3 Affected Environment

The physical and biological environment that may be affected by the proposed introduction of the Suminoe oyster or the alternatives presented in this Draft PEIS can be described from two perspectives, geographic and ecological. Geographically, the affected environment includes the entire historical range of the Eastern oyster within Chesapeake Bay and its tributaries, as well as estuaries along the Atlantic coast from Canada through the Gulf of Mexico to which the Suminoe oyster might spread if the species is introduced to Chesapeake Bay and is able to establish a reproductively viable population there. The primary focus of this Draft PEIS is to characterize the potential effects of the proposed action and alternatives within Chesapeake Bay, the site of the proposed action. (Section 3.15 briefly addresses potentially affected resources outside Chesapeake Bay.)

The surface area of Chesapeake Bay is approximately 3,225 square miles (8,386 km^2), and the shoreline stretches for 4,650 miles (7,441 km^2). One hundred-fifty rivers and streams empty into the Bay; the James, York, and Rappahannock rivers in Virginia and the Potomac and Susquehanna rivers in Maryland are the largest. Important smaller tributaries include the Patuxent and Severn rivers on Maryland's western shore and Elk, Sassafras, Chester, and Choptank rivers on the eastern shore. Salinity determines the potential geographic limit of oysters within the Bay. Oysters are not commonly found at salinities lower than 5 ppt, cannot survive for more than short periods at salinities lower than 2 ppt, and occur most commonly at higher salinities (Kennedy et al. 1996). Figure 3-1 shows the geographical range of the Eastern oyster in Chesapeake Bay.

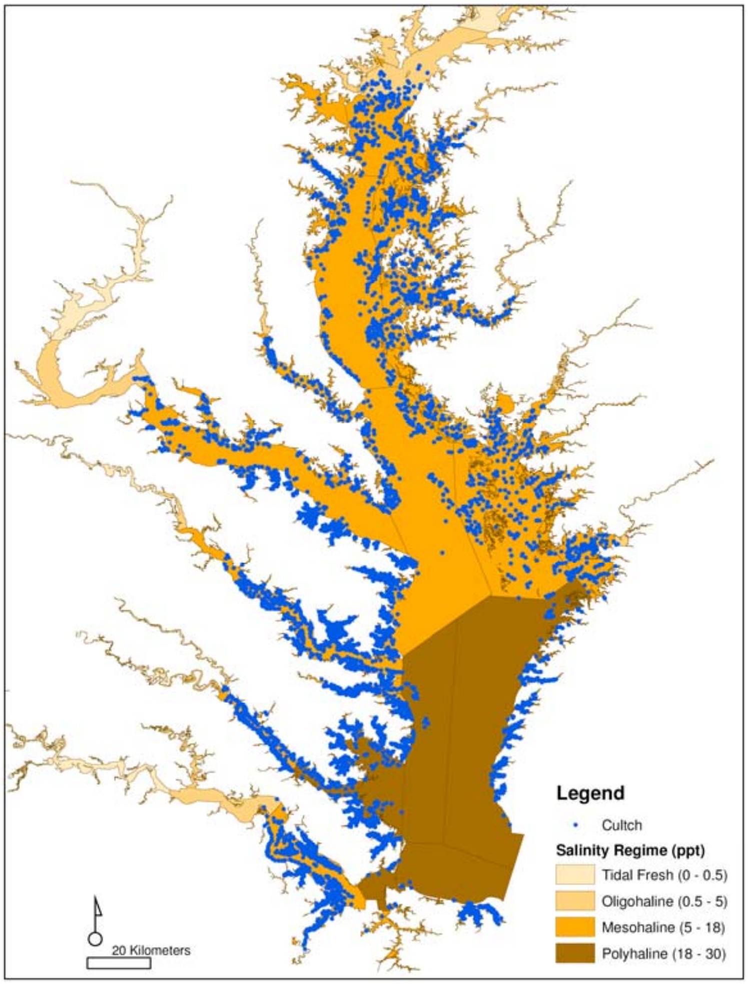

Figure 3-1. Distribution of existing oyster cultch in Chesapeake Bay, with salinity zones

From an ecological perspective, the affected environment being evaluated in this Draft PEIS includes all components of the ecosystem that could reasonably be expected to be influenced by the proposed action or alternative strategies for restoring the Bay's oyster population. Thorough general descriptions of the ecosystem of Chesapeake Bay are widely available in other documents (e.g., Lippson 1973; Funderburk et al. 1991). The following description of potentially affected ecological resources and interactions is based largely on the findings of an Ecological Risk Assessment (ERA) conducted to support the preparation of the Draft PEIS (Appendix B). Section 3.1 describes the roles of oysters in important ecosystem processes in Chesapeake Bay, as defined for the ERA. Section 3.2 describes other components of the ecosystem that might be affected by the proposed action or alternatives, as identified for the ERA. Subsequent sections describe all other potentially affected attributes of Chesapeake Bay.

3.1 OYSTERS AND THEIR ROLES IN ECOSYSTEM PROCESSES

An ecosystem is defined as a system composed of biotic communities and their abiotic environment interacting with each other (Odum 1953). The ecosystem of Chesapeake Bay includes the plants, animals, and physical conditions of the bay and the surrounding watershed, including humans. Oysters[1] interact with other organisms and the physical features of their habitat in ways that affect both their own population and the populations of other biota. Organisms that are affected by changes in the abundance of oysters also affect each other, thereby creating complex webs of interactions. These interactions, called ecosystem processes, may be direct or indirect. Ecosystem processes in Chesapeake Bay occur at varying levels of intensity and magnitude depending, in part, on the abundance of oysters. Because of the diverse ecosystem processes to which oysters contribute, biologists generally believe that increases in oyster abundance in Chesapeake Bay would contribute positively toward achieving goals established by the CBP for restoring the Bay's ecosystem. The following discussion summarizes the major relationships between oysters and the other components of the Chesapeake Bay ecosystem and describes the mechanisms through which changes in oyster production and abundance might affect ecosystem processes.

The term "mechanism of interaction" is used throughout this section in the context of an ecological risk assessment. A mechanism does not necessarily equate to an actual effect but rather describes how species interact in the ecosystem. Potential mechanisms of interaction must be identified in order to assess the probability and magnitude of effects. For example, competition for food is one mechanism by which oysters might interact with other filter feeding organisms in the Bay; however, under current circumstances the availability of food is not a limiting factor for filter feeders in most parts of Chesapeake Bay, and no effects related to competition for food would be expected on a Bay-wide scale. This section of the Draft PEIS describes the major mechanisms of direct and indirect interaction between oysters and other components of the ecosystem; the expected effects of the proposed action and alternatives that might occur through those mechanisms are described in Section 4, Environmental Consequences.

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[1] Throughout this section, the term "oyster" refers to both the native Eastern oyster (*C. virginica*) and the Suminoe oyster (*C. ariakensis)* unless otherwise indicated. Although the magnitude of some of the interactions and processes described here may differ between the two species, the nature of the interactions and the processes are considered to be the same for both.

The status of the native oyster (*Crassostrea virginica)* in the Bay and its current estimated population size were described in detail in Section 1 of this Draft PEIS. An important factor that controls the abundance of oysters, and many other species, at various locations throughout the Bay is the volume of sediment and nutrients being carried into the Bay. Sediment is carried into the estuary by rivers that drain the Bay's extensive watershed, eroded from the Bay's lengthy shoreline, transported up-estuary from the Atlantic Ocean through the mouth of the Bay, introduced from the atmosphere, or generated by primary productivity. The contributions of each of these sources of sediment vary in different areas of the Bay, and the proportions of particles of sand, silt, and clay that compose the sediment also vary. Nutrients attached to sediment contribute to determining the amount of algae and other small primary producers, collectively called phytoplankton, that grow in the water. Phytoplankton provides food for oysters and small invertebrate animals called zooplankton, which in turn provide food for fish and other animals in the Bay. Small increases in nutrient loads can increase production throughout the food chain, all the way up to fish and other animals. Large nutrient increases can cause phytoplankton blooms that reduce the penetration of light through the water and adversely affect water quality in the Bay (Sections 3.2.4 and 3.3). Shading by phytoplankton and sediment suspended in the water reduces the amount of light available to support the growth of submerged aquatic vegetation (SAV), which provides habitat for many species and helps to trap sediment. As the abundance of SAV decreases, the amount of oxygen in the Bay also decreases because fewer plants are present to produce oxygen through photosynthesis. If dissolved oxygen is severely depleted, oysters and fish may become stressed or die.

Although transportation and deposition of some sediment in the Bay is a natural process, excess sedimentation resulting from human activities within the watershed is one of the most important contributors to degraded water quality in the Bay (Mackenzie 2007; Langland and Cronin 2003). Human activities have increased the volume of sediment and nutrients that enter the Bay and have contributed to altering the system from one dominated by benthic production and SAV to one heavily influenced by pelagic (water column) processes (mainly phytoplankton production). Although food for oysters is plentiful under these conditions, the amount of habitat available for them decreases because the hard surfaces that oyster larvae require to settle and grow become covered with sediment and are no longer suitable for oysters. When shading caused by excessive amounts of suspended sediment and phytoplankton in the water kills SAV, the concentration of sediment in the water increases, in part because the SAV is no longer there to trap it. Eventually suspended sediment settles to the bottom throughout the Bay. As it settles, sediment covers oyster reefs and other hard-bottom substrates that oysters need to settle on; consequently, sedimentation has dramatically reduced the amount of hard-bottom habitat in Chesapeake Bay (Smith et al. 2005), which may limit future increases in oyster abundance.

Several historical and current surveys of the bottom of the Bay illustrate the magnitude of the effect of sedimentation. Oyster grounds in Chesapeake Bay once encompassed more than 450,000 acres. The Yates Survey (1911) and the Maryland Bay Bottom Survey (1985) charted about 215,000 acres of historic oyster grounds in Maryland. The Baylor survey (1894) charted 243,000 acres of historic oyster grounds in Virginia. It is estimated that only about half of these historic oyster grounds were productive habitat because the original reefs were interlaced with patches of mud and sand. Most of the historical oyster shell substrate in Chesapeake Bay is now covered with sediment. The amount of oyster habitat currently remaining in the Bay and the method used to estimate it are described in Appendix A. New acoustic techniques for surveying the bottom suggest that less than 1% of Maryland's historical oyster grounds can be classified as clean or lightly sedimented shell. Most of such suitable substrate occurs within areas where the State has planted shell recently; however, planted shell becomes covered with sediment after an average of 5.5 years (Smith et al. 2005). Excessive sediment loads delivered by increased runoff bury shell faster than current oyster populations can create new shell, resulting in a severe and continuing decline in habitat suitable for oysters.

Oysters can affect other organisms by changing the physical and chemical environment of the Bay ecosystem. Oysters filter water while feeding, thereby removing sediment and other particles from the water and depositing it on the bottom in pellets called pseudo-feces. Filtration by large numbers of oysters can reduce the time that sediment remains suspended in the water column and increase the clarity of the filtered water. Oysters' pseudo-feces are rich in nutrients and, therefore, help to support primary production among bottom-dwelling organisms in areas immediately surrounding oyster reefs. Local nutrient enrichment also stimulates the exchange of various forms of nitrogen and nitrogen compounds from one part of the system to another (Newell et al. 2002). In addition to filtering suspended particles, large populations of oysters create bars and reefs of accumulated shell that are unique among kinds of habitat in Chesapeake Bay. Successive generations of oysters growing on the shells of previous generations gradually accrete large, three-dimensional structures that can compensate for sedimentation, if the rate of growth of the oyster reef exceeds the rate of sedimentation. Oyster reefs provide important and unique structural habitat for fish and invertebrates, as illustrated by the large variety of organisms that can be found on these structures (Rodney and Paynter 2006). In the absence of functioning oyster reefs, some organisms compete with oysters for limited space on hard surfaces such as pilings, rip-rap, and boat bottoms. Oyster reefs are such important components of the Bay ecosystem that oysters have been considered "keystone species" and "ecosystem engineers" (Jones et al. 1994; NRC 2004). When oysters were abundant, expansive areas of reef habitat, relatively clear water, and large areas of SAV characterized the Bay. Now that oyster abundance is low, the density of phytoplankton has increased, areas covered by reef and SAV have contracted, and the species composition of the Bay has changed in response to the altered conditions (Newell 1988).

Oysters can affect other organisms directly through biological mechanisms of interaction such as competition and predation. Oysters feed primarily on phytoplankton and may compete for food with other filter-feeding invertebrates (e.g., hard clams, *Mercenaria mercenaria*, and Baltic clams, *Macoma balthica*), planktivorous fish (i.e., fish that eat minute, free-floating plants and animals collectively called plankton), and zooplankton (i.e., minute aquatic invertebrate animals) (Kennedy et al. 1996; NRC 2004). The extent of such competition depends on the food preferences of the competing species; moreover, significant competition is likely to occur only when the concentration of phytoplankton in the water is low in relation to the number of consumers. Currently, competition for phytoplankton is believed to be minimal because oyster numbers are low compared with their historical abundance and because nutrient input and the resultant production of phytoplankton are high (Newell 1988). Factors such as predation, disease, and the limited availability of habitat probably are more important than competition for food in controlling the abundance of planktivorous species now. Predation on oysters is an important interaction in the Bay ecosystem. For example, blue crabs (*Callinectes sapidus*), cow-nosed rays (*Rhinoptera bonasus*), and at least one species of bird, the American oystercatcher (*Haematopus palliates*), prey on oysters directly. Humans are major predators of oysters, and harvest of oysters by humans has historically been biologically, economically, and culturally important in the Chesapeake Bay region (Newell 1988).

Oysters can affect other organisms indirectly when the direct effects of changes in oyster abundance on some species have cascading effects on other species. Such indirect interactions with oysters could extend all the way up the food chain to high-level predators (i.e., trophic interactions). For example, if populations of reef-oriented fish such as the naked goby (*Gobiosoma bosci*) decrease because of a decline in oysters and the oyster reefs that are important habitat for gobies, the numbers of larger fish that consume gobies might also decrease, and the numbers of birds and mammals that consume the large fish might similarly decrease. Many of the species described in the ERA for Oyster Restoration Alternatives (Appendix B) are potentially affected by oysters through indirect trophic interactions. Some species may be affected through a complex series of indirect interactions via multiple pathways, which makes predicting the effects of changes in oyster abundance difficult. Evaluating the indirect effects of oysters through trophic interactions is challenging because negative feedback relationships sometimes contribute to population regulation. For example, an increase in the abundance of planktivorous fish, which are food for larger predatory fish, may actually limit the number of predators that reach adulthood because all fish consume plankton as larvae. When populations of planktivorous fish are very large, competition for plankton can limit the number of predators that survive the larval period. The indirect effects of changes in oyster abundance on other species in the Bay are much more difficult to quantify than the effects of direct biological interactions.

Oysters are affected by the physical characteristics of their environment, including climate. Climatic conditions affect oyster populations through interannual differences in precipitation runoff, which influences water temperature, salinity, and sediment load in the Bay. The Chesapeake Bay has a moderate climate with average air temperature of 13°C (55° F), and mean annual temperature range of about 0° to 25°C (32° - 77°F). Winter temperatures average 1°C (34°F), and summer temperatures average 24°C (75°F). Mean annual rainfall for the Chesapeake watershed is 1,067 mm (39.4 in), most of which occurs during the spring and late fall. Water temperatures range from 0°C to 29°C (0° to 84°F) and are highly correlated with seasonal air temperatures due to the relatively shallow depth of the Bay. Both the Eastern and Suminoe oyster are able to persist throughout the range of climatic conditions typical for the Bay (NRC 2004). Survival rates are likely to differ between the two species during dry years, when discharge into the Bay is relatively low, and water temperature and salinity are high. Warm, salty water favors the oyster diseases Dermo and MSX (Section 1.2); therefore, the greater disease resistance of the Suminoe oyster could result in differing survival rates between the two species during dry years. Wet years, which may reduce disease prevalence, also increase the amount of sediment that is washed into the Bay, which can negatively affect oysters though further siltation of oyster bars.

Historically, the region’s climate has tended to shift between wet and dry conditions over several years. That is, wet or dry years tended to occur in clusters through time. During the last 10 years, however, rainfall patterns have shifted between wet and dry years more randomly (Figure 3-2). These unpredictable changes in climate are expected to become more prevalent as average global temperatures rise, following the current trend (Jones and Moberg 2003). According to the U.S. Global Change Research Program (2000), “this rise is very likely to be associated with more extreme precipitation and faster evaporation of water, leading to greater frequency of both very wet and very dry conditions." Hurricanes and severe tropical storms strike the Chesapeake Bay area during some years. Storms that cause large-scale oyster mortality are relatively rare but can have important population-level effects when they occur. For example, nearly all oysters north of the Chesapeake Bay Bridge died due to a reduction in DO and an influx of sediment and pollutants following the landfall of Hurricane Agnes in 1972 (http://www.publicaffairs.noaa .gov/releases2003/sep03/noaa03r450.html).

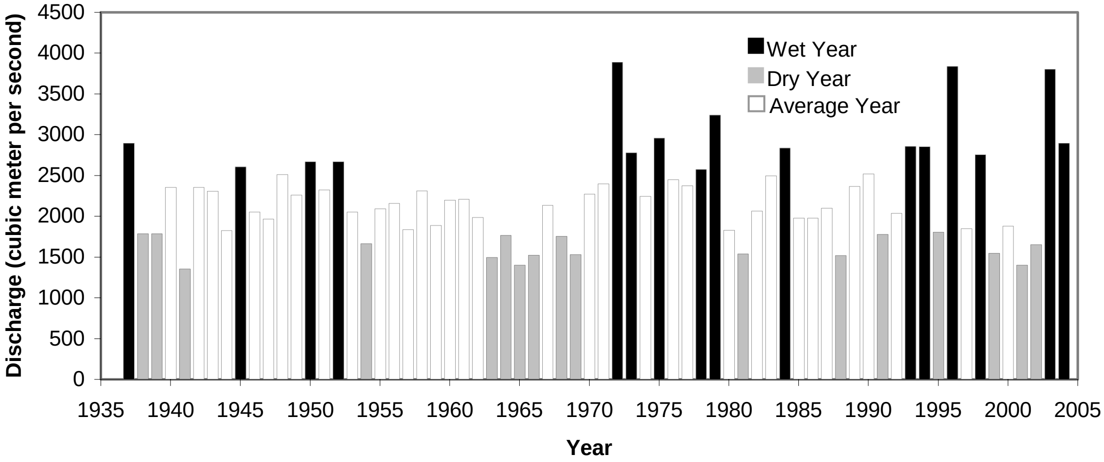

Figure 3-2. Mean annual discharge into the Chesapeake Bay between 1935 and 2005 (Source: U.S. Geological Survey)

Land use also can affect oysters because it influences the amounts of sediment and nutrients that are washed into the Bay. Before European settlement, forests covered about 95% of the Chesapeake Bay watershed. Forests act as filters, capturing rainfall, trapping nutrients, and reducing stormwater runoff. Forests also protect soil from erosion and stabilize stream banks. Now, forests are concentrated in the Appalachian region of Pennsylvania and West Virginia and account for only 60% of the total land area in the watershed. Agricultural land, which contributes more sediment and nutrients than forest, is most common in the coastal lowlands north and east of the Bay and accounts for 28% of the total land area of the watershed. Developed lands and wetlands each account for about 3% to 4% of the total land area; the remaining 5% is open water and other land uses.

Urban development and population growth affect oysters because impervious surfaces created by roads, parking lots, buildings, and other structures result in increased runoff, which alters salinity patterns, increases sediment loading, and contributes to nutrient enrichment within the Bay. Extensive development also contributes to nutrient enrichment in the Bay, which may lead to algal blooms. Municipal and industrial wastewater treatment facilities accounted for 21% of the total nitrogen load delivered to the Chesapeake Bay in 2001. More than 300 municipal wastewater facilities and 58 industrial facilities collectively add 59 million pounds of nitrogen to Chesapeake Bay each year. Between 1970 and 1990, the human population in the Chesapeake Bay region grew by 21%, and housing density increased by 49% to accommodate the new residents. From 1990 through 2000, the human population in the Chesapeake Bay watershed increased 8%, and the amount of impervious cover (land impenetrable to water) increased 41%

(http://www.chesapeakebay.net/status_population.aspx?menuitem=19842). The population is expected to grow from about 16 million in 2000 to 18 million by 2020. This population increase will bring additional development that is likely to exacerbate the problems of heavy erosion and sedimentation in the Bay; however, some of these increases may be offset by efforts to reduce and remove nutrients.

3.2 OTHER POTENTIALLY AFFECTED COMPONENTS OF THE ECOSYSTEM

Given the complexity of ecosystem processes and species interactions within Chesapeake Bay, describing the potential effects of changes in the abundance of oysters on every species present is not possible within a reasonable time frame and level of effort. To make the ERA and PEIS efforts manageable, the suite of interactions to be considered was simplified by identifying groups of species that collectively represent the major functional components of the Bay ecosystem in consultation with the Ecological Risk Assessment Advisory Group (ERAAG), describing a representative species from each group, and evaluating the effects of each oyster-restoration alternative on each representative group. Representative groups and species were selected based on characteristics of the Bay ecosystem as described in published literature (e.g., Funderburk et al. 1991) and the expert opinions of biologists participating in the development of the ERA and this Draft PEIS. Although the assessment is limited to the selected representatives, the underlying assumption is that effects will be comparable for other species that perform the same ecological function within the Bay ecosystem. For example, blue fish (*Pomatomus saltatrix*) and striped bass (*Morone saxatilus*) are described as representatives of predatory fishes, but the effects of oyster restoration under each alternative would be expected to be similar for other predators, such as weakfish (*Cynoscion regalis*). The following sections describe the ecological components of the Chesapeake Bay ecosystem addressed in the ERA and this Draft PEIS, the species selected to represent each one, and the kinds of interactions or ecological links that may occur between oysters and the selected ecosystem components (Table 3-1). These interactions served as the basis for the risk assessment analyses described in Appendix B.

3.2.1 Soft-bottom Benthos

Benthic (i.e., bottom-dwelling) organisms live in a variety of environments in Chesapeake Bay, ranging from intertidal flats to deep channels. Distinct benthic communities are associated with different habitats, including mudflats, marshes, SAV beds, and oyster reefs. The benthos of habitats that remain submerged during low tide occupy mostly soft substrates. Benthic communities are structured by the physical and chemical environment as well as by complex interactions among species in the ecosystem. As a result, they can serve as an indicator of the environmental status of the location in which they reside. In 2006, 59% of the Bay's benthic habitat was considered degraded according to the Benthic Index of Biotic Integrity (CBP 2007). The percentage of habitat classified as degraded in 2006 was substantially greater than the values for 2004 and 2005, probably as a result of prolonged persistence of low DO during 2006. Research has suggested that benthic health could be improved by reducing the amounts of nutrients, sediments, and chemical contaminants entering the Bay (CBP 2007).

Table 3-1. Summary of potentially affected ecosystem components and representative species evaluated in the ERA (Appendix B).

Ecosystem Component	Representative Species	Nature of Ecological Link with Oysters
Oyster population	Eastern oyster (*Crassostrea virginica*)	Direct competition for food and space
Soft-bottom benthos	Hard clam (*Mercenaria mercenaria*)	Direct competition for food and space
	Baltic clam (*Macoma balthica*)	
SAV	All species	Indirect via oysters' influences on water quality
Blue crab (*Callinectes sapidus*)		Indirect trophic interactions
Phytoplankton	All species	Direct predation by oysters; indirect via oysters' influences on water quality
Zooplankton	*Acartia tonsa*	Indirect trophic interactions
Planktivorous fish	Bay anchovy (*Anchoa mitchilli*)	Indirect trophic interactions
	Menhaden (*Brevoortia tyrannus*)	Direct competition for food
Reef-oriented fish	Naked goby *(Gobiosoma bosci)*	Direct via habitat creation by oysters
	Black sea bass *(Centropristis striata)*	
	Atlantic croaker *(Micropogonias undulates)*	
Piscivorous fish	Striped bass (*Morone saxatilus*)	Indirect trophic interactions
	Bluefish (*Pomatomus saltatrix*)	
Reptiles	Loggerhead turtle (*Caretta caretta*)	Indirect trophic interactions
	Diamondback terrapin (*Malaclemys terrapin*)	
Avian oyster predators	Oystercatcher (*Haematopus palliates*)	Direct via change in food availability
Avian piscivores	Bald eagle (*Haliaeetus leucocephalus*)	Indirect trophic interactions
	Osprey (*Pandion haliaetus)*	
Avian bottom feeders	Black duck (*Ana rubripes*)	Indirect trophic interactions
	Canvasback duck (*Aythya valisineria*)	
Mammalian piscivores	Racoon (*Procyon lotor)*	Indirect trophic interactions
	River otter (*Lontra canadensis)*	

In Chesapeake Bay, the distribution and kinds of benthic organisms (> 500 µm) are strongly correlated with salinity and are further influenced by the kind of sediment, patterns of DO, and other physical factors in a given location (Diaz and Schaffner 1990; Llansó et al. 2002). The variety and density of organisms generally increase with increasing salinity. Tidal freshwater habitats are numerically dominated by tubeworms and insect larvae, and the Asian clam (*Corbicula fluminea)* contributes to high biomass. Mildly to moderately salty regions exhibit a greater variety of organisms and feeding types than are observed in freshwater habitats. The shoals and channels of regions of medium salinity (i.e., mesohaline – 5 to 18 ppt) exhibit high densities of bivalves (e.g., clams, oysters), except where low oxygen conditions prevail. Segmented worms (i.e., polychaete annelids), small crustacea, and suspension-feeding bivalves (*Rangia cuneata, Macoma* spp.) dominate these areas. The blue crab (*Callinectes sapidus*) is an important predator of bivalves, such as young oysters, in these regions of the estuary. High-salinity areas are dominated by a large variety of organisms. Suspension feeding polychaetes and tunicates are important contributors to biomass in high-salinity environments, and their filtering capacity is comparable to that of bivalves in low-salinity environments. Oyster reefs and the polychaete annelid *Chaetopterus variopedatus* provide hard substrate for species-rich epifaunal (i.e., species that live on the surface of the bottom) communities (Dauer et al. 1982; Schaffner 1990). Benthic communities play a central role in the transfer of materials from the water column to higher levels in the food web. Much of the productivity of fisheries in Chesapeake Bay is linked directly to the benthos through feeding (Virnstein 1977; Holland et al. 1988; Diaz and Schaffner 1990).

The soft-bottom benthic community interacts with oysters in a variety of ways. Some of the soft-bottom species can be found on substrate created by oysters, which can serve as a refuge from predation. Oysters augment the organic content of sediments in adjacent soft-bottom habitats through biodeposition, which increases the nutritive potential of the substrate for organisms occupying those habitats (Newell 1988; Dame 1993). Biodeposits contain a large proportion of organic matter (Newell and Jordan 1983) and provide a medium for the growth of bacteria, which deposit-feeding benthic organisms depend upon for energy (Levinton et al. 2001). An increase in biodeposits generally produces increased benthic productivity in the area immediately surrounding an oyster bed or reef. Biodeposits also change the physical and chemical characteristics of local sediments, including sediment texture, grain size, and chemical gradients (Pryor 1975; Risk and Moffat 1977; Dame 1993). These changes tend to increase the diversity of benthic fauna locally.

Suspension-feeding bivalves, such as clams, dominate the soft-bottom benthic community in mesohaline regions of Chesapeake Bay (Holland et al. 1987). Two key species of bivalves considered to be representative of the soft-bottom benthic community are the hard clam (*Mercenaria mercenaria*) and the Baltic clam (*Macoma balthica*). These two species occupy different salinity regimes covering the range of salinities in which oysters occur (*M. mercenaria* is found predominantly in higher salinities and *M. balthica* in lower salinities), and both are filter-feeding infauna (i.e., species that live completely or mostly buried within the bottom sediment). The major potential mechanisms for these species to interact with oysters are through competition for food and space. As noted earlier, however, the existence of a mechanism of interaction does not necessarily mean that the proposed action or alternatives would produce a related effect; identifying the mechanism provides the means of assessing whether an effect might occur and helps to ensure a comprehensive evaluation of potential effects. Competition for space could occur on a local scale if an increase in oyster population causes an expansion of hard-bottom habitat over existing soft-bottom habitat. Increased competition between clams and oysters for food could result in a reduction in the abundance of infaunal bivalves. Clams are important food items for blue crabs and epibenthic fish (Hines et al. 1990); therefore, the potential for reduction in the abundance of infaunal bivalves due to an increase in the abundance of oysters is an indirect mechanism of interaction that could trigger a shift in the prey selections of crabs from clams to oysters.

3.2.2 Submerged Aquatic Vegetation

The term submerged aquatic vegetation (SAV) refers to both marine angiosperms (the so-called true seagrasses) and freshwater macrophytes that occupy Chesapeake Bay and its tributaries (http://www.vims.edu/bio/sav/). SAV encompasses 19 taxa from 10 families of vascular macrophytes and 3 taxa from one family of freshwater macrophytic algae, the

Characeae, but excludes all other algae. The SAV community as a whole was evaluated as an important ecological component of the Bay (Table 3-1). SAV were considered collectively because monitoring data for SAV is recorded as acreage in the Bay (regardless of species), and the model used to assess the responses of SAV to changes in oyster abundance does not distinguish among species. The SAV community of Chesapeake Bay and its tidal tributaries includes 15 species (exclusive of the algae). Eelgrass (*Zostera marina*) is found only in the lower reaches of the Bay. Nonnative Eurasian watermilfoil (*Myriophyllum spicatum)*, sago pondweed (*Stuckenia pectinata*), redhead grass (*Potamogeton perfoliatus*), wild celery (*Vallisneria americana*), water starwort (*Callitriche* sp.), curly pondweed (*Potamogeton crispus*), common elodea (*Elodea canadensis*), water stargrass (*Heteranthera dubia*), hydrilla (*Hydrilla verticillata*), coontail (*Ceratophyllum demersum*), southern naiad (*Najas guadalupensis*), and spiny naiad (*Najas minor*) are less tolerant of high salinities and are found in the middle and upper reaches of the Bay (SAV Restoration Workshop 2005; Orth et al. 1979; Orth and Moore 1981, 1984). Widgeon grass (*Ruppia maritima*) and horned pondweed (*Zannichellia palustris*) tolerate a wide range of salinities and are found throughout Chesapeake Bay. SAV plays a critical role in the Chesapeake Bay ecosystem, serving as a sediment stabilizer, important habitat for juvenile fish and crabs, food for waterfowl, and a seasonal nutrient sink that can help offset the growth of algae. Due to degradation of water quality in Chesapeake Bay, SAV populations today are greatly reduced in both density and abundance compared with levels documented in the early 1960s (Kemp et al. 2005). In 2006, SAV decreased by 25% throughout the Bay, reaching the lowest level since 1989. That level is only about 32% of the CBP’s restoration goal for SAV (CBP 2007).

Oysters can interact with the SAV community indirectly by inducing changes in water quality and providing physical protection for plants. Filtration by oysters can increase the penetration of light through the water due to the removal of suspended sediment and phytoplankton, thereby potentially improving growing conditions for SAV. SAV is known to benefit from the presence of oyster reefs, which dampen wave energy (Turner et al. 1999; Heiss and Bortone 1999). Historically, the presence of tall, three-dimensional oyster bars in fairly deep water may have reduced shoreline wave energy, thereby helping to prevent SAV from being dislodged or damaged. The probability and magnitude of potential effects on SAV via this mechanism of interaction are discussed in Section 4.3.

3.2.3 Blue Crab

The blue crab is difficult to associate with any single component of the Bay ecosystem because it occupies a variety of aquatic habitats ranging from the mouth of the Bay to fresher rivers and creeks and occupies different trophic levels during various stages of its life cycle. Throughout the year, crabs may burrow into the bottom, shed and mate in shallow waters and beds of SAV, or swim freely in open water. The first life stage of a blue crab, called the zoea, lives a planktonic, free-floating existence. After several molts, the zoea reaches its second larval stage: the megalops. Following recruitment to the estuary, blue crab megalopae metamorphose into the first crab stage. These small crabs (2-3 mm) prefer habitats that can provide refuge from predation. In Chesapeake Bay, SAV is preferred habitat for juvenile blue crabs from the first crab stage to approximately 20 mm (Orth and van Montfran 1982, 1987). Although the presence of SAV can enhance survival of juvenile blue crabs, it is not essential for strong year classes; large harvests have occurred during periods of low SAV coverage. In the absence of SAV, macroalgae and oyster reefs may provide the necessary structural refuges (Brumbaugh 1996). Both juvenile and adult blue crabs forage on the bottom and hibernate there through the winter. During spring, blue crabs migrate from the southern part of the Chesapeake to tidal rivers and northern portions of the Bay. During the rest of the year, adult blue crabs are dispersed throughout the Bay.

Blue crabs are opportunistic predators; they exploit prey species at sizes that are most common in each of the habitats they visit (Micheli 1997). Although adult oysters are too large for blue crabs to open and prey upon (reviewed in White and Wilson 1996), crabs feed readily and opportunistically on juvenile oysters (Eggleston 1990). Oysters attain a partial refuge from predation at low densities (Eggleston 1990), but predation by blue crabs might increase with increasing oyster abundance. Mobile predators such as the blue crab produce strong direct effects of predation and disturbance on the benthic communities in Chesapeake Bay (Hines et al. 1990). Changes in the community structure and population density of predators and of prey species resulting from complex interactions with introduced species usually have cascading trophic effects that alter the entire structure of an ecosystem, as documented for the Hudson River estuary (Strayer et al. 1999) and San Francisco Bay (Carlton et al. 1990). An increase in the oyster population could increase the food supply for blue crabs. An increase in the abundance of SAV resulting from increased filtration by oysters could enhance the blue crab population by providing more refuge for juvenile crabs.

Annual commercial harvests of blue crabs from Chesapeake Bay since 2004 have been approximately 60 million pounds, which is well below the 73-million-pound annual average for the period 1968 to 2004 (CBP 2007). This is attributed to low exploitable stock abundance and restrictive harvest management measures enacted in 2001 and 2002. In 2006, the abundance of adult crabs was about 57% of the CBP's interim restoration goal of 232 million crabs (CBP 2007).

3.2.4 Phytoplankton

Phytoplankton are minute, free-floating aquatic plants. Phytoplankton communities in Chesapeake Bay are structured by salinity, temperature, light, and nutrient availability (Harding 1994). Although an abundant supply of phytoplankton provides more food for organisms at higher trophic levels, too much phytoplankton can harm the overall health of Chesapeake Bay. An excess of nutrients in the estuary can result in large algal blooms. If left ungrazed, excess phytoplankton from such large blooms die and sink to the bottom. The process of decay of this excess organic matter consumes oxygen and worsens the seasonal oxygen depletion in the bottom waters of the Bay (Section 3.3). This seasonal oxygen depletion is detrimental to organisms such as fish and shellfish and can result in high rates of mortality among fish during summer. Scientists use the Phytoplankton Index of Biotic Integrity to establish the environmental status of the habitats in which the communities reside. In 2006, 69% of the areas sampled were occupied by phytoplankton communities that were considered degraded (CBP 2007).

Major groups of phytoplankton in Chesapeake Bay include diatoms (*Bacillariophyta*), golden-brown algae (*Chrysophyta*), green algae (*Clorophyta*), blue-green algae or cyanobacteria (*Cyanophyta*), dinoflagellates (*Pyrrophycophyta*), cryptomonads (*Cryptophyta*), and microflagellates (*Prasinophyta, Euglenophycota, Protozoa*). Diatoms dominate the spring bloom, which constitutes the greatest algal biomass of the year. The timing, position, and magnitude of the spring bloom vary greatly between years and depend largely on flow (Harding 1994). Dinoflagellates replace diatoms during the summer, but at much reduced concentrations. Large blooms of dinoflagellates and cyanobacteria, which sometimes occur during spring and summer, produce red tides that are toxic to fish, shellfish, and sometimes humans. Red tides are prevalent on the western side of the Bay and at the mouths of certain tributaries and can result in significant economic losses due to closures of shellfish beds. Dinoflagellates of the genus *Pfiesteria* have appeared recently in the Bay and have been implicated in massive fish kills and some human illness.

Phytoplankton is the principal food of oysters. The native Eastern oyster is an active suspension feeder that exhibits complex feeding responses when exposed to seasonal variations in temperature and seston (reviewed in Langdon and Newell 1996). Larval oysters feed on a wide range of suspended particulate matter, including bacteria (Baldwin and Newell 1991). Oyster larvae that are offered plankton ranging from 0.2 µm to 30 µm feed preferentially on the 20-µm to 30-µm size-fraction, which is dominated by heterotrophic protozoans and dino-flagellates (Baldwin and Newell 1991). Other studies have shown that oyster larvae typically ingest particles between 0.5 and 12 µm but will consume larger particles (16 to 30 µm) when blooms of dinoflagellates of that size are present (Baldwin and Newell 1995). A mixed algal diet has been shown to be superior to single-species diets for the growth of juvenile oysters (Enright et al. 1986a). Although detrital complexes (i.e., non-living organic matter and attached bacteria) contribute to the nutritional requirements of the native oyster (Langdon and Newell 1990; Crosby et al. 1990), most of the carbon incorporated into oysters’ tissues is derived from phytoplankton (Haines 1977). In one study, adult Eastern oysters in a salt-marsh estuary fed preferentially on phototrophic nanoflagellates (Wetz et al. 2002). The Suminoe oyster is generally believed to use the same food resources as the Eastern oyster (NRC 2004).

Oysters interact with the phytoplankton community both directly and indirectly. The primary interaction is direct: selective feeding reduces phytoplankton biomass and alters the species composition of the community. Many studies have demonstrated that benthic suspension feeders exert top-down control on phytoplankton production in freshwater, estuarine, and coastal waters (Cohen et al. 1984; Riemann et al. 1988; Cloern and Alpine 1991). Phytoplankton densities were 40% to 60% lower in a 6-km to 8-km segment of the Potomac River with the highest densities of an Asian clam (*Corbicula fluminea*) than in upstream or downstream areas with fewer clams (Cohen et al. 1984), suggesting that phytoplankton production was not sufficient to compensate for the rate of filtering by the highest densities of clams. Daily rates of primary productivity in northern San Francisco Bay were much lower after the introduction of another Asian clam, *Potamocorbula amurensis*, when compared with pre-invasion levels, which led to a dramatic decline in annual phytoplankton production (Cloern and Alpine 1991). Based on feeding rates and densities in the field, researchers concluded that this decline in primary production was a result of the consumption of phytoplankton by *P. amurensis*. Results of a study by Newell et al. (2002) suggest that an ecosystem dominated by benthic primary production may develop in shallow waters when reduced turbidity associated with bivalve feeding increases light penetration to a level that can sustain benthic microalgal production. Turbidity is reduced when bivalves filter phytoplankton and inorganic particles larger than 3 µm from the water column and transfer undigested material to the sediment surface in their feces and pseudofeces (collectively called biodeposits).

3.2.5 Zooplankton

Zooplankton are minute, aquatic invertebrate animals, including the free-floating larval stages of oysters, clams, and crabs. Zooplankton communities in Chesapeake Bay act as the middle step between the very productive phytoplankton and bacteria at the bottom of the food chain and the many economically important species at higher levels in the food chain (i.e., trophic levels), such as fish and their larvae. Zooplankton consume phytoplankton and bacteria and can be a regulating force over these communities. In turn, excretion by zooplankton is one of the most significant recycling mechanisms that supplies phytoplankton with nitrogen and phosphorus for growth. Brownlee and Jacobs (1987) reviewed the composition and distribution of zooplankton in Chesapeake Bay. Protozoans, rotifers, and copepod nauplii dominate the microzooplankton (< 200 µm). Dominant mesozooplankton (> 200 µm) species are the copepods *Acartia tonsa* and *Eurytemora affinis* in Maryland and *Acartia hudsonica* in Virginia. Copepods account for greater than 65% of all species collected in zooplankton monitoring programs in Chesapeake Bay. Cladocerans, barnacle nauplii, and polychaete larvae are important at certain times of the year and in particular salinity regimes. In summer, gelatinous species of zooplankton (especially ctenophores) are important predators of copepods and oyster larvae. Zooplankton communities in the freshwater and oligohaline regions of Chesapeake Bay are diverse, and their abundance and biomass are usually high. Abundance, biomass, and diversity are generally lower in the mesohaline and polyhaline zones, although high densities of larval polychaetes, mollusks, and decapods occur in specific areas.

The major consumers of zooplankton are larval fish, adult fish of certain species, ctenophores (*Mnemiopsis leidyi*), and jellyfish (e.g., the sea nettle *Chrysaora quinquecirrha*). Fish such as the bay anchovy (*Anchoa mitchili*) feed primarily on zooplankton, and particularly on *A. tonsa* (Peebles et al. 1996). Bivalve larvae in the free-floating stage, known as veligers, can be considered part of the zooplankton and are subject to the same predators. Purcell et al. (1991) found that while in the medusa stage, sea nettles capture bivalve larvae but do not ingest them. They concluded that sea nettles are not important predators of bivalve larvae but may reduce their mortality by consuming ctenophores, which do prey upon the veligers. Breitburg and Fulford (2006) found a significant decrease in the abundance of sea nettles in Chesapeake Bay since the mid 1980s and a simultaneous increase in the biovolume of ctenophores (i.e., milliliters of ctenophores per cubic meter of water). They estimated that ctenophores currently consume an average of 10% to 25% of oyster larvae throughout the summer and may consume 40% to 100% of oyster larvae locally in areas of peak density of ctenophores. Using a simple quasi-equilibrium, mass-action model (Ulanowicz and Tuttle 1992), researchers have predicted that an increase in the abundance of oysters in the Bay would decrease phytoplankton productivity; the abundances of pelagic microbes, ctenophores, and medusae; and particulate organic carbon. The model also predicted increases in benthic primary production and fish stocks. Many reef-dwelling benthic invertebrates produce planktonic larvae; therefore, oyster reefs might provide both sources of larvae and recruitment sites at the end of planktonic development (Harding 2001).

Because of its ubiquity and importance in the trophic structure of the Bay, we selected *A. tonsa* to represent the zooplankton community. *A. tonsa* is the dominant copepod species in the mesohaline portion of Chesapeake Bay from April to October (Brownlee and Jacobs 1987). The ability of *A. tonsa* to thrive on various kinds of food, including phytoplankton, microzooplankton, and detritus, may enable it to maintain a high production rate under widely different conditions (White and Roman 1992). The primary mechanism of interaction between oysters and the zooplankton community would be indirect, through competition for planktonic food.

3.2.6 Planktivorous Fish

Planktivorous fish are a key part of the food web in Chesapeake Bay. They consume small organisms that drift or swim in the water column, collectively called plankton, and are preyed upon by larger fishes such as striped bass and bluefish, known as piscivores. The larval and early juvenile stages of all fish species in the Bay feed on plankton; however, bay anchovy and menhaden are the only two major species in Chesapeake Bay that feed primarily on plankton throughout their life cycles. Because oysters also feed on some types of phytoplankton, and phytoplankton serve as a food source for zooplankton, the mechanism of interaction between oysters and planktivorous fishes would be through the food chain.

The small bay anchovy occurs in coastal waters from Maine to Yucatan. It is the most abundant fish in the Bay and is a major source of food for nearly all predatory fish. Humans do not exploit the species because of its small size. The population of bay anchovy fluctuates greatly from year to year but has exhibited a declining trend since about 1994. Recruitment of juveniles into the population depends partly on the concentration of planktonic food available (Jung and Houde 2004b). The bay anchovy is particularly sensitive to pollution (Bechtel and Copeland 1970; Livingston 1975), which could affect its abundance in the Bay. Although bay anchovies and oysters both consume plankton, they prefer different types. Bay anchovies feed primarily on zooplankton, particularly the copepod *Acartia tonsa* (Peebles et al. 1996). Oysters consume some zooplankton, but most of their diet consists of phytoplankton (Haines 1977); therefore, the potential for direct competition between oysters and bay anchovies is limited. A variety of indirect interactions are possible, however. For example, *A. tonsa* consumes phytoplankton, which may be reduced by oysters, thereby affecting the food supply for bay anchovy.

Menhaden occur in coastal and estuarine waters from Nova Scotia to northern Florida. The species is abundant in the Bay during the spring, summer, and fall, but generally migrates south to the Carolinas during the winter. In addition to being a major source of food for striped bass and other piscivorous fishes, menhaden support one of the largest fisheries in the United States. Menhaden are used for fishmeal, fish oil, and bait for other fisheries. Although the stock is considered healthy, recruitment of juveniles into the population has declined recently, and harvest limits are in effect for Chesapeake Bay (Cosby et al. 2007; ASMFC 2006). Menhaden are planktivorous throughout their life cycle but undergo a series of changes in feeding behavior as they grow and develop (Friedland et al. 1989). Larvae feed on small plankton of all kinds, but juveniles are obligate filter feeders and consume mostly phytoplankton (June and Carlson 1971; Govoni et al. 1983). As juveniles grow into adults, their diets gradually shift to include more zooplankton (Durbin and Durbin 1975). Amorphous organic matter composed of dissolved detritus and decaying plants also constitutes a substantial proportion of their diet in some environments (Lewis and Peters 1994). Oysters consume mainly phytoplankton (Haines 1977) but also detritus and other material (Langdon and Newell 1990; Crosby et al. 1990); therefore, the primary mechanism of interaction between oysters and planktivorous fish would be the potential to compete for food.

3.2.7 Reef-oriented Fish

Oyster bars, which are remnants of the oyster reefs that were present historically in the Bay (Hargis 1999), provide habitat for several species of fish, many of which are important in commercial and recreational fisheries. Although some tropical fishes reside on reefs throughout their life cycles, few Bay species exhibit this pattern. The naked goby *(Gobiosoma bosci)*, a small forage species, resides on oyster bars throughout its juvenile and adult lifestages (Breitburg 1991) and is considered an exclusively reef-dwelling species. Black sea bass *(Centropristis striata)*, which is considered to be a temperate reef fish, is found seasonally on oyster bars and other hard substrates and structures in the middle and lower Bay during warm months. Although black sea bass generally migrate to ocean waters during the winter, they are reef dependent for a significant portion of each year. A third category of reef-oriented fish includes species that use a variety of habitats but frequent hard-bottom habitat, such as oyster bars; the Atlantic croaker *(Micropogonias undulates)* is an example of such reef-aggregating species. These three species, naked goby, black sea bass, and Atlantic croaker, represent the suite of species that orient to and may be affected by changes in the availability of oyster-reef habitat.

Breitburg et al. (2000) discussed the role that restored oyster reefs may play in enhancing the production of finfish and decapod crustaceans, such as crabs; however, the role of oyster bars in the population dynamics of reef-oriented fishes has not been documented. Several studies have investigated differences in the abundance of reef-oriented species among sites with and without oyster bars and reefs. Harding and Mann (2001) documented patterns of species richness, abundance, and size-specific use of habitat by transient fish along a gradient from complex reef habitat through simple sand bottom in the Piankatank River, Virginia. They found that as habitat complexity increased, the size and abundance of transient fishes increased. They concluded that oyster reefs may be important habitat, but were not essential for the species they investigated, which included Atlantic croaker, Atlantic menhaden, striped bass, and weakfish. Peterson et al. (2003) used results from six different field studies to estimate the enhancement of production for several species of fish that could be attributed to restoration of oyster-reef habitat. They classified the species evaluated in the study into two groups: (1) species that recruit exclusively to reefs, such as naked goby and oyster toadfish, and (2) species that aggregate around reefs, such as black sea bass and bay anchovy. For the second group, the investigators noted that the absence of reef habitat did not limit their production, but the presence of reef habitat augmented it. Rodney and Paynter (2006) compared macrofaunal assemblages on restored and unrestored oyster reefs in mesohaline regions of the Bay. They found that densities of demersal fish, primarily naked goby, were four times greater on the restored reefs than on the unrestored reefs. They also found that densities of prey species were much greater on restored reefs (e.g., 20 times more amphipods than on unrestored reefs).

The mechanism of interaction between oysters and reef-oriented fish is related to the habitat created by oyster reef. An increase in the amount (area and volume) of oyster reef in Chesapeake Bay could directly affect the populations of some species of reef-oriented fish and indirectly affect others through increases in the availability of prey items and valuable habitat associated with reefs. For the exclusively reef species, represented by the naked goby, an increase in the amount of available habitat could directly affect the population size. For the reef-dependent species, represented by black sea bass, an increase in the amount of available habitat and the resultant increase in food resources could affect the population size. For reef-aggregating species, represented by Atlantic croaker, a change in reef habitat could change the food resources associated with the habitat and, thus, the size of the croaker population.

3.2.8 Piscivorous Fish

The piscivorous segment of the fish community of Chesapeake Bay includes some of the most sought-after species in recreational and commercial fisheries. Species such as striped bass, bluefish, weakfish, and Spanish mackerel can be found seasonally and are sought by anglers throughout the Bay. Striped bass, an anadromous species, and bluefish, a marine species that uses the Bay as a nursery area, can be considered to be representative of the piscivorous segment of the fish community. In Chesapeake Bay, the population of striped bass has increased greatly over the past decade due to responsible management of the fishery, but susceptibility to disease and availability of prey are both of concern to resource managers (CBP 2007). Changes in oyster populations in the Bay would not affect these species directly, but they could be affected indirectly through the food chain. A change in the oyster population (abundance and distribution) could influence planktivorous fish directly through competition for food, and piscivorous fish could be influenced by the associated change in the availability of their fish and non-fish prey. The probability and projected magnitude of potential effects via this mechanism of interaction are described in Section 4.2.

3.2.9 Reptiles

Four of the seven sea turtles found throughout the world appear seasonally in Chesapeake Bay. The loggerhead turtle (*Caretta caretta*) accounts for nearly 90% of the summer population of sea turtles in the Bay and, therefore, is a representative species for the ERA and this Draft PEIS. The loggerhead turtle is on the Federal list of threatened species and on Maryland's and Virginia's lists of threatened species. Juvenile loggerheads enter Chesapeake Bay during the late spring and early summer (Lutcavage and Musick 1985) and migrate out of the Bay from late September to early November, as water temperatures drop (Klinger and Musick 1995). They have been documented throughout the mainstem as far north as the Magothy River, and in several of the tributaries, including the Potomac, Patuxent, Choptank, and Severn rivers. Chesapeake Bay provides ideal foraging habitat for the development of juvenile sea turtles. Loggerheads eat a variety of foods including horseshoe crabs, crustaceans, jellyfish, and mollusks. They concentrate their feeding along channels near the mouths of rivers and areas of the Bay that are deeper than 13 feet.

The diamondback terrapin (*Malaclemys terrapin*) is the Maryland State reptile and another representative species. It is the only North American turtle that lives exclusively in brackish water. Diamondbacks feed mostly on mollusks, especially snails, clams, and mussels. Diamondbacks spend their entire lives in local creeks, salt marshes, and coves. Whitelaw and Zajac (2002) demonstrated that resource availability may not be the primary driver of terrapin distribution. Distribution may be driven more by the physical structure, plant density, and tidal amplitude of the creeks in which they reside. Diamondbacks and, particularly, their nests are susceptible to predation by raccoons, crabs, crows, gulls, rats, muskrats, foxes, skunks, and mink. Because of the appeal of terrapin as a gourmet delicacy, harvest pressure decimated terrapin populations throughout the Bay by the early 1900s. To aid in conserving the population, the State of Maryland passed legislation in 2007 banning the commercial harvest of terrapins in Maryland waters.

The mechanism of interaction between oysters and sea turtles and terrapins is indirect; changes in the oyster population in Chesapeake Bay could change the availability of prey items for these species, specifically clams, crabs, mussels, jellyfish, and SAV. Although indirect interactions such as these are extremely difficult to quantify and may be undetectable, this ecosystem component is included as part of the standard approach for conducting an ecological risk assessment.

3.2.10 Avian Oyster Predators

Numerous avian species in the Chesapeake Bay watershed use benthic species as a primary food source. An important representative species is the American oystercatcher (*Haematopus palliates*). Oystercatchers are large shorebirds with strong white or black-and-white markings. They consume oysters and other shellfish and have powerful, brightly colored bills that they use to open the shells of bivalves. Oystercatchers were once hunted almost to extinction but are now conspicuous shorebirds found throughout the Chesapeake Bay region.

Several studies have shown that a decrease in shellfish stocks negatively affects the oystercatcher population (Goss-Custard et al. 2003; Atkinson et al. 2003; Tuckwell and Nol 1997a). When the abundance of shellfish is low, the birds can survive on alternative prey species, but these species often do not enable the birds to maintain good body condition (Smit et al. 1998). Tuckwell and Nol (1997b) showed that kleptoparasitism by other species (e.g., gulls) increases when oystercatchers are feeding on non-oyster shellfish.

The primary mechanism of interaction for oystercatchers is direct, through a change in the availability of oysters as a food source. A secondary mechanism of interaction could be through competition between oysters and other shellfish, which could shift the prey-suite for oystercatchers.

3.2.11 Avian Piscivores

Many avian species use the abundant fish populations of Chesapeake Bay as their primary food sources. Two of the species documented best in the literature are the bald eagle (*Haliaeetus leucocephalus*) and the North American osprey (*Pandion haliaetus*).

The bald eagle is a large raptor that is on the Federal list of threatened species and on State lists of threatened species in Maryland and Virginia. Bald eagles require large areas of undisturbed mature forest close to aquatic foraging areas. Bald eagles eat fish when they are available but will shift to a variety of other birds, mammals, and turtles – both live and as carrion – when fish are scarce. Chesapeake Bay may once have provided habitat for as many as 3,000 breeding pairs of bald eagles. The population declined dramatically due to habitat destruction, poaching, and contamination with DDT. In 1973, the bald eagle was listed as endangered in 43 of the lower 48 states. After a ban on the use of DDT, the population slowly began to increase, and the bald eagle was reclassified as threatened in 1995 and delisted in 2007.

The osprey is the only diurnal bird of prey that feeds exclusively on live fish. The species is situated at the top of the aquatic food chain and is a good indicator of habitat destruction, dwindling fish populations, and environmental contamination. Ospreys build conspicuous nests on tall, offshore structures such as channel markers and duck blinds to protect their young and to be located near their food supply. Ospreys eat a host of fish species and are vulnerable to predation by animals such as raccoons.

The mechanism of interaction for both of these avian species is indirect: a change in the oyster population could cause changes in the populations of planktivorous fish (particularly menhaden) through competition for food, which could affect avian piscivores. Although indirect interactions such as these are extremely difficult to quantify and may be undetectable, ecosystem components such as this one are included as part of the standard approach for conducting an ecological risk assessment.

3.2.12 Avian Bottom Feeders

Chesapeake Bay is located along the Atlantic flyway, which channels the annual seasonal flights of millions of migratory waterfowl to the Bay. The shallow waters and wetlands of the Bay and its temperate climate offer a fertile and diverse environment for waterfowl. Four categories of waterfowl inhabit Chesapeake Bay: dabbling ducks, diving ducks, geese, and swans. All four kinds depend on agricultural areas, bay bottom, and wetlands for food and nesting habitat.

The black duck (*Anas rubripes*) is a good representative of a benthic-feeding avian species. The black duck is a medium to large dabbling duck that is most similar to the mallard (*Anas platyrhynchos*), but it lacks the male mallard's characteristic green head and white collar. Black ducks feed on a combination of plants and animals. They forage underwater by dabbling and upending. Their diet consists mainly of the seeds of grasses, sedges, pondweeds, and other aquatic vegetation. They will also readily eat snails, Baltic clams, ribbed mussels, and fish (Krementz 1991). Black ducks depend upon the condition of the bottom of the bays and wetlands in which they feed. Diving ducks such as canvasbacks (*Aythya valisineria*) depend totally on aquatic habitats throughout their life cycle. They feed on plants and animals in wetlands and shallow benthic habitats. At one time, canvasbacks in Chesapeake Bay consumed wild celery almost exclusively, but the decline in wild celery caused the species to shift its diet to small clams. As bottom feeders, canvasbacks are likely to be able to forage on and around many oyster bars.

Neither black ducks nor canvasback ducks, nor any of the other waterfowl known to inhabit Chesapeake Bay, feed directly on oysters to any significant extent; however, canvasbacks may feed on or around oyster bars. The primary mechanism of interaction between oysters and these benthic-feeding birds is indirect, through changes in the kinds and distribution of benthic invertebrates that could result from competition with oysters for food and habitat.

3.2.13 Mammalian Piscivores

Many piscivorous mammals inhabit the shores and waters of Chesapeake Bay. Although these mammals do not feed directly on oysters to any significant extent, a change in oyster populations could affect them indirectly through competition between oysters and planktivorous fish, which are food for piscivorous mammals. Although indirect interactions such as these are extremely difficult to quantify and may be undetectable, this ecosystem component is included as part of a standard approach for conducting an ecological risk assessment. Two representative species are the raccoon and the river otter.

The raccoon (*Procyon lotor*) is an omnivorous nocturnal mammal that prefers to inhabit trees near streams, springs, or rivers. Raccoons feed on mice, insects, fish, and frogs (Dewey and Fox 2001). Raccoons also will eat the eggs of turtles and some birds (e.g., gull-billed terns, osprey).

The river otter (*Lontra canadensis*) spends most of its life in the rivers, marshy ponds, and wooded riparian areas of the Chesapeake and its tributaries. The river otter population is increasing on Maryland's Eastern Shore, and some otters have been captured and released in other parts of the state where they had become scarce. River otters feed on fish, crayfish, crabs, frogs, and small mammals (Dewey and Ellis 2003).

3.3 WATER QUALITY

Oysters both affect water quality and are affected by water quality. Water quality in Chesapeake Bay is influenced by the characteristics of its watershed and by the interaction of physical, chemical, biological, and anthropogenic processes. The watershed drains a large area encompassing 64,000 square miles of streams, rivers, and land within parts of six states. The waters that flow into the Bay carry effluent from wastewater treatment plants and septic systems serving a population of 18 million people, and nutrients, sediment, and toxic substances from a variety of anthropogenic sources, such as agricultural lands, industrial discharges, automobile emissions, and power generating facilities. Five major rivers contribute 90% of the fresh water delivered to the Bay: Susquehanna, Potomac, Rappahannock, James, and York. Except for a few deep troughs associated with the ancient bed of the Susquehanna River, Chesapeake Bay is shallow, averaging 6.5 meters deep. This shallowness makes the Bay's waters sensitive to temperature fluctuations, mixing events, and interactions with the sediments (http://www.chesapeakebay.net/ecoint2b.htm; Jasinski 2003).

Physical processes in Chesapeake Bay control the seasonal distribution of salinity, temperature, and DO and play an important role in determining water quality. During spring and summer, surface and shallow waters are warmer and fresher than deeper waters; therefore, the water column stratifies into a two-layer system. The zone of change between those two layers is called the pyncnocline. The strength of the stratification depends on river flow: the larger the volume of the incoming fresh water, the stronger the stratification. The deeper, more saline water moves up the Bay from the Atlantic Ocean. During autumn, vertical mixing occurs rapidly due to cooling and sinking of the surface waters and the passage of weather fronts. Water temperature and salinity are relatively constant from surface to bottom during winter. Stratification of the Bay and the development of the pyncnocline during warm months restrict the exchange of water between the upper and lower layers and, consequently, limit the supply of oxygen available in water near the bottom. During the spring and summer, as organisms consume increasingly more oxygen, the oxygen content decreases in bottom waters. As stratification persists, the concentration of oxygen in bottom waters may decrease to less than is needed for organisms to function (i.e., the water becomes hypoxic). This process occurs naturally in many estuaries, but in Chesapeake Bay it is exacerbated by excess nutrients from anthropogenic sources (Kemp et al. 2005).

Hypoxic waters generally occur in Chesapeake Bay during the summer of each year in deep areas of the mainstem and at the mouths of the major tributaries. The volume of hypoxic water in Chesapeake Bay varies with changes in hydrology (dry versus wet years) and with seasonal changes in water temperature. Years with little precipitation and minimal river flow show less intense hypoxia than years with greater precipitation and river flow. Also, as water temperature increases during the summer months, hypoxia becomes more prevalent. From 1985 to 2006, during the period June through September, on average 1.44% of the volume of the mainstem was anoxic, and 5.25% was hypoxic (D. Jansinski, USEPA CBP, pers. comm.). Data throughout the Bay suggest a general increasing trend in DO since 1985; however, the Bay experienced extensive hypoxia from 2003 to 2005 due to unusually wet conditions. Water quality data gathered between 2004 and 2006 indicate that only about 33% of the Bay's tidal waters met standards for DO (i.e., the concentrations established by regulatory agencies as appropriate for biota that occupy different habitats in the Bay, including open water, deep water, and deep channel) during the months of June through September (http://www.chesapeakebay.net/do.htm).

Impaired water quality in Chesapeake Bay is linked to nutrient over-enrichment and high concentrations of suspended sediment. Forest clearing, agricultural practices, and urban development contribute large amounts of nutrients and sediment that are transported to the Bay by its tributaries[2]. Excess nutrients stimulate the growth of phytoplankton populations. When the increasingly abundant phytoplankton (i.e., an algal bloom) die, large amounts of organic matter sink to the bottom. The presence of excess organic matter on the bottom increases the demand for DO, which is required for bacterial decomposition of the organic matter. This increased oxygen demand hastens the seasonal oxygen depletion in the bottom waters of the Bay. Increased algal growth and sediment runoff also contribute to reducing water clarity in Chesapeake Bay. These processes suggest three good indicators of water quality in the Bay: DO concentration, chlorophyll a concentration, and water clarity (http://www.chesapeakebay.net/wqcchlorophylltech.htm, http://www.chesapeakebay.net/wqcclaritytech.htm, http://www.chesapeakebay.net/do.htm).

Oxygen concentrations of less than 5 milligrams per liter (mg/l) of water affect the behavior and survival of fish. Concentrations below 2 mg/l are considered to be severely hypoxic and affect the structure, distribution, and productivity of benthic organisms, including oysters. Frequent hypoxic events result in benthic populations dominated by fewer, short-lived species. Persistent hypoxia and anoxia (a complete absence of oxygen) can result in mass

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[2] Although oysters and other filter feeding organisms play a role in cycling nutrients through the ecosystem of Chesapeake Bay, they do not contribute to the amount of nutrients being introduced into the Bay. This aspect of their role in the Bay ecosystem is not addressed further in this Draft PEIS.

mortality of benthic organisms and often in the complete elimination of the macrofauna. For example, Seliger et al. (1985) documented a catastrophic anoxic episode in the Bay that occurred in 1984. As a result of an unusual combination of factors that together contributed to oxygen depletion, oxygen levels at water depths greater than five meters dropped to 0 mg/l beginning in June of that year, followed by total mortality of shellfish and associated fauna at depths greater than six meters. Subsequent studies conducted from 1986 to 1988 in the Choptank River specifically to investigate relationships between DO levels and oyster mortality found no significant correlation, possibly because DO levels never declined or persisted to the extent that occurred in 1984. Sessile estuarine organisms such as oysters have adapted to variable environmental conditions that typically occur in estuaries and are capable of surviving short episodes of hypoxia. Also, the fact that oyster bars in the Bay are located in shallow areas reduces their exposure to seasonal hypoxia in deeper waters (R. Mann, VIMS, pers. comm.). For example, the mean depth of existing oyster habitat in Maryland's portion of the Bay is 4.2 m, with a range of 1.5 m to 9.7 m (DNR 2007). Virginia considers the potentially deleterious effects of hypoxia in planning its oyster restoration and enhancement programs. Virginia routinely limits the placement of shell for restoration to shallower areas where oysters once were present; locations where low DO may be an issue, as identified during Virginia's fall oyster surveys, are avoided when placing shell (J. Wesson, VMRC, pers. comm.). DO at levels that do not cause mortality of oysters may cause stress that contributes to increases in mortality from other causes. For example, Boyd and Burnett (1999) and Anderson et al. (1998) documented immune suppression and consequent increased mortality from Dermo among oysters that experienced mild hypoxia. Hypoxia also affects the behavior of a variety of predators of benthos and influences the trophic transfer of energy from benthos to fish.

The concentration of chlorophyll *a* in a water sample is used as an indicator of the amount of phytoplankton present. Large concentrations of chlorophyll *a* usually result from the presence of excess nutrients that contribute to increases in phytoplankton populations and have been linked to decreased water clarity, hypoxia, and changes in the structure of plankton communities in Chesapeake Bay. Harmful algal blooms may result from the altered community composition. Recent Bay Program data show decreasing trends for chlorophyll *a* concentrations (i.e., decreasing phytoplankton populations) in the upper portion of many tributaries, such as the Patuxent, Potomac, York, James, Choptank, Nanticoke, and Pocomoke rivers, and in the smaller tributaries of the upper western shore of Maryland, but increasing trends in the Rappahannock River, lower Choptank River, and Tangier Sound (http://www.chesapeakebay.net).

Clear water, which allows light to pass freely, is important for the growth of SAV (Section 3.2.2). Water clarity decreases with algal blooms and large volumes of sediment runoff. Increases in water clarity have been observed to occur with increases in filter feeding organisms. For example, during the summer of 2004, water clarity in the Magothy River reached an all time high value concurrent with a dramatic increase in the population of the dark false mussel (*Mytilopsis leucophaeta*), a small filter-feeding shellfish (DNR 2004). A similar dramatic increase in water clarity of some of the Great Lakes occurred concurrently with the accidental introduction and explosive population growth of the nonnative, invasive zebra mussel (*Dreissena polymorpha*). Since zebra mussels became established in Lake Erie, water clarity has increased from 6 inches to 30 feet in some areas. The material that zebra mussels remove from the water includes other organisms and algae that supply food for larval fish and other invertebrates, and this change in food supply appears to have contributed to declines in populations of some native fauna (USGS 2007).

Water clarity is usually low in the upper Bay (above 39ºN latitude). The lower Bay generally has the clearest waters. Water clarity is also low in most of the tributaries. Recent Bay Program data show a trend toward decreasing water clarity in many tributaries, including the Patuxent, Potomac, York, James, and Choptank rivers, the smaller tributaries of the lower eastern shore of Maryland, Tangier Sound, and the mainstem of the Bay. Only 7% of the Bay's waters had acceptable water clarity in 2006 relative to water clarity goals established by the CBP (http://www.chesapeakebay.net).

3.4 RARE, THREATENED, AND ENDANGERED SPECIES

Species of plants and animals that have been designated as rare, threatened, or endangered (RTE) are protected under Federal and State regulations. The Endangered Species Act (ESA) of 1973 (16 USC 1531-1543) regulates activities affecting plants and animals classified as endangered or threatened, as well as the designated critical habitat of such species. Federal agencies are required to provide for the conservation of threatened and endangered species and are prohibited from carrying out any action that would jeopardize a listed species or destroy or alter its critical habitat. The ESA was reauthorized in 1988, and its provisions apply only to species listed in the Federal Register as endangered or threatened. An “endangered species” is any species that is in danger of extinction throughout all or a significant portion of its range. Threatened species are defined as species that are likely to become endangered within the foreseeable future throughout all or a significant portion of their ranges. Actions affecting species proposed for listing require the same coordination with State and Federal agencies as actions affecting listed species. FWS and NMFS are the Federal agencies responsible for ESA compliance. Overall, FWS is responsible for terrestrial and freshwater species and migratory birds, and NMFS protects marine species and anadromous fish. The Department of Agriculture, Animal and Plant Health Inspection Service, oversees listed terrestrial plants. State regulations for the protection of sensitive species include the Maryland Nongame and Endangered Species Conservation Act of 1975, and the Virginia ESA. Under Section 7(a) of the ESA, Federal agencies are required to consult with FWS and NMFS as well as resource agencies in all states within the potentially affected area to ensure that their actions are not likely to jeopardize the continued existence of designated endangered or threatened species or to adversely modify or destroy their critical habitats.

The following agencies were contacted to fulfill Federal and State requirements to identify which RTE species in the Chesapeake Bay region may be affected by the proposed action and alternatives: NOAA, NMFS; the United States Department of Interior (DOI), FWS; the Virginia Department of Conservation and Recreation (VDCR); and DNR. Based on information provided by those agencies, 23 RTE species were identified as potentially affected within the project area because of ecological links with oysters similar to those described in Section 3.2 for the representative species. Table 3-2 shows the 23 RTE species and lists their Federal and State status. All 18 of the species with official Federal or State status are listed as indicated in the table; no species currently proposed for listing were identified as occurring in the project area. Two listed RTE species, bald eagle and loggerhead sea turtle, were described in Section 3.2 as representatives of potentially affected components of the Bay ecosystem that were selected as ecological receptors for the ERA (Appendix B). The sections following Table 3-2 describe potentially affected RTE species that were not described in Section 3.2. Details about interactions between oysters and the RTE species, the likelihood that the species would be affected by the proposed action or alternatives, and the mechanisms of projected effects will be discussed in Section 4, Environmental Consequences.

Table 3-2. RTE species that may be present in the project area*

Common Name	Scientific Name	Federal Status	Maryland Status	Virginia Status
Sea Turtles				
Atlantic hawksbill turtle	*Eretmochelys imbricate*	E	E	E
Loggerhead turtle	*Caretta caretta*	T	T	T
Kemp's ridley turtle	*Lepidochelys kempii*	E	E	E
Leatherback turtle	*Dermochelys coriacea*	E	E	E
Green turtle	*Chelonia mydas*	T	T	T
Fish				
Shortnose sturgeon	*Acipenser brevirostrum*	E	E	E
Atlantic sturgeon	*Acipenser oxyrhynchus*	FSC	R	SSC
Spotfin killifish	*Fundulus luciae*		R	
Birds				
Bald eagle	*Haliaeetus leucocephalus*		T	T
Peregrine falcon	*Falco peregrinus*			E
Wilson’s plover	*Charadrius wilsonia*		E	E
Piping plover	*Charadrius melodus*	T	E	T
Black skimmer	*Rynchops niger*		E	NHR
Brown pelican	*Pelecanus occidentalis*	FSC	HR	
Roseate tern	*Sterna dougallii*	E	X	E
Gull-billed tern	*Sterna nilotica*		E	T
Least tern	*Sterna antillarum*		T	SSC
Caspian tern	*Sterna caspia*			SSC
Royal tern	*Sterna maxima*		E	NHR
Sandwich tern	*Sterna sandvicensis*		HR	SSC
Insects				
Puritan tiger beetle	*Cicindela puritana*	T	E	
Northeastern beach tiger beetle	*Cicindela dorsalis dorsalis*	T	E	
Plants				
Sensitive jointvetch	*Aeschynomene virginica*	T	E	

* Includes VA Natural Heritage Resource (NHR) species, which are protected through management programs even though they do not have State-protected status, and species listed as rare or highly rare in MD; no regulations are associated with these categories of sensitive species.

X: extirpated
T: threatened
E: endangered
FSC: Federal species of concern
SSC: State-designated special concern
R: MD rare
HR: MD highly rare
NHR: VA Natural Heritage Resource species

3.4.1 Fish

Shortnose sturgeon (*Acipenser brevirostrum*) – Adult sturgeon in estuarine waters feed primarily on small mollusks (*Mya arenaria, Macoma balthica*). Juvenile sturgeon forage on insect larvae (*Hexagenia sp*., *Chaborus sp*., and *Chrionamus sp*.) and small crustaceans (*Gammarus sp*., *Asellus sp*., *Cyathura polita*; NMFS 1998). They reach lengths of up to 100 cm, are long-lived (15-20 years), mature late in life, and are highly fecund. They are anadromous and migrate to freshwater to spawn during late winter and early summer. Juveniles migrate to and from freshwater for several years, eventually remaining in estuarine waters and joining adult migration patterns (FWS 2004). Shortnose sturgeon were once abundant in Chesapeake Bay; however, the population has declined significantly since the first published account of their presence in 1876 (NMFS 1998). In 1996, eight shortnose sturgeon were captured in the upper Bay between Kent Island and the Chesapeake and Delaware Canal, and one in the Potomac River. In 1997, nine shortnose sturgeon were captured in the upper Chesapeake Bay between Miller's Island and the mouth of the Susquehanna River. In 2006, two female, egg-bearing shortnose sturgeon were found in the Potomac River (Blankenship 2007).

Atlantic sturgeon (*Acipenser oxyrhynchus*) – The basic life history pattern of the Atlantic sturgeon is similar to that of the shortnose except for more wide-ranging marine movements of adults. Both species are bottom feeders, but the Atlantic sturgeon is larger than the shortnose, reaching lengths of up to 200 cm. Atlantic sturgeon begin their freshwater spawning migration later than shortnose; juveniles move to brackish waters for a few months before migrating to coastal waters. Adults migrate extensively along the coast. Juveniles may occur in the Bay and its tributaries (NMFS 2007). A combination of overfishing and deterioration of habitat have caused the Atlantic sturgeon population in Chesapeake Bay to decline drastically. In 1996, 3,000 tagged, juvenile, hatchery-raised Atlantic sturgeon were released into Chesapeake Bay; 1,700 of these were subsequently recaptured, confirming their use of existing Bay habitats. The lack of clean hard substrate for the attachment of eggs, an important habitat requirement for the Atlantic sturgeon, limits the species' use of Chesapeake Bay as a spawning habitat (Atlantic Sturgeon Status Review Team 2007).

Spotfin killifish (*Fundulus luciae*) – The spotfin killifish inhabits salt marshes of the Bay, where it feeds on zooplankton and emergent insects (NANFA 2005).

3.4.2 Birds

Bald eagle (*Haliaeetus leucocephalus*) – see Section 3.2.11 for description.

Peregrine falcon (*Falco peregrinus*) – This species is found in terrestrial inland, aquatic, and coastal areas. It nests almost exclusively on rocky cliffs of varying sizes (in mountainous areas or river gorges, usually associated with water) or on manmade structures such as unfinished bridge piers, bridges, or skyscrapers. Migrant and wintering falcons are well known for frequenting coastal estuaries and intertidal mudflats, where they prey heavily on shorebirds and waterfowl (VAFWIS 2007). Reintroduced peregrine falcons are now nesting on artificial structures throughout the Chesapeake Bay region.

Wilson's plover (*Charadrius wilsonia*) – Wilson's plover breeds along barrier islands but is an increasingly uncommon summer resident on the coast of Chesapeake Bay's Eastern Shore, where it is observed less than annually now. The species is an abundant breeder elsewhere in its range, but is not a common breeder anywhere on the United States Atlantic coast. Its diet consists mainly of crustaceans, including small marine insects, minute shellfish, and a few mollusks and flies (VAFWIS 2007).

Piping plover (*Charadrius melodus*) – Piping plover habitat includes sandy beaches and associated intertidal areas within the Bay, where it feeds on invertebrates. It nests above the high-tide line on beaches, sand flats, barrier islands, foredunes, and blowout areas behind primary dunes. Loss of habitat along with increased recreational use of beaches has led to a continuing decline in the breeding populations in coastal states (FWS 2004).

Black skimmer (*Rynchops niger*) – This species is a common transient and summer resident along the Atlantic coast and in the lower Chesapeake Bay, where it requires undisturbed beach habitat for nesting colonies and open water for foraging. In Virginia, this species' diet is made up of nearly 100% fish, of which more than 90% were reported to be silversides (*Menidia* spp.) and killifishes (*Fundulus* spp.; VAFWIS 2005).

Brown pelican (*Pelecanus occidentallis*) – This species was added to the Federal list of endangered species in 1970 as a result of reproductive failure attributed to ingestion of pesticide residues (i.e., DDT and PCBs). The brown pelican was removed from the Federal endangered list for the Atlantic coast and Florida in February of 1995 due to population recovery following the DDT ban; nevertheless, it is considered a State Special Concern (SSC) species in Virginia because of limited nesting and restricted nesting habitat. Brown pelicans typically feed in shallow estuarine waters on crustaceans, menhaden, mullet, sardines, and pinfish but are also observed offshore. They nest on offshore islands that are free from human disturbance. Populations of brown pelican are growing, largely due to bans on DDT and related contaminants (VAFWIS 2005).

Roseate tern (*Sterna dougallii*) – This species is a rare transient on the east coast, and populations are concentrated in a few sites. Nesting is observed on high beaches amongst vegetation. The roseate tern is prey for owls, marsh hawks, and crows. Roseate terns typically feed on fish and occasionally mollusks (VAFWIS 2005).

Gull-billed tern (*Sterna nilotica*) – Typical habitat includes salt marshes and beach dunes with recent trends toward nesting on barrier islands near ocean inlets. The tern arrives in the Chesapeake Bay area during the early spring and migrates in the winter as far south as northern South America. Gull-billed terns are vulnerable to predation by raccoons, coyotes, skunks, fox, gulls, egrets, herons, and falcons. They feed almost exclusively on insects (VAFWIS 2005).

Least tern (*Sterna antillarum*) – The population of terns was threatened by hunters in the past and is in decline due to habitat loss. Coastal nesting is observed on islands, sand spits, peninsulas, beaches, and sandbars. Typical diet includes small crustaceans (VAFWIS 2005).

Caspian tern (*Sterna caspia*) – This species is listed as a special concern in Virginia due to the small size of the existing breeding population and increasing recreational and development activities on the barrier islands. Caspian terns nest in large colonies on sandy or pebbly beaches and islets. They are common as transients on barrier islands. Typical diet includes mullet, menhaden, and suckers (VAFWIS 2005).

Royal tern (*Sterna maxima*) – Royal terns nest in dense colonies on undisturbed sandy beaches. The species' diet is composed primarily of fish smaller than 4 inches long (VAFWIS 2005).

Sandwich tern (*Sterna sandvicensis*) – Nests have been found only on barrier islands of the Eastern Shore. Post-breeding birds are uncommon to fairly common visitors to the lower Chesapeake Bay in Virginia. Numbers of breeding pairs have increased in Virginia in recent years. Nesting occurs on low-lying islands that are devoid of vegetation. The species' diet is composed of small fish, shrimp, worms, and squid (VAFWIS 2005).

3.4.3 Reptiles

Atlantic hawksbill turtle (*Eretmochelys imbricate*) – Hawksbills use different habitats depending on life stage; post-hatchlings are pelagic but reenter the coastal zone when they reach 20 to 25 cm. Coral reefs are their main habitat. Hawksbills range along the eastern seaboard, including the lower Bay, but sightings north of Florida are rare (NMFS 2005).

Loggerhead turtle (*Caretta caretta*) – See Section 3.2.9 for description.

Kemp's ridley turtle (*Lepidochelys kempii*) – Fishermen of Chesapeake Bay often refer to this turtle, the smallest of the Bay's sea turtles, as the green fin turtle. In Chesapeake Bay, they are found during May through November in shallow, near-shore sea grass beds, especially where their preferred food, blue crabs, are found. They also prey on clams, snails, and occasionally marine plants. The Bay is a major developmental habitat for immature ridleys; no other location in the world harbors as many individuals in this size class each summer. The Kemp's ridley turtle is the world's most endangered sea turtle. Declines in its numbers have been attributed to environmental contaminants, pollution, shore-line modification/development, oil spills, commercial exploitation, poaching, incidental capturing/killing, and subsistence hunting, fishing and trapping (VAFWIS 2007).

Green turtle (*Chelonia mydas*) – When not migrating, green turtles prefer sea grass flats, which occur in shallow areas of Chesapeake Bay. Their nesting beaches are distributed widely in tropical and subtropical regions. The green turtle has the unique ability among marine turtles to digest plant material. Juvenile green turtles are primarily carnivorous, and mature specimens eat marine animals, particularly cniderians, mollusks, crustaceans, sponges, and jellyfish, along with vascular sea grass. Stomach contents of individuals stranded in Virginia included both eelgrass and macroalgae, especially the sea lettuce *Ulva*. The green turtle is listed as endangered in Florida.

Leatherback turtle (*Dermochelys coriacea*) – This species, the largest marine turtle, is sometimes called the leathery turtle, and fishermen in Chesapeake Bay often refer to it as the rubberback turtle. Breeding is not likely to occur in Chesapeake Bay. The leatherback is the most pelagic of the sea turtles, coming to shore only to nest and occasionally to feed. Leatherback turtles feed on soft-bodied pelagic invertebrates, primarily the moon jellyfish.

3.4.4 Insects

Puritan tiger beetle (*Cicindela puritana*) – Habitat for this species includes bay shorelines with sandy beaches below high bluffs. The larvae are considered especially sensitive to natural and man-made disturbances of the beaches and bluffs they occupy (USFWS 1993). Larvae might be affected by new or expanded aquaculture operations if such operations involve disturbing the beaches they occupy.

Northeastern beach tiger beetle (*Cicindela dorsalis dorsalis*) – The northeastern beach tiger beetle inhabits sandy bay beaches. Larvae inhabit vertical borrows in the intertidal zone, where they are sensitive to natural and man-made disturbances of the beach (USFWS 1994). Larvae might be affected by new or expanded aquaculture operations if such operations involve disturbing the beaches they occupy.

3.4.5 Plants

Sensitive jointvetch (*Aeschynomene virginica*) – Sensitive jointvetch is an annual species of intertidal marsh plant that occurs in the freshwater tidal sections of river systems in the Bay, mainly in Virginia (USFWS 1995).

3.5 ESSENTIAL FISH HABITAT

The Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), 1996 revision, defines essential fish habitat (EFH) as “those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity.” The MSFCMA applies only to Federally-managed species. Under the MSFCMA, fishery management plans must identify and describe EFH for the fishery and minimize adverse effects on the fishery to the extent practical (NMFS 2005). The MSFCMA also defines associated habitat areas of particular concern (HAPC). This designation denotes EFH that is particularly important to the long-term productivity of the species, is particularly vulnerable to degradation, or both. The intent of the designation is to focus greater attention on conservation efforts. The six summary EFH designations specific to major portions of Chesapeake Bay in Maryland are as follows: Chesapeake Bay Mainstem; Chester River; Choptank River; Patuxent River; Potomac River; and, Tangier/Pocomoke Sound. The four summary EFH designations specific to major portions of Chesapeake Bay in Virginia are Chesapeake Bay Mainstem, James River, Rappahannock River, and York River. In addition, there are summary designations for a number of discreet areas of the lower Bay in Virginia not covered by the other geographical listings (http://www .nero.noaa.gov/hcd/est.htm).

Twenty-one federally-managed species have designated EFH within Chesapeake Bay. Table 3-3 provides a summary of EFH for those species. In order to relate EFH to the ERA approach used to support this PEIS, the table also indicates which ecosystem component(s) described in Section 3.2 most closely relates to each species or its EFH. The mechanism by which the proposed action or the alternatives might affect the EFH for these species would be the same as is described in the relevant subsections of Section 3.2. Because the

Table 3-3. Summary of EFH within Chesapeake Bay for 21 Federally managed species.

Species	Life Stage*	Description of EFH	Description of HAPC	Ecosystem Component (Section 3.2.x)
Atlantic herring (*Clupea harengus*)	A	Pelagic and bottom habitats in the lower portions of the Chesapeake Bay and Eastern Shore of Virginia.	None	Planktivorous fish (3.2.6)
Red hake (*Urophycis chuss*)	J, A	Juveniles: Substrates of shell fragments and live scallop beds in the lower Chesapeake Bay and Eastern Shore of Virginia. Adults: Bottom habitats of sand and mud.	None	Reef-oriented fish (3.2.7)
Windowpane flounder (*Scophthalmus aquosus*)	J,A	Juveniles & Adults: Bottom habitats of mud or fine-grained sand in most of the tidal Chesapeake Bay	None	Soft-bottom Benthos (3.2.1)
Winter flounder (*Pleuronectes americanus*)	J,A	Juveniles & Adults: Bottom habitats of mud, sand, and gravel in the coastal bays only.	None	Soft-bottom Benthos (3.2.1)
Summer flounder (*Paralichthys dentatus*)	L,J,A	Larvae: Tidal creeks and mouths. Juveniles: Lower estuaries in flats, channels, salt marsh creeks, and eelgrass beds. Adults: Estuary waters during the warmer months.	Juveniles and adults limited to native macroalgae, SAV, and fresh and tidal macrophytes in beds of any size within their EFH.	Soft-bottom Benthos (3.2.1) SAV (3.2.2)
Bluefish (*Pomatomus saltatrix*)	J,A	Juveniles: Estuaries used as nursery areas; seasonal in the Chesapeake Bay from May to October Adults: Estuaries from April to October Juveniles and adults are pelagic	None	Piscivorous fish (3.2.8)
Black sea bass (*Centropristis striata*)	J,A	Juveniles: Rough bottom, shellfish and eelgrass beds, and artificial structures on sandy and shell bottoms in estuaries, salt marsh edges, and channels during spring and summer. Adults: Natural and artificial structured habitats, and sand and shell substrates in estuaries from May to October.	None	Reef-oriented fish (3.2.7)
Atlantic Butterfish (*Peprilus tricanthus*)	E, L,J,A	Estuaries for eggs in spring and summer, larvae from summer through fall, juveniles from spring to fall, adults from summer to fall. All life stages are pelagic.	None	Planktivorous fish (3.2.6)
Scup, porgy (*Stenotomus chryops*)	J,A	Juveniles: Bottom habitats of sand, mud, and mussel and eelgrass beds in estuaries during spring and summer. Adults: Inshore estuaries on various bottom substrates.	None	SAV (3.2.2) Reef-oriented fish (3.2.7)
Red drum (*Sciaenops ocellatus*)	L,J,A	Larvae: Estuarine wetlands such as flooded salt marshes, brackish marshes, tidal creeks, and SAV beds. Juveniles: Shallow backwaters of estuaries, which are used as nursery areas until the fish migrate to the deeper waters of the estuaries, river mouths, and oyster bars; found throughout the Chesapeake Bay from September to November. Adults: Shallow bay bottoms, oyster reef substrate or artificial reefs within coastal inlets, shoals and capes of the Chesapeake Bay and Eastern Shore of Virginia during the spring and fall.	Coastal inlets, barrier islands, and State-designated habitats where SAV is critical.	SAV (3.2.2) Reef-oriented fish (3.2.7)
Cobia (*Rachycentron canadum*)**	E,L,J,A	High-salinity bays, estuaries, seagrass beds, and coastal inlets.	None	Piscivorous fish (3.2.8)
King mackerel (*Scomberomorus cavella)***	E,L,J,A	Coastal inlets	None	Piscivorous fish (3.2.8)
Spanish mackerel (*Scomberomorus maculates*)**	E,L,J,A	Coastal inlets	None	Piscivorous fish (3.2.8)

Table 3-3. (Continued)

Species	**Life Stage***	**Description of EFH**	**Description of HAPC**	**Ecosystem Component (Section 3.2.x)**
Dusky shark *(Charcharinus obscurus)***	L, J	Neonate/Early Juvenile: Shallow coastal waters, estuaries, and inlets to 25 m deep during April to July Late Juvenile/Sub-adult: Exposed nearshore water of Virginia and rarely enter the estuaries as a summer secondary nursery area. In areas from 20 to 200 m deep. Adult: Pelagic waters offshore Virginia/North Carolina border to the 200m isobath	None	Piscivorous fish (3.2.8)
Sandbar shark *(Charcharinus plumbeus)***	L, J, A	Neonate/Early Juvenile: Nursery areas in the shallow, coastal waters of Chesapeake Bay during March to July where salinity is greater than 22 ppt and temperatures greater than 70ºF Late Juveniles/Sub-Adults: Shallow, coastal waters from the coast to the 80-feet isobath. Summer secondary nursery area from May to October in the lower Chesapeake Bay, VA, and the tidal creeks and lagoons along Virginia's eastern shore. Adults: Shallow, coastal waters from the coast to the 165-feet isobath	Important nursery and pupping grounds have been identified in shallow areas and the mouths of tributaries in lower Chesapeake Bay	Piscivorous fish (3.2.8)
Sand tiger shark *(Odontaspis taurus)***	L, A	Neonate/Early Juvenile: Estuaries of the Mid-Atlantic bight and coastal sounds of Chesapeake Bay in March and April Adults: Found worldwide in shallow coastal waters	None	Piscivorous fish (3.2.8)
Atlantic sharpnose shark *(Rhizopriondon terraenovae)***	A	Adult: Summer migrant into Virginia coastal waters	None	Piscivorous fish (3.2.8)
Scalloped hammerhead shark *(Sphyrna lewini)***	J	Juveniles: All shallow coastal waters of the U.S. Atlantic seaboard from the ocean shoreline to the 200m isobath from 39 º N and south	None	Piscivorous fish (3.2.8)
Clearnose skate (*Raja eglanteria)*	J, A	Juvenile/Adult: Appear in Chesapeake Bay between April and December with peak abundance between May and August; most abundant near the Bay mouth during spring and summer; rarely appear in tributaries. Can be found in Chincoteague Bay (VA), and Sinepuxent Bay (MD) from May to November. Prefer habitats with soft bottom, rocky, or gravelly substrates in 7-15m of water, and salinities greater than 22 ppt.	None	Soft-bottom Benthos (3.2.1)
Little skate (*Leucoraja erinacea)*	J, A	Juvenile/Adult: In lower Chesapeake Bay in December and in March and around the Bay mouth in high-salinity waters during April and May. Prefers sandy, gravelly, or muddy substrates	None	Soft-bottom Benthos (3.2.1)
Winter skate (*Leucoraja ocellata)*	J, A	Juvenile/Adult: Found in Chesapeake Bay from December to April. Prefers habitats with a substrate of sand and gravel or sometimes mud	None	Soft-bottom Benthos (3.2.1)

* Life stages: E = egg, L = larvae, J = juvenile, A = adult
** These coastal migratory pelagic species move through different habitats in open water based on their life-cycle requirements but also have EFH within Chesapeake Bay.

proposed action and alternatives would result in ecosystem changes in nearly all portions of the Bay (Figure 3-1), all of the species in Table 3-3 could be affected.

Portions of the lower Bay totaling approximately 89,000 acres of open water have been designated as HAPC for the sandbar shark (*Charcharinus plumbeus*). The sandbar shark uses the lower Chesapeake Bay as a "pupping ground." Female sandbar sharks move into the lower Bay during the summer (Springer 1960). They typically bear 8 to 12 live young and depart the Bay shortly thereafter, apparently without feeding. The young average approximately 24 inches at birth. They remain in the Bay until the onset of winter, feeding on a variety of fish and crustaceans. Blue crabs are a particularly important food item (Medved and Marshall 1981). In winter, the young migrate to warmer waters off the coast and southward. They may return to estuary mouths and costal bays in the mid-Atlantic region the next year in late spring. Other HAPC that may occur in the Bay has been defined for summer flounder (*Paralichthys dentatus*) and red drum (*Sciaenops ocellatus*).

The follow sections describe the EFH-designated species that occur within the Bay. Planktivorous species are described in Section 3.5.1. Piscivorous species are described in Section 3.5.2. Reef-oriented species are described in Section 3.5.3, and skates and flounders are described in Section 3.5.4. The primary source for each description is cited once near the end of the description.

3.5.1 Planktivorous Species

Atlantic herring (Clupea harengus): Adults – Atlantic herring is a schooling, coastal pelagic species that ranges from Labrador, Canada, to Cape Hatteras. Adults are highly migratory, making extensive feeding, spawning, and overwintering migrations. During the spring, adults migrate north to the Gulf of Maine, Georges Bank, and Nantucket Shoals, where they spawn. After spawning, adults migrate south into southern New England and mid-Atlantic shelf waters, where they winter (Reid *et al.* 1999). Adult Atlantic herring may occupy deeper waters in the Bay as they winter along the mid-Atlantic shelf.

Atlantic butterfish (Pehrilus tricanthus): All Stages – Butterfish are fast-growing, short-lived, pelagic fish that range from Newfoundland to Florida and are most abundant from the Gulf of Maine to Cape Hatteras. Butterfish form loose schools, often near the water surface. Butterfish winter near the edge of the continental shelf in the Mid-Atlantic Bight and migrate inshore in the spring. In the summer, butterfish can be found from sheltered bays and estuaries out to about 200 meters offshore along the entire mid-Atlantic shelf. During the late fall months, butterfish move offshore and south due to falling water temperatures. Eggs and larvae are commonly found in high-salinity zones of bays and estuaries from Massachusetts to New York and in the Chesapeake Bay. Eggs and larvae and are found in surface waters from the continental shelf into estuaries and bays to about 60 meters deep in shelf waters. Eggs survive in water temperatures between 12ºC and 23ºC and are found during the spring and summer. Larvae prefer water temperatures between 4ºC and 28ºC and are found during summer and fall. Juvenile and adult butterfish can tolerate a wide range of salinities (3 to 37 ppt) and temperatures (4ºC to 30ºC). Survival is inhibited below 10ºC, and spawning will not occur when water temperatures drop below 15ºC. Butterfish are frequently found over sand, mud, and mixed substrates. Adults spawn in the continental shelf, inshore areas, and in bays and estuaries. Butterfish feed mainly on planktonic prey including, mollusks (primarily squids), crustaceans (copepods, amphipods, and decapods), coelenterates (primarily hydrozoans), polychaetes (primarily Tomopteridae and Goniadidae), small fishes, and ctenophores (Cross et al. 1999). All stages of the Atlantic butterfish can be expected to occur in Chesapeake Bay.

3.5.2 Piscivorous Species

Bluefish (Pomatomus salatrix): Juveniles and Adults – Bluefish range from Nova Scotia and Bermuda to Argentina but are rare between southern Florida and northern South America (Robins et al. 1986). They travel in schools of like-size individuals and undertake seasonal migrations. Bluefish spawn in open waters near the edge of the continental shelf. Juvenile bluefish move inshore in early to mid-June, when temperatures reach approximately 20ºC. Juveniles use a variety of habitats in estuaries, bays, and the coastal ocean of the Mid-Atlantic Bight and South-Atlantic Bight but are not found in marshes. During the day, they are usually found near shorelines or in tidal creeks; at night, they move to open bay or channel waters. They prefer sandy substrates but can also be found over silt and clay bottoms. They are usually found in salinities of 23 to 33 ppt but can tolerate salinities as low as 3 ppt. Juvenile bluefish are active swimmers, feeding on small forage fish found in nearshore habitats. Juveniles remain inshore in waters up to 30ºC until their fall migration to the continental shelf when water temperatures cool to 15ºC. In Chesapeake Bay, most bluefish are found where DO levels are between 6 and 9 mg/l. Adult bluefish occur in the open ocean, large embayments, and estuaries. They occur in a wide range of conditions but prefer warmer waters (at least 14ºC to 16ºC) and high salinities. Adults are found at much deeper depths than juveniles, ranging from 1 to 400 m (Shepherd and Packer 2005). Juvenile bluefish can be expected to be present throughout the Bay. Adults could be found in deep portions of the Bay.

Cobia (Rachycentron canadum): All Stages – Cobia are pelagic, warm water fish that prefer water temperatures between 20°C and 30°C. They spend their winters near the Florida Keys and migrate north during spring and summer to spawn in the mid-Atlantic region. Spawning occurs between mid-June and mid-August in estuarine and offshore areas, including near the mouth of the Chesapeake Bay. Eggs and larvae are generally not found in lower salinities of estuaries. Juveniles and adults are occasionally present in deeper waters of Chesapeake Bay during the summer but are rarely found as far north as Massachusetts. In Chesapeake Bay, sports fishermen catch cobia as far north as the mouth of the Potomac River (Richards 1967; National Audubon Society 1983; CBP 2008). Juvenile and adult cobia may be present in the Bay, particularly during the summer.

King mackerel (Scomberomorus cavella): All Stages – King mackerel are highly migratory, epipelagic fish that migrate from Florida as far north as the Gulf of Maine during summer and fall. Temperature and salinity appear to be the most important factors in their distributions, and all stages prefer salinities between 32 and 36 ppt. King mackerel spawn in coastal waters of the Gulf of Mexico and the along the southern Atlantic coast. Larvae are found near or off the continental shelf, near the Gulf Stream, in waters with temperatures between 22 to 28°C (Godcharles and Murphy 1986; Collette and Nauen 1983). Adult king mackerel may pass through Chesapeake Bay to feed during their annual northward migration and when they return south in the fall. Early life stages are not expected to occur in the Bay.

Spanish mackerel (Scomberomorus maculates): All Stages – Spanish mackerel are highly migratory, epipelagic fish that migrate from Florida as far north as the Gulf of Maine during summer and fall. The northernmost part of their range is near Block Island, Rhode Island. Temperature and salinity appear to be the most important factors in their distributions, and all stages prefer salinities between 32 and 36 ppt. This species usually avoids freshwater or low-salinity areas near the mouths of rivers. Spanish mackerel prefer water temperatures between 21°C and 27°C and are rarely found in waters cooler than 18°C. Spanish mackerel typically spawn at night when water temperatures drop below 26°C. During mid-June, Spanish mackerel can be observed spawning in the lower part of Chesapeake Bay. Larvae have been found in waters from 30 to 300 feet deep. Some juvenile Spanish mackerel use estuaries as nursery grounds, but most juveniles remain in nearshore, open-beach waters (Godcharles and Murphy 1986; Collette and Nauen 1983). Adults may pass through the Bay to feed during their annual northward migration and when they return south in the fall. Early life stages are not expected to occur in the Bay.

Dusky shark (Charcharinus obscurus): Larvae and Juveniles – The dusky shark is a coastal-pelagic, migratory shark found in the continental insular shelves and oceanic waters from Nova Scotia to Cuba. Dusky shark is warm-temperate, tropical species that does not frequent areas with reduced salinities and tends to avoid estuaries. It is most often found along continental coastlines, where it ranges from shallow inshore waters to the outer continental shelf and adjacent oceanic waters up to 1,310 feet deep. This species is highly migratory, moving north during the summer and south in the winter. Dusky sharks are viviparous, with a yolk-sac placenta. Mating occurs in the spring, after which female dusky sharks move inshore to give birth to their young, departing the nursery area shortly thereafter. Prime nursery areas are estuaries and bays from New Jersey to Cape Hatteras. Early juvenile life stages are found primarily in shallow coastal waters, inlets, and estuaries from the eastern end of Long Island, New York, south to West Palm Beach, Florida, in waters up to 100 m deep (Compagno 1984; USDOC 1999). Females move to nearshore water to spawn; therefore, neonates and juveniles are expected to occur in Chesapeake Bay.

Sandbar shark (Charcharinus plumbeus): Larvae, Juveniles, and Adults – Sandbar shark is an abundant, coastal-pelagic species that occurs inshore and offshore in temperate and tropical waters. Sandbar sharks are found on continental and insular shelves and are common at bay mouths, in harbors, inside shallow muddy or sandy bays, and at river mouths. Sandbar sharks tend to avoid sandy beaches and the surf zone. They are bottom dwelling and are most common in 20 to 55 m of water but are occasionally found at depths of about 200 m. Sand bar sharks migrate north and south along the Atlantic coast, as far north as Massachusetts in the summer. Sandbar sharks mate in the spring or early summer (May through June). Females are viviparous, and pups are born in shallow bays and estuaries from Great Bay, New Jersey, to Cape Canaveral, Florida, (especially in Delaware and Chesapeake bays) from June through August. The young inhabit shallow coastal nursery grounds until late fall and move southward and further offshore in winter months, returning to nursery ground during the summer months. This movement between shallow coastal waters and warmer, deeper waters may occur for up to five years. Neonates and juveniles require salinity levels greater than 22 ppt and water temperatures greater than 21°C. Late juveniles and adults occupy coastal waters as far north as southern New England and Long Island (Compagno 1984; USDOC 1999). Chesapeake Bay is a known nursery ground for this species; therefore, neonates and juveniles are likely to occur there.

***Sand tiger shark (Odontaspis taurus): Larvae and Adults* –** The sand tiger shark is a large, coastal species found in tropical and warm temperate waters from Maine to Brazil. It moves inshore to offshore and from littoral areas to deep water. It is often found in very shallow water (less than 4 meters deep) but can also be found in waters as deep as 5,250 feet. Sand tiger sharks are occasionally seen along the tide line near beaches or entering mouths of rivers. They are also found in shallow bays and around coral reefs. Sand tiger sharks have been observed hovering motionless just above the seabed in or near deep, sandy-bottom gutters or rocky caves, usually near inshore rocky reefs and islands. Sand tiger sharks congregate in coastal areas in large numbers during the mating season. They give birth in March and April, and after birth, neonates migrate northward in the summer to estuarine nursery areas. These nursery areas include Mid-Atlantic Bight estuaries including Chesapeake, Delaware, Sandy Hook, and Narragansett bays, as well as coastal sounds (Compagno 2002). The Chesapeake Bay is a primary estuarine nursery area for this species, so both neonates and adult sand tiger sharks can be expected in the area.

***Atlantic sharpnose shark (Rhizopriondon terraenovae): Adults* –** The Atlantic sharpnose shark is a small, coastal species that inhabits the waters of the northeastern coast of North America. These sharks are common, year-round residents of the South Atlantic Bight and are found in schools of uniform size and sex. Adults prefer temperatures between 20°C and 30°C and salinities between 21 and 35 ppt (USDOC 1999). Adult Atlantic sharpnose sharks can be expected to occupy the Bay.

***Scalloped hammerhead shark (Sphyrna lewini): Juveniles* –** The scalloped hammerhead shark is a very common, large, schooling species that is most often found in warm waters along the Atlantic coast. This species has been found in coastal regions, including shallow waters such as estuaries and inlets. It migrates seasonally north-south along the eastern United States. This species occupies surface waters as well as waters as deep as 900 feet. Early juveniles are typically associated with shallow coastal waters of the South Atlantic Bight, and late juveniles are typically associated with shallow coastal waters along the Atlantic coast from the shoreline to depths of 600 feet. Juveniles are known to avoid areas of construction (USDOC 1999). Juvenile scalloped hammerhead shark can be expected to occur in the Bay.

3.5.3 Reef-Oriented Species

***Red hake (Urophycis chuss): Juveniles and Adults* –** Red hake is a demersal species that ranges from southern Newfoundland to North Carolina. Red hake make seasonal migrations to follow preferred temperature ranges. During warmer months, they are found at depths less than 100 m, but during colder months they prefer depths greater than 100 m. Juvenile red hake prefer habitats with shelter or structure and are often associated with scallops, surf clams, and seabed depressions. Juveniles prefer depths from the low tide line to less than 395 feet and temperatures between 2°C and 22°C. Adults are common on soft sediments, including depressions or shell beds, and are not usually found on open sandy bottom. Adults are also found in the water column. Adults prefer depths between 100 and 425 feet and temperatures similar to juveniles. Red hake spawn offshore in the Mid-Atlantic Bight in the summer, primarily in southern New England (Steimle et al. 1999a). Juveniles, in particular, tend to associate with structures, including reefs and shellfish and, therefore, are expected to be present in the Bay and to be affected by the proposed action and all alternatives except Alternative 1 (No Action).

Black sea bass (Centropristis striata): Juveniles and Adults – Black sea bass is a warm, temperate species that ranges from Nova Scotia to Florida and the Gulf of Mexico. Black sea bass are typically found on the continental shelf associated with structures such as reefs and shipwrecks, but young-of-the-year fish also occur in estuaries. During the fall, juvenile black sea bass migrate from nearshore summer habitats to overwintering habitats on the outer continental shelf. During warm winters, juveniles may also overwinter in the deeper waters of the lower Chesapeake Bay (MAFMC 1996; CBP 1996). Juveniles are most abundant in higher salinities, including polyhaline regions of estuaries and the ocean, but can occur at salinities as low as 8 ppt. Adult black sea bass use rocky reefs, cobble and rock fields, stone coral patches, exposed still clay, and mussel beds as habitat. Adults remain near complex structures during the day but may move to nearby soft-bottom habitats for feeding in the early morning or evening. Adults show strong habitat fidelity. In the summer, adults are located on the nearshore continental shelf where water depth is less than 60 meters. Adults can also be found in lower reaches of large, shallow (approximately 5 meters) estuaries. In the fall in the Mid-Atlantic Bight, adults migrate from nearshore continental shelf habitats to outershelf overwintering areas as bottom water temperatures approach 7ºC. In April, as waters warm to greater than 7ºC, adults return inshore. Sea bass in more southern areas appear to be non-migratory and stay at specific reefs throughout the year. Adult black sea bass are vulnerable to low DO levels (Drohan et al. 2007). Black sea bass are expected to be found in the Bay associated with three-dimensional structures, including reefs.

Scup, porgy (Stenotomus chryops): Juveniles and Adults – Scup are temperate fish distributed primarily from Massachusetts to South Carolina. During the summer, scup from the Mid-Atlantic Bight population are found in larger estuaries and coastal waters in open and structured habitats. During the winter, scup occur along the outer continental shelf to depths of about 200 m. Spawning occurs along the inner continental shelf off southern New England from May through August. Eggs and larvae are pelagic, but adults are mainly demersal. Neither juveniles nor adults tolerate low salinities (less than 15 ppt). During warmer months, juvenile scup inhabit inshore coastal and estuarine areas, including sand, mud, mussel beds, and eelgrass beds, but are not found directly along the shoreline. They move offshore during the winter. Adults use similar habitats as juveniles, including soft, sandy bottoms, on or near structures such as mussel beds, reefs, or rough bottom. Adults are common in the Mid-Atlantic Bight from spring to fall and are often found in size-structured schools. Like juveniles, once water temperatures fall below 7.5ºC to 10ºC in the fall, adults move to warmer, deeper waters where salinities are greater than 30 ppt (Steimle et al. 1999b). Both juvenile and adult scup are expected to occur in sandy-bottom areas, and sandy shoals within the Bay during spring and summer months.

Red drum (Sciaenops ocellatus): Larvae, Juveniles and Adults – Red drum are estuarine-dependent fish distributed along the Atlantic Coast and the Gulf of Mexico. In the mid- and south Atlantic, red drum spawn from mid-August through late September in nearshore waters adjacent to channels and patches. Salinity affects the success of spawning. It has been suggested that eggs and larvae are transported by deep subsurface currents of high-density water in the Chesapeake Bay. Larvae are found in vegetated and unvegetated bottoms in estuaries, and are affected by temperature as they develop. At water temperatures below 20°C, larvae may not be able to make the transition to active feeding. Juveniles and adults are euryhaline and eurythermal. Juveniles have been found at salinities from 0 to 50 ppt and at water temperatures of 13 to 28°C. Young-of-the-year juveniles live in protected waters where there is little wave action. After their first year, they move into deeper bays and marine littoral areas in fall and winter and then return to the estuary in the spring. Adults are most abundant at salinities of 30 to 35 ppt. Adults have been found in water temperatures between 2°C and 33°C (Buckley 1984). Larvae, juveniles, and adults could be present throughout the Bay, particularly in or around coastal inlets.

3.5.4 Skates and Flounders

Clearnose skate (Raja eglanteria): Juveniles and Adults – Clearnose skates can be found from the Nova Scotian shelf to Florida and in the northern Gulf of Mexico. They have been captured from shore depths in the northern part of their range to 329 meters, but are most abundant at depths less than 111 meters. They are found over a temperature range of 9°C to 30°C. In general, clearnose skates spend the spring and early summer months inshore along the continental shelf, and move offshore and south during fall and early winter months when water temperatures cool. Clearnose skates prefer soft bottoms along the continental shelf and are also found along rocky and gravelly bottoms. Both juveniles and adults prefer salinities greater than 20 ppt, although some have been found in areas with salinities as low as 15 ppt. Clearnose skates have been found throughout Chesapeake Bay from April to December and are most abundant near the mouth of the Bay during spring and summer. In the Chesapeake Bight, clearnose skates were found to be more abundant in shallow water during spring and summer than during fall and winter (Packer et al. 2003a). Juveniles and adults could occur in the Bay, particularly during the summer months.

Little skate (Leucoraja erinacea): Juveniles and Adults – Little skates are demersal fish distributed from Nova Scotia to Cape Hatteras but concentrated in the northern section of the Mid-Atlantic Bight and on Georges Bank. Little skates do not make extensive migrations, but those that live inshore move onshore and offshore with seasonal temperature changes. In the southern fringe of their range, little skates move north and south with seasonal temperature changes. Juveniles and adults may move from estuaries to deeper waters during warmer months. Both juveniles and adults prefer sandy or gravelly bottoms but can also be found on muddy substrates. Skates often remain buried in depressions during the day and are more active at night. Overall, their temperature range is 1°C to 21°C, but most are found between 2°C and 15°C. Juveniles and adults are found in depths from 1 to 400 meters, but most are between 5 and 20 meters. In Delaware Bay, little skates were collected at salinities as low as 15 to 20 ppt, but their preferred salinities are in the range of 31 to 34 ppt. Little skates have been found in the lower part of Chesapeake Bay in high-salinity waters. They are generally absent from the Chesapeake Bight during the summer months (Packer et al. 2003b). Juveniles and adults could occur in the Bay, particularly during the spring and fall months.

Winter skate (Leucoraja ocellata): Juveniles and Adults – The winter skate is distributed from the south coast of Newfoundland and the southern Gulf of St. Lawrence to Cape Hatteras. Winter skates are concentrated on Georges Bank and in the northern section of the Mid-Atlantic Bight. It has been suggested that winter skates undertake seasonal movements, particularly in the southern part of their range, moving toward shore in the fall and off shore in the summer (McEachran 2002). Winter skates have been reported in Chesapeake Bay from December to April (Hildebrand and Schroeder 1928; Geer 2002). Winter skates generally range from the shoreline to 371 m, although they are most abundant where water depth is less than 111 meters. They have been found in water temperatures ranging from -1.2°C to 19°C. Winter skates prefer sandy and gravelly bottoms but are also found in muddy bottoms. Bottom type seems to influence the distribution of winter skate more than water depth. Winter skatea remain buried in depressions during the day and become more active at night. They prefer salinities of 32 to 34 ppt but have been found in waters between 15 ppt and 36 ppt (Packer et al. 2003c). Juveniles and adults could occur in the Bay, particularly during the winter months.

Summer flounder (Paralichthys dentatus): Larvae, Juveniles, and Adults – Summer flounder inhabit shallow estuarine waters and the outer continental shelf from Nova Scotia to Florida. They are most abundant within the Mid-Atlantic Bight from Cape Cod, Massachusetts, to Cape Hatteras, North Carolina. Summer flounder exhibit strong seasonal inshore-offshore movements, although not to the degree of other highly migratory species. Adults and juveniles inhabit shallow coastal and estuarine waters during spring and summer and move offshore during the fall and winter. Adults spawn in the open ocean during the fall and winter while they are moving offshore or onto their wintering grounds. Larvae are most abundant 12 to 50 miles from shore at depths of 100 to 230 feet in the northern part of the Mid-Atlantic Bight from September through February. Larvae migrate inshore, entering coastal and estuarine nursery areas to complete transformation. They then leave the water column and settle to the bottom, where they bury in the sediment and complete development to the juvenile stage. Juveniles remain inshore and in many estuaries during spring, summer, and fall. They may move to deeper waters offshore with the adults during colder winter months. Juveniles use a variety of estuarine habitats, including estuarine marsh creeks, which serve as important nursery habitat, and seagrass beds, mud flats, and open bay areas. Juveniles are sometimes found in Chesapeake Bay, where young of the year occupy tidal creeks with salinities greater than 15 ppt. Abundance of juveniles increases in high-salinity systems. Substrate preference and prey availability affect distribution. Some juveniles prefer mixed or sandy substrates, and others use mud and vegetated habitats. Adult summer flounder prefer sandy habitats, but because they can camouflage themselves to match their substrate (Mast 1916), they also occupy various habitats with mud and sand substrates. Distribution by depth in the water is related to temperature. During the summer, adults are found in the high-salinity areas of estuaries, but this may be due to substrate preference, rather than to salinity preference (Packer et al. 1999). Larvae, juveniles, and adult summer flounder are common throughout lower portions of the Chesapeake Bay. In Maryland, coastal bays are excellent habitat for adults and juveniles, but in areas of significant pollution, a lack of food sources and/or insufficient water circulation may prevent subsistence.

Windowpane flounder (Scophthalmus aquosus): Juveniles and Adults – Windowpane flounder is a eurythemal, euryhaline, fast-growing species distributed from the Gulf of Saint Lawrence to Cape Hatteras. Windowpane flounder inhabit estuaries, near-shore waters, and the continental shelf, preferring shallow waters (< 110 m) and sand to sand/silt or mud substrates. They can be found in most bays and estuaries south of Cape Cod throughout the year at a wide range of depths (less than 5 to 130 ft) and temperatures (0-28ºC). Juveniles and adults occur at salinities of 5.5 to 36.0 ppt (Tagatz 1967) and are sensitive to hypoxic conditions (DO less than 3 mg/l). Windowpane flounder are not targeted by commercial fisherman but are by-catch in other bottom-trawl fisheries. Spawning occurs throughout most of the year (April-December) with peaks in the central Mid-Atlantic Bight in the spring and fall (Morse and Able 1995; Able and Fahay 1998). Windowpane flounder spawn primarily in offshore areas and may spawn in the high-salinity portions of estuaries and in coastal habitats of the Carolinas. Juveniles settle in shallow inshore waters and then move to deeper waters as they grow. Both juveniles and adults may migrate to nearshore or estuarine habitats in southern Mid-Atlantic Bight during spring through autumn. Adults are known to travel along the coast for great distances (Chang et al. 1999). Juvenile and adult windowpane flounder are expected to occur throughout the Bay, particularly during spawning and during spring through autumn.

Winter flounder (Pleuronectes americanus): Juveniles and Adults – Winter flounder is a valuable commercial and recreational species. Winter flounder are distributed along the Atlantic Coast from Labrador, Canada, to North Carolina and Georgia. They are common on Georges Bank and in shelf waters as far south as Chesapeake Bay. Winter flounder are omnivorous, opportunistic feeders, consuming a wide variety of prey. Adults migrate inshore during the fall and early winter and spawn during late winter and early spring throughout most of their range. Peak spawning occurs during February and March near Cape Cod and somewhat earlier in more southern waters. Spawning occurs in coves and inlets. After spawning, most adults leave the inshore areas, although some remain in shallow waters year-round. Young of the year have different habitat requirements than larger juveniles. Recently settled young-of-the-year juveniles are found close to spawning grounds and in depositional areas with slow currents. They spend their first year in very shallow inshore waters before moving to deeper water in the fall, and remain in the deeper, cooler water for much of the next year. Juveniles can be found in both inshore and offshore waters. Young-of-the-year flounder subsist in lower salinities (5 ppt) than do yearling flounder (10 ppt; Reynolds and Thomson 1974). Habitat utilization by young-of-the-year flounder is not consistent across habitat types or years. Adult winter flounder prefer temperatures in the range of 12ºC to 15ºC and salinities above 22 ppt. Their salinity tolerance is age dependent, and some have survived in salinities as low as 15 ppt (McCracken 1963; Pereira et al. 1999). Juveniles and adults can be expected to be common in the Bay throughout the year.

3.6 CULTURAL AND SOCIOECONOMIC ENVIRONMENT

The cultural and socioeconomic environment of the Chesapeake Bay region is complex and diverse. Oysters play a variety of significant roles in this environment. The Eastern oyster is highly valued as a source of food, a symbol of heritage, an economic resource supporting families and businesses, and a contributor to the health of the Chesapeake Bay ecosystem. Harvesting, selling, and eating oysters has historically been a central component and driver of social and economic development in the region. From the colonial period to the 20th century, oyster harvests supported a vibrant regional industry, which in turn supported secondary industries, fishing communities, and a culinary culture centered on the bivalve.

Chesapeake Bay provides one of the primary focal points for tourism in Maryland and Virginia. Recreation in the Bay region includes a wide range of activities such as hunting, fishing, sailing, hiking, touring historical landmarks, dining, and shopping. Tourism attracted almost 28 million people to Maryland in 2005. Those visitors spent more than $10 billion on accommodations, services, and attractions throughout the state (MD Tourism Development Board 2006). Domestic tourists spent $16.5 billion in Virginia (Travel Industry Association

2006). These expenditures contribute significantly to the economies of each state, particularly by generating employment and tax revenue. Shared valuations of the Chesapeake as an accessible, safe, clean recreational resource influence the benefits that surrounding states derive from recreational use of the Bay.

A culture can be defined as a body of knowledge and shared values that are learned through membership and participation in a specific group or community. The cultural value of oysters in the Chesapeake can be perceived in two different but related ways. Oysters are an economic resource that supports unique communities and an industry that is an important component of the region's heritage and identity. Within these communities, oysters are a source of income for families of watermen and those employed in the processing of oysters (e.g., shuckers); they support multigenerational businesses and contribute to a regional economy. Oysters also give people the opportunity to interact with the marine environment in the most salient way possible – through work. These communities have helped to shape the character of the Chesapeake Bay region. Oysters are also a natural resource that carries cultural meaning as one symbol of a productive, healthy, beautiful Chesapeake Bay. These natural values are more implicit than stated, but they play a critical role in determining how different groups interact with each other and the environment. Economic and natural values combine to define what Chesapeake Bay means to people. To incorporate cultural meaning into policy, all groups' knowledge and values (implicit and explicit) must be recognized and evaluated based on an understanding of (1) how each group understands and uses oysters, and (2) how each group's perception of oysters affects its understanding of, support for, or resistance to policies and programs designed to manage and sustain the Bay's natural resources. A wide range of behaviors can be affected by changes in cultural meaning, including political support for oyster restoration plans, consumption of oysters, and participation in oyster recovery programs, commercial fishing, or the operation of oyster-dependent businesses (Paolisso et al. 2006).

The seafood industry contributes approximately $400 million each year (State of MD 2006) to Maryland's total gross domestic product of $257.8 billion (http://www.bea.gov/regional/gsp/). Virginia's seafood industry is the fourth largest producer of marine products in the nation, with an annual economic impact of more than $500 million (http://www.virginiaseafood.org) to Virginia's total gross domestic product of $383.0 billion. In 2004, commercial fisheries landings (i.e., the weight, number or value of a species of seafood caught and delivered to a port) alone earned $49,293,942 in Maryland and $160,509,226 in Virginia (NMFS, pers. comm., Fisheries Statistics Division, Silver Spring, 2005 data available at http://www.st.nmfs.noaa.gov/st1/commercial /landings/annual_landings.html). More than 6,600 watermen work Chesapeake Bay, providing seafood to 74 seafood processing plants in Maryland; these plants employ more than 1,300 people (MD Seafood 2005). Virginia has more than 194 processing plants, and the seafood industry provides more than 11,000 part-time and full-time jobs (VA Seafood 2004). These jobs represent an assortment of positions including day laborers, sales representatives, managers, maintenance workers, delivery personnel, and others. The sector relies on immigrant workers, particularly in oyster and crab processing facilities (Kirkley et al. 2005).

Although the cultural influence of changes in oyster populations in the Bay extends to all residents, people with familial or historical ties to the region, taxpayers, and varieties of users, the socioeconomic dimensions of such changes are most relevant for direct users. Direct users include watermen, oyster growers, and oyster processors, packagers, shippers, and retailers. The oyster industries in Maryland and Virginia are quite distinct due to differences in oyster populations, regulatory frameworks, and structure. Processing, wholesale, and retail operations continue to operate in the region but depend increasingly on oysters imported from elsewhere. The processing sector in Maryland, which consisted of 11 processing plants employing 249 people in 1997, is smaller than in Virginia, where 21 plants employed 389 employees that same year (NRC 2004; Muth et al. 2000). In Maryland, most oysters are harvested from public grounds during the winter (depending on the kind of equipment used, a designated time frame between October and March; DNR 2006a). In Virginia, a significant portion of landings comes from privately held leases, which often are harvested during the summer, whereas public beds are harvested during the winter (NRC 2004). During the 1990s, more than 96% of the oyster harvest in Maryland came from public beds, while less than 40% of Virginia's harvest came from public beds, and the rest came from leased beds. Although oystering earns watermen much less money than they earn from crabbing during the spring and summer, dredging or tonging for oysters during fall and winter enables them to continue to earn a small income, providing a financial safety valve for watermen and their families (NRC 2004; Appendix E3).

Watermen in both Maryland and Virginia must purchase a special license to harvest oysters. Virginia licenses are purchased by gear type. In Maryland, anyone seeking to harvest oysters must first obtain an Oyster Harvesting License (OHL) or a Tidal Fish License (TFL), which allows the holder to harvest a range of commercially valuable, marine species in the Bay. To qualify to harvest oysters in any particular year, holders of an OHL or TFL must pay an annual oyster surcharge, which currently costs $300. In any given year, many TFL holders elect not to fish for oysters; consequently, the number of oyster surcharges purchased by OHL and TFL holders is the best indicator of the number of Maryland harvesters active in the fishery during a year. In 2001, more than 1,000 watermen in Maryland paid the oyster surcharge, and 320 in Virginia held gear-specific oyster licenses. That same year, these harvesters earned an estimated $5,300 per license (either OHL or TFL) in Maryland and $1,800 per license in Virginia (NRC 2004). In 2004, only 284 watermen in Maryland paid the oyster surcharge (MD DNR 2006b), while 420 watermen in Virginia held oyster licenses (VMRC 2005; see Table 3-4). Overall, the decline in the number of watermen paying the oyster surcharge in Maryland was more pronounced between 1999 and 2006 compared to changes in oyster licensing in Virginia, where the trend was shorter periods of decline and increase (Table 3-4).

Table 3-4. Oyster surcharges and licenses per year for Maryland and Virginia

Year	1999	2000	2001	2002	2003	2004	2005	2006
Maryland Number of Oyster Surcharges	1135	1031	1004	725	461	284	420	577
Virginia Licenses Sold for All Kinds of Harvesting Gear	406	255	320	546	312	420	N/A	N/A

Source: Data from Maryland Department of Natural Resources (2006b) and Virginia Marine Resource Commission (2005).

Direct users of the oyster resource are diverse within all sectors of the industry (i.e., wild harvesting, aquaculture, processing, wholesale, and retail sales). Harvesters of wild oysters (i.e., oysters that settled and grew naturally in public waters, not those cultured on leased bottom) range from young heads of households to older, semi-retired persons. Wild harvesters' dependence on oysters varies widely according to their degree of time and financial investment in oystering, their family and labor situation (which often are closely related), and their reliance on blue crabs or other sources of income. For some watermen, oysters are an integral and essential component of their livelihood. For others, oysters represent a way to earn some extra money during the winter. For most watermen, oysters are a significant component that enables harvesters to continue working the water during winter, which is central to their cultural identity as watermen.

Aquaculture operations are equally diverse and can include growers singly engaged in oyster aquaculture, wild harvesters who also grow oysters, and processors engaged in aquaculture to serve their shucking needs. Shellfish aquaculture is more prevalent and developed in Virginia, although a small number of active growers operate in Maryland. Within Maryland, approximately 94% of bar acreage is public (DNR 2007). In Virginia, about 67% of bar acreage is public, and the rest is leased bottom. Before February 2007, Virginia had no system for permitting and recording production of oysters or clams in the shellfish aquaculture industry (M. Oesterling, VIMS, pers. comm.). Furthermore, applications to lease bottom for culturing oysters were not differentiated from applications to lease bottom for culturing clams. The VMRC is now responsible for administering an aquaculture permitting system and collecting production information; however, limited data are available to estimate the number of acres being leased to culture oysters and clams at this time. The best available estimate is that about 100,000 acres of bottom in Virginia are leased for clam and oyster aquaculture combined, and about 200,000 acres are public shellfishing grounds; however, much of the public fishing ground is no longer productive, and only about 12,000 of the leased acres are believed to be good habitat for clam and oyster aquaculture (J. Wesson, VMRC, pers. comm.). VIMS conducted a mail survey to collect information about clam and oyster growers. Eighteen clam growers and 26 oyster growers responded to the survey; these growers represented 95% of the total production of Virginia's aquaculture during 2005 (Murray and Oesterling 2006). In 2004, Virginia growers used 265 leases for oyster culture; in 2005, the number of leases for oyster culturing grew to 282. Based on the mail survey, the number of acres leased in Virginia that are under cultivation for clams was estimated at 6,569 acres in 2005; however, that estimate includes all cultivation along the eastern shore, both seaside and bayside, as well as a small area of the western shore of Chesapeake Bay in Virginia that is leased for clam cultivation (Murray and Oesterling 2006; M. Oesterling, pers. comm.).

Intensive aquaculture of native oysters can be undertaken in several different ways to serve a variety of markets. Historically, oyster grow-out operations involved moving wild seed to privately leased ground (Murray and Oesterling 2006). Due to increased rates of disease and mortality, this type of aquaculture is rarely practiced today. Intensive native aquaculture is conducted in contained racks, floats, or bags either on-bottom or off-bottom. Growers' dependence on oysters varies with the size and nature of their operation, the degree to which they are diversified or vertically integrated, and the markets they target. A significant number of growers are employed in oyster aquaculture part-time. A 2006 survey a oyster growers in Virginia reported that 30 out of 44 growers who participated were employed part-time (Murray and Oesterling 2006). Virginia growers expected part-time and full-time employment in the aquaculture industry during 2007 to increase significantly beyond levels during 2005 and 2006 and projected a near tripling of the harvest and sale of market-size oysters (Murray and Oesterling 2007; Figure 3-3).

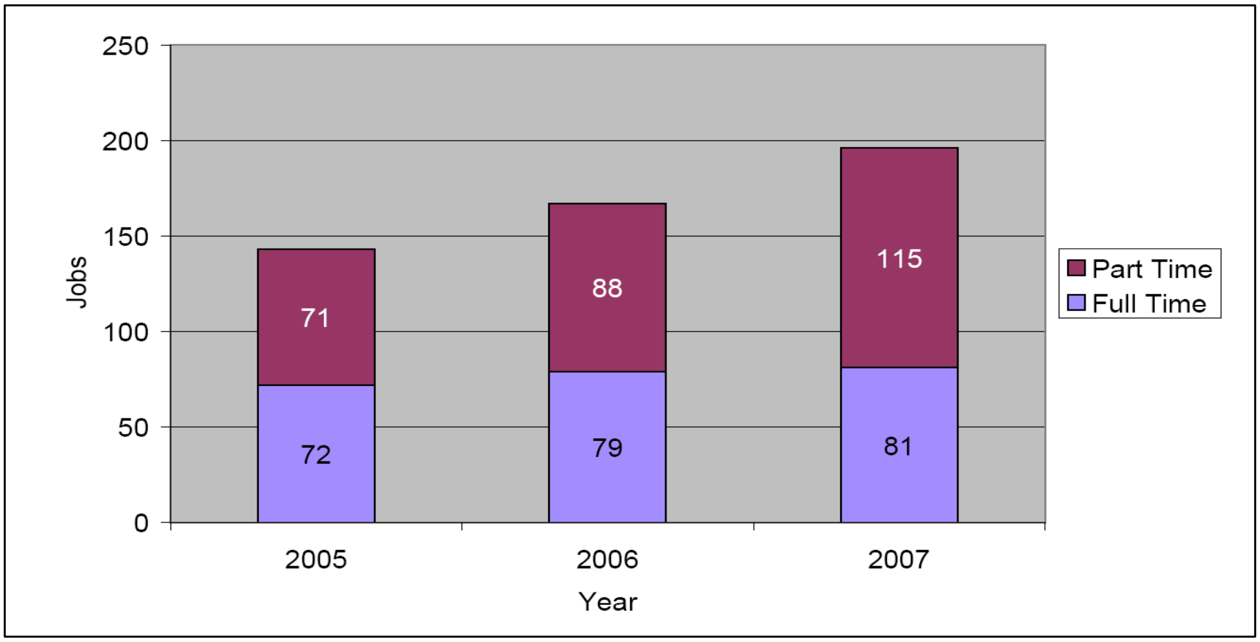

Figure 3-3. Employment in Virginia oyster aquaculture sector during 2005 and 2006; estimated 2007 employment (source: Murray and Oesterling 2007)

Despite the structural variations of the oyster fisheries in Maryland and Virginia and the effects of severely reduced harvest levels, oysters in Chesapeake Bay remain important culturally and economically at the regional, community, and household levels.

3.7 VISUAL, AESTHETIC, AND RECREATIONAL RESOURCES

3.7.1 Visual and Aesthetic Resources

The Chesapeake Bay’s diverse landscape has long been revered for its scenic beauty. The western shore of Chesapeake Bay in Maryland, from the Susquehanna River to the Potomac River, has comparatively high topographic relief, sandy beaches, and actively eroding coastal bluffs. Landscape on Virginia’s western shore is typical coastal plain dissected into three broad peninsulas by four tidal rivers: Potomac, Rappahannock, York, and James. Vegetation ranges from uplands dominated by oak and loblolly pine to bald cypress swamps and freshwater marshlands in the region’s series of smaller tributaries.

Low topographic relief, irregular shoreline, and offshore islands characterize the eastern shore of Chesapeake Bay in Maryland and Virginia and provide a unique aesthetic appeal. Areas of open water and extensive wetlands with tall marsh grasses, shrubs, and trees characterize much of the middle and lower eastern shore. Hummock-and-hollow microtopography (upland mounds surrounded by lowlands) is predominant in the near-shore habitats in this region.

In addition to the Chesapeake's natural beauty, the traditional waterfront communities are of particular aesthetic value. The historic watermen's communities along the Chesapeake's western and eastern shores offer an aesthetic charm and have contributed greatly to tourist-based industries in these areas. Traditional Maryland and Virginia workboats operating in these areas bring aesthetic appeal to the region as well as cultural value. Notably, Maryland's historic skipjack fleet has become a visual symbol of the state and has received attention as the nation's last sail-powered, commercial fishing fleet. Some shellfish-related activities, such as certain types of aquaculture, have the potential to create conflicts with shoreline residents, as has been evident in Maryland's coastal bays in recent years. Homeowners have objected to in-water structures that alter their scenic views and to the noise of workboats.

3.7.2 Recreation

3.7.2.1 Fishing

Chesapeake Bay supports a significant recreational fishery. Estimates indicate that 701,000 resident and non-resident anglers engaged in recreational fishing in Maryland during 2001. In 2001 there were 7.5 million days of fishing in Maryland (FWS 2003a). Approximately 1 million resident and non-resident anglers fished a total of 14.5 million days of fishing in Virginia during 2001 (FWS 2003b).

The principal species of fish sought throughout the Bay include striped bass (*Morone saxatilis*), black sea bass (*Centropristis ocyurus*), bluefish (*Pomatomus saltatrix*), channel catfish (*Ictalurus punctatus*), white catfish (*Ictalaurus catus*), winter flounder (*Pleuronectes americanus*), summer flounder *(Paralichthys dentatus*), spotted sea trout (*Cynoscion nebulosus*), weakfish (*Cynoscion regalis),* Spanish mackerel (*Scomberomorus maculates*), croaker (*Micropogon undulatus*), white perch (*Pomoxis annularis*), yellow perch (*Perca flavescens*), and spot (*Leiostomus xanthurus*). Many recreational fishers specifically target striped bass. The striped bass stock of Chesapeake Bay is one of four east coast migratory stocks (i.e., Roanoke, Delaware, and Hudson rivers) and contains premigratory juveniles and transient adult populations that immigrate to waters in Maryland and Virginia during the spring spawning season. Maryland's trophy striped bass season opens during April and May, and the regular season continues until December in Maryland. Recently the striped bass seasons in Virginia have opened in May, closed in June, and reopened from October to December. Red drum (*Sciaenops ocellata*) and black drum (*Pogonias cromis*), which migrate into Tangier Sound and the lower Bay during the spring, are highly sought by recreational fishers. Fishing for various target species may occur throughout the year, according to State regulations; however, productive fishing for each species varies seasonally. Additionally, recreational fishing for blue crab (*Callinectes sapidus*) is a popular near-shore activity throughout the Bay from May through mid-October, peaking during the summer months. Largemouth bass (*Micropterus Salmoides*) and crappies (*Pomoxis nigromaculatus*) are common catches in freshwater tributaries (FWS 2001). There is no recreational oystering in the Bay, although many owners of shoreline property participate in oyster-rearing programs coordinated by the Chesapeake Bay Foundation.

3.7.2.2 Boating and Navigation

Boating on Chesapeake Bay is a popular recreational activity and an important component of the economies of Maryland and Virginia. Approximately 209,500 boats are registered in Maryland (MD Sea Grant 2004). In 2000, recreational boating contributed approximately 1.6 billion dollars in revenue for Maryland and supported 28,200 jobs in the state (MD Sea Grant 2003). In 2002, 243,590 boats were registered in Virginia. Nationally, Virginia ranks 19th in the nation for the number of registered boats; Maryland ranks 26th (NMMA 2002). Trailered powerboats represent most of these licenses, followed by in-water powerboats, and sailboats. Oyster bars currently present in the Bay have low profiles; therefore, they pose no greater threat to navigation of recreational vessels than any other kind of bottom in the Bay.

DNR recently agreed to remove a newly installed concrete artificial reef from Sillery Bay on the Magothy River in response to complaints from recreational boaters about the possibility that the reef could interfere with navigation in the shallow waters of the area (Kobell 2007). No accidents or damage involving the reef were reported in the area in the two months between its installation and DNR's decision to remove it; however, the installation did not consistently conform to the 8-foot clearance between the top of the reef and the surface of the water required by DNR's permit for the structure.

3.7.2.3 Waterfowl Hunting

Waterfowl hunting is a popular sporting tradition in near-shore areas throughout Chesapeake Bay. The Delmarva Peninsula is an important resting and wintering ground for many species of migratory waterfowl and other birds during winter months. Canada geese (*Branta canadensis*) are by far the most sought after waterfowl species hunted on Maryland's Eastern Shore. Puddle ducks such as mallards (*Anas platyrhynchos*), black ducks (*Anas rubripes*), and teal (*Anas spp.*) are major target species for Bay-area hunters in Virginia. Sea ducks and diving ducks, including surf scoter (*Melanitta perspicillata*), white-winged scoter (*Melanitta fusca*), black scoter (*Melanitta nigra*), long-tailed duck (*Clangula hyemalis*), and canvasback (*Aythya valisineria*), are among the principal game species sought in open waters of Chesapeake Bay. Many outfitters advertise waterfowl guiding on Maryland and Virginia's western and eastern shores.

Most waterfowl hunting is conducted from shore blinds constructed above the mean high-water line or from field blinds. Offshore hunting for diving ducks and sea ducks takes place predominantly from specialized gunning boats anchored in open waters, although wading on the natural bottom is permitted in some locations. Although shoreline blinds are licensed by the State, Maryland regulations permit open-water waterfowl hunting in locations at least 800 yards from the low-water shoreline. The Maryland Offshore Waterfowl Hunting Zone includes the mainstem of Chesapeake Bay and the Potomac River and restricts offshore hunting within Tangier Sound, Eastern Bay, and other major tributaries (DNR 2004). Virginia regulations establish an offshore hunting zone as being 800 yards from any shoreline. The hunting zone includes Chesapeake Bay proper and all tributaries up to the first highway bridge (VDGF 2005).

3.7.2.4 Swimming

Recreational swimming is a popular summertime activity in the Chesapeake Bay region. The erosional landscape lining much of the Maryland portion of the Bay's western shore has created sandy beaches that are popular destinations for swimmers. The Baltimore metropolitan area encompasses more than 9,100 acres of public beaches that are open to swimming. Virginia offers several public beaches along the Potomac River and at numerous public access points along Chesapeake Bay. Several areas, including Hilton Beach, Huntington Beach, Buckroe Beach, Ocean View, Willoughby, and First Landing State Park are popular swimming destinations.

3.7.2.5 Wildlife Viewing

Wildlife viewing is a popular activity in the forests, marshes, and waterways of the Chesapeake Bay area. Over 1,500,000 people engaged in wildlife viewing in Maryland in 2001; waterfowl watching activities were the most popular (FWS 2001). The region offers nationally recognized birding areas on public lands at Blackwater National Wildlife Refuge (NWR), Eastern Neck NWR, North Point State Park, and the Conowingo Dam area. Private birding areas open to the public include Jean Ellen duPont Shehan Audubon Sanctuary and Wildfowl Trust of North America's Chesapeake Bay Environmental Center located on Maryland's eastern shore.

The eastern shore of Virginia, an equally important stopover for migratory shorebirds, is another nationally recognized area for wildlife viewing. The State established the Virginia Bird and Wildlife Trail system to promote access to wildlife viewing. This system consists of 18 trails in the Chesapeake Bay region with loops ranging along the shorelines of the western peninsulas to the eastern shore.

3.8 HISTORIC AND ARCHAEOLOGICAL RESOURCES[3]

Historic and archaeological resources are prehistoric and historic sites, structures, districts, artifacts, or any other physical evidence of human activity considered important to a culture, subculture, or community for traditional, religious, scientific, or any other reason. These resources are discussed in terms of archaeological sites, which include both prehistoric and historical occupations either submerged or on land, and architectural resources. Archaeological sites become submerged when they are inundated following water level rise, e.g., after impoundment of rivers. Shipwrecks are a specific type of submerged archaeological site.

3.8.1 Legal and Regulatory Background

Section 106 of the National Historic Preservation Act of 1966 (NHPA), as amended (16 USC 470), governs Federal actions that could affect properties eligible for listing in the National Register of Historic Places (NRHP). Section 106 requires Federal agencies to consider

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[3] Past oyster management programs that involved the dredging of buried shell deposits and placement of that dredged shell in restoration areas are discussed in Section 1.3.1. Such programs have the potential to affect underwater historic and archeological resources; however, the proposed action and alternatives do not include such dredging activity.

the effects of their undertakings, including licensing and approvals, on NRHP-eligible properties and to afford the Advisory Council on Historic Preservation and other interested parties a reasonable opportunity to comment. As defined broadly by the regulations implementing Section 106 (36 CFR 800), "historic property" means "any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the NRHP maintained by the Secretary of the Interior." Section 101(b)(4) of NEPA requires Federal agencies to coordinate and plan their actions so as to preserve important historic, cultural, and natural aspects of the country's national heritage.

Properties that qualify for inclusion in the NRHP must meet at least one of the following four criteria:

- Criterion A – associated with events that have made a significant contribution to the broad patterns of our history;
- Criterion B – associated with the lives of persons of significance in our past;
- Criterion C – embodies the distinctive characteristics of a type, period, or method of construction, or represents the work of a master, or possesses high artistic values, or represents a significant and distinguishable entity whose components could lack individual distinction; or
- Criterion D – has yielded, or could be likely to yield, information important in prehistory or history (36 CFR 60.4).

Properties that qualify for the NRHP also must possess integrity as defined by the following seven aspects: location, design, setting, materials, workmanship, feeling, and association. The term "eligible for inclusion in the NRHP" includes properties formally designated as eligible and all other properties determined to meet NRHP criteria. Normally, NRHP eligibility requires a property to be at least 50 years old. Resources less than 50 years old that are highly significant and meet the "special criteria considerations" as outlined in the regulations (36 CFR 60.4) also may be eligible for the NRHP.

3.8.2 Research Methods

This Draft PEIS focuses on alternatives for restoring the oyster population in Chesapeake Bay; therefore, the cultural resources addressed here are specific to the historical range of the Eastern oyster within the Bay and its tributaries. Potentially affected resources were identified in accordance with the regulations implementing Section 106 and the Secretary of the Interior's *Standards and Guidelines for Archaeology and Historic Preservation*. Cultural resources outside the Bay could be affected by alternatives that involve the Suminoe oyster, if that species were to become established outside the Bay. Specific cultural resources outside Chesapeake Bay that might be affected are not identified here; nevertheless, the nature of effects on those resources would be similar to those expected in Chesapeake Bay.

The procedures used to identify cultural resources potentially affected by the proposed project began with consultation with the State Historic Preservation Officers (SHPOs) of the two states included in the study area: the Virginia Department of Historic Resources (VDHR) and the

Maryland Historical Trust (MHT). These sources maintain archaeological and architectural site files, maps, NRHP and National Historic Landmark nomination forms, and cultural resource inventories and surveys. Additional information was obtained from the NRHP on-line database. In addition, individuals with knowledge of the area, including archaeologists with NOAA, and the Corps of Engineers, Baltimore and Norfolk Districts, were consulted about known or potential historic properties in the project area and about recent cultural resources studies within the Chesapeake Bay region. Because the project area encompasses such a large geographic area without clearly delineated boundaries, preparation of a comprehensive list of all historic properties in the area is not feasible. Instead, these searches generated approximate numbers of archaeological sites or potential sites in the proposed project area, which were incorporated into a spreadsheet. Greater emphasis has been placed on the development of historic context information gleaned from State and regional guidelines and a wide variety of published and unpublished sources to establish the cultural framework for the potential for historic properties within the project area. The historic context for the study area is included as Appendix F of the Draft PEIS. As specific programs and projects are planned in response to this PEIS, precise project areas will need to be defined in consultation with the appropriate SHPOs. Site-file searches specific to those areas should then be conducted to refine knowledge about particular cultural resources and areas of high probability for the discovery of cultural resources in each project area.

3.8.3 Kinds of Cultural Resources within the Project Area

The National Park Service (NPS) developed the Draft Chesapeake Bay Special Resource Study (SRS) and PEIS to help protect and convey the national significance of Chesapeake Bay, including its natural, cultural, and recreational resources. The study identified a comprehensive list of cultural resource types present in the Bay region (NPS 2003). This list provides broad categories of the types of resources that might be located in the Bay and should be used only as a baseline for identifying potentially significant properties in the project area (Table 3-5). More specific resource types can be obtained by searching site-files at the Maryland and Virginia SHPOs.

Table 3-5. General kinds of cultural resources present in the Chesapeake Bay region.

Cultural Resource Category	Groups	Specific Sites/Areas
Water-oriented settlement sites	Native American	Domestic sites, watercraft, fish gathering locations (e.g., weirs and traps), fords
	Colonial	
	Plantations	
	Port/maritime communities	Docks, boatyards and shipbuilding sites, fishing piers and wharves, seafood processing establishments, maritime historic districts
Chesapeake Bay vessels		Skipjacks, bug-eyes, etc.
Water-based transportation routes		
Watermen fishing areas		
Bay-oriented agricultural landscapes		Working farms
Water-connected military sites on the Bay		Revolutionary War sites, War of 1812 sites, Civil War sites, 20th Century sites

A comprehensive discussion of cultural resources within the project area is not feasible because of the size of the project area and wide distribution of sites. Research relied primarily on sorting information contained in the databases of the MHT and VDHR and did not include extensive map-based research to identify the specific locations of submerged archaeological sites given the size and complexity of the Chesapeake Bay region and all tributaries potentially affected by the proposed action and alternatives.

No review of specific architectural resources was undertaken at this point; however, these may represent an important class of resources that should be considered. The NPS has identified buildings and structures associated with port and maritime communities including docks, boatyards, shipbuilding sites, fishing piers and wharves, seafood processing establishments, and maritime historic districts that contribute to the national significance of the Chesapeake Bay region (NPS 2003). Although implementing the alternatives proposed in the PEIS would be unlikely to affect architectural resources directly, the potential for significant indirect effects should be considered; therefore, potentially affected architectural resources should be identified before implementing any specific projects that might proceed from a decision based on this PEIS.

3.8.3.1 Known Submerged Archaeological Sites in the Project Area

A search of site files at the MHT indicated that at least 596 underwater archaeological sites have been identified in Maryland's bay and tidal regions. Table 3-6 provides an overview of the number of sites by county or city in the project area. The table includes numerous prehistoric sites such as shell middens, lithic scatters, isolated finds, and camp sites. Many of these sites occur along the shoreline of the Bay and tributaries and may be only partially submerged. Historical archaeological sites include shipwrecks, shipyards, ferry landings, wharves, historic shell middens, and artifact concentrations spanning the 17th to the 20th centuries. This list is not intended to be comprehensive but to provide a broad overview of the kinds of sites that have been identified and recorded in Maryland waters in and around the Bay. Of these, site 18ST636, a submerged German submarine, the U-1105 "Black Panther," in the Potomac River off St. Mary's County is listed in the NRHP. Many other sites may be eligible for listing in the NRHP.

In 1994 Blanton and Margolin conducted research on underwater archaeological sites identified in Virginia based on record searches at VDHR. A total of 283 sites classified as "underwater" were identified. Approximately 210 of these are located in counties and independent cities in Virginia's Coastal Plain physiographic province where Chesapeake Bay and the mouths of its tributaries are located (Table 3-6). Blanton and Margolin (1994) organized information on sites by region and body of water. The two regions that cover the area of Chesapeake Bay and its tributaries are defined as the Eastern Shore and the Northern Coastal Plain. Within these regions, site information is broken down by body of water, site number, cultural period, site type, and function. Most prehistoric sites are defined as camps, but shell middens and village sites also are included. Historical site functions include watercraft, bridges, wharves, canals, and piers in addition to sites of unknown or undetermined function. The undetermined group epitomizes the difficulty in classifying underwater resources, many of which are identified solely as magnetic or sonar anomalies; however, even some of the sites that have been investigated could not be identified. Since this overview study was conducted in 1994, the number of archaeological sites classified as submerged has increased to 571 (Quatro Hubbard, pers. comm. May 25, 2007). Research to update the site information collected by Blanton and Margolin (1994) is currently being conducted.

Table 3-6. Submerged archaeological sites in the project area by state and county or city

Maryland City/County	Number of Sites	Virginia City/County	Number of Sites
Anne Arundel County	77	Accomack County	18
Annapolis (City)	7	Northampton County	20
Baltimore County	1	Chesterfield County	4
Baltimore (City)	3	Virginia Beach (City)	4
Caroline County	9	Mathews County	5
Cecil County	25	Northumberland	4
Charles County	5	Norfolk (City)	1
Calvert County	37	York County	59
Dorchester County	50	Fairfax County	5
Harford County	4	Gloucester County	27
Kent County	33	Hampton (City)	7
Prince Georges County	21	James City County	6
Queen Anne’s County	71	Henrico County	3
Somerset County	71	Newport News (City)	6
St. Mary’s County	38	Prince George County	2
Talbot County	64	Suffolk (City)	2
Wicomico County	76	Surry County	5
Worcester County	4	Charles City County	2
Maryland Total	***596***	Williamsburg (City)	1
		Chesapeake (City)	1
		King and Queen County	2
		Caroline County	1
		King William County	3
		New Kent County	3
		King George County	1
		Westmoreland County	5
		Spotsylvania County	4
		Stafford County	5
		Lancaster County	1
		Richmond County	1
		Middlesex County	1
		Isle of Wight County	1
		Virginia Total	***210***
Project Area Total	**806**		

3.8.3.2 Potential Submerged Archaeological Resources

In addition to previously identified resources, the potential effects of the proposed action and alternatives on undiscovered, submerged cultural resources were considered. Submerged resources in the Bay and its tributaries may be associated with Native American occupation of the region as well as resources associated with Euro-American exploration and settlement of the area, including shipwrecks.

There have been few attempts to model settlement patterns or predict prehistoric site locations in areas of the mid-Atlantic region that are now submerged. Locations of submerged terrestrial sites have been successfully predicted in coastal areas of other regions of the United States by analysis of topography, bathymetry, and relict landforms (Faught 2004). In the late 1970s, Roberts (1979) considered prehistoric site potential for the entire continental shelf from Cape Hatteras to the Bay of Fundy as Edwards and Merrill (1977) attempted to reconstruct the environment of the region from the late Pleistocene to the early Holocene. Blanton and Margolin (1994) elaborated on earlier models for underwater resources in Virginia including the Chesapeake Bay region. More recently, the USACE, Baltimore District, has developed prehistoric and historic contexts for submerged sites in Chesapeake Bay as part of a Dredged Material Management Plan (DMMP) and Environmental Impact Statement (EIS) for the Baltimore Harbor and channels in the Bay (Krivor 2004).

Prehistoric Resources – The following general discussion of the potential for submerged resources associated with the prehistoric occupation of the Chesapeake Bay region was developed primarily from *An Assessment of Virginia's Underwater Cultural Resources* (Blanton and Margolin 1994).

Due to rising sea level, large areas comprising the former ranges of Native Americans are likely to have been inundated along the continental shelf and by Chesapeake Bay. Blanton and Margolin (1994) proposed two potential models for Paleoindian settlement. One is a modified version of the model presented by Gardner (1974; 1979) that would include base camps for exploitation of coastal resources and attendant smaller procurement camps in the uplands and elsewhere along the coast. The other is a "modified interior" pattern suggested by Custer (1986) that involves seasonal alteration of subsistence strategies to inland or coastal resources. Site types predicted for this time period include medium- to low-frequency, coastal and estuarine shell middens; estuarine and interior fishing camps; and upland camps (Barber 1979). These settlement patterns are thought to have remained largely consistent through the transition to the Early Archaic, although there may have been a trend toward "opportunistic expansion" with an increasing diversity in site locations.

As the rise in sea level slowed between 4000 and 3000 B.C., environmental conditions began to stabilize and approach modern conditions. This stabilization resulted in the development of rich estuarine environments that are present in the area today, and models of prehistoric settlement are more certain due to a more complete record, with fewer inundated sites, and a more developed context. Riverine orientation is well-documented in inland areas, but there is less certainty about the extent of a coastal or estuarine focus in the Late Archaic. Although there are some Late Archaic shell middens along Chesapeake Bay, they are small and infrequent. This is often interpreted as an indication that coastal and estuarine resources were subject to only seasonal or short-term exploitation, and models of Late Archaic settlement patterns do not have a significant coastal component. It is also likely, however, that sites of this period, which would probably have occurred along the banks of major streams and brackish wetlands, are now submerged.

By the beginning of the Woodland period (1000 B.C.), sea level was within 2.5 m of present levels, and by the period of early European contact (1600 A.D.), levels had risen to within 1 m. The frequency of shell middens increased through time in the Woodland period, and the largest accumulations occurred in the late Middle Woodland. Prior to this shift, subsistence strategies are viewed as an elaboration of Late Archaic patterns in which coastal and estuarine resources played only a minor part. By the terminal Middle Woodland, however, large shell middens interpreted as base camps were common throughout the area. Shoreline erosion has significantly damaged some Middle Woodland middens, so models of settlement patterns from this period are limited. By the Late Woodland and Protohistoric periods, settlement is found in areas not likely to be submerged; nevertheless, some known-contact-period villages are eroding into the Bay or its tributaries. For instance, the probable location of Quomacac village, described by James Smith, has been the subject of four shoreline erosion prevention projects (CBP 2005). Shell scatters found in association with village sites provide evidence of the continued contribution of coastal and estuarine foods to diets based increasingly on cultivated resources during the Late Woodland and Protohistoric periods.

Historical Resources: Shipwrecks – Dr. Susan Langley, State Underwater Archaeologist with the MHT, indicated that although only 700 to 800 shipwrecks have been identified in Chesapeake Bay, as many as 5,000 are thought to exist based on historical and archival data (pers. comm. May 9, 2007). No systematic underwater archaeological survey of the Bay for shipwrecks has been conducted. Only portions of a few of the main tributaries, including the Chester River in Maryland, and the York and James rivers in Virginia, have been systematically surveyed for underwater resources. In Virginia, only a few shipwrecks have been identified although more than 2,000 sinkings have been reported (J. Broadwater, NOAA, Monitor National Marine Sanctuary, pers. comm.).

NOAA maintains navigation charts that include shipwrecks, obstructions, and other underwater hazards covering the entire Chesapeake Bay and portions of tributaries. This information is incorporated in an electronic database, the Automated Wreck and Obstruction Information System (AWOIS). These data include all wrecks and obstructions known to NOAA, both historic and recent (NOAA 2005). A total of 992 wrecks and obstructions were identified in the Bay region. Further investigation of these locations may be required in advance of specific projects to determine if they represent potentially significant cultural resources.

3.9 WETLANDS

Wetlands are important ecological resources that improve and maintain water quality, reduce flood damage, and provide habitat for a wide variety of plants and animals, including many threatened and endangered species. Rapid loss of wetlands resulting from rural and urban development and rising sea level has prompted the Federal government and many State governments to regulate development activities in and near wetlands to preserve their important ecological functions. Section 404 of the Clean Water Act establishes regulatory authority governing the protection of wetlands at the Federal level and allows individual States to develop their own regulatory programs, which can be even more stringent. Both Maryland and Virginia have developed regulatory programs that specifically address tidal wetlands. In 1974, FWS created the National Wetlands Inventory Project (NWI) to map the location, type, and distribution of the nation's wetlands. The NWI uses the classification system of Cowardin et al. (1979) for wetland habitat type codes on its maps. Oyster reefs are the second subclass of the RF (Reef) class in the "1-Subtidal" ecological subsystem in the "E-Estuarine" ecological system. Figure 3-4 is a map based on NWI data of tidal estuarine wetlands within Chesapeake Bay that could encompass oyster habitat and, therefore, might be affected by the proposed action or alternatives. According to the most recent assessment of status and trends in wetlands specifically for the mid-Atlantic states, the Chesapeake Bay watershed encompasses about 205,000 acres of estuarine wetlands, including 120,009 acres (59%) in Maryland and 84,475 acres (41%) in Virginia (Tiner et al. 1994). As shown in Figure 3-4, estuarine wetlands are most abundant on the Bay's lower eastern shore.

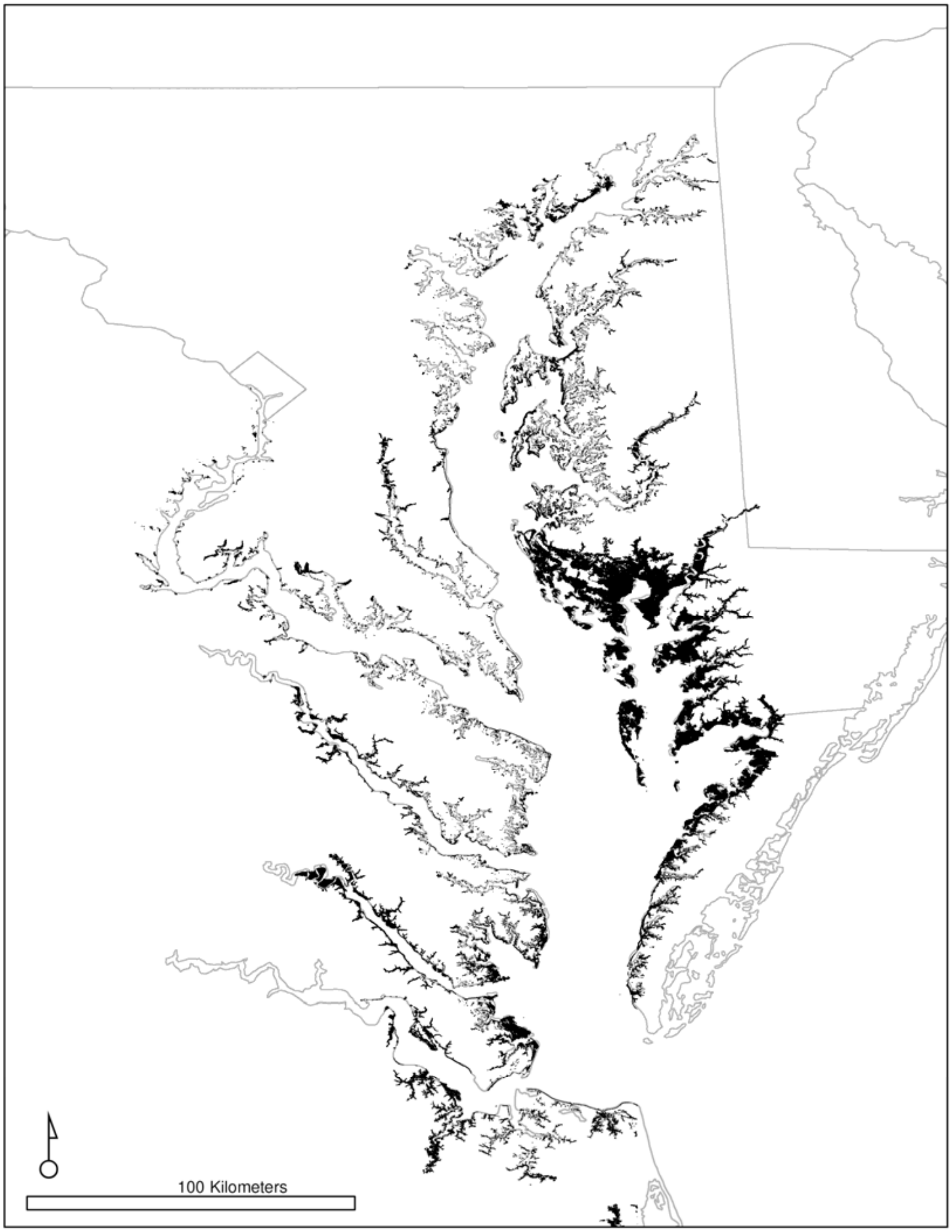

Figure 3-4. Estuarine wetlands within Chesapeake Bay and its tributaries (USGS 2007).

Estuarine wetlands experience periodic flooding by ocean-driven tides. The most common types of estuarine wetlands are emergent wetlands. Estuarine emergent wetlands, commonly called salt marshes, are characterized by grasses whose upper stems and leaves remain emergent during high tides. Salt-tolerant grasses such as smooth cordgrass (*Spartina alterniflora*), salt hay grass (*Spartina patens*), big cordgrass (*Spartina cynosuroides*), and switchgrass (*Panicum virgatum*) generally dominate these wetlands. Other herbaceous plants, such as black needlerush (*Juncus roemerianus*), Olney three-square (*Scirpus americanus*), narrow-leaved cattail (*Typha angustifolia*), and rose mallow (*Hibiscus moscheutos*), may be abundant, especially in brackish water areas. The nonnative grass known as common reed (*Phragmites australis*) is becoming a dominant plant species in many of the tidal emergent wetlands due to anthropogenic alterations of hydrology and inputs of sediment and nutrients (Marks et al. 1994). Estuarine wetlands are particularly important habitats for brackish and marine fishes and shellfish, various waterfowl, shorebirds, wading birds, and several mammals. Many commercial and game fishes use estuarine marshes and estuaries as nursery and spawning grounds. Menhaden, bluefish, flounder, sea trout, mullet, croaker, and striped bass are among the most familiar fishes that depend on estuarine wetlands. Blue crabs and other shellfish, such as oysters, clams, and shrimp, also use coastal marshes for a variety of functions at various stages in their life cycles.

The potentially affected ecosystem components and mechanisms of effect of the proposed action and alternatives within estuarine wetlands in the Chesapeake Bay region are as described in sections 3.1, 3.2, and 3.3 of this Draft PEIS.

3.10 SANCTUARIES AND REFUGES

3.10.1 Sanctuaries[4]

The National Estuarine Research Reserve System (NERRS), formerly known as the National Estuarine Sanctuary Program, was established under the Coastal Zone Management Act of 1972 and is administered by NOAA. NERRS is a network of 27 estuaries in 22 states and Puerto Rico that are protected for long-term research, water-quality monitoring, education, and coastal stewardship (http://www.nerrs.noaa.gov). Nineteen of the 27 estuaries lie along the Atlantic coast or within the Gulf of Mexico. Chesapeake Bay counts as 2 (i.e., Maryland and Virginia portions) of the 19 eastern estuaries. NOAA provides funding, national guidance, and technical assistance for management and research within these estuaries. A lead State agency, non-profit organization, or university manages each estuary in the NERRS locally and identifies areas within the estuary for particular designation as reserves. The portion of Chesapeake Bay in Maryland is a NERRS estuary administered by DNR. The Maryland Reserve encompasses three components representing distinct estuarine habitats, including a salt marsh at Monie Bay, a tidal freshwater marsh at Otter Point Creek, and a tidal riverine system at Jug Bay (Table 3-7, Figure 3-5). The portion of Chesapeake Bay in Virginia is a NERRS estuary administered by VIMS. The Virginia Reserve is a multi-site system representing habitats ranging from tidal freshwater to high-salinity conditions along the York River; components include Sweet Hall Marsh, Taskinas Creek, the Catlett Islands, and the Goodwin Islands (Table 3-7, Figure 3-5).

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[4] Oyster sanctuaries, from which harvest is prohibited, are discussed separately in Section 1.3.2.

Table 3-7. Components of the Maryland and Virginia NERRS reserves

Site Name	Area (acres)	Designated	Description	Species Present*
Maryland Reserve (Source: http://www.nerrs.noaa.gov)				
Monie Bay	3,426	1985	A tributary of Tangier Sound located on the Deal Island Peninsula in northwest Somerset County; habitats include wetland creeks and rivers, marshes, scrub-shrub wetlands, forested wetlands, forested uplands and coastal grasslands.	Fish: mummichog, white perch, spot, **menhaden**. Invertebrates: fiddler crab, **blue crab**, **Eastern oyster**, marsh periwinkle, common grass shrimp. Birds: **bald eagle**, **peregrine falcon**, **osprey**, numerous hawk species. Waterfowl: Canada geese, mallard, **black duck**, green-winged teal. Vegetation: salt marsh vegetation characteristic of East Coast mid-salinity regimes; smooth cordgrass, salt cordgrass, big cordgrass, salt and three square grass, needlerush, marsh elder.
Jug Bay	722	1990	A shallow embayment of the Patuxent River, located in Prince George's and Anne Arundel counties; habitats include creeks and rivers, freshwater tidal marshes, scrub-shrub wetlands, forested wetlands, forested uplands and fields.	Waterfowl: 22 species of wintering waterfowl, including tundra swans, Canada geese, green winged teal; Sora rail; wood duck. Birds: **peregrine falcon, bald eagle**
Otter Point Creek	672	1990	One of the last remaining freshwater tidal marshes in the upper Chesapeake Bay, located in Harford County, flows into the Bush River; habitats include open water, tidal marshes (valuable spawning area for several species of anadromous fish), forested wetlands, upland hardwood forests	Fish: banded killfish, mummichog, tidewater silverside, **bay anchovy**, tesselated darter, spottail shiner; catadromous American eel. Reptiles: snapping turtle, painted turtles. Invertebrates: **blue crab**, various other invertebrates, including radiferous, protozoans and the larval forms of larger organisms. Mammals: muskrat, **raccoon, river otter**, beaver. Waterfowl: herons, great white and snowy egrets, mallard, **black duck**, Virginia rail.
Virginia Reserve (Source: http://www.vims.edu/cbnerr)				
Taskinas Creek	980	1991	Located within the boundaries of York River State Park, the Taskinas Creek watershed is representative of an inner coastal plain rural watershed within the southern Chesapeake Bay system. The watershed is dominated by forested and agricultural land uses with increasing residential land use. The non-tidal portion contains feeder streams that drain oak-hickory forests, maple-gum-ash swamps, and freshwater marshes. Freshwater mixed wetlands are found in the upstream reaches.	Vegetation: Three-square and big cordgrasses; salt marsh cordgrass in the lower reaches of the creek, near the outlet

Table 3-7. (Continued)

Site Name	Area (acres)	Designated	Description	Species Present*
Virginia Reserve (continued)				
Sweet Hall Marsh	871	1991	The lower-most extensive tidal freshwater marsh, located in the Pamunkey River, one of two major tributaries of the York River; habitats include emergent fresh-water marsh, permanently flooded broad-leaved forested wetlands, and scrub-shrub. The marsh community is classified as freshwater mixed.	Vegetation: arrow-arum, smooth cordgrass, big cordgrass, smartweeds, rice cutgrass, wild rice, water hemp, water dock, Walter's millet, marsh milkweed, Sedges, reed grass, rushes, cattail, marsh mallow, panic grass, **sensitive jointvetch**
Goodwin Islands	777	1991	Located on the southern side of the mouth of the York River at the northeastern tip of York County, the Goodwins are an archipelago of salt-marsh islands surrounded by intertidal flats, extensive SAV beds (300 acres), a single constructed oyster reef, and shallow open estuarine waters.	Vegetation: salt marsh vegetation is dominated by salt marsh cordgrass and salt meadow hay; forested wetland ridges are dominated by estuarine scrub/shrub vegetation.
Catlett Islands	690	1991	The islands, located on the north side of the York River in Gloucester County, consist of multiple parallel ridges of forested wetland hammocks, forested upland hammocks, emergent wetlands, and tidal creeks surrounded by shallow subtidal areas that once supported beds of submerged aquatic vegetation.	Vegetation: salt marsh cordgrass, salt meadow hay in the marsh/shrub wetland ecotone; marsh elder and groudsel tree bushes towards higher ground of the saltmarsh.

* Representative species for this PEIS and RTE species are shown in boldface type.

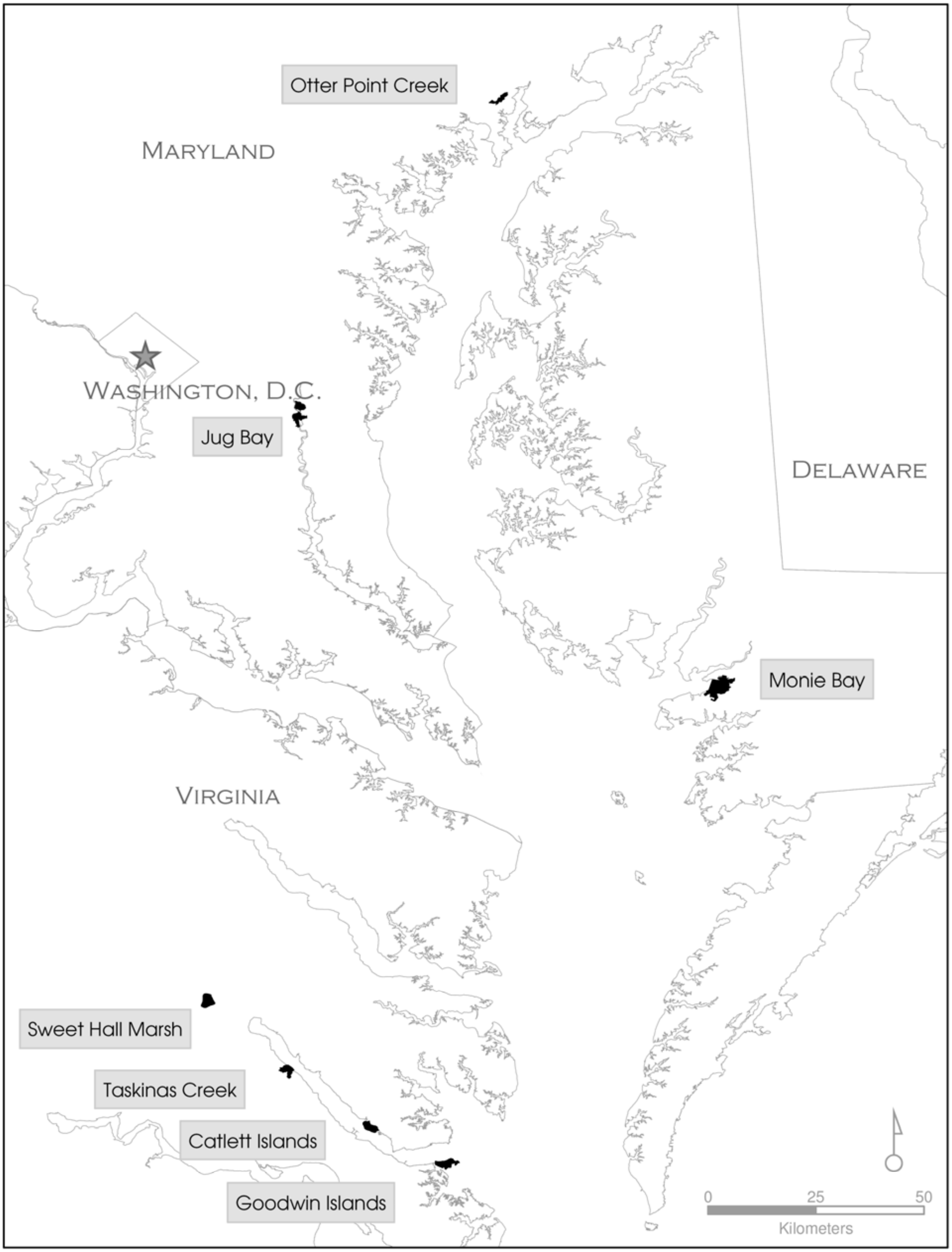


Figure 3-5. Components of the NERRS reserves in Maryland and Virginia

NOAA and the coastal states have defined the following priority issues related to management within the reserves: land use and population growth, habitat loss and alteration, water quality degradation, and changes in biological communities. The potential effects of the proposed action and alternatives have implications for three of these four priority coastal management issues (i.e., habitat loss and alteration, water quality degradation, and changes in biological communities), as described in sections 3.1, 3.2, and 3.3 of this Draft PEIS. The regulations governing NERRS state that restoration of degraded areas is not a primary purpose of the System but may be permitted to improve the representative character and integrity of a Reserve.

Restoration activities must be carefully planned and approved by NOAA through the Reserve management plan (CFR 2003a). The regulations further specify that habitat manipulation for resource management purposes is prohibited, except as specifically approved by NOAA as (1) an approved restoration activity, (2) an activity necessary to protect the public health or to preserve sensitive resources that are listed or eligible for protection under relevant Federal or State authority (e.g., threatened/endangered species, significant historical or cultural resources), or (3) if the manipulative activity is a long-term, pre-existing use (i.e., occurred before NERRS designation) occurring in a buffer area. Habitat manipulation activities must be limited to the reasonable alternative that has the least adverse and shortest-term effect on the representative and ecological integrity of the Reserve (CFR 2003b).

3.10.2 Refuges

The National Wildlife Refuge System is the world's largest network of lands and waters dedicated to protecting wildlife and habitat. The system was established by Theodore Roosevelt in 1903 and currently includes more than 535 designated refuges administered by FWS. Table 3-8 lists the National Wildlife Refuges in Maryland and Virginia that encompass estuarine habitat suitable for oysters and, therefore, that might be affected by the proposed action or alternatives. Figure 3-6 shows the locations of the refuges.

Table 3-8. National Wildlife Refuges that encompass estuarine habitat in Chesapeake Bay

Maryland (area in acres)	**Virginia (area in acres)**
Blackwater (16,667)	Occoquan Bay (644)
Eastern Neck (2,286)	Back Bay (4,589)
Martin (4,424)	Chincoteague (13,444)
	Eastern Shore (651)
	Featherstone (164)
	Nansemond (208)
	Plum Tree Island (3,276)
	Wallops Island (3,373)
	Fisherman Island (1,850)
	Great Dismal Swamp (111,000)

The mechanisms of effect and potentially affected ecosystem components within these refuges are as described in Sections 3.1, 3.2, and 3.3 of this Draft PEIS.

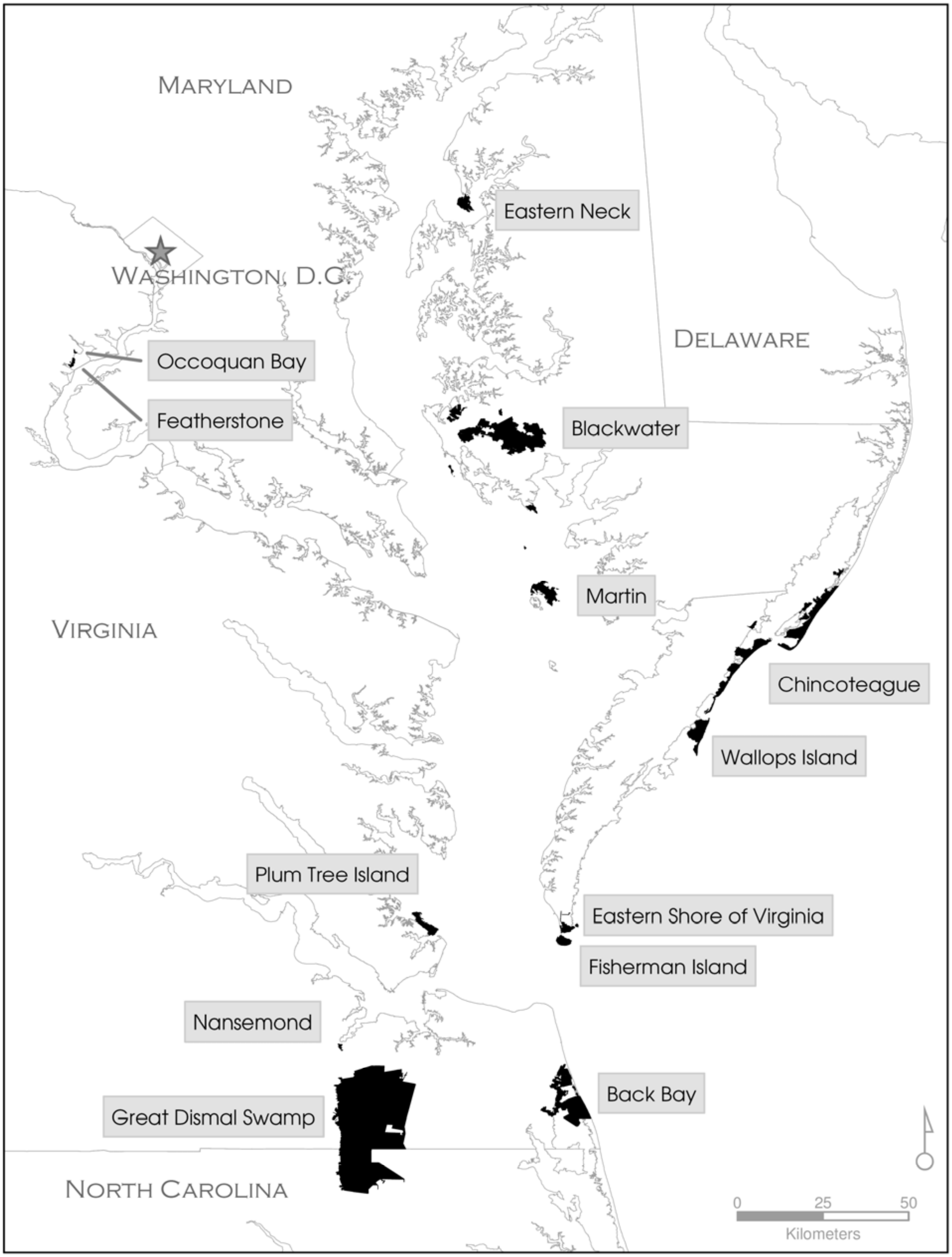


Figure 3-6. National Wildlife Refuges in Maryland and Virginia that encompass oyster habitat

3.11 ENVIRONMENTAL JUSTICE

President Clinton issued Executive Order (EO) 12898, Environmental Justice, on February 11, 1994. Objectives of the EO, as it pertains to this evaluation, include development of Federal agency implementation strategies, identification of low-income and minority populations for which proposed Federal actions would have disproportionately large and adverse effects on human health and the environment; and participation of low-income and minority populations. A Presidential Transmittal Memorandum that accompanied EO 12898 referred to existing Federal statutes and regulations to be used in conjunction with the EO. The memorandum addressed the use of the policies and procedures of NEPA. Specifically, the memorandum indicates that, "Each Federal agency shall analyze the environmental effects, including human health, economic and social effects, of Federal actions, including effects on minority communities and low-income communities, when such analysis is required by the National Environmental Policy Act of 1969 [NEPA], 42 U.S.C. section 4321 et seq." Agencies are responsible for identifying and addressing, as appropriate, any disproportionately great and adverse effects of their programs, policies, and activities on the health of minority and low-income populations and their environments.

Based on recent survey work, no low-income or minority populations appear to be significantly involved in harvesting oysters in the Bay. Historically, significant numbers of African-Americans were employed in shucking houses, but today most shuckers are immigrant Hispanic workers. Any potential effects on these workers are described in Section 4.11. Most employment in the oyster industry today consists of harvesters, growers, and processors (including buyers); harvesters are the largest group. Although minorities participate in these activities, none dominate. Harvesters' incomes generally fall in the middle to lower-middle levels, and growers' and processors' into somewhat higher levels. There is no evidence of significant Native American involvement in oystering or the oyster industry in the Bay (M. Paolossi, University of Maryland, pers. comm.).

Within the context of this PEIS, any change in the Bay's oyster population that affects water quality and habitat in the Bay will affect all residents of the Bay area, regardless of minority or economic status. To the extent that minorities or low-income individuals are involved in oystering or in other components of the oyster industry, they would be positively affected by alternatives that result in increases in oyster populations or oyster-related businesses.

3.12 AIR QUALITY

Non-attainment areas are localities where air pollution levels exceed National Ambient Air Quality standards or that contribute to ambient air quality in a nearby area that does not meet standards. Designating a non-attainment area is a formal process undertaken by the EPA and usually occurs only after air quality standards have been exceeded for several consecutive years. Non-attainment areas are given a classification based on the severity of the violation and the air quality standard they exceed. Ozone is a leading air pollution problem in the Bay area. EPA has rated Washington, D.C.; Northern Virginia; and several Maryland counties as severe non-attainment areas for ozone. Maryland, Virginia, and the District are listed as maintenance areas for carbon monoxide because these areas once exceeded the national standard for carbon monoxide but are now within the standard.

Pollution in the air can affect the water quality and living resources of Chesapeake Bay. Contaminants are transferred to land or water through a process called atmospheric deposition. Airborne pollutants return to the earth's surface either by wet deposition (i.e., rain) or dry deposition, and are transported into streams, rivers, and the Chesapeake Bay by runoff or groundwater flow. Air pollution can be man-made or naturally occurring. Man-made sources of pollution include utilities, chemical and manufacturing plants, transportation, and agriculture. Natural sources of air pollution include pollutants emitted from plant life, erupting volcanoes, forest and prairie fires, and dust storms. The principal pollutants from atmospheric deposition that affect the Chesapeake Bay are nitrogen oxides and chemical contaminants. Although deposited nitrogen oxides are known for damaging aquatic life because of their acidity (i.e., acid rain), the potential effects of acid rain on oysters are poorly understood. Some of the nitrogen oxide deposited in the Bay is converted into a form that is useable by algae, thereby increasing nutrient enrichment that contributes to causing anoxic conditions in the Bay. The CBP estimates that a quarter of the total nitrogen load to the Bay comes from atmospheric deposition; 75% of that load is deposited on land and later transported to the Bay by surface water runoff and groundwater flow. The remaining 25% is deposited directly into the Bay. Nitrogen-oxide emissions in the watershed have increased by 3.5 million tons since 1970, and this trend is likely to continue in the immediate future as the population increases within the Bay’s watershed.

3.13 PUBLIC SAFETY AND FOULING

Public safety factors in and around Chesapeake Bay include such activities as emergency services, law enforcement, and fire protection. No information suggests that the current oyster population or the oyster fishery have caused any significant demand for public safety services. Public safety issues related to recreational boating have arisen in recent years as a result of using construction debris to create new artificial reefs. In 2007, the Mary Jo Garreis Memorial Reef, which was projected to support up to 4 million oysters, was constructed at the mouth of the Magothy River in Maryland. It was placed in a location that was too shallow, creating a potential boating hazard. Although no actual boating accidents related to the reef were reported, the reef material was removed in response to complaints from members of the public. Potential effects on boating are considered in selecting sites for artificial three-dimensional reefs in Maryland and Virginia.

The ability of oysters to absorb and accumulate hazardous and toxic chemicals and bacteria present in the water may present a public safety concern associated with implementing the proposed action if Suminoe oysters accumulate such things differently than Eastern oysters. In the Bay, contamination of water and sediment occurs through urban point sources such as sewage and industrial outfalls, urban runoff, and atmospheric deposition. The most pervasive contaminants are metals (arsenic, cadmium, copper, chromium, lead, mercury, nickel, and zinc), organic compounds, pesticides, and acid-mine drainage (EPA 1999). Although high concentrations of contaminants may inhibit the development of larval oysters, weaken their immune systems, or create other health problems, oysters are relatively tolerant of many common pollutants (Capuzzo 1996; Roesijadi 1996), and population-level effects of contaminants have not been observed among oysters in the Chesapeake Bay. Oysters, however, may accumulate contaminants in their tissue, which could present a health hazard for humans that consume them. Metals are of particular concern because oyster tissue may accumulate metals to concentrations that are much greater than those in the surrounding water. The same is true of bacteria that enter the Bay via sewage discharges and land runoff. Although high concentrations of fecal bacteria do not affect the health of oysters, extensive areas of the Bay are closed to oyster harvest each year due to bacterial contamination (Strebel et al. 2006). Some people are advised to limit or eliminate their consumption of fish and invertebrates containing high levels of metals, and most health agencies prohibit harvest and sale of shellfish taken from waters that have been closed to fishing and recreational use because of large concentrations of coliform bacteria.

Because oysters settle on hard surfaces, they have the potential to become a fouling organism by settling and growing on surfaces where their presence may become an inconvenience or impair the function of those surfaces. Fouling is generally of greatest concern in areas involving water withdrawals. Fouling can adversely affect facilities that withdraw water because organisms that settle on structures through which water is flowing can impede or block the flow; moreover, the flowing water enhances the growth of organisms, such as oysters, that feed by filtering food from the continuous supply of water passing over them. The nonnative, freshwater zebra mussel has created serious fouling problems at drinking water intakes throughout the regions it now inhabits. Oysters cannot survive in fresh water; therefore, they cannot foul drinking water intakes in the Chesapeake Bay watershed. Steam electric-generating stations located on the Bay withdraw large volumes of saline water for cooling. In Maryland alone, 14 generating facilities are permitted to withdraw 7,734 million gallons (29.3 billion liters) of water per day from Chesapeake Bay and its tributaries (PPRP 2006). No significant fouling of power-plant intakes by the Eastern oyster has ever been reported in Chesapeake Bay.

In its broadest sense, public safety might be considered to include indirect effects of changes in the population of oysters, such as the role that oysters may play in affecting the size of the population of the stinging sea nettle *(Chrysaora quinquecirrha)*. This relatively large, swimming jellyfish might be considered a public safety issue because its sting is rated from "moderate" to "severe" and can cause discomfort for swimmers and other water users who come in contact with its tentacles. Its sting, however, is not potent enough to kill a person, except by allergic reaction. The stinging sea nettle produces eggs or sperm that are shed into the water daily during the summer. Fertilized eggs form larvae that attach to hard surfaces, such as oyster shells, and grow into tiny polyps. The bottom-dwelling polyps live through the winter in a dormant state. During May through August, the polyps bud off tiny sea nettles about 1 mm in diameter that grow rapidly into visible jellyfish (NOAA 2007). Biologists do not know if the decreasing availability of hard surface, including oyster bars, in the Bay is a limiting factor for nettle populations. Sea nettles have been particularly abundant in some recent years despite the small population of oysters in the Bay.

3.14 COMMERCIAL NAVIGATION

The Virginia Port Authority owns four general-cargo terminals that are destinations and departure points for commercial ship traffic in the lower Bay: Norfolk International Terminals, Portsmouth Marine Terminal, Newport News Marine Terminal, and the Virginia Inland Port in Front Royal. These terminals are operated by Virginia International Terminals, Inc. The ports, which are located approximately 18 miles from the mouth of Chesapeake Bay, are accessible via a 50-foot-deep shipping channel and service a wide range of commercial traffic. The Maryland Port Administration owns and operates the Port of Baltimore, which is accessible from the south via the main Bay shipping channel and from the north via the Chesapeake & Delaware Canal. In 2005, 2,119 ships arrived in the Port of Baltimore, including deep-draft cargo vessels, passenger vessels, and tug-and-tow vessels. Commercial ship traffic occurs throughout the length of Chesapeake Bay but is limited to dredged shipping channels (Figure 3-7). Comparing Figure 3-1 with Figure 3-7 shows that no oyster habitat is present within dredged shipping channels; existing oyster habitat occurs in shallower waters that cannot accommodate deep-draft commercial boat traffic.

Figure 3-7. Areas of commercial ship traffic in Maryland and Virginia (from Maryland Sea Grant, "Keep Clear: Big Ships in Chesapeake Bay")

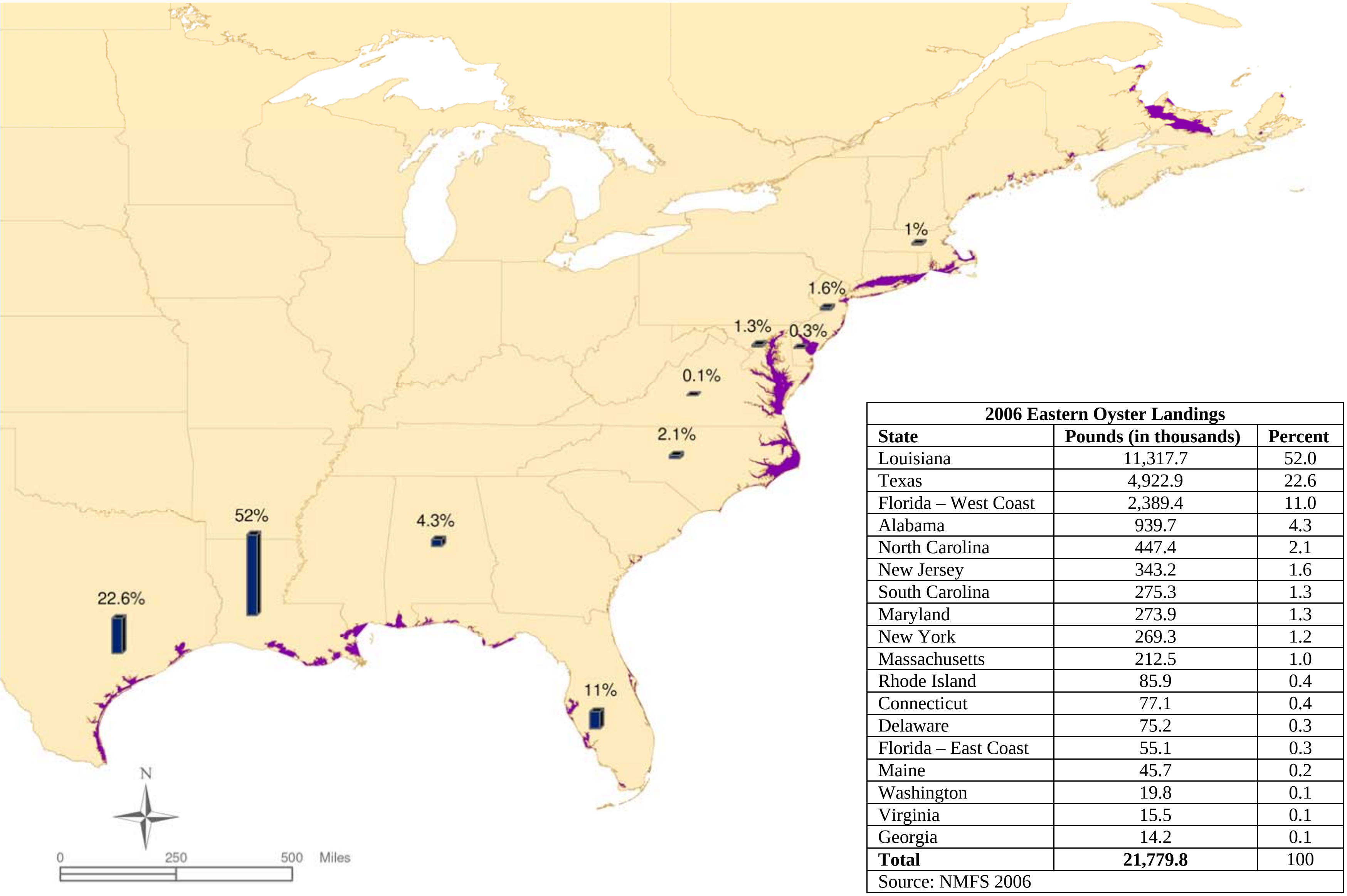
Oyster reefs, whether developed naturally or created artificially, could become navigation hazards for shallow-draft commercial vessels transiting small inlets and tributaries in the Bay (Section 3.7.2.2). Aquaculture facilities and activities that are elements of several of the alternatives also could pose navigation hazards. In addition, commercial vessels that release or take on ballast water could serve as vectors for dispersing the Suminoe oyster into regions other than Chesapeake Bay.

3.15 POTENTIALLY AFFECTED RESOURCES OUTSIDE OF CHESAPEAKE BAY

Alternatives addressed in this PEIS that involve only the Eastern oyster would not affect resources outside of Chesapeake Bay. The establishment of a self-sustaining, diploid population of the Suminoe oyster in Chesapeake Bay, however, could affect resources outside of the Bay. A self-sustaining population of Suminoe oysters could be established in Chesapeake Bay in one of three ways: (1) by implementing the proposed action; (2) by implementing the aquaculture alternative using triploid Suminoe oysters, if some reproductively viable oysters escape containment (Section 4.1.6.2 and Appendix B); or (3) by an unauthorized introduction of the Suminoe oyster. NRC (2004) identified the high probability of an unauthorized, or rogue, introduction given the apparent desirability of this species to many stakeholders in the oyster fishery.

The environmental tolerances of the Suminoe oyster are within the tolerance ranges of the Eastern oyster (NRC 2004). Temperature and salinity are the two main environmental factors affecting survival, growth, and reproduction of oysters (Shumway 1996; NRC 2004). The Eastern oyster can tolerate water temperatures ranging annually from -2ºC to 36ºC and salinity ranging annually from 5 to 40 ppt, although most major populations occur in salinities between 10 and 30 ppt. In the native range of the Suminoe oyster in Zhanjiang Bay, China, water temperatures range from about 14ºC to 31.8ºC, and salinities range from about 9 to 30 ppt. (Cai et al. 1992). Triploid Suminoe oysters used in the field trials in the Bay have tolerated and survived winter temperatures below those suggested for their native range (R. Mann, VIMS, pers. comm.) Given these similarities in tolerances, the areas outside Chesapeake Bay that could be affected by alternatives involving the Suminoe oyster include most of the areas that currently support the Eastern oyster. Eastern oysters occur in every major bay system along the Atlantic coast from the Gulf of St. Lawrence, Canada, through the Gulf of Mexico, and into the West Indies (Carriker and Gaffney 1996; FWRI 2006). Figure 3-8 illustrates the range of the Eastern oyster in the United States and the potential range of the Suminoe oyster along the Atlantic and Gulf coasts based on its temperature and salinity tolerances and shows the major Eastern oyster production areas on those coasts.

The ecosystem components that might be affected by the dispersal of Suminoe oyster from Chesapeake Bay to other estuaries and the mechanisms of effect would be similar to those described in Sections 3.1, 3.2, and 3.3 for Chesapeake Bay; however, indicator species for the various ecosystem components would differ geographically. To the extent possible, regionally appropriate indicator species for key ecosystem elements will be identified and discussed in evaluating potential effects outside Chesapeake Bay of alternatives involving the Suminoe oyster.



2006 Eastern Oyster Landings		
State	**Pounds (in thousands)**	**Percent**
Louisiana	11,317.7	52.0
Texas	4,922.9	22.6
Florida – West Coast	2,389.4	11.0
Alabama	939.7	4.3
North Carolina	447.4	2.1
New Jersey	343.2	1.6
South Carolina	275.3	1.3
Maryland	273.9	1.3
New York	269.3	1.2
Massachusetts	212.5	1.0
Rhode Island	85.9	0.4
Connecticut	77.1	0.4
Delaware	75.2	0.3
Florida – East Coast	55.1	0.3
Maine	45.7	0.2
Washington	19.8	0.1
Virginia	15.5	0.1
Georgia	14.2	0.1
Total	**21,779.8**	100

Source: NMFS 2006

Figure 3-8. Range of the Eastern oyster. Bars indicate the percent of total oyster landings for 2006 taken from major production areas and areas of particular interest for the PEIS.

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