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Anthropogenic transport of macrofauna through a sand transfer plant

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ABSTRACT

The South Lake Worth Inlet Sand Transfer Plant in Palm Beach County, Florida pumps subtidal sediment from the upcurrent to the downcurrent side of the jetty to correct jetty-induced sediment transport disruption. This pumping accounts for 35% of the overall net longshore transport. We investigated if living macrofauna could survive the sediment pumping process. We also examined the effects this activity had on the subtidal macrofaunal invertebrate communities. Subtidal sediment cores were taken near the intake pipe, at the outflow pipe, and just outside the direct effects of the sand transfer plant. Benthic macrofauna and sand grain size were examined and compared. Macrofauna, live and preserved, were confirmed exiting the outflow pipe. Low diversity, low abundance macrofaunal communities were found at all sample sites. Macrofaunal abundance was primarily isopods (79%) and polychaetes (14%). Three isopod and one polychaete species constituted 89% of the community diversity. Both inflow borrow pit and outflow deposition sampling sites exhibited different community structure compared to adjacent control sites. The inflow borrow pit presented a high population of the isopod *Eurydice personata*. The outflow deposition site had the highest species diversity. The outflow deposition site also showed much coarser mean sediment grain size compared to other sites. The differences found at the sites direct associated with the sand transfer plant demonstrated localized disturbance. We concluded that although the plant disturbs the adjacent community it also helps maintain the macrofaunal community structure and sand grain size on the downdrift side of the South Lake Worth Inlet. Further studies integrating abiotic and biotic components will assist in management practices and our understanding of nearshore systems.

1. Introduction

Movement of sediments in nearshore marine systems is conducted by wave action and currents. Both littoral and longshore currents disperse local sediment throughout beaches and shorelines (Komar, 1977; Komar and Inman, 1970; Watanabe, 1993). Longshore current can be naturally disrupted by headlands and shorelines trapping sediment on one side of the process (accretion) and causing reduction of sediment on the other side (erosion) (Bruun, 1995). Man-made structures along shorelines (e.g. jetties, groins) disrupt sediment transport in a similar manner (Kraus and Galgano, 2001; Pilkey and Wright, 1988).

Jetties and groins trap sediments on the updrift side while starving beaches of sediment on the downdrift side (Bruun, 1995; Kraus and Galgano, 2001; Stutz and Pilkey, 2005). Jetty structures are built to improve the longevity of inlets and improve access from intercoastal waters and bays to open oceans. In Palm Beach County Florida, South Lake Worth Inlet (Boynton Beach Inlet) is a man-made inlet cut in 1927 (Bruun, 1995; Caldwell, 1950; Zurmuhlen, 1957). This inlet caused accretion on the updrift (northern) side of the jetty and erosion on the downdrift (southern) side, altering the shoreline in the local area (Finkl et al., 1988; Kraus and Galgano, 2001). A sand transfer plant was installed in 1937 to solve the problematic accretion and erosion (Bruun, 1995; Caldwell, 1950; Zurmuhlen, 1957). The plant removes subtidal sediments from the updrift side and deposits it into the intertidal waters on the downdrift side at a discharge rate of 172 m^3/hr (188 yd^3/hour) (Finkl et al., 1988; Pierro, 2016; Zurmuhlen, 1957). Grates at the mouth of the intake pipe keep out large materials from passing through the plant, while allowing smaller rocks, shells and sand to pass through easily. The South Lake Worth Inlet sand transfer plant moves sediment with an annual transport of 53,000 m^3/yr (in 1990) (Dombrowski and Mehta, 1993; Pierro, 2016). Sediment pumping occurs as sedimentation rates allow ranging from a few hours a week to up to 32 h over 4 days (Palm Beach County pers.comm.2016). This contributes about 35% of the area's downdrift littoral sediment transport (Boswood and Murray, 2001; Dombrowski and Mehta, 1993). Combined with natural littoral sediment bypass around the jetty system, the net sediment transport south of the jetty was calculated at 80% of the natural transport, if littoral transport was unimpeded (no jetty present). This creates a sand

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shortage of approximately 20% along the downdrift side of the jetty and the continuing barrier island (Finkl et al., 1988; Yeend and Hatheway, 1989; Zurmuhlen, 1957). Examining other sand transfer/bypass systems found rates of transport ranging from 53 to 86% (Keshtpoor et al., 2013). There still remains a net loss of sediment on downdrift beaches (Bruun, 1995, 2001; Galgano, 2009; Keshtpoor et al., 2014).

Within the subtidal sediments, benthic communities exist within, between, and on sand grains (Charvat et al., 1990; Knott et al., 1983; Wilson, 1990). The sediment makeup controls the type of community as many species are particular to a certain grain size (Gray, 1974; Snelgrove and Butman, 1994; Wieser, 1959). Small benthic macrofauna are an important community when evaluating nearshore marine ecosystems. These benthic species are an important component of the food chain providing both nourishment to nearshore fish communities and foraging birds in the intertidal zone (Alheit and Scheibel, 1982; McCormick, 1995; Peterson et al., 2006; Wilson, 1990). Many dominant benthic species in subtidal sand undergo direct development and lack a pelagic stage (Borowsky, 1996; Richards, 1970). This reduces their dispersal ability. Nearshore benthic communities may take advantage of longshore transport by migrating down coastlines.

In this paper we examine the process of transfer for both sediments and benthic macrofauna through the South Lake Worth Inlet transfer plant. It has been suggested that organisms may pass through the transfer plant. We investigated this possibility though examination of unpreserved and preserved samples along with benthic macrofaunal community similarities at each study site. Samples were taken within the borrow pit of the sand transfer plant on both the north side of the jetty and the deposition pipe on the south side of the jetty. If transfer of macrofauna was occurring as expected then we intended to determine the community structure and composition of benthic macrofaunal to determine the effect of disturbance at this locale. Interruption of the longshore transport may interrupt the downcurrent recruitment of new individuals or alter community structure. This may create a localized or larger disturbance as seen in sediment studies (Bruun, 1995, 2001; Keshtpoor et al., 2013, 2014). Changes in community structure and diversity might transmit up the local food chain into fish and into birds (DeLancey, 1989; McCormick, 1995; Peterson et al., 2006; Pires, 1987).

2. Methods

2.1. Study site and design

This project focused on the sand transfer plant at the South Lake Worth Inlet, Boynton Beach, Florida (Figs. 1 and 2). Samples were collected over 3 days during May and June 2016 on each side of the inlet and jetty. Sampling occurred on days when waters were calm and waves were under 0.5 m. A control and a survey site were located on each side of the inlet and jetty. At the north jetty where the sand transfer plant is located (and sediment accumulation occurs), sampling occurred within the borrow pit (B) via SCUBA and outside the borrow pit (the inflow control, A) (Figs. 1 and 2). Beyond the south jetty where the beach has eroded, the outflow pipe at the terminal end is elevated roughly 4 m above the beach in the intertidal zone (Fig. 2). Sediment slurry is forced out of the pipe creating a deposition mound in the lower intertidal and subtidal zone. Samples were taken on the seaward facing slope of this mound (deposition, D) and about 50 m south of the deposition site (outflow control, C) (Fig. 1).

2.2. Macrofaunal and sediment collection

Macrofaunal sediment cores were collected at each site (inflow control, borrow pit, outflow control, deposition). Twenty cores were taken per location, except the deposition site which we took only 11 cores. Totaling 71 macrofaunal cores preserved for this study. Each core was taken at a minimum distance of 2 m from any nearby core to avoid

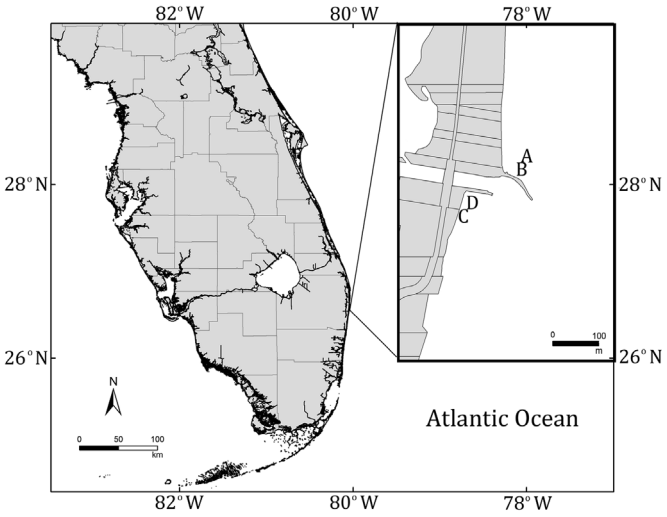

Fig. 1. Location of study in Boynton Beach, Palm Beach County, Florida. Four sampling sites were identified in relation to the South Lake Worth Inlet jetty: A = inflow control; B = borrow pit; C = outflow control; and D = deposition.

Fig. 2. Photographs taken of the South Lake Worth Sand Transfer Plant system in June 2016. A) sand transfer plant on the north jetty to the South Lake Worth Inlet. B) outflow pipe along the eroded beach just beyond the south end of the South Lake Worth Inlet.

pseudoreplication. Cylindrical PVC pipe was used in core sampling for both sediment and macrofauna. Cores taken measured 10 cm × 10 cm (0.00785 m^2). Total macrofaunal surface area collected was 0.56 m^2. All cores were taken by hand and snorkel in water depths of 1–1.5 m, except for the borrow pit which was 4 m deep on average and taken by hand and SCUBA. Core sampling at the deposition site was along the outer seaward margins. The outflow pipe projected sediment from a height of 4 m into a discharge mound located in the intertidal/subtidal