Appendix C

BACKGROUND INFORMATION ON THE CASCO BAY/SACO BAY REGION

The Casco Bay/Saco Bay study region includes the portion of Maine's coastline extending from the City of Saco to the Town of Brunswick, including Old Orchard Beach and Saco in York County, and Scarborough, Cape Elizabeth, South Portland, Portland, Falmouth, Cumberland, Yarmouth, Freeport and Brunswick in Cumberland County. (*See Figure C.1*)

A. GEOLOGIC SETTING OF STUDY

Casco and Saco Bays, Maine are adjoining estuaries along the western margin of the Gulf of Maine. Each embayment is framed by a bedrock skeleton which is partially covered by unconsolidated glacigenic deposits of Pleistocene-Holocene age. Along the shoreline these deposits have been reworked by modern processes into intertidal environments such as mud flats and sand beaches.

Casco Bay is characterized by linear chains of islands, shoals and peninsulas controlled by the orientation of bedrock (Kelley, 1987). The rocks are often directly overlain by till, a mixture of gravel, sand and mud deposited by glacial ice. This material is highly variable in thickness and often occurs in the form of elongate ridges called moraines (Thompson and Borns, 1985). Till is often overlain by glacial-marine sediment, locally called the Presumpscot Formation (Thompson and Borns, 1985). The Presumpscot Formation was deposited in early postglacial times, and is a generally muddy, and often thick deposit. It crops out widely along the Casco Bay shoreline and covers much of the seafloor of the bay as well (Kelley, et al., 1989b).

Following deposition of the Presumpscot Formation, the land in Maine was uplifted as a result of the removal of the load of glacial ice. The surface of the Presumpscot Formation, the former seafloor, became deeply gullied in places and experienced landslides as it became emergent. The large rivers which carved Casco Bay, the Kennebec and Androscoggin, were blocked by glacial deposits from entering Casco Bay as sea level fell, and when the sea reached its lowstand at -60 m, around 10,500 years ago (Kelley et al., 1992) (*Figure C.2*), only small streams like the Presumpscot and Royal Rivers entered Casco Bay.

As sea level rose during the Holocene, the glacial deposits of the bay were reworked by waves and currents. As a result, most of the seafloor of the outer bay is bare rock or gravel, and significant accumulations of modern sediment exist only in areas in the lee of islands and peninsulas (Kelley et al., 1987a). As the rate of sea-level rise slowed during the past few thousand years (*Figure C.2*), the outer, ocean-facing islands were swept clean of most glacial deposits by storms, and gravel beaches and bedrock form most intertidal environments (Kelley, 1987). In the inner bay, protected from direct wave attack by islands, substantial bluffs of glacigenic deposits continue to erode. It is the erosion of this material

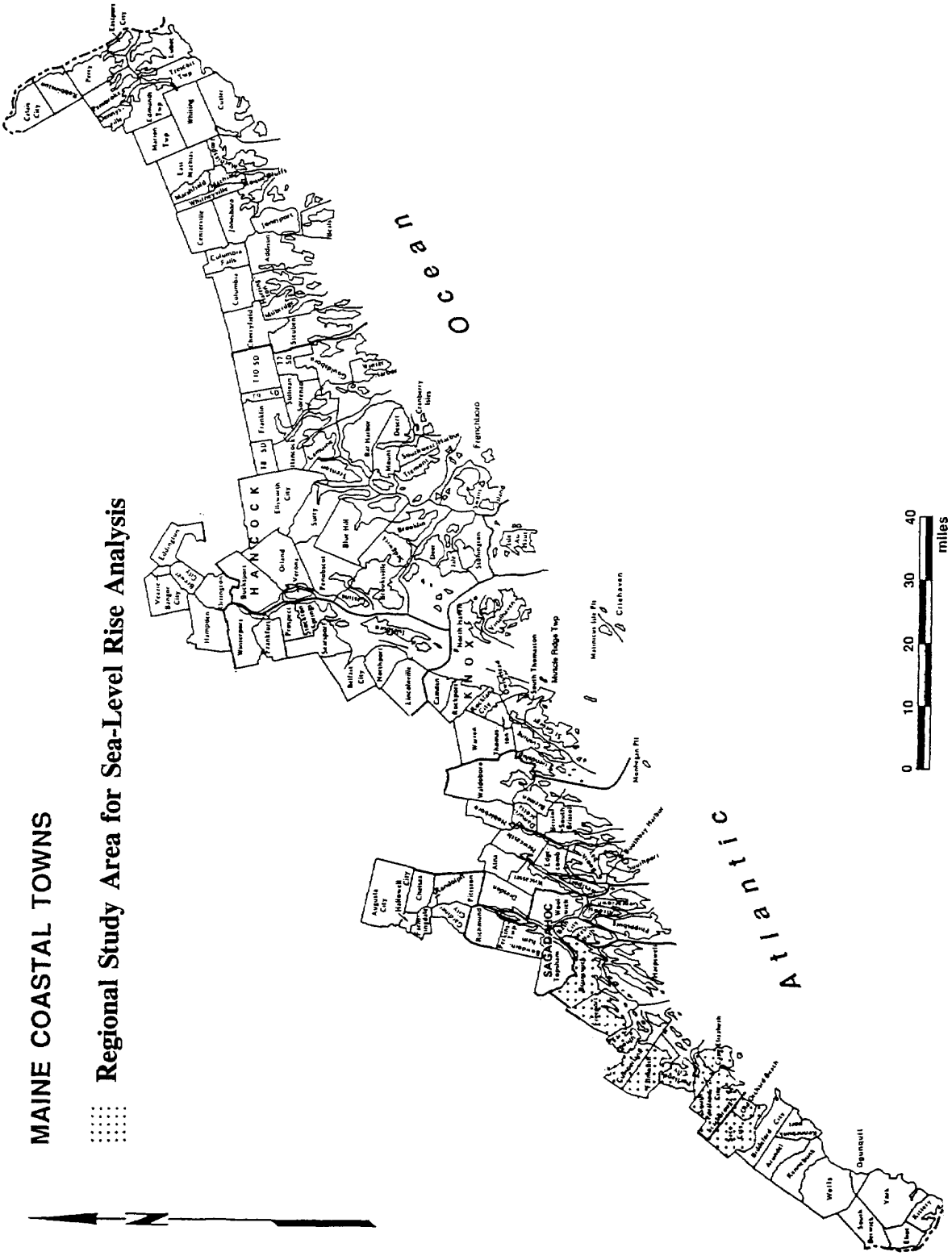
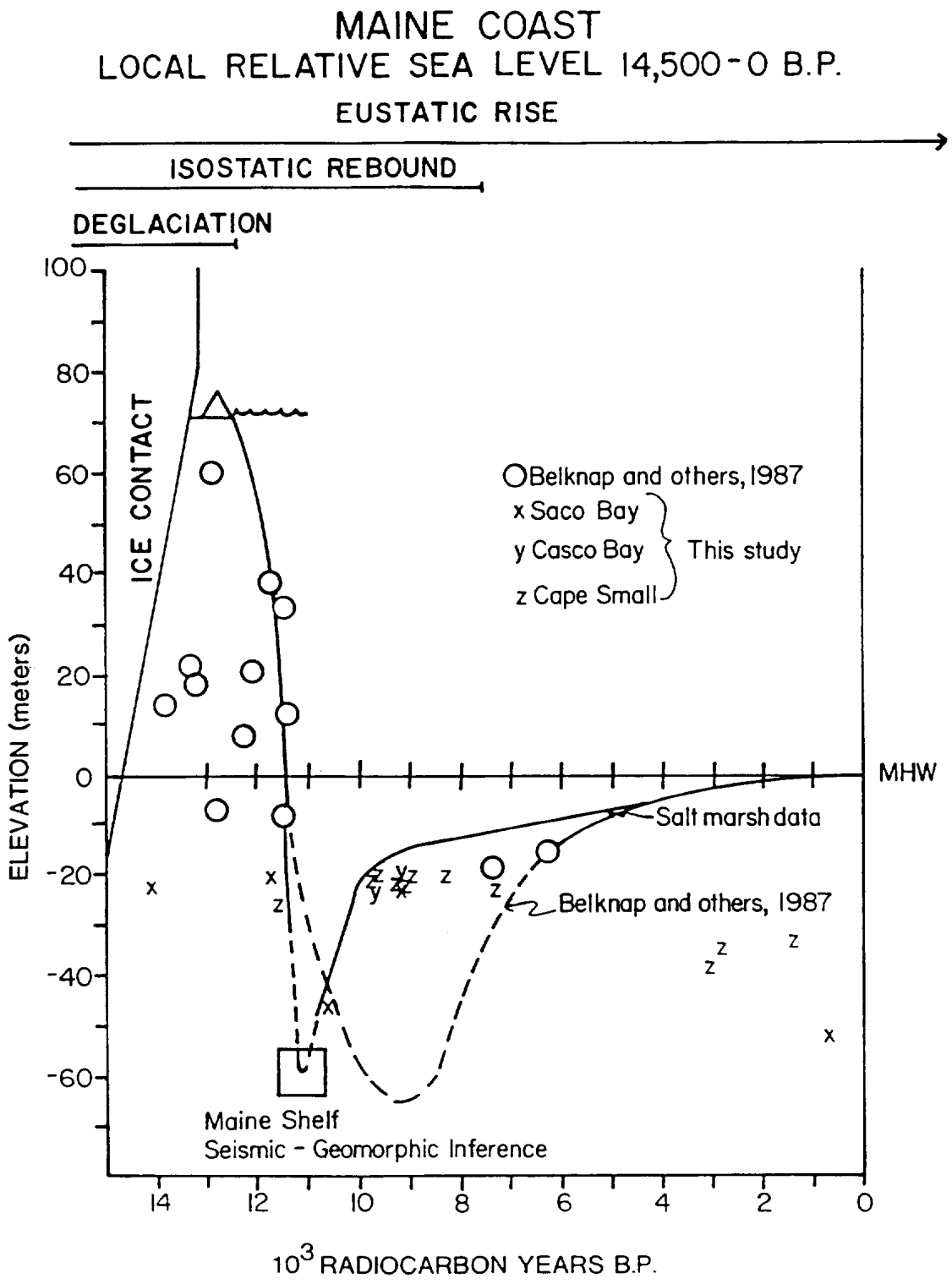


Figure C.1. Regional Study Area for Sea-Level Rise Analysis.



ion

Figure C.2. Sea-level change curve for coastal Maine (from Kelley et al., 1992).

which provides sand and mud to create contemporary tidal flats and salt marshes. Owing to the abundant occurrences of the muddy Presumpscot Formation in Casco Bay, there are few natural beaches in the embayment. Those beaches that do exist are "pocket beaches" protected by rock outcrops at either end (Kelley et al., 1986; Kelley, 1987).

Saco Bay is arcuate in shape and located directly south of Casco Bay. Despite its proximity, its geological history is different from Casco Bay and this difference is manifest in most aspects of the bay's appearance (Kelley et al., 1986). Although there are till deposits on the seafloor of Saco Bay (Kelley et al., 1987b), none crop out on land. Similarly, the Presumpscot Formation is a common deposit on the bay bottom, but few exposures may be seen on land (Kelley et al., 1989c). Saco Bay experienced a similar history to Casco Bay until the time of lowering of the sea, around 10,500 years ago (Kelley et al., 1986). At that time the Saco River contributed great quantities of sand from as far away as the White Mountains of New Hampshire to the bay (Kelley et al., 1992). Sand covered the muddy Presumpscot Formation and beaches became common environments. As sea level rose during the Holocene, sand from the river maintained beaches in the bay up to the present time, although it is unclear whether sand continues to be brought down the river. Where beaches front embayments, extensive salt marshes have colonized most of the intertidal, back- barrier environments (Kelley et al., 1986, 1989c).

The effects of coastal erosion on developed and undeveloped property are not as conspicuous in Maine as they are south of New England. This may be because the rate of sea-level rise in the region is only 2.3 mm/yr, slightly more than half the rate for some mid-Atlantic states. A recent study suggests that sea level may have reached near its present elevation in Maine around 1000 years ago, however, and that many of the beaches and marshes developed during that pause of the sea (Kelley et al., in press). The current rate of sea-level rise is much greater than has occurred in several thousand years, and some contemporary erosion and land loss has been attributed to the recent increase in sea level (Wood et al., 1989; Jacobson, 1988).

B. Socio-Economic Characteristics

1. Population

While the exact number of residents that stand to be affected by accelerated sea-level rise along the Casco and Saco Bay shorelines was not calculated, based on knowledge of existing shoreline development patterns, it is reasonable to estimate that of the total 1990 regional population of 180,172, roughly 3,600 to 9,000 people currently live in the immediate vicinity of the shore (2-5% of the total population). Assuming the same proportion of waterfront dwellers as compared to the total population for the region, and using population projections for the Year 2015 (the latest year for which county population projections are available) between 4,300 and 10,800 people may live in the immediate vicinity of the region's waterfront in the Year 2015.

2. Land Use and Property Values

Land use is varied along the region's shoreline. Old Orchard Beach contains Maine's only area of beachfront high-rise condominiums. The shoreline of Saco, Scarborough and Freeport includes a mix of cottage development and more substantial homes on larger lots. The wealthier suburbs of Falmouth, Yarmouth, Cumberland, are characterized by estate development along the shoreline, with small enclaves of cottage development. Industrial, commercial and institutional development predominates along the waterfronts of Portland and South Portland.

No figures were compiled for total value of properties in the region that may potentially be influenced by rising sea level. However examples of ranges of coastal property values are given for specific mapped study area sites in Chapter Three.

3. Anticipated Land Use Change

Discussions with town officials and analysis

of current development patterns throughout the region indicate that shoreline areas within 100 meters of current mean high water are already (for the most part), built out, with little usable, vacant, appropriately zoned land available for new development. During the last five years, building permits in the shoreland areas have consisted mostly of seasonal conversions, infill development in grandfathered subdivisions or on grandfathered lots, renovation or improvement of single family residences, and only very limited new single family development. However, the depressed real estate market during the last five years probably understates the potential for future demand. If development pressures reach 1980s levels, the most likely opportunities for growth in the shoreland area will be the subdivision/redevelopment of larger estates, consolidation/ redevelopment of marginal seasonal homes and marginal commercial structures, and redevelopment of seasonal cottages to multi-unit residential structures.

4. Infrastructure

Each of the municipalities in the region is served, to varying extent, by public water and sewer, and by an improved road network. There are numerous sewage treatment and stormwater outfalls along the region's shoreline.

Information provided by Maine's Department of Environmental Protection did not indicate the presence of any landfills within 100 meters of the shoreline. However, past practice in many communities was to use estuarine shorelines as dump sites. Interviews with local officials may reveal that there are, in fact, historic dumps located within this area of concern.

The only large utility of concern within the study area is Central Maine Power's Wyman power-generating facility on Cousin's Island in Yarmouth. According to plant manager David Potter, the distance from high tide to upland is about 4 ft., but during abnormal high tides, the plant has experienced some flooding. No floodproofing of the facility has taken place.

Also of concern due to the possible types of materials stored there, are sites scattered through out the study region (most on Casco Bay's islands) that were formerly used by the U.S. Defense Department. Further research would be needed to assess individual site vulnerability, and the presence of hazardous materials.

5. Cultural and Recreational Features

The shoreline parks and natural areas in the study region attract thousands of visitors each year. They include wide sandy beaches such at those at Ferry Beach State Park, Old Orchard, and Pine Point, nature trails around salt marshes such as Scarborough Marsh and Gilsland Farm, rocky promenades such as Two Lights State Park in Cape Elizabeth, forested paths like those at Wolf Neck Woods State Park in Freeport, and urban amenities such as the fitness trail around Back Cove in Portland.

The shoreline of Casco and Saco Bays is rich in history. There are more than 60 sites of known or suspected archeological resources along the shores, many of which are located on Casco Bay's islands. There are seven historic sites and two historic districts within 100 meters of the sea that may be potentially affected by rising sea level.

6. Habitat/Critical Areas

Maine's coastal waters support an extremely diverse array of marine life. High value wetlands, and marine habitats of national significance are scattered throughout the region. According to the U.S. Fish and Wildlife Service (Maine State Planning Office, 1992), some locations contain the highest diversity of marine life in all the coastal waters of the United States.

There are at least 20 registered, state critical areas within 100 meters of the shoreline. "Critical areas" are sites containing habitat for rare plants and animals, unusual geologic formations, or other important natural features.

7. Fisheries

A significant commercial fishery, both finfish and shellfish (landed value of $154 million in

1991) exists in the Gulf of Maine (MSPO, 1992). Softshell clams continue to be a valuable component of Maine's annual fish landings, and within the study area, Brunswick, Freeport, and Scarborough support sizable shellfish populations. Clusters of shellfish aquaculture leases are located in Freeport and further south in the study area.

No analysis has yet been completed which focuses on projected changes in estuarine conditions in the Gulf of Maine due to climate change. However, an analysis of the Gulf of Mexico found that those Gulf coast fisheries could be negatively affected by the loss of critical wetland habitat associated with sea-level rise. That study concluded that warmer water temperatures will be at or above tolerances for many important commercial species of finfish and shellfish and other fish could be threatened by increased salinity. The Gulf of Mexico study predicted that sea-level rise between 50 and 200 cm would reduce available food supply for marine species by 42-78%, resulting in a disproportionate loss in seafood population. A sea-level rise of 1 meter was associated with a major loss of fisheries. (Livingston, as reported in Smith & Tirpak, 1989)

It is beyond the scope of this study to attempt to quantify potential impacts to Gulf of Maine fisheries associated with global climate change. However, it is important to note that some experts project that an already threatened, multi-million dollar industry may be further affected by changes in fisheries habitat caused by sea-level rise and global warming.

C. REFERENCES APPENDIX C

Cohen, J. Freeport Town Planner. Personal communication.

Fossum, D. Assistant Town Planner, Old Orchard Beach. Personal communication.

Greater Portland Council of Governments. 1994. "Population Projections for Cumberland County."

Jacobson, H.A. 1988. "Historical development of the salt marsh at Wells, Maine." *Earth Surface Process and Landforms* 13:475-486.

Kelley, J.T., A.R. Kelley, D.F. Belknap, and R.C. Shipp. 1986. "Variability in the evolution of two adjacent bedrock-framed estuaries in Maine." In Wolfe, D., *Estuarine Variability* 21-42. Orlando, FL: Academic Press.

Kelley. 1987. "An inventory of coastal environments and classification of Maine's glaciated coastline." In Ed. FitzGerald, D.M., and P.S. Rosen. *Glaciated Coasts* 151-176. Orlando, FL: Academic Press.

Kelley, J.T., D.F. Belknap, and R.C. Shipp. 1987a. "Geomorphology and sedimentary framework of the inner continental shelf of southcentral Maine." Technical Report to the Minerals Management Service, Maine Geological Survey Open File Report 87-19; 75 pp.

Kelley, J.T., R.C. Shipp, and D.B. Belknap. 1987b. "Geomorphology and sedimentary framework of the inner continental shelf of southwestern Maine." Technical Report to the Minerals Management Service, Maine Geological Survey Open File Report 87-5; 86 pp.

Kelley, J.T., D.F. Belknap, and R.C. Shipp. 1989a. "Sedimentary framework of the southern Maine inner continental shelf: influence of glaciation and sea-level change." *Marine Geology* 90:139-147.

Kelley, J.T., R.C. Shipp, and D.B. Belknap. 1989b. "Geomorphology and late quaternary evolution of the Saco Bay region, Maine coast." In *Studies in Maine Geology*, Vol. 5, 47-66, R.D. Tucker and R.G. Marvinney, (eds.). Augusta, ME: Maine Geological Survey.

Kelley, J.T., S.M. Dickson, D.F. Belknap, and R. Stuckenrath. 1992. "Sea-level change and the introduction of late Quaternary sediment to the southern Maine inner continental shelf." Wehmiller, J. and C. Fletcher C., (eds.). Quaternary Coasts of the United States, Soc. Econ. Paleo. and Mineralogists, Spec. Pap. 48, pp. 23-34.

Kelley, J.T., R.W. Gehrels, and D.F. Belknap. 1994, "Late Holocene relative sea-level rise and the geological development of tidal marshes at Wells, ME, U.S.A." *Journal of Coastal Research* (in press).

Maine Department of Human Services, Office of Data, Research and Vital Statistics. 1994. "POPULATION

PROJECTIONS OF MAINE COUNTIES AND MINOR CIVIL DIVISIONS."

Maine Department of Inland Fisheries and Wildlife. 1988. "The identification and management of significant fish and wildlife resources in southern coastal Maine." Augusta, ME.

Maine State Planning Office, Economics Division. 1994. "Population statistics for minor civil divisions and counties."

Maine State Planning Office, Maine Coastal Program. 1992. "Policy options for Maine's marine waters." A Report of the Marine Policy Committee of the Land and Water Resources Council, Augusta, ME.

Morelli, P. and R. Roedner, Saco Town Planners. Personal communication.

Naylor, A., former Brunswick Town Planner. Personal communication.

Nugent, M., Codes Officer, Old Orchard Beach. Personal communication.

Potter, D., Plant Manager, Central Maine Power, Wyman facility. Personal communication.

Smith, J.B. and D.A. Tirpak, eds. 1990. "Potential effects of global climate change on the United States." Vol. 1, pp. 6-3, 6-7. NY: Hemisphere Publishing Corporation.

Southern Maine Regional Planning Commission. 1993. "Population and growth statistics for York County."

Thompson, W., and H. Borns,. 1985. "Surficial geologic map of Maine." Augusta, ME: Maine Geological Survey, 1:500,000.

Wood, M., J.T. Kelley and D.F. Belknap. 1989. "Patterns of sediment accumulation in the tidal marshes of Maine." *Estuaries* 12:237-246.