Appendix C. The New Jersey Shore

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The New Jersey shore has included popular resorts since the steamship first facilitated travel from Philadelphia to Cape May, and from New York to Long Branch in the early 19th century (Salvini, 1995). As the dry land close to the ocean became developed, people began to build homes on lands that were somewhat more marginal. The narrow fringing marsh on the bay sides of barrier islands was often filled to create buildable lots[67]. Sea level has continued to rise in the ensuing decades, leaving some of the bay sides of developed barrier islands with some very low land. In some cases, the extensive marshes on the mainland side of the back-barrier bays have converted to dredge-and-fill canal estates, such as Beach Haven West.

Severe storms have been a regular feature of the New Jersey shore, although hits from hurricanes have been rare. The northern most numbered street in Barnegat Light is 4th Street, because other portions eroded until shoreline armoring and jetties were constructed to stabilize the inlet. Harvey Cedars extended 1-2 blocks farther seaward in the 1880s than today.

67 See, *e.g.*, Lloyd, J.B. Eighteen miles of history at Long Beach Island. Down The Shore Publishing. (showing substantial marsh on the bay side of Beach Haven in areas that are developed today).

The dense development of the New Jersey shore led many people to take the view that people should not simply retreat in response to storm erosion, but instead hold back the sea. In 1898 the U.S. Army built a seawall between Sandy Hook and Sea Bright to protect the operations at Fort Hancock (NPS, 2007). Over time, the seawall was extended south as far as Long Branch, and there was little or no beach along most portions of the New Jersey shore between Long Branch and Sandy Hook. During the 1970s oceanographer Orrin Pilkey and coastal geologists began to warn people around the nation about the disadvantages of what they called "New Jerseyization," by which they meant replacing beaches with seawalls (Pilkey, et al., 1978). As we discuss in this chapter, however, the state has reversed that trend and restored the beaches, although the seawalls remain.

BOX C.1: Tuckers Island, New Jersey's First Resort

In spite of the historical importance of Cape May and Long Branch, some historians believe that New Jersey's first seashore resort was Tuckers Island (Lloyd, 1994), a barrier island that was partly to the south and partly inland — and sheltered by — Long Beach Island. Tuckers Island was across the bay from Tuckerton, a major port, where ships destined for Philadelphia sometimes offloaded when the Delaware River was frozen (Nash, 1947). During the 1790s, wealthy Quakers who had made their fortunes in Tuckerton during the Revolution began organizing 5-day meetings on Tuckers Island (Lloyd, 1994). The Tucker family eventually converted their farm house on Tuckers Island to a boarding hotel. Soon there was regular stagecoach service from Camden to Tuckerton. After staying overnight in Tuckerston, visitors took a boat ride to Tuckers Island.

On nearby Long Beach Island, resort hotels opened in 1822 at what is now called Surf City and Holgate. A few decades later, several hotels were built in Beach Haven, Barnegat City, and the community of Bonds near the southern end of Long Beach Island. By 1880, Beach Haven was a small town. Still, proximity to Tuckerton kept Tuckers Island popular, even when rail was extended to Atlantic City. Streets were platted on Tuckers Island for a proposed community. But in 1886 the Pennsylvania Railroad connected to nearby Beach Haven, diverting most investor interest in the area to Long Beach Island.

But it was coastal processes, not the railroad, that caused the decline of Tuckers Island. During a storm in 1920, what we now call the Beach Haven inlet opened up near the southern most street on Long Beach Island. The portion of Long Beach Island that had sheltered Tuckers Island from the Atlantic Ocean — generally known as Tuckers Beach — was south of new inlet. Tuckers Beach eroded within five years, exposing Tuckers Island to the Atlantic Ocean. Residents relocated, and by 1933, the hotels, homes and lighthouse on Tuckers Island had all disappeared.

C.1 VULNERABILITY TO INUNDATION AND EROSION

The New Jersey shore has three types of ocean coasts (see Chapter 2 for more on ocean coasts). At the south end, Cape May and Atlantic Counties have short and fairly wide "tide-dominated" barrier islands. Behind the islands, 253 sq km of marshes dominate the relatively small open water bays. To the north, Ocean County has "wave dominated" coastal barrier islands and spits. Long Beach Island is 29 km (18 miles) long and only 2-3 blocks wide in most places; Island Beach to the north is also long and narrow. Behind Long Beach Island and Island Beach lies Barnegat and Little Egg Harbor Bays. These shallow estuaries ranges from 2 to 7 km wide, and have 167 sq km of open water (USFWS, 1997) with extensive eelgrass, but only 125 sq km of tidal marsh (Jones and Wang, 2008). Monmouth County's ocean coast is entirely headlands, with the exception of Sandy Hook at the Northern tip of the Jersey Shore.

Figures C.1 and C.2 show the elevations of lands close to sea level along the New Jersey shore, south and north of Tuckerton, respectively. Between 67 and 129 square kilometers of land lie within one meter above the tides along the Atlantic Ocean and adjacent back barrier bays (see Table C.1). Nontidal wetlands are immediately inland of the tidal wetlands along most of the mainland shore, and account for more than half of the land close to sea level[68].

Between 18 and 61 sq km of dry land are within 50 cm above the tides (Jones and Wang, 2008). The maps suggest that most of the land close to sea level is either on the bay side

68 The estimates are based on 2-foot contours and spot elevation data with RMS errors of 30 cm. Therefore, it was possible to derive a meaningful estimate of the land within 50 cm above the tides.

of a barrier island or relatively compact peninsulas of very low land that extend out into the marsh, such as Beach Haven West and Mystic Isle. Most of these "peninsulas" are dredge-and-fill developments that were created by filling the wetlands and thereby elevating the land surface.

The vulnerability suggested by the maps is consistent with what one actually sees when visiting these areas. In several neighborhoods in the southern half of Long Beach Island, streets and yards are flooded by spring high tides whenever the bay is elevated by either strong winds from the East or a rainy period. (See box on Long Beach Island and Figure C.3.) Portions of Sea Bright, Monmouth Beach, Manasquan (and small areas of Brielle and West Wildwood) also flood during spring tides. Small floodwalls have been constructed along the bay side of Avalon, and drainage is slow enough that pumping is often necessary. Water tables are often close enough to the land surfaces to prevent rainwater from draining into the soil, allowing water to stand for days in minor land surface depressions, generally in back yards. Over the last decade, the elevation of homes and yards has become commonplace.

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10578 **Figure C.1** Cape May, Burlington, and Atlantic counties, New Jersey: Elevations relative to spring high
10579 water. Source: Titus and Wang, 2008.

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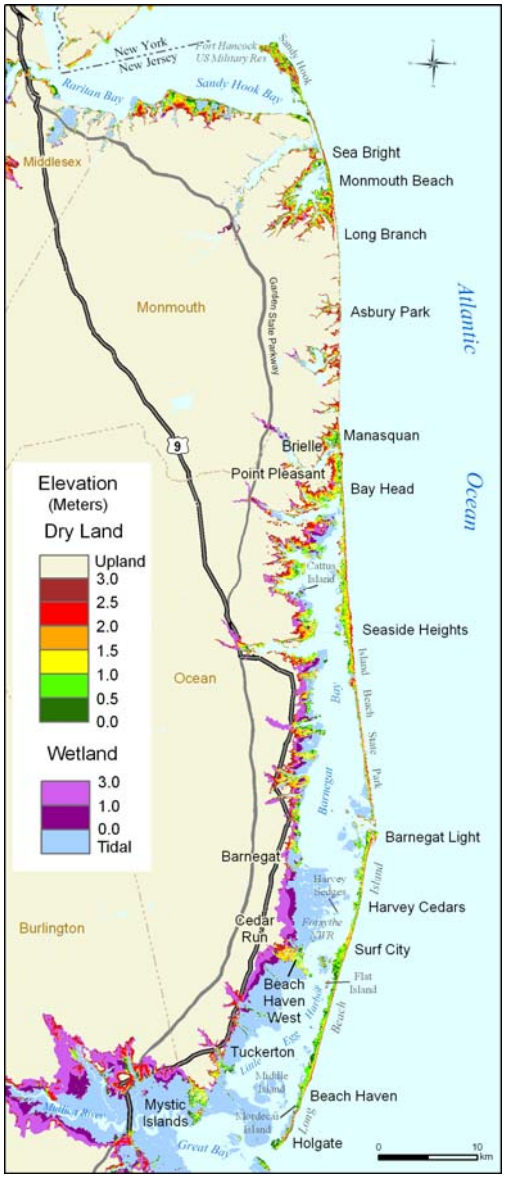

10581

10582 **Figure C.2** Ocean and Monmouth counties, New Jersey: Elevations relative to spring high water. Source:
10583 Titus and Wang, 2008.

10584

Table C.1 Low and high estimates for the area of dry and wet land close to sea level New Jersey Shore (square kilometers).

Elevations above spring high water:	Tidal	50 cm		1 meter		2 meters		3 meters		5 meters	
		Low	High	Low	High	Low	High	Low	High	Low	High
County	Cumulative (total) amount of Dry Land below a given elevation										
Cape May		7.6	21.8	23.8	42.0	56.1	73.5	78.4	102.2	124.2	144.1
Atlantic		4.0	13.5	14.0	29.0	40.8	53.9	57.3	71.0	88.5	105.8
Burlington		0.0	2.1	1.3	4.1	4.0	8.9	7.0	15.1	18.4	27.1
Ocean		4.6	18.7	21.8	44.0	67.3	80.6	93.2	106.8	136.6	149.1
Monmouth		2.1	4.9	5.5	9.4	15.3	19.9	26.4	31.8	50.4	54.9
Total		**18.3**	**61.1**	**66.5**	**128.5**	**183.5**	**236.9**	**262.3**	**326.9**	**418.1**	**481.0**
	Cumulative (total) amount of wetlands below a given elevation										
Cape May	153.2	2.9	12.0	10.2	20.4	22.2	33.1	32.2	42.7	47.6	55.2
Atlantic	204.0	4.8	17.9	14.7	29.2	31.9	50.1	48.3	68.2	82.0	102.9
Burlington	37.3	0.2	9.7	6.2	19.1	18.7	32.7	30.0	41.3	45.8	57.2
Ocean	124.8	2.3	11.6	10.0	21.7	25.8	38.3	39.0	49.4	56.5	65.8
Monmouth	4.4	0.5	0.9	1.0	1.4	1.9	2.3	2.9	3.2	4.8	5.1
Total	**523.6**	**10.7**	**52.1**	**42.1**	**91.9**	**100.5**	**156.5**	**152.4**	**204.9**	**236.5**	**286.3**
Dry and nontidal wetland		29	113	109	220	284	393	415	532	655	767
All land	524	553	637	632	744	808	917	938	1055	1178	1291

Source: Titus and Cacela, 2008. The low and high estimates are based on the on the contour interval and/or stated root mean square error (RMSE) of the data used to calculate elevations. See Chapter 1 for more details.

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Figure C.3 Ship Bottom, New Jersey. Labor Day Weekend 2006, high tide, after a moderate northeaster.

The land within one meter above the tides is not the only land vulnerable to rising sea level. The ocean shores have been eroding. As we discuss below, substantial efforts are underway to rebuild these beaches to promote recreation and protect the buildings behind the beaches. A panel of USGS experts expects that, as long as sea-level rise does not accelerate by more than 2 mm/yr, the conditions that affect beaches today are likely to continue. The panel is almost certain, however, that if sea level were to rise one meter per century, most barrier islands would start to disintegrate over the next two hundred years unless shore protection activities are accelerated compared to what they have been in the past. During the next century, the long, narrow "wave-dominated" islands (and spits) of Ocean County appear to be more vulnerable than the short and wide "tide-dominated" islands of Cape May and Atlantic Counties. While refraining from predicting the future

for any specific island, the USGS panel views disintegration of the narrow islands as "very likely," while the disintegration of the wider islands is only "more likely than not."

C.2 VULNERABLE HABITAT

Species and habitats along the Atlantic Coast of south-central New Jersey are potentially at risk because of sea-level rise. This region encompasses the barrier islands, barrier spits, and back-barrier lagoons of New Jersey's Ocean, Atlantic, and Cape May counties. The region contains important habitats for a wide variety of fishes, invertebrates, terrapins, and birds, and a great deal is known about the ecology and habitat needs of these species. Although it is possible to make qualitative statements about the ecological implications if sea-level rise causes a total loss of habitat, our ability to say what the impact might be if only a portion of the habitat is lost is more limited. A total loss of habitat might be expected if shores are protected with hard structures and the wetlands are unable to keep pace with sea level rise.

There have been many efforts to conserve and restore species and habitats in the barrier island backbarrier lagoon system. Some of the larger parks and wildlife areas in the region include Island Beach State Park, Great Bay Boulevard State Wildlife Management Area, and the E.B. Forsythe National Wildlife Refuge (Forsythe Refuge) in Ocean and Atlantic counties. Parts of the Cape May Peninsula are protected by the Cape May National Wildlife Refuge (TNC, date unknown), the Cape May Point State Park (NJDEP, DEP, date unknown), and The Nature Conservancy's (TNC's) Cape May Migratory Bird Refuge (NJDEP, date unknown). The peninsula is renowned as one of the primary

stopover sites for migrating birds along the U.S. Atlantic Coast. The North Brigantine Natural Area is a critical nesting area for least terns and piping plovers, and a critical stopover habitat for a number of migrating shorebirds (Strange, 2008). Corson's Inlet State Park and Strathemere Natural Area, which straddle Corson's Inlet, have historically provided critical habitat area for black skimmers, least terns and piping plovers, and in an important stopover habitat for migratory shorebirds (Strange, 2008). Stone Harbor Point and Champagne Island, part of the Hereford Inlet system, are critical nesting areas for least terns, black skimmers, piping plovers, common terns, and American oystercatchers, and provide critical resting and feeding habitat for migrating shorebirds, including red knot (Strange, 2008). Marsh islands behind this inlet system and behind Stone Harbor host the largest concentration of nesting laughing gulls in the world (Strange, 2008). The TNC refuge alone supports an estimated 317 bird species, 42 mammal species, 55 reptile and amphibian species, finfish, and shellfish and other invertebrates (NPS, 2008). All of these areas are likely to be placed at increased risk by rising sea levels.

Tidal and Nearshore Nontidal Marshes. There are 18,440.7 ha (71.2 mi^2), 29,344.6 ha (113.3 mi^2), and 26,987.7 ha (104.2 mi^2) of tidal salt marsh in Ocean, Atlantic, and Cape May counties, respectively (Jones and Wang, 2008). Based on a review of available studies, a panel of accretion experts convened for this report concluded that marshes in the study are keeping pace with current local rates of sea-level rise of 4 mm/yr, but will become marginal with a 2 mm/yr acceleration, and will be lost with a 7 mm/yr acceleration except where they are near local sources of sediments (e.g., rivers such as the Mullica and Great Harbor rivers in Atlantic County) (Reed, 2008).

There is potential for wetland migration in Forsythe Refuge, and other lands that preserve the coastal environment such as parks and wildlife management areas. Conservation lands are also found along parts of the Mullica and Great Egg Harbor rivers in Atlantic County. However, many estuarine shorelines in developed areas are hardened, limiting the potential for wetland migration (Strange, 2008). The narrow fringing salt marshes along protected shorelines north of Barnegat Inlet could be lost even with a 2 mm/yr acceleration in rate of sea-level rise. With continued sea-level rise, natural sedimentary processes will be increasingly disrupted and lead to "drowning" of marshes. Many typical back-bay areas will likely become lakes.

As marshes along protected shorelines experience increased tidal flooding, there may be an initial benefit to some species. This is because as tidal creeks become wider, deeper, and more abundant, fish species may benefit because of increased access to forage on the marsh surface (Weinstein, 1979). Fish species such as Atlantic silverside, mummichog, and bay anchovy move into the creeks during low tide, but have greater access and are more common on the marsh surface during high tide (Talbot, 1984). Sampling of larval fishes in high salt marsh on Cattus Island, Beach Haven West, and Cedar Run in Ocean County showed that high marsh is important for production of mummichog, rainwater killifish, spotfin killifish, and sheepshead minnow (Talbot, 1984). The flooded marsh surface and tidal and nontidal ponds and ditches appear to be especially important for the larvae of these species (Talbot, 1984). However, as sea levels continue to rise, and marshes along hardened shorelines convert to open water, marsh fishes will lose access to

these marsh features and the protection from predators, nursery habitat, and foraging areas provided by the marsh.

Loss of marsh area would also have negative implications for the dozens of bird species that forage and nest in the region's marshes. Initially, deeper tidal creeks and marsh pools will become inaccessible to short-legged shorebirds such as plovers (Erwin, 2004). Long-legged waterbirds such as the yellow-crowned night heron, which forages almost exclusively on marsh crabs (fiddler crab and others), will lose important food resources.[69] High marsh nesting birds such as northern harrier, black rail, clapper rail, and willet may be most at risk[70]. Eventually, complete conversion of marsh to open water will affect the hundreds of thousands of shorebirds that stop in these areas to feed during their migrations. The New Jersey Coastal Management Program estimated that some 1.5 million migratory shorebirds stopover on New Jersey's shores during their annual migrations (Cooper, 2005). Waterfowl also forage and overwinter in area marshes. Mid-winter aerial waterfowl counts in Barnegat Bay alone average 50,000 birds (USFWS, 1997). The tidal marshes of the Cape May Peninsula provide stopover areas for hundreds of thousands of shorebirds, songbirds, raptors, and waterfowl during their seasonal migrations (USFWS, 1997). The peninsula is also an important staging area and overwintering area for seabird populations. Surveys conducted by the U.S. Fish and Wildlife Service from July through December 1995 in Cape May County recorded more than 900,000 seabirds migrating along the coast (USFWS, 1997).

69 Dave Jenkins, Acting Chief, New Jersey Division of Fish and Wildlife, Endangered and Nongame Species Program, Trenton, New Jersey. Personal communication 7/25/07 in email to Stephen Keach of PQA.
70 *Ibid.*

As feeding habitats are lost, local bird populations may no longer be sustainable. For example, avian biologists suggest that if marsh pannes and pools continue to be lost in Atlantic County as a result of sea-level rise, the tens of thousands of shorebirds that feed in these areas may shift to feeding in impoundments in the nearby Forsythe Refuge, increasing shorebird densities in the refuge by ten-fold and reducing population sustainability due to lower per capita food resources and disease from crowding (Erwin,et al., date unknown).

Local populations of marsh nesting bird species will also be at risk where marshes drown. This will have a particularly negative impact on rare species such as seaside and sharp-tailed sparrows, which may have difficulty finding other suitable nesting sites. According to synthesis of published studies in Greenlaw and Rising (1994) and Post and Greenlaw (1994), densities in the region ranged from 0.3 to 20 singing males per hectare and 0.3 to 4.1 females per hectare for the seaside and sharp-tailed sparrows, respectively (Greenlaw, et al., 1994). Loss and alteration of suitable marsh habitats are the primary conservation concerns for these and other marsh-nesting passerine birds (BBNEP, 2001). Non-passerine marsh nesting birds may also be at risk, particularly high marsh species such as northern harrier and black rail, which are state-listed as endangered. Species that nest in other habitat but rely on marshes for foraging, such as herons and egrets, will also be affected as marshes drown.

Shore protection activities are underway to protect the vulnerable freshwater ecosystems of the Cape May Meadows (The Meadows), which are located behind the eroding dunes near Cape May Point (USACE, 2008).Freshwater coastal ponds in The Meadows are found within a few hundred feet of the shoreline and therefore could easily be inundated as seas rise. The ponds provide critical foraging and resting habitat for a variety of bird species, primarily migrating shorebirds (Strange, 2008). Among the rare birds seen in The Meadows by local birders are buff-breasted sandpipers, arctic tern, roseate tern, whiskered tern, Wilson's phalarope, black rail, king rail, Hudsonian godwit, and black-necked stilt (Kerlinger, date unknown). TNC, the U.S. Army Corps of Engineers (USACE), and the New Jersey Department of Environmental Protection (NJDEP) have undertaken beach replenishment to protect a mile-long stretch of sandy beach found in the Cape May Migratory Bird Refuge that provides nesting habitat for the rare piping plover and least tern (Blair, date unknown).

Estuarine Beaches. Estuarine beaches will largely disappear as a result of erosion and inundation of sandy habitat as seas rise. This could eliminate the billions of invertebrates that are found within or on the sandy substrate or beach wrack along the tide line of estuarine beaches (Bertness, 1999). These species provide a rich and abundant food source for bird species. Small beach invertebrates include isopods and amphipods, blood worms, and beach hoppers, and beach macroinvertebrates include soft shell clams, hard clams, horseshoe crabs, fiddler crabs, and sand shrimp (Shellenbarger Jones, 2008).

Northern diamondback terrapin nests on estuarine beaches in the Barnegat Bay area (BBNEP, 2001). Loss of these habitats will make terrapins even more dependent on habitats modified by humans (roadways). Local scientists consider coastal development, which destroys terrapin nesting beaches and access to nesting habitat, one of the primary threats to diamondback terrapins, along with predation, roadkills and crab trap bycatch[71].

Loss of estuarine beach could also have negative impacts on the northeastern beach tiger beetle. There are two sub-species, *Cincindela dorsalis dorsalis*, which is a federally listed threatened species and a state species of special concern and regional priority, and *Cincindela dorsalis media*, which is considered rare, though it has not been considered for state listing[72]. In the mid-1990s, the tiger beetle was observed on the undeveloped ocean beaches of Holgate and Island Beach. The USFWS does not know whether this species is also found on the area's estuarine beaches, but studies indicate that it feeds and nests in a variety of habitats (USFWS, 1997). The current abundance and distribution of the northeastern beach tiger beetle in the coastal bays is a target of research (State of NJ, 2005). At present, there are plans to reintroduce the species in the study region at locations where natural ocean beaches remain (State of NJ, 2005).

Tidal Flats. The tidal flats of New Jersey's back-barrier bays are critical foraging areas for hundreds of species of shorebirds, passerines, raptors, and waterfowl (BBNEP, 2001). Tidal flats support invertebrates, such as insects, worms, clams, and crabs, that provide an

71 See the website of the Wetlands Institute's terrapin conservation program at http://www.terrapinconservation.org. Accessed January 24, 2008.
72 Dave Jenkins, Acting Chief, New Jersey Division of Fish and Wildlife, Endangered and Nongame Species Program, Trenton, New Jersey. Personal communication 7/25/07 in email to Stephen Keach of PQA.

10757 important food source for these and other birds that forage in the study region. Some
10758 shorebirds, such as semipalmated sandpiper, dunlin, and dowitcher, forage preferentially
10759 on mudflats and shallow impoundments (BBNEP, 2001). Important shorebird areas in the
10760 study region include the flats of Great Bay Boulevard Wildlife Management Area, North
10761 Brigantine Natural Area, and the Brigantine Unit of the Forsythe Refuge (USFWS,
10762 1997). The USFWS estimates that the extensive tidal flats of the Great Bay alone total
10763 1,358 ha (3,355 ac). Inundation of tidal flats with rising seas would eliminate critical
10764 foraging opportunities for the area's abundant avifauna. As tidal flat area declines,
10765 increased crowding in remaining areas could lead to exclusion and mortality of many
10766 foraging birds (Galbraith, 2002; Erwin, 2004). Some areas may become potential sea
10767 grass restoration sites, but whether or not "enhancing" these sites as eelgrass areas is
10768 feasible will depend on their location, acreage, and sediment type (Strange, 2008).[73]
10769
10770 *Shallow Nearshore Waters and Submerged Aquatic Vegetation (SAV)*. The Barnegat
10771 Estuary is distinguished from the lagoons to the south by more open water and SAV and
10772 less emergent marsh. Within the Barnegat Estuary, dense beds of eelgrass are found at
10773 depths under 1 m (3.28 ft), particularly on sandy shoals along the backside of Long
10774 Beach Island and Island Beach, and around Barnegat Inlet, Manahawkin Bay, and Little
10775 Egg Inlet. Eelgrass is relatively uncommon from the middle of Little Egg Harbor south to
10776 Cape May, particularly locations where water depths are more than 1 m (3.28 ft), such as
10777 portions of Great South Bay (USFWS, 1997).
10778

Seagrass surveys from the 1960s through the 1990s indicate that there has been an overall decline in seagrass in Barnegat Estuary, from 6,823 ha (16,847 ac) in a 1968 survey to an average of 5,677 ha (14,029 ac) of seagrass beds during the period 1996 to 1998 (BBNEP, 2001). Numerous studies indicate that eelgrass has high ecological value as a source of both primary (Thayer, et al. 1984) and secondary production (Jackson et al., 2001) in estuarine food webs. In Barnegat Estuary eelgrass beds provide habitat for invertebrates, birds, and fish that use the submerged vegetation for spawning, nursery, and feeding habitat (BBNEP, 2001). In addition, many species graze on eelgrass, including gastropods, fishes, ducks, and muskrats (BBNEP, 2001).

Short and Neckles (1999) suggested that a 50 cm (19.7 in) increase in water depth as a result of sea-level rise could reduce the light available for eelgrass photosynthesis by 50%, resulting in a 30-40% reduction in seagrass growth. The researchers suggested that this will, in turn, result in reduced productivity and functional values of eelgrass beds (Short and Neckles, 1999).

Results of a study in Barnegat Bay indicated that shoreline protection may exacerbate this problem. The study found that where shorelines are bulkheaded, SAV, woody debris, and other features of natural shallow water habitat are rare or absent. In these bulkheaded areas, there were reduced abundances of fishes compared to sites that were not bulkheaded sites (Byrne, 1995).

Marsh and Bay Islands. Large bird populations are found on marsh and dredge spoil islands of the back-barrier bays in the study region. These islands include nesting sites protected from predators for a number species of conservation concern, including gull-billed tern, common tern, Forster's tern, least tern, black skimmer, American oystercatcher, and piping plover (USFWS, 1997). Diamondback terrapins are also known to feed on marsh islands in the bays (USFWS, 1997).

Some of the small islands in Barnegat Bay and Little Egg Harbor are several feet above mean spring high water (Jones and Wang, 2008), but portions of other islands are very low, and some low islands are currently disappearing. Many of the islands used by nesting common terns, Forster's terns, black skimmers, and American oystercatchers are vulnerable to sea-level rise and erosion (MLT, date unknown). With the assistance of local governments, the Mordecai Land Trust is actively seeking grants to halt the gradual erosion of Mordecai Island, a 45-acre island just west of Beach Haven on Long Beach Island (MLT, date unknown). Members of the land trust have documented a 37% loss of island area since 1930. The island's native salt marsh and surrounding waters and SAV beds provide habitat for a variety of aquatic and avian species. NOAA Fisheries considers the island and its waters Essential Fish Habitat for spawning and all life stages of winter flounder as well as juvenile and adult stages of Atlantic sea herring, bluefish, summer flounder, scup, and black sea bass.[74] The island is also a strategically-located nesting island for many of New Jersey's threatened and endangered species, and it contains

moderate-size black skimmer colony, common terns, and most recently, a very small colony of royal terns (Strange, 2008).

Sea-level fens. Sea-level fens are a tidally influenced seepage wetland, located at the upland/freshwater swamp/tideland interface where fresh groundwater seepage discharges and occasional tidal inundation occurs. New Jersey has identified 12 sea-level fens, encompassing 126 acres. This rare ecological community is restricted in distribution to Ocean County in New Jersey, between Forked River and Tuckerton, in an area of artesian groundwater discharge from the Kirkwood - Cohansey aquifer. Additional recent field surveys have shown possible occurrences in the vicinity of Tuckahoe in Cape May and Atlantic counties (Walz 2004).

These communities provide significant wetland functions in the landscape as well as supporting 18 rare plant species, of which one is listed as State Endangered. Sea-level fen is an ecological community recognized in the National Vegetation Classification System and is ranked as a G1, or critically globally imperiled, community. It is not clear what effect sea-level rise may have on these wetlands. Fens do not tolerate nutrient-rich ocean waters, and therefore if a fen is at an elevation where it can become inundated by rising seas it may not persist[75]. On the other hand, sea-level rise could cause the natural seep (groundwater discharge) to migrate upslope and increase in volume at some locations, which would benefit fens[76].

75 Chris Bason, Delaware Inland Bays Program, written communication to EPA 5/14/07.
76 Barry Truitt,Chief Conservation Scientist, The Nature Conservancy, Virginia Coast Reserve, written communication to EPA, 7/25/07.

C.3 DEVELOPMENT AND SHORE PROTECTION

Chapter 5 describes the basis for ongoing studies that are analyzing land use plans, land use data, and coastal policies to create maps depicting the areas where shores may be protected and where wetlands may migrate inland. Because the maps from those studies have not yet been finalized, this section describes some of the existing and evolving conditions that may influence decisions related to future shore protection and wetland migration.

C.3.1 Statewide Policy Context

The implications of sea level rise for New Jersey are sensitive to policies related to the Coastal Facilities Review Act, the State Plan, an unusually strong public trust doctrine, and the state's strong support for beach nourishment — and opposition to both erosion-control structures and shoreline retreat — along ocean shores. The first three of these policies are discussed in Appendix D; we briefly describe the latter here.

In 1997, then-Governor Whitman promised coastal communities that: "There will be no forced retreat," and that the government would not force people to leave the shoreline. That policy does not necessarily mean that there will always be government help (in terms of state-sponsored shore protection, permits for private actions, guarantees of insurance availability, maintenance of bridges, highways and causeways, etc.) for shore protection. Nevertheless, although subsequent administrations have not expressed this view so succinctly, they have not withdrawn the policy either. If fact, the primary debate

in New Jersey tends to be the level of public access required before a community is eligible to receive beach nourishment, not the need for shore protection itself[77].

The state generally prohibits new hard structures along the ocean front; but that was not always the case. A large portion of the Monmouth County shoreline was once protected with seawalls, with a partial or total loss of beach. During the 1970s, Orrin Pilkey and others pointed to the irony of governments subsidizing the owners of valuable homes by providing shore protection structures that protected the homes but destroyed the primary asset that made the homes valuable to begin with: a nearby beach. Sea Bright and Long Branch were commonly cited by coastal geologists who decried the "New Jerseyization" (i.e., shoreline hardening) of coastal communities elsewhere (Pilkey et al., 1978).

Today, beach nourishment is the preferred method for reversing beach erosion and providing ocean front land with protection from coastal storms (Maureillo, 1991). The entire Monmouth County shoreline now has a beach in front of the old seawalls. Beach nourishment has been undertaken or planned for at least one community in every coastal county from Middlesex along Raritan Bay, to Salem along the Delaware River.

Coastal officials are well-aware of the dynamic nature of barrier islands and have often sought to develop plans to allow development to adapt to shifting shores. If a catastrophic storm caused substantial beach erosion and property damage, it might be economically infeasible to reclaim all the land lost to ocean side erosion. A severe storm might also cause new land to be created on the bay sides of some barrier islands, through

77 See Chapter 7.

the geological overwash process. Nevertheless, current plans assume that permanent changes to the shoreline along the densely developed New Jersey shore would be confined to a very small number of unusually vulnerable areas.

C.3. RESPONSES TO SEA LEVEL RISE

With extensive development and tourism along its shore, New Jersey has a well-established policy in favor of shore protection along the ocean shores[78]. In particular, the state's policies specifically promote the use of beach nourishment to protect property and tourism[79]. For example, Island Beach State Park, a barrier spit along the central portion of Barnegat Bay just north of Long Beach Island, is heavily used by New Jersey residents and includes the official beach house of the Governor. Although it is a state park, it is currently included in the authorized Corps of Engineers Project for beach nourishment from Manasquan to Barnegat Inlet. In the case of Cape May Meadows, however,[80] environmental considerations have prompted shore protection efforts (USACE, 2008). The areas critical freshwater ecosystem is immediately behind dunes that have eroded severely as a result of the jetties protecting the entrance to the Cape May Canal.

78 For example, the primary coastal policy document during the Whitman administration suggested that even mentioning the term "retreat" would divide people and impede meaningful discussion of appropriate policies. See NJDEP, 1997 ("The mere use of the word serves to divide people . . . . '[R]etreat' can mean government-imposed prohibition on construction or reconstruction of oceanfront development . . . . [which] often fuels the divisive `retreat' debate . . . ."). Governor Whitman promised coastal mayors and residents that "there will be no forced retreat."

79 See Coastal Engineering N.J.A.C. 7:7E –7.11

80 The Meadows are within Cape May Point State Park and the Nature Conservancy's Cape May Migratory Bird Refuge.

Chapter 2 suggests the possibility of disintegrating barrier islands along the New Jersey shore. If this risk is substantiated, it is more likely to be a motivation for continued nourishment than an abandonment of these coastal communities. Communities are just starting to think about how the low bay sides of barrier island shores should be protected. Although the baysides of these islands are bulkheaded, communities are unlikely to seriously consider the option of being encircled by a dike as sea-level rises (see BOX C.2 on Long Beach Island). However, Avalon uses a combination of floodwalls and checkvalves to prevent tidal flooding; and Atlantic City's stormwater management system includes underground tanks with checkvalves. These systems have been implemented to address current flooding problems; but they would also be a logical first step in a strategy to protect low lying areas with structural solutions as sea-level rises[81].

With 72 square kilometers of nontidal wetlands within 1 meter above the tides (Jones and Wang, 2008), wetlands along the back-barrier bays of New Jersey's Atlantic coast are likely to have some room to migrate inland. On effort at the state level to preserve such coastal resources is the State's Stormwater Management Plan, which establishes a special water resource protection area that limits development within 300 feet along most of its coastal shore (NJDEP, DWM, April 2004). While the primary objective of the regulation is to improve coastal water quality and reduce potential flood damage, it serves to preserve areas suitable for the landward migration of wetlands.

81 See Chapter 5 for explanation of progression of structural mechanisms to combat flooding.

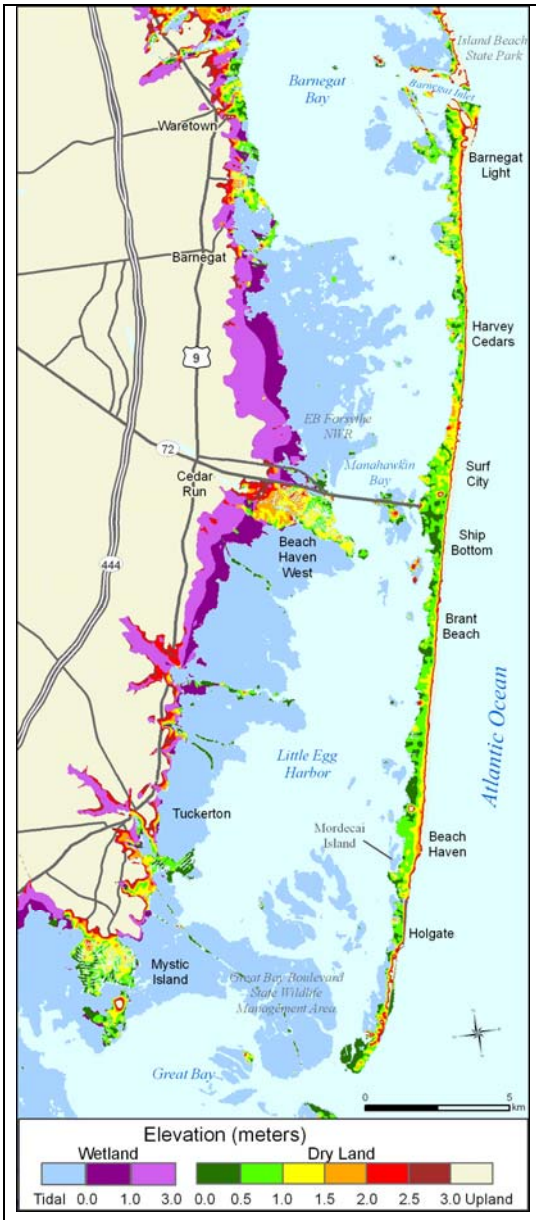
BOX C.2: Shore Protection on Long Beach Island

The effects of sea-level rise can be observed on both the ocean and bay sides of this 18-mile long barrier island. Along the ocean side, shore erosion has threatened homes in Harvey Cedars and portions of Long Beach township. During the 1990s, a steady procession of dump trucks brought sand onto the beach from inland sources. In 2007, the Corps of Engineers began to restore the beach at Surf City and areas immediately north. The beach had to be closed for a few weeks, however, after officials discovered that munitions (which had been dumped offshore after World War II) had been inadvertently pumped onto the beach.

High tides regularly flood the main boulevard in the commercial district of Beach Haven, as well as the southern two blocks of Central Avenue in Ship Bottom. Referring to the flooded parking lot during spring tides, the billboard of a pizza parlor in Beach Haven Crest boasts "Occasional Waterfront Dining."

EPA's 1989 Report to Congress used Long Beach Island as a model for analyzing alternative responses to rising sea level, considering four options: a dike around the island, beach nourishment and elevating land and structures, an engineered retreat which would include the creation of new bayside lands as the ocean eroded, and making no effort to maintain the island's land area. Giving up the island was the most expensive option. The study concluded that a dike would be the least expensive in the short run, but unacceptable to most residents due to the lost view of the bay and risk of being on a barrier island below sea level. In the long run, fostering a landward migration would be the least expensive, but it would unsettle the expectations of bayfront property owners and hence require a leadtime of a few generations between being enacted and new bayside land actually being created. Thus, the combination of beach nourishment and elevating land and structures appeared to be the most realistic, and EPA used that assumption in its nationwide cost estimate.

Long Beach township, Ship Bottom, Harvey Cedars, and Beach Haven went through a similar thinking process in considering their preferred response to sea-level rise. In resolutions enacted by their respective councils, they concluded that a gradual elevation of their communities would be preferable to either dikes or the retreat option. In the last ten years, several structural moving companies have had ongoing operations, continually elevating homes.



Box Figure C.2-1 Elevations relative to spring high water on and around Long Beach Island. Source: Titus and Wang, 2008.

C.4 POPULATION OF LANDS CLOSE TO SEA LEVEL

Table C.2 estimates the population of lands close to sea level for each of the counties along the Atlantic coast of New Jersey. Because Census data measures official residents, these figures omit the many summer residents. Nevertheless, thousands of people inhabit the very-low lying lands along the back barrier bays of Ocean, Cape May, and Monmouth Counties. Tens of thousands of people live within two meters above the tides in coastal communities from Cape May to Sea Bright.

Table C.2 Population of lands close to sea level: New Jersey Shore.

County	Low and high estimates of population below a given elevation (thousands)					
	50cm		1m		2m	
	Low	High	Low	High	Low	High
Jersey						
Atlantic	0.1	39.6	21.3	67.1	72.4	86.6
Burlington[1]	0.0	23.7	0.0	27.6	2.6	46.2
Cape May[1]	2.1	30.5	17.3	44.2	38.9	56.9
Monmouth[2]	4.9	19.5	15.2	36.8	46.5	68.5
Ocean	1.0	21.6	11.3	50.4	64.8	89.5
Total	**8.1**	**134.9**	**65.1**	**226.1**	**225.2**	**347.7**

[1] Figures are for the entire county. County is split between New Jersey Shore and Delaware Bay Watersheds.
[2] Figures are for the entire county. County is split between New Jersey Shore and Hudson River Watersheds.

C.5 STATEWIDE POLICY CONTEXT

We will see in Appendix D (Delaware Estuary) that the implications of sea-level rise for New Jersey are sensitive to policies related to the Coastal Facilities Review Act, the State Plan, and an unusually strong public trust doctrine. Let us now examine the state's strong support for beach nourishment — and opposition to both erosion-control structures and shoreline retreat — along ocean shores.

Strong Commitment to Beach Nourishment. In 1997, then-Governor Whitman promised coastal communities that: "There will be no forced retreat," and that the government

would not force people to leave the shoreline. That policy does not necessarily mean that there will always be government help (in terms of state-sponsored shore protection, permits for private actions, guarantees of insurance availability, maintenance of bridges, highways and causeways, etc.) for shore protection. Nevertheless, although subsequent administrations have not expressed this view so succinctly, they have not withdrawn the policy either. If fact, the primary debate in New Jersey tends to be the level of public access required before a community is eligible to receive beach nourishment, not the need for shore protection itself[82].

The state generally prohibits new hard structures along the ocean front; but that was not always the case. A large portion of the Monmouth County shoreline was once protected with seawalls, with a partial or total loss of beach. During the 1970s, Orrin Pilkey and others pointed to the irony of governments subsidizing the owners of valuable homes by providing shore protection structures that protected the homes but destroyed the primary asset that made the homes valuable to begin with: a nearby beach. Sea Bright and Long Branch were commonly cited by coastal geologists who decried the "New Jerseyization" (i.e., shoreline hardening) of coastal communities elsewhere (Pilkey et al., 1978).

Today, beach nourishment is the preferred method for reversing beach erosion and providing ocean front land with protection from coastal storms (Maureillo, 1991). The entire Monmouth County shoreline now has a beach in front of the old seawalls. Beach nourishment has been undertaken or planned for every coastal county from Middlesex along Raritan Bay, to Salem along the Delaware River.

82 See Chapter 7.

If a catastrophic storm caused substantial beach erosion and property damage, it might be economically infeasible to reclaim all the land lost to ocean side erosion. A severe storm might also cause new land to be created on the bay sides of some barrier islands, through the geological overwash process. Nevertheless, current plans assume that permanent changes to the shoreline along the densely developed New Jersey shore would be confined to a very small number of unusually vulnerable areas.

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