Effects of Erosion Control Structures on Shoreline Evolution of the Tainan Gold Coast, Taiwan

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ABSTRACT

In-site bathymetric measurements are too expensive to be sufficiently available for the investigation on beach changes. We proposed a series of image processing to detect waterlines from 31 satellite images over 12 years. A correction method is used to determine the corresponding shorelines considering tidal variations. Annual and seasonal shoreline changes at the Tainan Gold Coast (TGC), Taiwan, were evaluated. Effect of groins at the southern TGC on beach evolution was also studied. The method is proven to be applicable for shoreline change.

KEY WORDS: Erosion control structures; shoreline evolution; image processing; satellite image.

INTRODUCTION

The beach of TGC provides visitors with various luxury activities. Three decades ago, TGC is one of top sightseeing attractions at Tainan. However, TGC has been suffering from beach erosion over the past two decades. Sixth River Management Office of Water Resources Agency engaged engineers to propose some countermeasures for the beach erosion in different periods.

Accurate estimation of the bathymetric changes and nearshore sediment transports using previous bathymetric measurements over a long period of time is a common way to investigate beach erosion. Based on analysis on the beach bathymetry some suitable treatments of shore protection are suggested by coastal engineers and then decided to a finalized project using multi-function assessment. Therefore, bathymetric data are the key to solve the problem of beach erosion.

The morphological changes resulted from tides, ocean waves or nearshore currents in a coast can be analyzed by some approaches. Shoreline change is an easier approach to visually represent beach evolution than two-dimensional bathymetric variation over a region or one-dimensional variation along a beach profile. Location of the shoreline and its changing rate can provide valuable information for the coastal protection works and for the numerical model calibration and verification.

Shorelines obtained from field measurements at different times which need sufficient funds are not easily available in most cases. A different way is waterline extraction from a satellite image which is more affordable and available than field measurements. The waterline is one type of shoreline indicator, defined as a wet/dry line on the beach, which is used to describe the land/water boundary at the instant of image processing (Foody et al., 2005; Niedermeier et al., 2005; Yamano, et al. 2006; Zhao et al., 2008; Liou et al., 2009). Ryu et al. (2002) noted that the waterline is also an important factor to be considered on the middle tidal flat. Pardo-Pascual et al. (2012) indicated that the applicability of waterline extraction in areas with high tidal ranges is an important issue in tidal flats.

For a calm sea, ocean tides represent the rhythmic rise and fall of the sea level with time. These tides are manifested on a coastline by the periodic advancing and receding of the waters over the shore. Thus, the extracted waterlines from different satellite images at the same place over a short period can be in various positions depending on the different tidal elevations at the shooting time of each satellite image. Boak and Turner (2005) proposed that the use of the instantaneous waterline seems misguided because it represents the position of the land/water interface at one instant in time rather than “normal” or “average” conditions. The waterline at mean sea level (MSL) is commonly defined as the shoreline in the coastal engineering. Considering the tidal variations for different satellite images, Chen and Chang (2009) proposed the one-line shift method, which shifts the extracted waterlines on three sequential satellite images to the corresponding shorelines even when the foreshore beach slope is unknown. Another minor correction on the shoreline position from a waterline is the effect of wave’s runup. Chang et al. (2015) proposed applicable methods to shift the waterline on each satellite image for the beachface slope of each section available or unavailable.

Chang et al. (2018) used the NDWI-based image from satellite images and the shifting correction to obtain shorelines from 2004 to 2011 and to estimate annual and seasonal rates of shoreline changes of TGC. Sixth River Management Office is in charge of coastal affairs. Sixth River Management Office constructed some groins to control the beach erosion for 2010 and 2013. Collecting some later images from 2011 to 2014 we study the effect of erosion control structures on the beach evolution in this paper.