory program. These descriptions should not be considered legal advice. For legal requirements, the reader is referred to the relevant statutes, regulations, executive orders, and other program documents.

- **Endangered Species Act of 1973**, as amended (Pub. L. 93-205; 16 U.S.C. 1532 et seq.) – requires an evaluation of the potential consequences of the program for Federally listed species within the project area and completion of Section 7 consultations with the FWS and NOAA's National Marine Fisheries Service (NMFS) as needed.

- **Magnuson-Stevens Fishery Conservation and Management Act**, as amended (Pub. L. 94-265; 16 U.S.C. 1801, et seq.) – requires evaluation of the potential consequences of the program for designated essential fish habitat for Federally managed species in the project area; NMFS reviews such evaluations.

- **National Historic Preservation Act of 1966**, as amended (Pub. L. 89-655; 16 U.S.C. 470. et seq.) – requires evaluation of the potential consequences of the program for historical and archeological resources in the project area; requires consultation with the appropriate State Historical Preservation Office(s) to ensure that cultural resources within the project area are identified and to obtain a formal opinion regarding potential loss or damage of important resources or to develop a Memorandum of Agreement about appropriate management or mitigation for any affected resources.

- **Fish and Wildlife Coordination Act of 1958**, as amended (Pub. L. 85-624; 16 U.S.C., 661 et seq.) – requires equal consideration for fish and wildlife resources in conjunction with water resources development programs and projects. It provides authority for the involvement of FWS and NMFS in evaluating potential effects on fish and wildlife and requires Federal agencies that construct, license, or permit water resource development projects to first consult with the FWS or NMFS, as appropriate, regarding the potential effects on fish and wildlife resources and measures to mitigate these effects.

- **Coastal Zone Management Act of 1972**, as amended (Pub. L. 92-583; 16 U.S.C. 1431, et seq.) – requires a Federal activity or program that may affect coastal areas to be consistent with applicable Coastal Zone Management (CZM) Plans and to receive a consistency determination from the applicable State CZM program(s) prior to taking action. According to legal precedent, states that have Federally approved CZM plans have the right to seek conditions on or prohibit the issuance of Federal permits and licenses that would affect those states (NRC 2004).

- **Clean Water Act of 1977**, as amended (Pub. L. 92-500; 33 U.S.C. 1251, et seq.) – Under Section 402, National Pollutant Discharge Elimination System permits could be required for stormwater discharges from, and sediment and erosion control at, construction sites (e.g., new hatcheries) or for other actions that might affect water quality (e.g., large-scale aquaculture operations). Depending on the nature of individual restoration projects, Maryland, Virginia, or both may have to apply to USACE for permits under Section 404 (a) or 404 (e), which regulate the discharge of dredged or fill material into waters of the United States. An Evaluation and Compliance Review of applications for such permits [per Section 404 (b)(1)]

probably could be incorporated into NEPA documents prepared for individual restoration projects if they are to be Federally funded.

- **Clean Air Act,** as amended (42 U.S.C. 7401 et seq.) – NEPA documents prepared for individual projects would be submitted to the Regional Administrator of USEPA for review pursuant to Sections 176 and 309 of the Clean Air Act. Conformity would depend on the nature and scope of activities that would generate air emissions and the attainment status of the project location.

- **Rivers and Harbors Act, Section 10** – requires permits from USACE for any work in, over, or under navigable waters of the United States. The USACE may consider some individual projects to be exempt.

- **Estuarine Areas Act** (16 U.S.C. 1221 et seq.) – Coordination with Federal and State resource agencies during the preparation of any NEPA documents for individual restoration projects would signify compliance with this act.

- **Federal Water Project Recreation Act,** as amended (16 U.S.C. 4601-12 et seq.), **Wild and Scenic Rivers Act, as amended** (16 U.S.C. 1271 et seq.), **and Land and Water Conservation fund Act of 1965,** as amended (16 U.S.C. 4601-4 et seq.) - Coordination with the National Park Ser4vice (NPS) and the relevant State agencies during the preparation of any NEPA documents for individual restoration projects would signify compliance with these acts.

Several Executive Orders and Memoranda also may apply to some projects intended to implement Preferred Alternative 8a:

- **Executive Order 11988, Floodplain Management** (24 May 1977, as amended by Executive Order 12148, 20 July 1979), **Executive Order 11990, Protection of Wetlands** (24 May 1977) – On-shore development, such as for hatcheries or support infrastructure for aquaculture operations, could occur in the floodplain or in wetland areas. NEPA documents prepared for individual restoration projects would need to be circulated for public review to comply with the provisions of these orders.

- **Executive Order 12898, Environmental Justice in Minority Populations and Low-Income Populations** (11 February 1994) - NEPA documents prepared for individual restoration projects would need to be circulated for public review to comply.

- **Executive Memorandum, Analysis of Impacts on Prime or Unique Agricultural Lands in Implementing NEPA** (11 August 1980) - On-shore development, such as for hatcheries or support infrastructure for aquaculture operations, could affect agricultural lands. NEPA documents prepared for individual restoration projects would need to be circulated for public review to comply.