Ocean & Coastal Management 151 (2018) 127–133

Contents lists available at ScienceDirect

Ocean & Coastal Management

journal homepage: www.elsevier.com/locate/ocecoaman

Beach replenishment and surf-zone injuries along the coast of Delmarva, USA

Mark W. Muller

Salisbury University, United States

ARTICLE INFO

Article history:
Received 20 June 2017
Received in revised form
14 September 2017
Accepted 7 October 2017
Available online 23 October 2017

Keywords:
Beach replenishment
Spinal injuries
Shoreline morphology

ABSTRACT

Beach replenishment is a common practice to repair eroded beaches along the beach communities of Delmarva. A consequence of beach replenishment is a significant increase in the slope of the beach within the surf-zone. Steepening of the beach slope can create conditions conducive to shorebreak. Shorebreak occurs when a wave approaches a beach unabated and breaks in shallow water near the shoreline. Accident reports are investigated to determine the statistics of shorebreak related injuries. From 2006 to 2015 shorebreak was a contributing factor in over 82% of reported surf-zone injuries in Ocean City, Maryland. Furthermore, this paper examines a beach slope before and after a beach replenishment project. The beach slopes are then utilized in a computational fluid dynamics model and solitary wave run-ups are simulated. It is determined that the beach replenishment project increased the beach slope enough to create shorebreak conditions as simulated in the computational model. Beach replenishment is linked to surf-zone injuries and alternative beach replenishment methods are proposed to reduce or eliminate shorebreak and shorebreak related injuries.

1. Introduction

Beach replenishment consists of dredging sand offshore and pumping the sand onto an eroded beach. It has become a common practice along the Atlantic and Gulf of Mexico beaches to repair, widen, and steepen beaches. Between 1950 and 2006, the U.S. Army Corps of Engineers conducted 87 major shoreline protection projects including beach replenishment projects over approximately 350 miles of Atlantic and Gulf of Mexico beaches. Although beach replenishment is vital for protecting our shorelines, it may create unsafe conditions for beach goers. In 2005, following a beach replenishment project, a significant increase in spinal injuries was reported along the Delaware beaches (Cresson, 2005). Some have speculated that beach replenishment causes spinal injuries due to the replenishment's effect on beach slope and wave interaction (Degener, 2015; Fichter, 2009; Murray and Rini, 2015). It is difficult to establish a link between beach replenishment and spinal injuries due to so many variables and factors. Such factors include surf conditions, tides, currents, coastal morphodynamics, storm activity, spatiotemporal correlation of beach replenishment sites, and frequency of occurrence of injuries. But upon investigation of injury statistics of beaches that have undergone replenishment projects, there is often a spike in injuries requiring emergency medical services—that same year or the following year, according to data reported to the United States Lifesaving Association.

Most of the Atlantic and Gulf of Mexico seaboards are protected by barrier islands. These barrier islands have become home to numerous beach towns and resorts. Americans have built 19 million homes in these coastal areas over the last 30 years, and development continues at the rate of 1500 homes a day (Bourne, 2006; U.S. Commission on Ocean Policy, 2004). These coastal towns are popular vacation destinations for tourists and play a vital role in the local economy. Each year, our coasts are the preferred vacation destination for an estimated 180 million people, who spend billions of dollars and support more than 2 million jobs (U.S. Commission on Ocean Policy, 2004). Vacationers from diverse economic, ethnic, and racial populations choose beach towns over any other American tourist destination (U.S. Department of Commerce, 2002). To maintain the vibrant economy and tourism industry of these coastal towns, it is imperative to maintain wide beaches to attract tourists each year and to protect property from storms and flooding. Beach replenishment has become the preferred method for shore protection and to maintain wide beaches.

Barrier islands are dynamic in nature and tend to migrate.

E-mail address: mwmuller@salisbury.edu.

https://doi.org/10.1016/j.ocecoaman.2017.10.013
0964-5691/

Evidence of this can be observed in Everts et al. (1983) which shows the migration of the Cape Hatteras shoreline between 1852 and 1980. In order to migrate, the ocean side of the barrier island moves by erosion and the sound or bay side of the barrier island moves by growth. Barrier islands maintain their elevation and natural beach profiles by dune formation and overwash fan deposition. Erosion is a natural process caused by rising sea levels, predominate winds, tides, currents, waves, and storms. It has even been argued that coastal development such as buildings and parking lots as well as beach replenishment itself are major contributors to coastal erosion (Kaufman and Pilkey, 1979). Erosion is only a problem on developed barrier islands where the shoreline is engineered and the migration process is combated in order to protect property and preserve wide beaches. A hurricane in 1933 split the barrier island of Ocean City, MD and Assateague Island, forming an inlet. Assateague remained an undeveloped barrier island and Ocean City continued to be built up. Aerial photographs of the inlet area between 1933 and 1960 are available elsewhere (Architectual.Gravitas, n.d.) The migration of the undeveloped Assateague Island relative to Ocean City can clearly be observed. Erosion, while not an issue on Assateague, became a growing problem for Ocean City and in 1988, Ocean City began replenishing its beaches.

Beach replenishment is necessary and may be the best approach to repairing eroded beaches. However the current practiced beach replenishment method creates a hazard because it is only focused on building up dunes and the upper portion of the beach down to the shoreline. Beach replenishment should also include the lower (underwater) portion of the beach out to a depth of 40 feet (Pilkey et al., 1980). However due to the high costs of beach replenishment, Trembanis et al. (1999) reports an average of $5.5 million per mile of beach, it may not be economically viable to replenish the entire beach profile; only the part seen above sea level. When only the dunes and upper portion of the beach are replenished, it creates a steep beach profile, as shown in Pilkey et al. (1980). A steep beach profile often increases the rate of erosion and subsequent replenishment projects must be performed in order for the original replenishment to remain effective (Pilkey et al., 1980). Another significant issue with a steep beach profile is the apparent correlation with injuries suffered by beach goers. According to McKenna (2007) surf related injuries occurred more frequently along beaches with steep profiles than with beaches with mildly sloped profiles. A condition known as shorebreak may have been a contributing factor to the injuries that occurred on the steeper beaches.

Shorebreak occurs when an ocean wave propagates unabated towards a beach and experiences an abrupt change in bottom depth. The abrupt change in bottom depth causes the wave to plunge over, thus unleashing most of its energy over a short distance in extremely shallow water. A shorebreak wave essentially slams onto the beach and can easily slam a beach goer onto the beach with so much force that even a 1 foot wave can cause a serious injury. Pictures of a breaking shorebreak wave can be seen elsewhere (Dreamstime, 2017). If a beach profile is steep enough, the elevation change of the bottom depth may be abrupt enough to create shorebreak. Naturally eroded beaches generally have mildly sloped or dissipative (Wright and Short, 1984) profiles which are conducive to spilling waves. As a spilling wave approaches shore, turbulent whitewater forms at the crest of the wave and spills down the face of the wave. The spilling wave's energy is slowly dissipated in the whitewater over a longer period resulting in a gentler wave. Naturally eroded beaches usually have offshore sandbars that help attenuate an ocean wave's energy. These sandbars are often dredged out and pumped onto the upper beach during replenishment. Shorebreak conditions may become more prevalent when a sandbar's effect on wave energy is eliminated from dredging. In addition, beach replenishment may increase the steepness of a beach profile thus creating a reflective profile (Wright and Short, 1984) which is conducive to shorebreak.

Ocean City, Maryland is a resort beach town in the Mid-Atlantic region of the United States. During the summer months, the population of the town can grow to as many as 345,000 (Town of Ocean City, MD 2011). The 10 miles of beach in Ocean City is guarded from May to September each year by the Ocean City Beach Patrol (OCBP). The OCBP is responsible for performing surf rescues, responding to medical emergencies, and enforcement of beach ordinances. Whenever a medical emergency incident occurs on the beach, an OCBP supervisor responds to the scene to provide patient care and to assist paramedics. The OCBP supervisor is responsible for ascertaining information about the incident including patient information and surf conditions at the time of the incident. A supervisor files a report for every incident that occurs on the beach during the season and all the incident reports are stored at the OCBP headquarters. The OCBP headquarters have all the incident reports archived for every season since the inception of written documentation of beach incidents. A copy of an OCBP accident/injury incident report form is shown in Fig. 1.

This paper investigates the relationship between beach replenishment, shorebreak, and surf zone related injuries. First, incident reports from the Ocean City, MD Beach Patrol archives are investigated over ten seasons spanning from 2006 to 2015. All water related injuries are recorded and if shorebreak was a contributing factor to any of those injuries it is also noted. This archival investigation is conducted to determine if any correlation exists between shorebreak conditions and water related injuries in the surf zone. Next, a computational fluid dynamics model is developed which consists of ocean waves approaching a beach. Broadkill Beach, Delaware, which recently underwent beach replenishment, is used as a case study. Beach profiles for Broadkill Beach are measured before and after replenishment occurred. These beach profiles are imported into the computational model and are exposed to simulated ocean waves. The propagation and location of breaking waves along the profiles are noted. This model is developed to determine if beach replenishment creates a profile conducive to shorebreak conditions. It is hypothesized from personal observations serving as an ocean lifeguard for 19 years that beach replenishment induces shorebreak thus creating a dangerous environment that can cause serious injuries for unaware beach patrons.

2. Methods

2.1. Shorebreak injury data

OCBP accident/injury reports are studied for 10 seasons spanning from 2006 to 2015. During the first iteration of categorizing the reports, all reports that consisted of neck/back (spinal injury) and bone/joint injury, which are indicated by the check boxes in the "Nature of Incident" section, are separated from all other incident reports. The next iteration consisted of examining whether the neck/back and bone/joint injury reports are water related, which is indicated by the "Was the accident water related?" section. If the incident is not water related, then it is not included in the data. All the water related incidents are then sorted into three categories; neck/back (spinal injury), shoulder (dislocations and broken collar bones), and leg injuries (including hip, knee, and ankle). The specific nature of each water related injury is reported in the "Additional Description of Incident" section. The total number of water related injuries for each of the three categories is recorded for each year between 2006 and 2015. The final iteration consists of