MAPPING OF ARTIFICIAL REEF HABITATS BY SIDE SCAN SONAR AND ROV IN THE NORTHWESTERN MID-ATLANTIC COASTAL OCEAN

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Coastal artificial reef sites near Little Egg Inlet, New Jersey (39.472°N/074.198°W) were surveyed with side scan sonar and remotely operated vehicle (ROV). Digital side scan sonar L-3/Klein 3900 dual frequency (455/900 kHz) was used to collect geo-referenced sea floor swath data. Sonar swaths were processed and mosaic maps produced with Chesapeake Sonar Wiz 5 software. A Seabotix LBV-s-6 ROV equipped with a BlueView P-900, 130° field imaging sonar and video was used to investigate sonar mapped structures associated with habitat. Depth of mapped sites ranged from 15-25 m on the New Jersey Department of Environmental Protection's Little Egg reef site or adjacent shipwrecks. Reefed ships, barges, armored vehicles, reef balls and concrete castings were observed. Mapping allowed these sites to be followed for repeated observation. Characterization of the communities on these habitat structures has included habitat preference and productivity of black sea bass and tautog, which are of particular interest to the recreational fishery. Seasonal and year-to-year variation was seen in percent coverage and number of sessile attached invertebrates. Video capture and laser scaling allowed mobile species identification and size discrimination. Tautog appears to prefer larger structures while black sea bass generally were less discriminate. Tautog was observed throughout the end of the year (Dec.) while black sea bass exhibited a seasonal move off the reefs in late fall to deeper water.

Introduction

One of the main rationales for artificial reef development in New Jersey and throughout the country is to enhance sport fisheries. The goal of this project was to survey and map artificial reef habitats for the purpose of evaluation of reef functions. Surveys and mapping were undertaken using digital side scan sonar and a remotely operated vehicle (ROV) with sonar and video capability. Small, lower cost, observation class ROVs are revolutionizing access to important fishery habitats located between shallow near-shore zones easily accessible by scuba and deep water sites more suitable for working class ROVs (Pacunski *et al*., 2008). Many New Jersey artificial reefs (small tanks and workboats, concrete castings, reef balls) occupy these shallow-to-intermediate depths that limit scuba bottom time and are frequently of a scale not amenable to traditional line transects (i.e., discrete structures with organisms aggregating at different depth intervals). Accurate mapping of the distribution of organisms and habitat utilization will facilitate the assessment of artificial reefs of varying structure and the idea that they enhance local productivity.

Methods

Study Site

The site selected for this study is the Little Egg (LE) reef, a part of the New Jersey Department of Environmental Protection (NJDEP) Artificial Reef Program. This 8.4 km^2 reef is convenient to access from Stockton's Marine Science and Environmental field station (~7 km offshore), is relatively shallow (~15-20 m depth), and is well established with most structures added from 1996-2005. Structures on the reef include reef ball fields, concrete castings, armored vehicles, deck barges and the *Jessie C*, a 20-m crew boat.

Instrumentation

Stockton's 9-m vessel the R/V *Gannet* was used as a work platform to deploy Stockton's ROV (the ROV *Shearwater*) and other instruments including an L^3/Klein (Salem, NH) 3900 high resolution digital side scan sonar with 455 kHz and 900 kHz frequencies. The *Shearwater* is a Seabotix (San Diego, CA) LBVs[6], six thruster, tethered vehicle rated for 300 m (Fig. 1).

Figure 1. The ROV Shearwater, a Seabotix (San Diego) LBVs[6] remotely operated vehicle fitted with a Blueview (Seattle, WA) P900-130 2-D sonar on the lower tool skid and a Hach Hydromet (Loveland, CO) MS5 water quality sonde on the top tool skid.

The vehicle is equipped with two internal video cameras, color and low level black and white, paired red light scaling lasers, external lighting, a Blueview (Seattle, WA) P900-130 900 kHz 2-D imaging sonar, a Tritech (Aberdeenshire, UK) echosounder, a Tritech ultra-short baseline (USBL) tracking navigation system, a fixed position grabber claw and an integrated Hach (Loveland, CO) MS5 water quality sonde for dissolved oxygen, pH, temperature, depth, salinity and chlorophyll determination in flight. The ROV was operated using a Seabotix (San Diego, CA) integrated navigation console (INC) with navigation data, GPS positioning, echosounder and video captured and logged and saved to the computer hard drive with Tritech (Aberdeenshire, UK) Seanet Pro 2.1 software and ROV sonar viewed and recorded with Blueview (Seattle, WA) Proviewer 3.

Surveys

A side scan survey was initiated to characterize a section of the Little Egg reef of approximately 0.25 km^2. Side scan sonar data was collected with L^3/Klein (Salem, NH) SonarPro 12.0 and post-processed using Chesapeake Technologies (Mountain View, CA) Sonar Whiz 5.0. Seven 0.5 km x 80 m overlapping bottom swaths were collected at 455 kHz low frequency and mosaiced to produce a geo-referenced map (geo-Tiff) which was converted for use (KMZ format) in Google Earth (Mountain View, CA). Additional high frequency sonar swaths were collected (900 kHz) for better target visualization. ROV survey missions visited structures on the mapped sites over a two-year period to collect video transect data, seasonal data and size distributions of attached and mobile fauna. Where transects were not appropriate, point count methods (modified Bohnsack and Bannerot diver method; Bohnsack and Bannerot, 1986) were used to efficiently survey reef fishes and associated invertebrates outside, above and inside a given structure within a predetermined volume of water column (Patterson *et al*., 2009). This method generally involves constructing a virtual cylinder around a given habitat and pivoting the ROV at fixed locations to conduct fish counts. The actual diameter and shape of the cylinder may vary somewhat depending on the type of structure being sampled (i.e., tank versus reef ball versus casting) – regardless, this methodology allows one to quantitatively calculate fish abundance (which can then be compared with other sampling dates, sites, structures, etc.) A "tiered" approach with respect to the height of the ROV reduces the likelihood of "double counts" (as opposed to simply circling the structure with the unit or running multiple, line transects at a fixed depth). A laser scaling system was incorporated to collect fish length data or size information of the structure itself. Video analysis for counts and sizing used Media Cybernetics' Image Pro Plus v 6.3 (Rockville, MD) for frame capture and calibration of images to scaling points.

Results

Side scan swath data was used to create a geo-referenced bottom mosaic of the LE reef study site to accurately map the position of bottom structures of interest to the survey (Fig. 2). Geo-referenced video was collected during a number of missions to the reef site structures. In general, the low light level black and white video camera was utilized as particles in the water and water color made the color video camera useful only at extreme close-up range and with external lighting. A "proof of concept" inventory using a modified version of the Patterson *et al*. (2009) technique (two tiers only) was conducted on an M578 armored recovery vehicle on the LE reef (Fig. 3). In this instance, the ROV Shearwater was initially flown ~1 m above the seafloor and pivoted ~180 degrees to survey fishes in and around the tank's running gear. A second segment was recorded ~1 m above the turret to capture individuals aggregating further away from the structure in the water column. This survey captured high quality video that was later quantified frame-by-frame in the laboratory (Fig. 3). A more traditional ROV transect survey was conducted at Southwick's Barge on the LE reef because of the flat, elongated nature of the structure (Fig. 4). In this case, average frequency of occurrence was calculated over three discrete digital video intervals. Both techniques proved to be minimally invasive and allowed for multiple, rapid, cost-effective surveys throughout the sampling season, in some cases capturing multiple life stages of a given species, i.e., juvenile, male and female adults (Fig. 5). With respect to the armored recovery vehicle, tautog (above turret) and cunner (alongside running gear) showed clear preferences for different regions of the overall structure (Fig. 3). The armored recovery vehicle generally harbored more attached organisms than Southwick's Barge and displayed a higher concentration of fish as well. Point counts were also made at reef ball sites and other structures including a large crew boat, the *Jessie C*, within the LE reef system. Reef balls, in general, were highly variable in terms of attached epifauna and fish diversity (tautog, black sea bass, cunner, etc.) and site, seasonal and annual variation in standing biomass of epifauna, particularly blue mussels, was noted at several sites (Fig. 6). Laser scaling from video frame capture allowed size and year class determination of mobile fauna (Fig. 7).

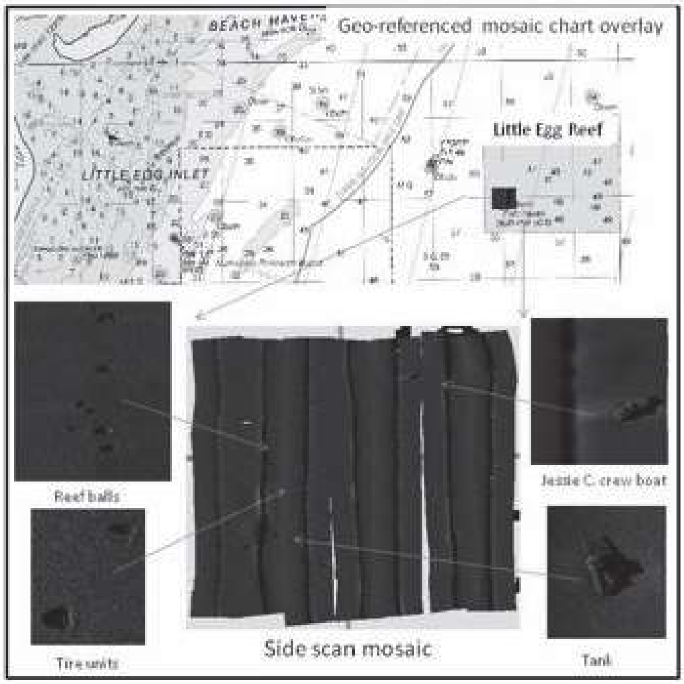

Figure 2. Geo-referenced map and chart overlay (NOAA Chart 12323) of the Little Egg (LE) reef study site off of southern New Jersey, USA, produced from a mosaic of 455 kHz side scan survey bottom swaths. Side photos show higher detail of reef structures.

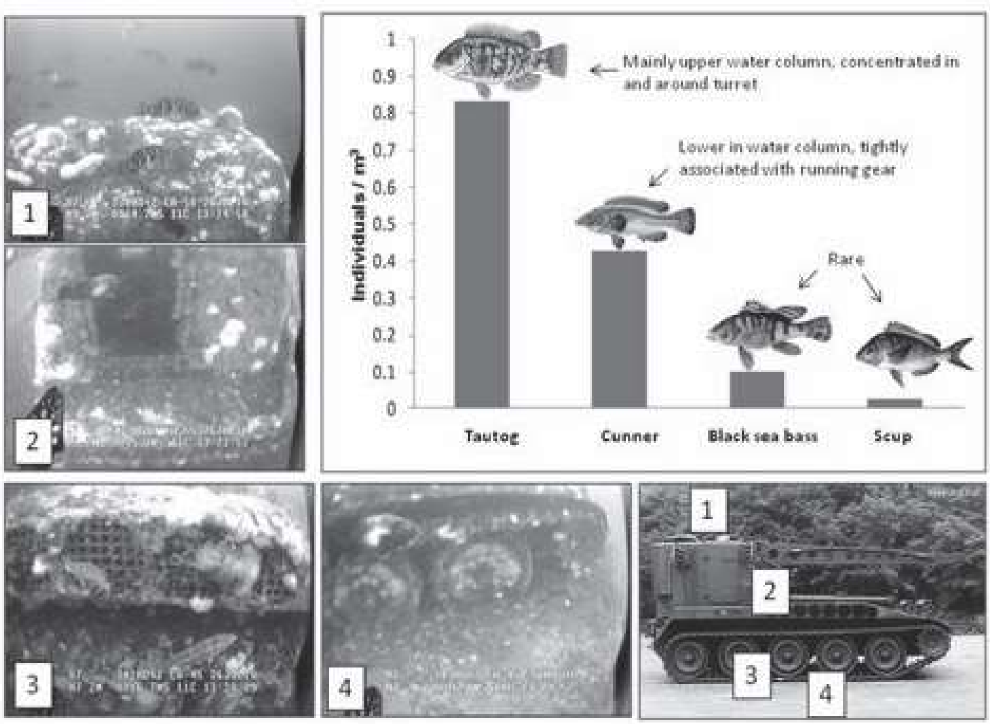

Figure 3. Results of M578 armored recovery vehicle survey with ROV Shearwater (Little Egg Artificial Reef) for four common reef species using a tiered approach and counts made in a modified "cylinder" transect. Numbered "habitat" boxes refer to details on pre-submerged armored vehicle image at lower right.

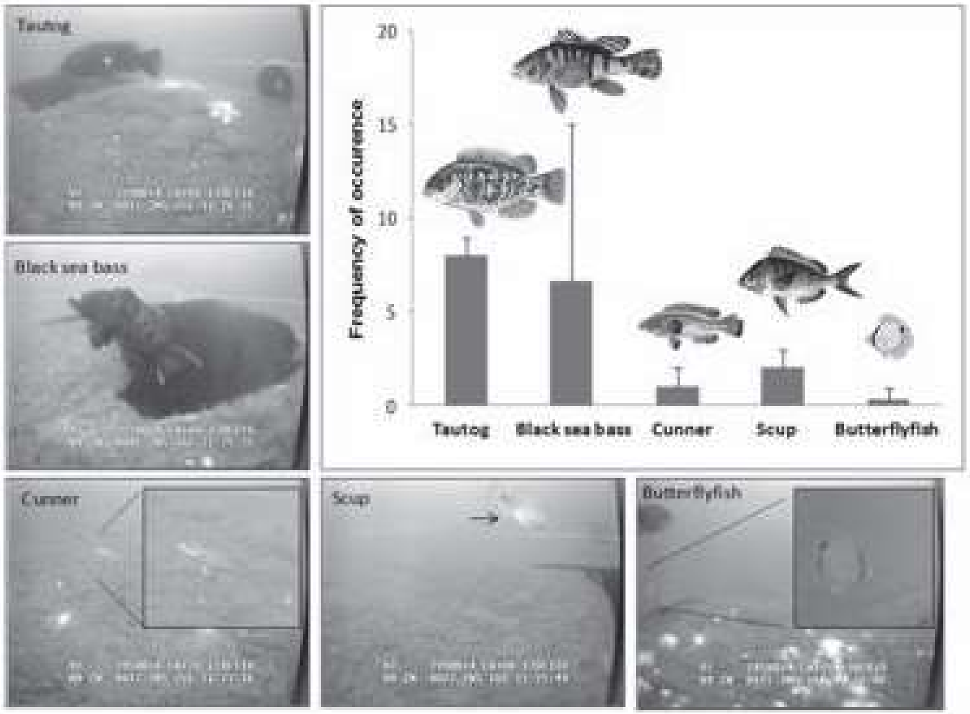

Figure 4. Results of Southwick's Barge traditional transect survey with the ROV Shearwater (Little Egg Artificial Reef). Digital video stills of each species are shown for reference purposes.

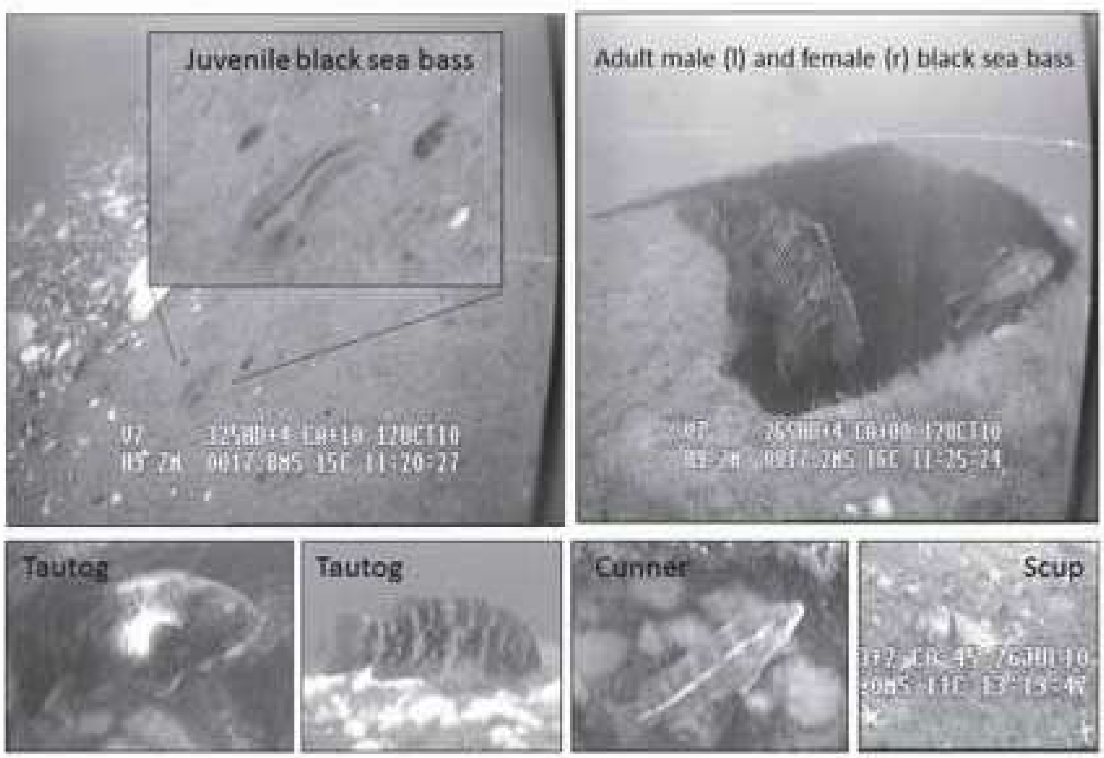

Figure 5. Top (left to right): Multiple life stages of black sea bass (*Centropristis striata*), imaged by the ROV Shearwater during Southwick's Barge and M578 armored recovery vehicle surveys, Little Egg Artificial Reef.

Figure 6. Top: video capture of the bow of the *Jessie C*, a 20 m reefed crew boat. Note the annual variation in attached organism cover. Bottom: video capture of reef balls from different sites and years. Note association of mobile fauna with high biomass of attached organisms. Note scaling laser is an older version and is 28 cm.

Figure 7. Video capture and laser scaling (30 mm) of grey triggerfish (*Balistes capriscus*) on the *Jessie C* site of the LE reef.

Discussion

Utilization of geo-referenced, digital side scan sonar mapping of the underwater sites allowed for precise location of structures and repeated observation over a number of seasons and years. Catch and effort surveys among fishers and experimental colonization studies have done much to define the increase in standing stocks of artificial reefs (Figley, 2003) but productivity determinants are more difficult to measure given seasonal and annual variability (Powers et al., 2003). Diver observation, while valuable, has the potential bias of disturbance of the observed fauna, in particular by bubbles of open circuit scuba and is limited by diver available gas supply and bottom time. However, small observation class ROVs have the potential to overcome some of the limitations of divers in an economic and scientifically valid manner. Direct observation and data collection in a non-intrusive manner by ROV has the potential to detect linkages among fine scale processes such as reef utilization throughout different life history stages, feeding and behavior of mobile fauna, territoriality, and predator prey interactions that otherwise might be missed. This would contribute greatly to the current goals of ecosystem based management in fisheries (Latour et al., 2003) and to the definition of Essential Fish Habitat (EFH) and Habitat Areas of Particular Concern (HAPC), (NOAA, 1996) particularly for black sea bass (Drohan et al., 2007) and tautog (Steimle and Shaheen, 1999).

Acknowledgements

Funding for this project was from the National Science Foundation, Major Research Instrumentation Program: DBI-0959426 and from the New Jersey Sea Grant Consortium with funds from the National Oceanic & Atmospheric Administration, Office of Sea Grant, US Department of Commerce NOAA-NA060AR4170086 (Publication# NJSG-13-843). Thanks to undergraduate students P. Madamba, A.J. Mottola, B. Gordon, A. Pacicco, J. Schlechtweg, M. Schubart and M. Berezin. Thanks also to E. Zimmermann and N. Robinson for vessel and ROV operations assistance.

References

Bohnsack, J.A., and S.P. Bannerot. 1986. A stationary visual census technique for quantitatively assessing community structure of coral reef fishes. *NOAA Technical Report*. 18 pp.

Drohan, A.F., J.P. Manderson, and D.B. Packer. 2007. Essential Fish Habitat Source Document: Black sea bass, *Centropristis striata*, life history and habitat characteristics (second edition). *NOAA Technical Memorandum* NMFS-NE-200.

Figley, W., 2003. Marine life colonization of experimental reef habitat in temperate ocean waters of New Jersey. New Jersey Department Environmental Protection, Division of Fish & Wildlife, Bureau of Marine Fisheries. 96 pp.

Latour, R.J., M.J. Brush, and C.F Bonzek. 2003. Toward ecosystem-based fisheries management. *Fisheries,* **28(9):** 10-22.

NOAA (National Oceanic and Atmospheric Administration). 1996. Sustainable Fisheries Act: Amendment to the Magnuson-Stevens Fishery Management and Conservation Act. 16 U.S.C. 1801.

Pacunski, R.E., W.A. Palsson, H.G. Greene, and D. Gunderson. 2008. Conducting visual surveys with a small ROV in shallow water. In: *Marine Habitat Mapping Technology for Alaska*. pp. 109-128. Alaska Sea Grant College Program. Fairbanks: University of Alaska.

Patterson, W.F., M.A. Dance, and D.T. Addis. 2009. Development of a remotely operated vehicle based methodology to estimate fish community structure at artificial reef sites in the Northern Gulf of Mexico. Pp. 263-270. *Proceedings of the 61st Gulf and Caribbean Fisheries Institute*. Fort Pierce: Gulf and Caribbean Fisheries Institute, Inc.

Powers S.P., J.H. Grabowski, C.H. Peterson, and W.J. Lindberg. 2003. Estimating enhancement of fish production by offshore artificial reefs: uncertainty exhibited by divergent scenarios. *Marine Ecology Progress Series,* **264:** 265-277.

Steimle, F.W., and P.A. Shaheen. 1999. Tautog (*Tautoga onitis*) Life History and Habitat Requirements. *NOAA Technical Memorandum* NMFS NE 118. Washington, DC: U.S. Department of Commerce. 23 p.