

was raised in elevation. The seawall has been subjected to seven major storms since 1915, during which overtopping and toe scour have required additional fill and rubble toe protection. Subsidence of the wall has also been a problem, especially in places where it is located over a soft clay stratum. Relative sea level at Galveston has risen approximately 24 cm since 1904 (Leatherman, 1984), and during that time most of the original beach fronting the wall (up to 90 m wide) has been lost. Leatherman also indicates that diking will be necessary in the future to preserve the city.

Breakwaters - are free-standing structures, usually of rubble mound construction, attached to the shoreline or seaward (detached) of the shoreline. Breakwaters cannot prevent inundation by sea level rise, but can modify shoreline response by blocking some of the incident wave energy. The resulting shoreline (for detached breakwaters) has a bulge associated with each structure, and holds the mean shoreline at a more seaward position. Effective in preventing beach erosion due to both longshore and on/offshore transport, offshore breakwaters have been used for shore protection in the U.S., Canada, Europe, and quite extensively (over 2,500) in Japan. Although initial construction costs can be high, proper design usually ensures low maintenance. The shoreline response and functional design of offshore breakwaters is extensively discussed in Dally and Pope (1986).

As sea level rises, an existing breakwater project will lose sediment from its salient(s) as its relative position moves offshore and overtopping becomes more frequent. In order to maintain shoreline position and a prescribed level of protection, the structure will need to be lengthened and its crest elevated. Otherwise, projected sea level must be used in both structural and functional design, with the margin of safety diminishing as sea level rises during the life of the project.

An example of a segmented breakwater project installed to provide shoreline protection and a recreational beach is found at Presque Isle, Pennsylvania. The project, shown in planform in Fig. 6.9, consists of three segments, each 38 m long and placed 46 m offshore of a beach fill. There is a substantial longshore drift (from left to right) from which the structures have entrapped additional sand to form a series of salients which progressively diminish in size in the drift direction. These salients erode during storms and accrete in calm weather, but the placed fill has remained relatively unscathed.