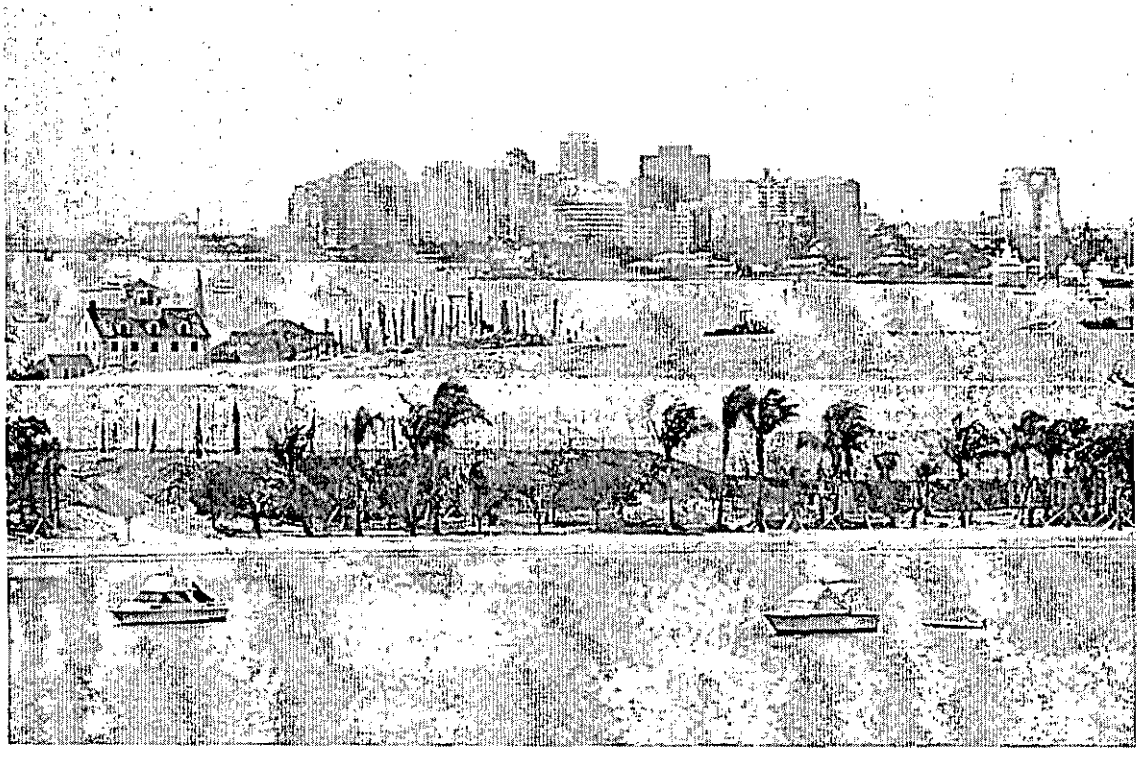
Sea Level Rise in the Treasure Coast Region



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Contents

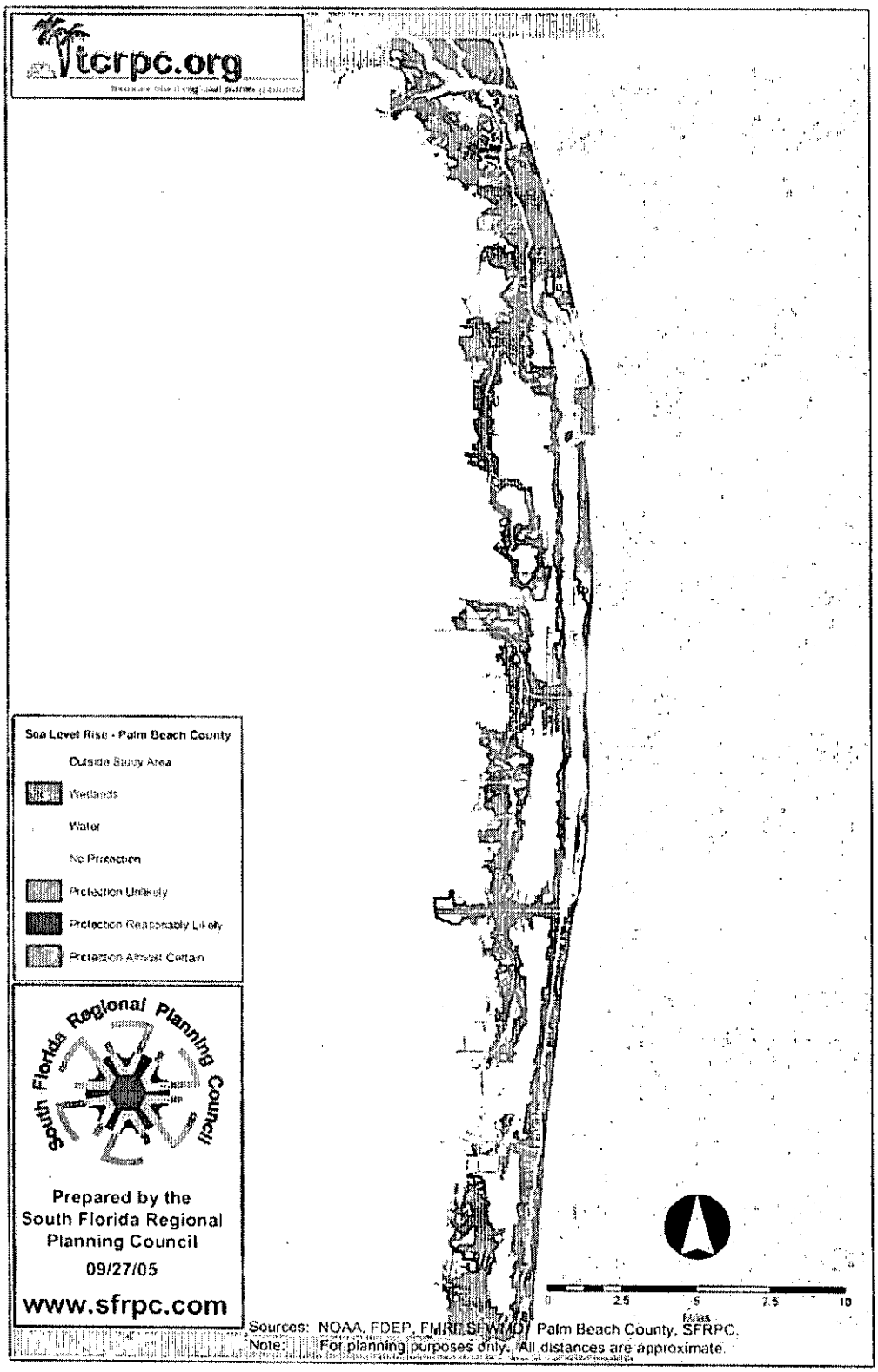
Palm Beach County

A total of 56,535 acres of uplands and 4,001 acres of wetlands were identified in the Palm Beach County portion of the study area (Map 4). The "Protection Almost Certain" category in this county accounts for about 44.1 % of the uplands in the study area within the region, and 93.0 % of the uplands in the study area in Palm Beach County. The combination of the "Protection Almost Certain" and "Protection Reasonably Likely" categories accounts for 96.7 % of the uplands mapped in this county. The wetlands remaining in the Palm Beach County portion of the study area account for only 16.7 % of the wetlands identified in the region. The county has no significant concentrations of areas classified as "Wetlands," and there are little or no opportunities for the inland migration of wetlands in Palm Beach County.

The upland areas most likely to be affected by sea level rise represent about 4.3 % of the total area of Palm Beach County. The main areas of impact are expected on the barrier islands and areas east of the ICW; shorelines of the Indian River Lagoon, Lake Worth Lagoon and other estuaries; shorelines of the Loxahatchee River; shorelines of several inland waterways; and within islands in the lagoon and river systems. The municipalities that boarder the ICW or Atlantic Ocean have the greatest potential to be affected by sea level rise. These include the following 23 municipalities in Palm Beach County:

- City of Boca Raton
- City of Boynton Beach
- Town of Briny Breezes
- City of Delray Beach
- Town of Gulf Stream
- Town of Highland Beach
- Town of Hypoluxo
- Town of Juno Beach
- Town of Jupiter
- Town of Jupiter Inlet Colony
- Town of Lake Park
- City of Lake Worth
- Town of Lantana
- Town of Manalapan
- Village of North Palm Beach
- Town of Ocean Ridge
- Town of Palm Beach
- City of Palm Beach Gardens
- Town of Palm Beach Shores
- City of Riviera Beach
- Town of South Palm Beach
- Village of Tequesta
- City of West Palm Beach

Map 4. Anticipated response to sea level rise in Palm Beach County.



Barrier Islands. The barrier islands in Palm Beach County are Jupiter Island north of the Jupiter Inlet, Singer Island north of the Lake Worth Inlet, and Palm Beach Island south of the Lake Worth Inlet. Nearly the entire shoreline along the Atlantic Coast, lagoon systems, and inland waterways of Palm Beach County is developed and classified as "Protection Almost Certain." An exception just south of the Jupiter Inlet is Carlin Park, which is red signifying "Protection Reasonably Likely."

The barrier island is light green signifying "No Protection" at MacArthur Beach State Park. This is an area where the Barrier Island is very narrow. It would be possible for the Island to be breached at this location without interrupting travel on State Road A1A, which runs on the west side of the island. If the island is breached in the park without affecting State Road A1A, it is likely that the breach would be allowed to remain. However, local planners indicate that the road would be repaired and protected if it is impacted by a hurricane.

Peanut Island. The only sizable dark blue area signifying "Protection Unlikely" in the county is Peanut Island, which is located adjacent to the Lake Worth Inlet. Peanut Island is home to a Palm Beach County Park with newly constructed recreational facilities, restored and created fish and wildlife habitat, Palm Beach Maritime Museum, historic former U.S. Coast Guard Station, and dredged material management area used by the Florida Inland Navigation District and the Port of Palm Beach. Local planners have indicated that the dark blue seems appropriate because much of it is used for recreation. The low lying historic structures in the red area on the south side of the island would likely be protected.

Mainland along ICW and Lagoon Systems. Nearly the entire length of the county is classified as brown signifying "Protection Almost Certain" on the western shore of the ICW and lagoon systems. This includes a portion of the downtown area of the City of West Palm Beach, the most urbanized portion of the county. This area also includes two main critical facilities, the Port of Palm Beach and FPL Riviera power plant, which are both located on the western shore of Lake Worth Lagoon in the City of Riviera Beach. Sea level rise issues should play an important role in the future planning for these facilities.

Inland along the Canal Systems. The sea level rise map for Palm Beach County identifies the areas adjacent to several inland canal systems as brown. These freshwater canals are managed by the SFWMD for flood control purposes. For example, the C-17 canal typically has a discharge elevation set from 8 to 9 feet above sea level; the C-51, C-16, and C-15 canals are typically controlled at from 8.5 to 9.5 feet; and the Hillsborough canal is typically controlled at an elevation from 7.5 to 8.5 feet. These areas were included in the mapping because the discharge elevations of these canals are below 10 feet above sea level. However, the land adjacent to these canal systems is generally above 10 feet in elevation. The mapping procedure that caused these areas to be included in the study area should be evaluated. Similarly, the adequacy of the flood control structures in these canals should also be examined as part of long range planning for sea level rise.

Planner Review. Palm Beach County planners had the following comments concerning the state-wide approach for identifying likelihood of land use protection (Table 2) and the Palm Beach County sea level rise map (Map 4):

- The maps would be more useful if one could zoom in to see more details on a computer.
- The maps would be improved if they contained the main roads and municipal boundaries.
- The barrier island is very narrow at several locations. If the island is breached it would likely be repaired and the road would be maintained. The road is very important for hurricane evacuation.
- The dark blue signifying "Protection Unlikely" on much of Peanut Island seems appropriate because much of it is used for recreation. The low lying historic structures on the Peanut Island would likely be protected.
- The county does not currently have policies specifically dealing with sea level rise.
- The county will be updating the comprehensive plan through the EAR process in 2009.
- County planners will consider adding new policies dealing with sea level rise in the next major update to the comprehensive plan.

Discussion

Responses to Sea Level Rise

Many coastal management, construction, and planning and zoning guidelines can prepare citizens and governments for rising sea levels. The Coastal Zone Management Subgroup of Intergovernmental Panel on Climate Change Response Strategies Working Group (1990) has described the three basic pathways for responding to sea level rise. The strategies of retreat, accommodation and protection are described below:

Retreat. This is the strategy of abandoning lands and structures in coastal zones and allowing marine ecosystems to move inland. In this response, there is no effort to protect the land from sea level rise. Governments exercising the retreat option generally prevent development in prone areas, allow development with conditions for abandonment (e.g. rolling easement) and/or withdraw subsidies for construction in danger zones. Governments can restrict development in coastal areas through a variety of policies. These approaches usually include land acquisitions, setbacks, low densities, planning and zoning restrictions on coastal land use, and banning the redevelopment of damaged structures.

Accommodation. This strategy allows for land use and occupancy of vulnerable areas to continue, but with no attempts to prevent flooding or inundation. It is a hybrid of retreat and protection, because structures are protected while floodplains and shorelines advance farther inland. Governments favoring accommodation can strengthen flood preparations, prohibit activities that may destroy protective coastal resources and/or deny government flood insurance coverage of inhabitants of vulnerable areas. Strengthened flood preparations may include countering rising seas and high winds through building code requirements, improvement of drainage and education. Like retreat, accommodation requires advance planning by local governments. Local governments must also accept that valuable land may be lost to rising seas. Although accommodation is a common short-term response, it may be less useful in the long run. While it may be practical in some circumstances to maintain habitable homes as wetlands advance onto people's yards, eventually the wetlands would become inundated and homes would be standing in the water.

Protection. This strategy involves using structural, defensive measures to protect the land from the sea, so that land use can continue. Shores can be protected by hard structures such as seawalls, revetments, and dikes, or by soft structural techniques like beach nourishment and elevating land surfaces with fill. Unlike the first two options, protection has a dramatic impact on both the immediate environment and ecosystems beyond the immediate area. The costs to wetlands, unprotected uplands and offshore fisheries must be assessed before protective measures are constructed.

Federal Policies and Programs

While a few federal policies specifically deal with the problems of sea level rise, a number of policies address the same effects of sea level rise, such as flooding, erosion, and wetland loss.

These policies are included in the Coastal Zone Management Act, the Coastal Barrier Resources Act, the Clean Water Act and the Rivers and Harbors Act and National Flood Insurance Act.

The Coastal Zone Management Act of 1972 is the federal law that created and guides the United States' coastal management programs. Congress created the CZMA to deal with the threats to the country's coastal zone caused by increasing and competing demands on the land and water of the zone. The CZMA establishes the coastal management policy of the United States as preserving, protecting, developing, and where possible, restoring or enhancing the resources of the nation's coastal zone by encouraging and assisting the states to exercise to develop and implement their own coastal management programs. Congress also specifically addressed the issue of sea level rise in the Act:

> *"Because global warming may result in a substantial sea level rise with serious adverse effects in the coastal zone, coastal states must anticipate and plan for such an occurrence."*
>
> *"The Congress finds and declares that it is the national policy --- the management of coastal development to minimize the loss of life and property caused by improper development in flood-prone, storm surge, geological hazard, and erosion-prone areas and in areas likely to be affected by or vulnerable to sea level rise, land subsidence, and saltwater intrusion, and by the destruction of natural protective features such as beaches, dunes, wetlands, and barrier islands."*

The provisions of the CZMA are realized through the Coastal Zone Management Program (CZMP), which is administered by NOAA. The CZMP is a voluntary federal-state partnership that has provided cost-sharing grants to states to develop and implement their own coastal zone management plans. The CZMP has based eligibility for federal approval of state plans on several factors. Each state's plan is required to define boundaries of the state's coastal zone and identify uses within the area to be regulated by the state plan, the criteria for regulations such uses and the guidelines for priorities of uses within the coastal zone. Subsequent to approval of the plan by NOAA, grants are awarded for implementation of the state's coastal management plan. In addition to providing financial assistance, the CZMP also supports states by offering mediation, technical services and information, and participation in priority state, regional, and local forums. Thirty-four states and territories with federally approved coastal management programs are participants in the CZMP. Almost all of the nation's shoreline (99.9%) is currently managed by the CZMP. The main effect of the CZMA on the issue of sea level rise is to make state policymakers aware of the matter when they create their own coastal management plans.

Another piece of federal legislation that has a bearing on coastal management policies is the Coastal Barrier Resources Act (CBRA), which was enacted in 1982. CBRA was designed to protect barrier islands along the United States coast. Coastal barrier islands are located off of the mainland coast and protect the mainland by receiving the majority of the ocean's energy contained in winds, waves and tides. Coastal barriers also protect and maintain productive ecosystems that exist within this protective zone. In drafting the law, Congress found that certain actions and programs of the Federal Government have subsidized and permitted development on

coastal barriers and the result has been the loss of barrier resources, threats to human life, health, and property, and the expenditure of millions of tax dollars each year.

CBRA established a Coastal Barrier Resources System, which designated various undeveloped coastal barrier islands for inclusion in the System. The boundaries of the System are contained on maps kept on file by the Department of the Interior. CBRA prohibits various federal actions and policies from occurring on islands within the System. The Act places several restrictions on Federal government spending on expenditures that encourage development or modification of a coastal barrier. No new expenditures or federal assistance can be used on coastal barrier islands for the following projects:

1) The construction or purchase of any structure, appurtenance, facility, or related infrastructure;

2) The construction or purchase of any road, airport, boat landing facility, or other facility on, or bridge or causeway to, any System unit; and

3) The carrying out of any project to prevent the erosion of, or to otherwise stabilize, any inlet, shoreline, or inshore area, except that such assistance and expenditures may be made available on (certain designated units) for purposes other than encouraging development and, in all units, in cases where an emergency threatens life, land, and property immediately adjacent to that unit.

Notwithstanding the previous restrictions, CBRA does provide exceptions to limitations on a variety of expenditures with the barrier system. These include military and Coast Guard activities; maintenance of federal navigation channels; maintenance of certain publicly owned roads, structures and facilities; scientific research; and non-structural projects for shoreline stabilization that mimics, enhances or restores a natural stabilization system. Non-structural shore erosion control projects usually use bioengineering to create protective vegetative buffers stabilizing stream banks and shorelines and creating near-shore habitats for aquatic species and waterfowl. Another feature of the Act is the prohibition of national flood insurance or HUD assistance to any projects within the barrier system that facilitate an activity that is not consistent with CBRA's provisions. CBRA is a good start in the prevention of development in areas that will be most affected by the effects of sea level rise.

The National Flood Insurance Program (NFIP) is another important component of federal coastal management policy. The NFIP is administered by the Federal Emergency Management Agency (FEMA), with its primary goals being to save lives and reduce future property losses from flooding. The NFIP is a voluntary program based upon a mutual agreement or partnership between the federal government and local communities. This partnership provides that the federal government will make federally backed flood insurance available to home and business owners in communities that agree to adopt and enforce comprehensive floodplain management standards designed to reduce flood damages. NFIP transfers most of the costs of private property flood losses from the taxpayers to people that choose to live within floodplains through insurance premiums and increased construction standards.

Community response to this requirement involves the adoption of land use, zoning and building code standards that, at a minimum, include the design and construction standards of the NFIP. The minimum NFIP design and construction standards are applicable to all new construction, substantial damages and substantial improvements to existing structures located in Special Flood Hazard Areas or in Special Flood Hazard Areas that have not yet been identified by FEMA. The Special Flood Hazard Areas represent the statistical chance of a 100-year flood occurring in any given year. The 100-year flood has a one-percent chance of occurring in any given year.

NFIP imposes stricter requirements on communities in the V-Zones of Flood Insurance Rate Maps. These are locales in coastal high hazard areas located along coastlines that are subject to high water levels, wave action, and erosion from strong storms and hurricanes. The wind and resultant waves and tidal surges associated with these storms cause water of high velocity to sweep over nearby land. Generally, the V-Zone indicates the inland extent of a three-foot breaking wave atop a storm surge. These areas are extremely hazardous to life and property.

There are a number of building requirements that NFIP requires for new construction or substantial improvements in coastal high hazard areas to be able to withstand wind and waves. New buildings and improvements must:

- Obtain and maintain the elevation of the bottom of the lowest horizontal structural member of the lowest floor;
- Be located landward of mean high tide and no new construction is allowed over water;
- Be elevated so that the bottom of the lowest horizontal structural member of the lowest floor is at or above the base flood elevation on a pile or column foundation;
- Allow the space below the lowest elevated floor to be free of obstruction or must be enclosed with non-supporting breakaway walls, open lattice-work, or insect screening designing to collapse under wind and water loads without causing damage to structural supports or the elevated structure;
- Not use fill for structural support of buildings; and
- Prohibit manmade alteration of sand dunes and mangrove stands that would increase potential flood damage.

As previously noted, the Coastal Barrier Resources Act (CBRA) prohibits new NFIP coverage for new or substantially improved structures in any coastal barrier in the CBRA system.

The Clean Water Act of 1972 is another federal law that has an impact on the health of our nation's coastal areas and wetlands. Sections 404 of the Clean Water Act sets national policy for the discharge of dredged or fill material into the nation's navigable waters and adjacent wetlands. The Act has even been interpreted to have authority over inland wetlands. Section 404 gives jurisdictional responsibility for issuing dredge permits to the COE. The EPA has responsibility for developing and interpreting the criteria used in permit issuances.

The Clean Water Act prohibits the discharge of dredged or fill material at a specific site if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem or if the discharge will cause or contribute to significant degradation of U.S. waters. Practicable alternatives under the Clean Water Act include activities that do not include a discharge into U.S. waters or discharges into waters other than the specific site requested. Degradation caused to U.S. waters is deemed to be significant adverse effects to human health or welfare, aquatic life stages and ecosystems, ecosystem diversity and productivity, and recreational, aesthetic and economic values. Discharges from established and ongoing farming, ranching and forestry activities are exempt from § 404 provisions.

To receive a permit to discharge dredge materials, the applicant must prove to the COE that they have taken steps to avoid wetland impacts where practicable, minimized potential impacts to wetlands and provided compensation for any remaining, unavoidable impacts through activities to restore or create wetlands. States also have a role in § 404 decisions, through State program general permits, water quality certification, or program assumption.

An additional federal law that gives the COE additional authority over construction in navigable waters and wetlands is the Rivers and Harbors Act (RHA). Sections 9 & 10 of the Act authorize the COE to regulate the construction of any structure or work within navigable waters of the United States. The types of structures the RHA allows the COE to regulate include the following: wharves, breakwaters, or jetties; bank protection or stabilization projects; permanent mooring structures, vessels, or marinas; intake or outfall pipes; canals; boat ramps; aids to navigation; or other modifications affecting the course, location condition, or capacity of navigable waters.

When issuing permits for construction of the aforementioned structures, the COE must consider the following criteria: (1) the public and private need for the activity; (2) reasonable alternative locations and methods; and (3) the beneficial and detrimental effects on the public and private uses to which the area is suited. The COE is also required to consult with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service to protect and conserve wildlife resources.

State Policies and Programs

As with federal policies, few State policies specifically address the issue of sea level rise. However, State coastal guidelines that cover beach management policies can be used to respond to sea level rise concerns. These policies are included in the Coastal Construction Line Program, the Beach Erosion Control Program, Coastal Building Zone and Strategic Beach Management Plans.

The Florida Beach and Shore Preservation Act was enacted by Florida's legislature to preserve and protect Florida's beach and dune system. Beaches and dunes are the first line of defense against storms, acting as a buffer between the sea and coastal development. One of the programs authorized by the Beach and Shore Preservation Act to be an essential element in the protection effort is the Coastal Construction Control Line (CCCL) Program (Beach and Shore Preservation Act, Florida Statutes Chapter 161).

The CCCL Program was designed to protect Florida's beach and dune system from irresponsible construction that could weaken, damage or destroy the health of the dune system. Structures that are built too close to the sea can inhibit the beach and dune system from its natural recovery processes and can cause localized erosion. Improperly constructed structures are a threat to other nearby coastal structures should they be destroyed by storms. The CCCL Program gives the State the jurisdiction to apply stringent siting and design criteria to construction projects within the control line. The CCCL is not a setback line, but is rather a demarcation line of the State's authority.

The CCCL is marked at the landward limit of coastal areas that are subject to the effects of a 100-year storm surge. While wind and flooding may intrude further inward than the 100-year storm surge area, effects landward of the CCCL are considerably less than within the CCCL. Within the CCCL, the State prohibits the construction or siting of structures that would cause a significant adverse impact to the beach and dune system, result in the destabilization of the system or would destroy marine turtle habitat. To meet these requirements, structures are required to be located a sufficient distance from the beach and frontal dune and must also be sited in a way that does not remove or destroy natural vegetation. The CCCL also requires all structures to be constructed to withstand the wind and water effects of a 100-year storm surge event. This involves creating structures that meet American Society Civil Engineering 7-88 Sect. 6 wind design standard for 110 mph winds and 115mph for the Florida Keys. Water standards include a foundation design to withstand a 100-year storm event--including the effects of surge, waves and scouring. There is no prohibition of rebuilding under the CCCL Program. Due to the effects of erosion, the CCCL Program discourages the construction of rigid coastal armoring (seawalls) and instead encourages property owners' use of other protection methods, such as foundation modification, structure relocation and dune restoration.

Another similar endeavor to regulate coastal construction is the Coastal Building Zone (CBZ). The CBZ was established as part of the Coastal Protection Act of 1985 to protect coastal areas and to protect life and property. The CBZ is similar to the Coastal Construction Line Program in that it is a regulatory jurisdiction, rather than a setback line. The CBZ envelops land from the seasonal high water line to 1500 feet landward of the CCCL. In those areas fronting on the ocean but not included within an established CCCL, the Coastal Building Zone includes the land area seaward of the most landward V-Zone line, as established by NFIP's flood maps. The V-Zone is an area likely to experience a wave greater than 3 feet high with storm surge or areas within the 100-year storm event used by the CCCL program. Local governments enforce the Coastal Building Zone, as a part of their building codes, rather than by the State.

Within the CBZ, new construction is required to meet the Standard Building Code 1997 wind design standard of 110 mph and 115 mph for the Florida Keys. As for water standards, structures are required to meet National Flood Insurance Program requirements or local flood ordinance requirements, whichever are stricter. Foundations must also be designed to withstand a 100-year storm surge. CBZ construction standards are less stringent than CCCL standards. This is due to the fact that NFIP flood maps have lower base flood elevations for 100-year storm events than do CCCL studies.

Another State effort to protect Florida's beaches, authorized by the Beach and Shore Preservation Act, is the Beach Erosion Control Program (BECP). The BECP is the primary program that implements the Florida Department of Environmental Protection's beach management recommendations. The BECP was created to coordinate the efforts of local, state, and federal governments in protecting, preserving and restoring Florida's coastal resources. One of the activities of this program is the offering of financial assistance to counties, local governments and other special districts for shore protection and preservation efforts. The BECP will provide up to 50 percent of project costs. The mix between federal, state and local funds is different for each project.

Beach management activities eligible for funding from the BECP include beach restoration and nourishment activities, project design and engineering studies, environmental studies and monitoring, inlet management planning, inlet sand transfer, dune restoration and protection activities, and other beach erosion prevention related activities.

Another endeavor of the BECP is the development and maintenance of a Strategic Beach Management Plan (SMBP) for Florida. The SBMP is a multiyear repair and maintenance strategy to carry out the proper state responsibilities of a comprehensive, long-range, statewide program of beach erosion control; beach preservation, restoration, and nourishment; and storm and hurricane protection. The SBMP is divided into specific beach management plans for Florida's coastal regions.

Local Government Policies

All of the counties in the Region have Comprehensive Plans that contain coastal management elements. None of the counties in the region has policies specifically dealing with sea level rise. However, each of the counties has goals, objectives, and policies that are related to sea level rise issues. Some of these objectives most relevant to sea level rise are summarized below:

Indian River County

Objective 4: *Beaches and Dunes*. By 1998, all natural functions of the beach and dune system in Indian River County shall be protected and no unmitigated human-related disturbance of the primary dune system shall occur.

Objective 5: Limiting Public Expenditures in the Coastal High-Hazard Area. Through 2004, there will be no expansion of infrastructure within the Coastal High Hazard Area other than that which is deemed necessary to maintain existing levels-of-service.

Objective 11: *Limit Densities in the Coastal High Hazard Area*. Through 2020, there will be no increase in the density of land use within the Coastal High Hazard Area.

St. Lucie County

Objective 7.1.1: *Future Development in the Coastal Area*. St. Lucie County shall continue to protect the natural resources of the coastal area from adverse impacts caused by future

development through the implementation and strengthening of existing environmentally related laws and the assignment of appropriate Future Land Use designations.

Objective 7.1.5: *Beaches and Dunes.* St. Lucie County shall provide for the protection and restoration of beaches and dunes. A comprehensive beach and dune management program shall be adopted by 2003 which enhances the natural functioning of the beach-dune system while reducing unnatural disturbances of the primary dune.

Objective 7.2.1: The County shall address development and redevelopment in the coastal area in the County's Hurricane Evacuation Plan.

Martin County

Objective. *Beach and dune and off-shore systems.* To develop procedures and standards to protect, enhance and restore beach and dune systems and minimize construction-related impacts

Objective. *Hazard mitigation and coastal high hazard area.* To limit public expenditures in the designated coastal high hazard area to necessary public services in order not to subsidize new development in this area.

Objective. *Direct population away from coast.* Encourage low density land uses within the coastal high hazard area in order to direct population concentrations away from this area.

Palm Beach County

Objective 1.2: *Shoreline Protection.* Palm Beach County shall protect, enhance and restore the beaches and dunes through implementation and maintenance of the Palm Beach County Shoreline Protection Plan.

Objective 2.2: *Public Subsidy of New Coastal Development.* Palm Beach County shall not subsidize new or expanded development in the coastal area.

Objective 2.3: *Development in High Hazard Area.* Palm Beach County shall direct population concentrations away from known or predicted coastal high-hazard areas and shall not approve increases in population densities n the coastal high hazard area.

Proposed Policies

Planners in each of the counties in the Treasure Coast Region indicated a willingness to consider the adoption of policies specifically related to sea level rise. The following policy statements are offered for consideration by local governments in coastal areas:

Policy 1: Consider the impact of sea level rise in all land use amendments in coastal areas less than 10 feet in elevation.

Policy 2: Obtain detailed topographic maps showing one foot contours in the coastal zone to assist in planning for sea level rise.

Policy 3: Develop a plan to protect or relocate all critical public facilities that are located in areas projected to be impacted by sea level rise in the next 50 years.

Policy 4: Closely monitor updates to sea level rise forecasts and predictions.

Policy 5: Develop a sea level rise response plan that specifically identifies the areas where retreat, accommodation and protection will be implemented.

Conclusions

This report is intended to stimulate local government planners and citizens to think about the problem of sea level rise. Although this project covers a timeframe of 200 years, planning for sea level rise should begin now. The sea is already rising and some shores are already eroding. Moreover, an effective response may require a lead time of many decades. If we develop areas where wetland migration is preferred in the long run, it might take a lead time of 50-100 years to relocate the development. Even in areas that we protect, shore protection measures can take decades to plan and implement.

The relevance of planning for sea level rise can also be seen by the events of 2004 hurricane season. The Treasure Coast Region suffered extensive damage from storm surges, wind and erosion. With strong hurricane seasons projected to continue into the future, because of warmer ocean waters, the events of the 2004 hurricane season are likely to reoccur.

The rate of development and increase in population in the Treasure Coast Region are other important factors in starting the preliminary stages of planning for sea level rise now. As sea levels continue to rise, much of the currently developed increasingly populated area can be expected to be flooded. Planners must begin to decide which land areas in their counties and municipalities will be protected against sea level rise, and what the cost will be to holding back the sea. Citizens living in these areas must also know the costs associated with protection against sea level rise.

The sea level rise maps provided in this report only depict the expected response scenarios to sea level rise based on the best currently available knowledge. Local planners may decide in the future that it will be wise to retreat from lands currently deemed to be protected lands, due to costs and environmental considerations. This project represents the first step in planning for sea level rise in the Treasure Coast Region.

Literature Cited

Bureau of Economic and Business Research. 2005. Projections of Florida population by county, 2004 – 2030. University of Florida, Bureau of Economic and Business Research Bulletin No. 141, Volume 38, No.2.

Coastal Zone Management Subgroup. 1990. Strategies for adaptation to sea level rise. Intergovernmental Panel on Climate Change Response Strategies Working Group. Ministry of Transport and Public Works, The Hague, Netherlands.

Fiedler, J., F. Mays, and J. Siry, Eds. 2001. Feeling the heat in Florida: Glogal warming on the local level. Natural Resources Defense Council and Florida Climate Alliance, New York and Orlando.

Florida Department of Environmental Protection and South Florida Water Management District. 2000. Loxahatchee River National Wild and Scenic River management plan, plan update. South Florida Water Management District, West Palm Beach, Florida.

Florida Department of Transportation. 1999. Florida land use, cover and forms classification system. Third edition. Florida Department of Transportation Surveying and Mapping Office, Geographic Mapping Section, Tallahassee, Florida.

Indian River County. 1998. Indian River County 2020 comprehensive plan. Indian River County, Vero Beach, Florida.

Leatherman, S.P., K. Zhang, and B.C. Douglas. 2000. Sea level rise shown to drive coastal erosion. EOS Transactions 81: 55-57.

Martin County. 1990. Martin County comprehensive growth management plan. Martin County, Stuart, Florida.

Palm Beach County. 1989. Comprehensive plan. Palm Beach County, West Palm Beach, Florida.

St. Lucie County. 2002. St. Lucie County comprehensive plan. St. Lucie County, Fort Pierce, Florida.

Titus, J.G. and V.K. Narayanan. 1995. The probability of sea level rise. U.S. Environmental Protection Agency. Office of Policy, Planning, and Evaluation. EPA-230-R-95-008.

Titus, J.G. 1998. Rising seas, coastal erosion and the takings clause: How to save wetlands and beaches without hurting property owners. Maryland Law Review 57: 1279-1399.

Titus, J.G., R.A. Park, S.P. Leatherman, J.R. Weggel, M.S. Greene, P.W. Mausel, S. Brown, C. Gaunt, M. Trehan, and G. Yohe. 1991. Greenhouse effect and sea level rise: The cost of holding back the sea. Coastal Management 19:171-204.

Treasure Coast Regional Planning Council. 1995. Strategic Regional Policy Plan. Treasure Coast Regional Planning Council, Stuart, Florida.

Treasure Coast Regional Planning Council. 1999. Loxahatchee River basin wetland planning project for Palm Beach County. Technical Summary Document, U.S. EPA Cooperative Agreement X994652-94-7, Treasure Coast Regional Planning Council, Stuart, Florida.

Twilley, R.R., E.J. Barron, H.L. Gholz, M.A. Harwell, R.L. Miller, D.J. Reed, J.B. Rose, E.H. Siemann, R.G. Wetzel, and R.J. Zimmerman. 2001. Confronting Climate Change in the Gulf Coast Region: Prospects for sustaining our ecological heritage. Union of Concerned Scientists, Cambridge, Massachusetts, and Ecological Society of America, Washington, D.C.

Warrick, R.A., C.L. Provost, M.F. Meier, J. Oerlemans, and P.L. Woodworth. 1996. Changes in sea level. Pp. 359-405 *In* Climate change 1995: The science of climate change. (J.T. Houghton, L.G. Meira Filho, B.A. Callender, N. Harris, A. Kattenberg and K. Maskell, Eds.). Cambridge University Press, London.

Yohe, G. 1990. The cost of not holding back the sea. Toward a national sample of economic vulnerability. Coastal Management 18:403-431.