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Measuring nearshore variability in benthic environments: An acoustic approach

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ABSTRACT

Hardbottom and sedimentary habitats in the nearshore are continually affected by natural and anthropogenic disturbances. Currently used monitoring practices rely on visual techniques, aerial and underwater photography, which are conducted on an annual basis. These practices do not allow for rigorous assessment of the effects of human-induced or natural events on the distribution and composition of these habitats. We investigated the use of an acoustic ground discrimination system (RoxAnn) to determine changes in benthic habitats in the nearshore area of northern Indian River County, FL where hardbottom outcrops occur. It was determined that this method was precise and repeatable when deployed in a highly variable surf zone environment. Multiple surveys assessed temporal and spatial changes in bottom types. Spatial distributions of several bottom types were identified: bare rock surfaces, Sabellarid worm reef, sponge covered rock, and rock covered with two dominant algal species. Short-term (weekly) changes in the distribution of sand coverage were detected during a relatively calm hydrodynamic period. At one site (R-15), there was an increase of 11% in sediments, which attributed to approximately 2 750 m^2 of coverage; 2.1 km south (R-22) there was a 6% decrease in sediments in six days. The latter equates to a change of almost 1 500 m^2 of available habitat. These results suggest that the current practice of annual surveying is limited for assessing the magnitude and impact of episodic disturbances on benthic habitats. Based on these data, acoustic ground discrimination systems provide an unbiased, technology-based data collection method to distinguish benthic habitats in the surf zone. Employing this method will benefit researchers and coastal resource managers.

1. Introduction

Nearshore hardbottom is regarded as essential fish habitat in the state of Florida and its environmental importance is unquestioned. Numerous species of fish, invertebrates, and algae depend on this hardbottom for habitat, and it serves as a transition zone between lagoons, inlets and the open ocean (Baron and Jordan, 2004). Nearshore reefs have a variety of classifications. Here we adopt the definition of a hardbottom habitat provided by the North Carolina Coastal Habitat Protection Plan: "exposed areas of rock or consolidated sediments, distinguished from surrounding unconsolidated sediments, which may or may not be characterized by a thin veneer of live or dead biota, generally located in the ocean rather than in the estuarine system" (Street et al., 2005). According the United States Fish and Wildlife Service's Multi-Species Recovery Plan for South Florida, 'nearshore reef' includes "all solid physical substrate below the mean high water line and seaward of Atlantic Ocean or Gulf of Mexico shoreline which may be vulnerable to fill deposition and turbidity (loss of light penetration through the water column) associated with beach nourishment. The zone has been defined by the State of Florida Department of Environmental Regulation (DEP) as the area landward of the 4 m depth contour" (USFWS, 1999).

There is growing concern in the United States, especially in the southeast, that the ecological ramifications of anthropogenic and natural disturbance events are not being adequately taken into consideration and that monitoring the associated environmental impacts is insufficient. According to the South Atlantic Fishery Management Council (the Federal entity that manages fisheries in the United States at the regional level), dredge and fill projects and

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large-scale engineering projects seldom provide adequate assessments of impacts on the environment (SAFMC, 2003). The scant discussion that exists surrounding environmental assessments is generally focused around dredging practices and economics, with the Endangered Species Act driving the environmental concerns. There has been little consideration for non-endangered species or fisheries that are affected by these projects (SAFMC, 2003). Few quantitative studies have been performed to address the impacts of beach nourishment projects on fishery resources. One exception, for example, is Baron and Jordan (2004) who found that non-renourished sites in southeast Florida yielded significantly greater mean abundance of fish compared to renourished areas.

The most widely used techniques for monitoring the effects of disturbances on nearshore hardbottom are aerial imagery analysis, direct visual observation, and/or photographic surveys conducted by divers. The most detailed of these methods is diver surveys. Divers place quadrats at specified distances and following predefined shore perpendicular transects. Within each quadrat, algal species, sediment thickness, invertebrates present, and reef composition are recorded. These techniques have limitations, and many factors hinder or prevent these efforts from occurring including: high turbidity levels, rough seas, strong currents, and/or storms. These surveys are also only performed on an annual basis, generally in the summer when wave energy is reduced. When waves surge or break over the hardbottom, a considerable amount of organic and inorganic particulates suspend in the water column. Oftentimes visibility is limited to almost zero, thus making it difficult or impossible to obtain usable aerial and underwater photography. The waves are often accompanied by surges of energy, which may place divers in danger over the reef areas. Employing the RoxAnn has several benefits to scientists and coastal managers; it will increase the temporal frequency and spatial extent of surveys and allow for an improved understanding of the impacts of storms and renourishment activities on nearshore hardbottom habitats.

In an attempt to reduce the reliance on diver involvement and imagery collection, researchers have started to use acoustic monitoring techniques (Chivers et al., 1990; Cholwek et al., 2000; Sze et al., 2000; Rukavina, 2001; Smith et al., 2001; Pinn and Robertson, 2003; Greenstreet et al., 2010; Bers et al., 2013). Studies using an acoustic ground discrimination system, specifically the RoxAnn, have been used in a range of marine environments. A variety of hardness and texture classes were identified over an oyster hardbottom by Smith et al. (2001). Greenstreet et al. (1997) used the RoxAnn system to texturally characterize sediments in northeast Scotland, while Bejarano et al. (2011) combined the RoxAnn with biological methods to determine coral reef complexity and fish abundance.

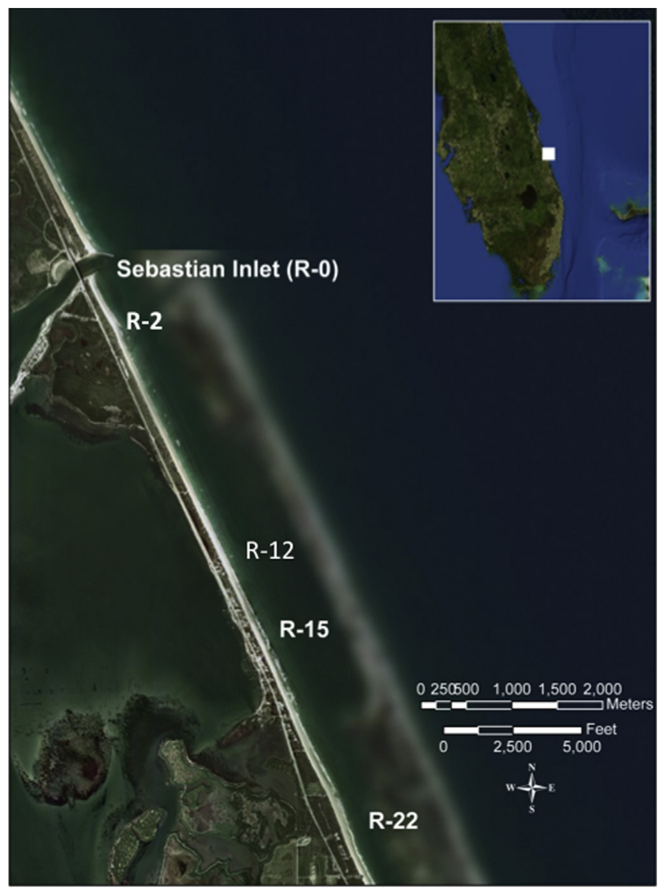
Although acoustic-based methods have been used in previous studies (Zheng et al., 2011, 2013), including side scan (Raineault et al., 2012), multibeam (Micallef et al., 2012), single beam (Greenstreet et al., 2010; Bartholomä et al., 2011) and a combined approach (Serpetti et al., 2011), there is little knowledge of the applicability of these methodologies in nearshore environments that have highly variable hydrodynamics. Therefore, the primary goal of this study is to determine whether an acoustic-based monitoring system, specifically, the RoxAnn GDX single beam system, is viable to identify and investigate variable nearshore hardbottom habitats. To achieve this goal, several objectives must be met: 1) determine the precision of the RoxAnn system; 2) assess how inter-transect distance influences the determination of percent cover estimates of bottom type; 3) assess temporal change in benthic habitat distribution; and 4) identify and map essential hardbottom habitats in the nearshore over multiple spatial scales.

2. Materials and methods

2.1. Study area

Sebastian Inlet, FL is located on the Atlantic Coast at approximately 27.8514° N, 80.4447° W (Fig. 1). The Unites States Army Corps of Engineers (USACE) benchmark R-0 is located at the northern border of Indian River County, FL, which is Sebastian Inlet. Subsequent R-markers increase in 1 000 ft (305 m) increments until the southern county border. The three major geographic areas of interest for this study are Sebastian Inlet (R-0) to R-22, R-15, and R-22.

During the Pleistocene interglacial periods the coastal environments of central Florida arose from accretionary ridges of lithified shell, coquina mollusks, and sand that formed parallel to the shore. Known as the Anastasia formation, this is the youngest lithified marine Pleistocene deposit found in the coastal waters of Florida (Lovejoy, 1998). Its rocky outcrops, with relief up to approximately 1.5 m, provide the basis for an expansive ecosystem



Date	Surveyed Area	Survey Type
9-Jun 2009	R-2 through R-12	broad
14-Jun 2009	R-12 through R-22	broad
21-Jun 2009	R-22	intense
22-Jun 2009	R-15	intense
9-Jul 2009	R-15	intense
27-Jul 2009	R-22	intense
31-Jul 2009	Artificial Reef	intense
1-Aug 2009	R-15	intense
1-Aug 2009	R-22	intense
2-Sep 2009	R-2 through R-22	broad

Fig. 1. Location map of study area (top) and dates for the broad (~30 m) and intense (~5 m) surveys (bottom). See Online version of the article has color figures.