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Fishery resource utilization of a restored estuarine borrow pit: A beneficial use of dredged material case study

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ABSTRACT

Numerous pits in coastal waters are subject to degraded water quality and benthic habitat conditions, resulting in degraded fish habitat. A pit in Barnegat Bay, New Jersey (USA) was partially filled with dredged sediment to increase flushing, alleviate hypoxia, and enhance benthic assemblages. Restoration objectives were assessed in terms of benthic community parameters and fishery resource occupation. Restoration resulted in increased benthic diversity (bottom samples) and the absence of water column stratification. Fisheries resources occupied the entire water column, unlike pre-restoration conditions where finfish tended to avoid the lower water column. The partial restoration option effectively reproduced an existing borrow pit configuration (Hole #5, control), by decreasing total depth from −11 m to −5.5 m, thereby creating a habitat less susceptible to hypoxic/anoxic conditions, while retaining sufficient vertical relief to maintain associations with juvenile weakfish and other forage fishes. Partially filling pits using dredged material represents a viable restoration alternative.

1. Introduction

Sand borrowing for beach nourishment in estuarine and coastal waters creates depressions on the underwater landscape. Variously referred to as borrow pits or dredged holes, these depressions often differ from dredged navigation channels in many respects, including volume, size, shape, and depth and are frequently much deeper than the surrounding ambient bottom. Borrow pits also tend to be disconnected, isolated features, which have implications for their ecology. Short term effects generally consist of localized, temporary increases in turbidity and sedimentation. However, long-term impacts of altered bathymetry such as reduced hydrodynamic flow, poor tidal flushing, and water column stratification can lead to degraded water and sediment quality, from the accumulation of fine grained sediments and organic material, and depressed dissolved oxygen (DO) concentrations leading to stagnation. These factors contribute to reduced ecological function, characterized by a highly stressed benthic community, and reduced finfish utilization, typically in the lower reaches of the borrow pit.

Restoration of estuarine and coastal habitats has been the subject of interest in recent years, although the focus has generally been on wetland, shellfish, and seagrass habitats. The potential beneficial use of dredged material to partially or completely return borrow pits to historical depth contours has been identified as a restoration alternative by Dial and Deis (1986), Yozzo et al. (2004), as well as by several Districts of the Army Corps of Engineers. Aside from the engineering aspect, decisions on the efficacy and desirability of filling pits have hinged upon ecological issues. On one end of the spectrum, returning subtidal bottoms in the estuary to their historical depth contours could re-establish pre-existing habitat attributes and functions. Detractors opposed to filling dredged holes claim that existing pits provide valuable recreational fishing areas and critical over-wintering habitat for various fishery resources. Potential benefits and detriments of borrow pits are reviewed in Yozzo et al. (2004). Previous characterizations of benthic resources in borrow pits include Murawski (1969), Jørgensen (1980), Cerrato and Scheier (1984), and Cerrato et al. (1989). Likewise, regional fishery resource use of borrow pits and surrounding open-water habitats have previously been assessed by Conover et al. (1985) and Woodhead and McCafferty (1986).

In 2006, the Dredging Operations and Environmental Research (DOER) Program began to retrospectively assess the potential benefits of using dredged material to create or restored essential fish habitat. Several projects were selected for study to include a borrow pit restoration project and fishery utilization of both an offshore dredged material mound and an artificial reef built from dredged rock. In 2005, two dredged holes, identified as #5 (control) and #6, located in Barnegat Bay, NJ was selected for study. Dredged Hole #6, had been filled the previously year to a target elevation of −5.5 m (original depth = 11.5 m) MLW by placing dredged material derived from the Double Creek Channel using a hydraulic pipeline

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cutterhead dredge. The final design included formation of six mounds in the elevated basin of the hole to add relief and increase the bathymetric complexity of the borrow pit basin. By mounding the sediments during the dredge and fill operation, it was theorized that the tops and sides of the mounds would provide conditions suitable to sustain and support a healthy and diverse benthic invertebrate community. Dredged sediments consisted primarily of sandy material (70–90% coarse fractions). Approximately 96,000 cubic meters (125,000 cubic yards) of dredged material was pumped into Dredged Hole #6. A minimum of 1 m (~3 ft) of sand was placed over the underlying fine-grained sediment as a foundation for creation of sand mounds. For purposes of comparison a nearby un-restored borrow site (Dredged Hole #5) was left at its existing depth of −5.5 m (−18 ft) MLW. The success of restoration efforts was assessed in terms of overall "health" of each borrow pit by examining water quality, sediment characteristics, benthic invertebrate communities, and fishery assemblages both between borrow pits and to baseline (pre-restoration) data results.

2. Methods

2.1. Study site

Barnegat Bay (39° 43.9′ N, 74° 9.1′ W) is a 75 square mile shallow estuary located in Ocean County, New Jersey. Situated behind a barrier spit and Long Beach Island, the estuary's primary connection to the ocean is via Barnegat Inlet (Fig. 1). Dredged Holes #5 and #6 are located less than 30.5 m (100 ft) from shore along the western side of Long Beach Island. Dredged Hole #5 is located adjacent to the Town of Loveladies, and covers an area of approximately 2.8 hectares (7 acres). Dredged Hole #6 is located in the Borough of Harvey Cedars, approximately 1.6 km (1 mile) south of Dredged Hole #5, and covers an area of approximately 4.9 hectares (12 acres).

2.2. Water quality

A calibrated YSI (Model 6920 V2) water quality sonde was used to measure DO concentration (mg/l), temperature (°C), and salinity (ppt) at surface, mid- and bottom depths at seven stations in each dredged hole during each sampling event.

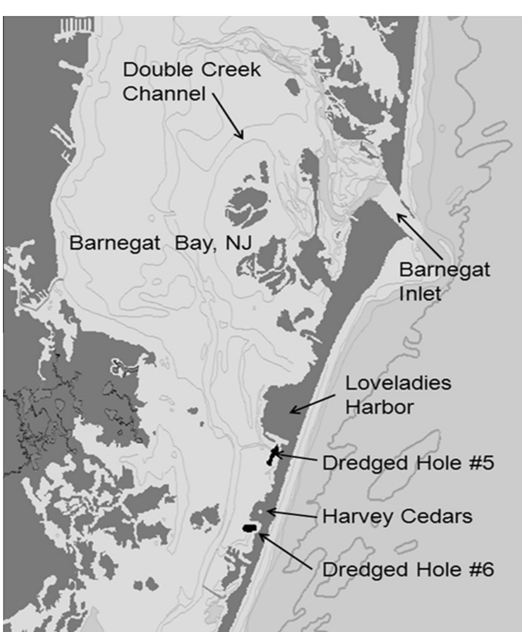

Fig. 1. Location of study borrow pits in the Barnegat Bay Estuary.

2.3. Sediments

Representative stations were sampled by Young grab during the May and November 2007 surveys for sediment grain size analysis. Grab samples were processed using a combination of wet-sieving and flotation procedures (Folk 1968; Galehouse, 1971). Sediment data analysis was conducted using Gradistat 4.0 (Blott, 2000). Sediment analyses were supplemented with visual observations of materials present in the grab samples.

2.4. Benthic sampling

Benthic macroinvertebrates were sampled in August 2006, and May and November 2007 at sites previously established during baseline collection efforts by Versar (1999), to evaluate recruitment and community structure in each dredged hole and to determine if benthic conditions were altered by restoration. In Hole #6, samples were collected from each of the tops, sides, and troughs of six mounds using a 0.044-m^2 stainless steel Young Grab Sampler, for a total of eighteen samples. In Hole #5, twelve samples were collected from the bottom and sides of the unaltered pit. Six samples were collected in a nearby reference area at each site in the natural bay bottom. A successful sample required a minimum penetration depth into the bottom sediment of at least 6 cm. Samples were sieved in the field using 0.5 mm mesh screening, preserved in 10% buffered formalin, and stained with rose Bengal for laboratory processing.

2.5. Fishery hydroacoustics

Fishery hydroacoustic surveys were conducted in August 2006, and May and November 2007. Acoustic backscatter data were collected with a BioSonics DT 6000 digital echosounder equipped with 200-kHz split-beam transducer (6-degree conical beam angle at −3 dB). Targets satisfying single target criteria with target strength (TS) above −52.6 dB (equivalent to a length of 4 cm) was accepted. The acoustic resolution (minimum target separation distance) of single targets was determined to be 0.23 m following $R = c\tau/2$ (Simmonds and MacLennan, 2005), where c = speed of sound in water (1500 m s^{-1}) and τ is pulse length duration (0.3 ms). Water temperature, salinity and depth were measured at stations in each borrow pit for correct calculation of speed of sound and absorption coefficients. Before each sampling period the hydroacoustic equipment was calibrated using a tungsten carbide sphere (38.1 mm diameter) standard target of known acoustic TS (~39.2 dB in seawater). The calibration was stable over all sampling periods.

The transducer was mounted in a downward, vertical orientation on an adjustable aluminum frame affixed to the gunnels of the survey vessel. Acoustic data were collected and stored on a laptop computer running BioSonics Acquisition Program (version 4.1) software. Post-processing analyses were performed using Hydroacoustic Data Analysis Software (HADAS), developed by the US Army Engineer Research and Development Center (ERDC). Data were collected during mobile surveys with boat speed limited to 5 km h^{-1}. Each site was divided into parallel transects, spaced at 30 m intervals, covering the full north to south footprint of each dredged hole. Transects extended the full width (shoal to shoal) of each borrow site. Fifteen transects (mean length = 235 m) were occupied at Hole #6 and 22 transects (mean length = 135 m) at Hole #5. Total survey distance was 2.5 km (Hole 5) and 3.5 km (Hole 6), respectively. To equalize effort among sampling units, individual transects were divided into 10 m segments, referred to