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Method for estimating relative abundance and species composition around oil and gas platforms in the northern Gulf of Mexico, U.S.A.

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A R T I C L E I N F O

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A B S T R A C T

We used hydroacoustics and video data collected contemporaneously at three standing and two toppled oil and gas platforms located ~130 km off the coast of Louisiana. Stereo-video and GoPro® cameras were used to profile the water column to estimate the number, length, and species composition of fishes present on the platforms. Hydroacoustics were used to determine the spatial distribution, both in distance and depth, of relative fish biomass, or mean volume backscatter, within 500 m of the center of each site. Mean volume backscatter (MVBS, S_V) was highest near the structure, then declined rapidly with distance. We estimated that background-noise level was obtained at ~100 m from the structures. Fish MVBS was highest in the lower water column (> 60 m depth), compared to 0–30 m and 30–60 m depth zones. Fish communities differed among depth layers, seasonally, and between structure types (standing/toppled), though red snapper (*Lutjanus campechanus*) was the dominant species present at both structure types. Coupled video sampling revealed that MVBS changed little seasonally, but different species contributed to community structure seasonally and among layers in the water column. This study is one of several studies to use video data combined with acoustics to describe species contribution to acoustic biomass at standing and toppled platforms. We contend that integrating these non-destructive sampling methods is an important step in understanding the efficacy of artificial structures as ecological valuable habitat.

1. Introduction

There are a variety of natural and artificial reef habitats within the US Exclusive Economic Zone (EEZ) in the Gulf of Mexico (GOM), including an estimated ~2700 km^2 of rock dominant or subdominant natural surficial substrate. Additionally, a myriad of manmade reef structures, such as oil and gas platforms, exist in the northern GOM, creating a large de-facto artificial reef complex comprised of standing and toppled oil and gas platforms (Dauterive, 2000). There are approximately 2000 oil/gas platforms, which add ~20 km^2 of artificial substrate, containing 1.7×10^4 km^3 of enclosed volume and $\sim 1 \times 10^5$ km^2 of footprint on the seafloor. Toppled and standing platforms are of interest to fishermen and resource managers because they are known to aggregate and attract various species of reef-associated fishes (Cowan and Rose, 2016).

Most information about reef-associated fishes is derived from the eastern GOM on low-relief artificial reefs (Patterson et al., 2001; Rademacher and Render, 2003; Schroepfer and Szedlmayer, 2006; McCawley and Cowan, 2007; Dance et al., 2011). By comparison, there has been less effort invested in the efficacy of standing and toppled oil and gas platforms as fish habitat. Programs such as Rigs to Reefs (RTR)[1] aim to better understand reef-associated fish distributions and abundance through monitoring and placement of toppled oil and gas platforms. Video and hydroacoustic surveys are currently being used to sample habitat or structures otherwise difficult to study. In recent decades, hydroacoustic surveys have helped to describe the spatial distribution of organisms associated with artificial reefs including: the North Sea (Løkkeborg et al., 2002), Mediterranean Sea (Fabi and Sala, 2002), Australia (Pradella et al., 2014), and the GOM (Stanley and Wilson, 1996; Boswell et al., 2010; Simonsen, 2013). Similarly, video surveys have also been used to sample habitat. Baited remote underwater video (BRUV) arrays have been a successful alternative to various

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[1] Rigs to Reefs (RTR) is the process in which material from decommissioned oil and gas platforms is used to create artificial reefs. The Louisiana Artificial Reef Program (LARP) relies heavily on this process.

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other video systems such as remote operated vehicles (ROVs). They are cost effective, robust sampling tools that can easily and efficiently assess community composition, distribution, relative abundance, and sizes of marine fishes. BRUV's have successfully been utilized in studies in Australia, Hawaii, the GOM, and other ecologically important locations (Rooker et al., 1997; Watson et al., 2005, 2010; Brooks et al., 2011; Martinez et al., 2011; Merritt et al., 2011; Dorman et al., 2012; Harvey et al., 2013; Misa et al., 2013; Whitmarsh et al., 2014). BRUV's incorporating stereo-video systems are commonly used because of the assumption that measurements of those fish are as precise as of those made of stationary objects, even under the best recording conditions (Harvey et al., 2002).

The use of BRUV's has been compared to SCUBA diver surveys to determine their effectiveness. In a recent study, the use of a stereo-BRUV array provided more accurate estimates of length-frequency distributions than those derived from fishery-independent line fishing (Langlois et al., 2012). Furthermore, Harvey et al. (2004) compared underwater visual distance estimates made by SCUBA divers to measurements made by stereo-video systems and concluded that even though SCUBA surveys are useful for a quick evaluation of the composition and abundance of reef fish communities, the data are often biased because fish may be recounted or mis-measured.

Acoustic surveys provide solutions to some of the problems that other nondestructive survey methodology presents. For example, when visual surveys are used to assess fish populations around platforms, limited visibility, diver avoidance, and gear bias can lead to unstandardized data that makes it difficult to compare results across multiple surveys and studies (Stanley and Wilson, 2000). Acoustics can be used to cost effectively sample the entire water column over large areas. In addition, acoustics operate over a broad frequency range and offer a high sampling rate (Simmonds and Maclennan, 2005; Lundgren and Nielsen, 2008; Ressler et al., 2015).

We combined video and hydroacoustic methods to expand current knowledge about the habitat value of standing and toppled platforms and how fishes relate to them in time and space. To that end, we develop a sampling methodology to determine how the fish community structure and biomass differs between structure type and location. We envision this application to be beneficial to programs like the Louisiana Artificial Reef Program (LARP). The Artificial Reef Council makes informed decisions on limited funding to determine which oil rigs would be most economically and ecologically viable to convert to artificial reefs. This new approach is one step forward in providing enhanced technology to help LARP and the Council make data-driven decisions for fisheries habitat management.

2. Methods

The study sites were located approximately 130 km off the coast of Louisiana at the Eugene Island Oil and Gas Lease Block. We sampled five sites over six cruises, consisting of three standing and two toppled oil and gas platforms (Fig. 1). Sites were sampled every cruise, weather permitting. However, five site surveys were not conducted due to weather. The following protocols were adopted for all surveys; on a given survey day, we collected the hydroacoustic (acoustic) or video data in random order.

2.1. Video data collection

Video camera arrays were deployed during daylight hours at all sites for one hour on six cruises between June 2013 and June 2014. A BRUV system containing six Vixia HF G10 high-definition camcorders mounted in a camera cage were employed at standing platforms. The cage consisted of two stereo camera pairs, located on opposite sides of the cage, and two single-cameras, that were mounted orthogonally to the stereo pairs for a complete 360° view. The stereo cameras within each pair were separated by 70 cm and angled inward at 7 ° to provide a 3-dimensional image used to estimate fish length. Before deployment, stereo pairs were calibrated with a calibration cube (1 m × 1 m × 0.53 m) and recorded video was processed with the software *Cal* (SeaGIS Pty. Ltd) to ensure accurate length measurements. Four 50-W HID lights (Light Monkey Enterprises LLC®, Florida, USA) were mounted on the top of the cage.

Toppled platforms are structurally complex, making it difficult to sample using video arrays, as toppled structures added to the seafloor increase the risk of gear entanglement. To mitigate this risk, we used a BRUV array to collect data from toppled platforms to reduce equipment loss. Initially, a stereo-BRUV system was used at the toppled platforms, but due to a single point anchoring system on the vessel in conjunction with structure that shifted over time, gear entanglement prevented its use. Therefore, we developed a four Go-Pro® camera array secured to 1.9 cm dia. copper pipe, in a pattern that provided a 360° view between the top three cameras and a downward facing view from the bottom camera. Lead weights (approximately 9–13 kg), were attached at the bottom of the array depending on the strength of the current, to ensure a vertical profile. The cameras were set on the highest resolution (1080 p), medium view frame, and placed in 1524 m depth rating underwater housings (Group B Distribution Inc.® Jensen Beach, Florida, USA) to reach the appropriate depths. Both camera systems were baited with fish (both whole and ground) and deployed using a winch when the vessel was approximately 20–30 m away from the standing platforms to avoid any collisions, while remaining as close as possible to the toppled platforms.

The upper, middle, and lower water columns were surveyed, purposefully avoiding the seafloor due to poor visibility. Depth layers were designated by dividing the water column into thirds to determine if community structure changed with depth (Stanley and Wilson, 1998; Simonsen, 2013). Following Simonsen (2013), depth bins were defined as: 0–30 m, 30–60 m, and > 60 m, referred to as layers one to three, respectively. Both camera systems were suspended for 20 min in the middle of each depth layer. We measured water temperature, salinity, and depth at each site (Sea-Bird SBE 25 Sealogger CTD) and recorded to correct calibration of sound speed and absorption coefficients.

2.2. Video data processing

All video data were post-processed in EventMeasure (SeaGIS Pty Ltd®) for use in a multivariate analysis. A continuous 20-min video was examined for each depth bin, for each camera (total video time for stereo $BRUV = 20 \times 4 = 80\,min$; $BRUVS = 20 \times 3 = 60\,min$). Start time began 30 s after the camera array reached depth layer one, to account for possible bias caused by noise and movement disturbances that may have affected fish behavior. Video data were processed from layers two and three, as it was assumed the fishes were acclimated to the camera array.

During video post-processing, fishes were classified to the lowest possible taxonomic level and counted. MaxN, defined as the maximum number of an individual species observed at any one frame of the video, was used for all analyses and comparisons (Priede et al., 1994; Langlois et al., 2012). This parameter provides a conservative estimate of the number of individuals of each species that were present. It is primarily used for stationary systems to account for possible recounting of fishes, which is likely to occur with the use of a centralized bait system (Kallayil et al., 2003). All four cameras from the stereo BRUV's were used to estimate MaxN, whereas only three (out of four) cameras from the Go-Pros® were used for this purpose. The downward-facing camera from the GoPro® was used for species identification, rather than for calculating MaxN.

Estimates of fork length (FL) were recorded when MaxN of an individual species was observed to eliminate repeated measurements of the same fish. Fishes were measured at the time of MaxN estimates, or at the next best opportunity.