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Research papers

Geology and biology of the "Sticky Grounds", shelf-margin carbonate mounds, and mesophotic ecosystem in the eastern Gulf of Mexico

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ABSTRACT

Shelf-margin carbonate mounds in water depths of 116–135 m in the eastern Gulf of Mexico along the central west Florida shelf were investigated using swath bathymetry, side-scan sonar, sub-bottom imaging, rock dredging, and submersible dives. These enigmatic structures, known to fisherman as the "Sticky Grounds", trend along slope, are 5–15 m in relief with base diameters of 5–30 m, and suggest widespread potential for mesophotic reef habitat along the west Florida outer continental shelf. Possible origins are sea-level lowstand coral patch reefs, oyster reefs, or perhaps more recent post-lowstand biohermal development. Rock dredging recovered bioeroded carbonate-rock facies comprised of bored and cemented bioclastics. Rock sample components included calcified worm tubes, pelagic sediment, and oysters normally restricted to brackish nearshore areas. Several reef sites were surveyed at the Sticky Grounds during a cruise in August 2010 with the R/V *Seward Johnson* using the *Johnson-Sea-Link* II submersible to ground truth the swath-sonar maps and to quantify and characterize the benthic habitats, benthic macrofauna, fish populations, and coral/sponge cover. This study characterizes for the first time this mesophotic reef ecosystem and associated fish populations, and analyzes the interrelationships of the fish assemblages, benthic habitats and invertebrate biota. These highly eroded rock mounds provide extensive hard-bottom habitat for reef invertebrate species as well as essential fish habitat for reef fish and commercially/recreationally important fish species. The extent and significance of associated living resources with these bottom types is particularly important in light of the 2010 Deepwater Horizon oil spill in the northeastern Gulf and the proximity of the Loop Current. Mapping the distribution of these mesophotic-depth ecosystems is important for quantifying essential fish habitat and describing benthic resources. These activities can improve ecosystem management and planning of future oil and gas activities in this outer continental shelf region.

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1. Introduction

Continental shelves host complex, geomorphic features resulting from repeated sea-level fluctuations and changing depositional environments. Seafloor features include relic structures from past shoreline environments combined with a history of modifications that include ongoing physical (sediment erosion or accumulation) and biological (carbonate production and accretion, bioerosion) processes. The resulting geologic framework is the foundation for present-day benthic habitats that comprise an essential and critical component of marine ecosystems. However, the abundance and character of seafloor benthic habitat is poorly known for marine ecosystems on outer continental shelves. Large portions of the seafloor remain unmapped due to the technical and financial constraints on remote sensing methods.

Several review papers that have focused on shelf-edge, mesophotic coral ecosystems (MCEs) and fish habitat off the southeastern U.S. and Gulf of Mexico (GOM) have illustrated a wide diversity in geomorphology and habitat type (e.g., Coleman et al., 2004a; Brooke and Schroeder, 2007; Hine et al., 2008; Messing et al., 2008; Locker et al., 2010). In the northern and eastern Gulf of Mexico, some well-known settings include the Flower Gardens (Clark et al., 2014), Pinnacles Reef Trend (Sager et al., 1992; Gardner et al., 2000; CSA and Texas A&M, 2001; Weaver et al., 2002), outer-shelf deltas (Gardner et al., 2005, 2007), Steamboat Lumps (Gardner et al., 2001), Florida Middle Grounds (Hopkins

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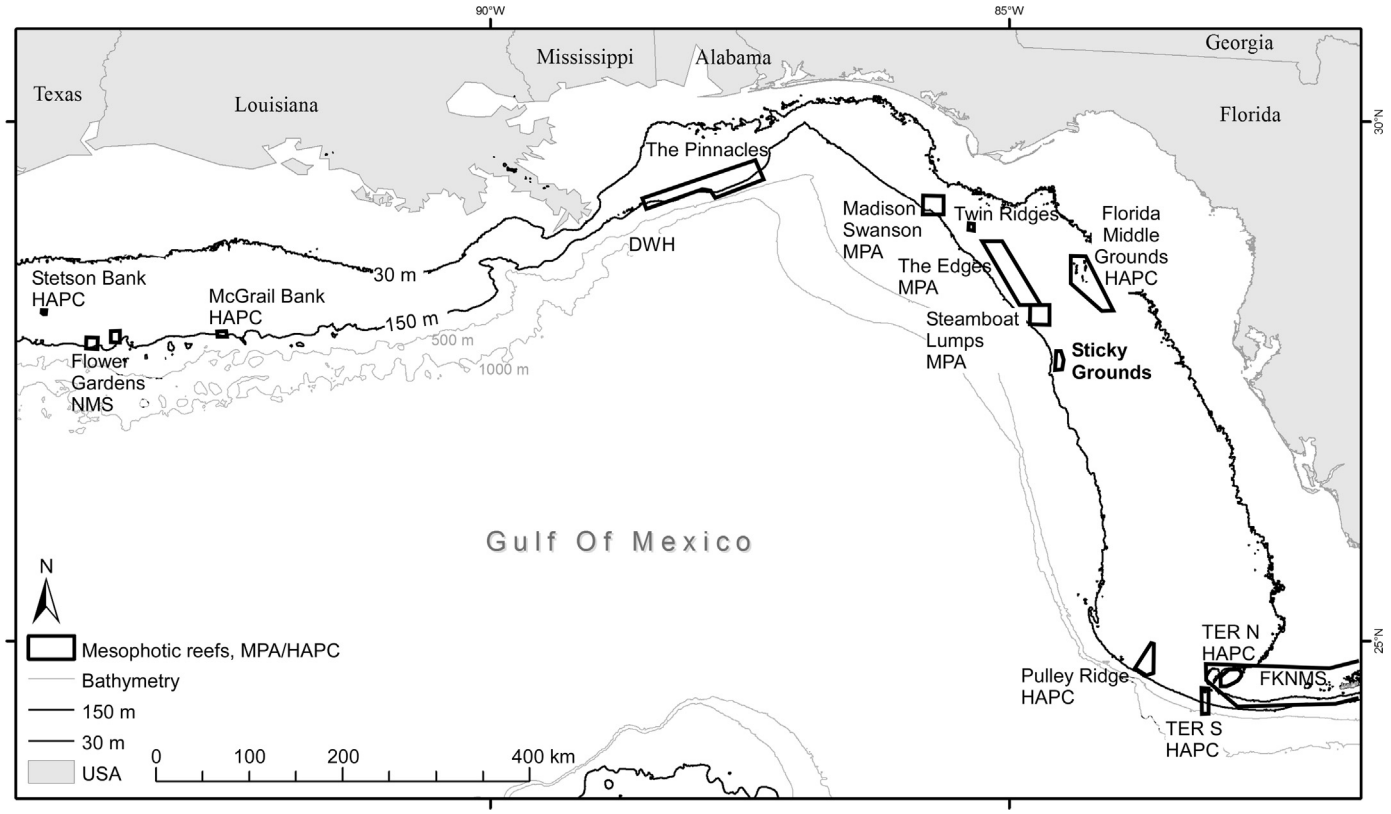

Fig. 1. Map of U.S. Gulf of Mexico showing extent of mesophotic depth habitat (30 m to 150 m depth contours) and major mesophotic reefs (boxes). The Sticky Grounds are located 200 km west of Tampa Bay, Florida. Marine reserves include Marine Protected Areas (MPA), Habitat Areas of Particular Concern (HAPC), and National Marine Sanctuaries (NMS). Deepwater Horizon oil spill site (DWH). North and South Tortugas Ecological Reserves (TER N, TER S). Florida Keys National Marine Sanctuary (FKNMS).

et al., 1977; Coleman et al., 2004b; Reich et al., 2013; Mallinson et al., 2014), Pulley Ridge (Jarrett et al., 2005; Reed et al., 2014; Reed, 2016), and Tortugas mesophotic reefs including Miller's Ledge, Riley's Hump and Sherwood Forrest (Schmidt et al., 1999; Weaver et al., 2006; Ault et al., 2013; Reed et al., 2014), (Fig. 1). These settings provide topographic relief that support Mesophotic Coral Ecosystems (MCEs) – important reef habitat for diverse communities of corals and sponges, and associated critical commercial and recreational fisheries that must be managed for future sustainability. Predominant geomorphic structures are linear paleoshoreline ridges and mounds that tend to occur in along slope trends, and small banks. Except for the Flower Gardens salt structures, these areas primarily reflect past depositional environments and enhanced relic geomorphology constructed in response to Pleistocene sea-level fluctuations and correspondingly changing coastal environments. The widespread occurrence of shelf-edge carbonate mound structures in the GOM indicates this habitat type is underestimated in terms of abundance and associated marine communities.

The generally accepted depth zone for mesophotic reef habitats worldwide is 30–150 m (Hinderstein et al., 2010). The mesophotic zone is generally broken into upper mesophotic (30–50 m depth), mid mesophotic (50–80 m), and lower mesophotic (80–150 m). The lower depth limit is somewhat site and species specific depending in part on water clarity with some mesophotic coral species extending to nearly 150 m in the Indo-Pacific (Kahng et al., 2010). The Sticky Grounds occurs at the lower mesophotic depth zone. Since understanding the diversity and interactions of the shelf-edge mesophotic community is critical for managing these deep, dimly lit communities, the mesophotic zone may be considered to include both photosynthetic taxa (30–100 m depth) and inclusive of other reef-associated, non-autotrophic fauna such as azooxanthellate scleractinian corals, octocorals, antipatharians and sponges (30–150 m in depth) (Baker et al., 2016). An analysis of the total area of mesophotic zone depths in U.S. waters indicates that the northern Gulf of Mexico region has an order of magnitude greater area for potential mesophotic depth habitats than either the U.S. Caribbean or main Hawaiian Islands (Locker et al., 2010).

In this paper we report on a previously unstudied shelf-edge environment that is of interest geologically (paleoshorelines, last glacial depositional environments, continental shelf hard grounds) and biologically (essential marine habitat in the Gulf of Mexico). This is the first detailed, quantitative characterization of the Sticky Grounds mesophotic reef habitat, fish populations, and their interrelationships. Currently this site is not a managed area. Sites that are protected and managed in the eastern GOM either as Habitat Areas of Particular Concern (HAPCs) by the Gulf of Mexico Fishery Management Council (GMFMC) or as Marine Protected Areas (MPAs) include Madison Swanson, Steamboat Lumps, the Edges, Florida Middle Grounds, Pulley Ridge, and the Tortugas Ecological Reserves. The long-term goals of this research are to provide baseline data useful to decision-makers in their deliberations regarding the possible designation of the Sticky Grounds as a MPA and/or HAPC by mapping and character/or HAPC by mapping and characterizing the benthic habitat, benthic biota, and fish populations of this unprotected area. These data may then be used as a relative baseline to document changes in these areas and to monitor the efficacy and health of designated managed areas. These data will be of value to the GMFMC, NOAA Fisheries Service, NOAA Office of National Sanctuaries, and perhaps state agencies for management decisions on these habitats and managed key species.

A distinction is made between the term “mounds,” used to refer to the geomorphology, and “reef,” used to refer to the mesophotic reef habitat that covers the mounds. The mounds cannot be considered reefs in a geologic sense because the presence of internal skeletal-framework building organisms is unknown.