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ACOUSTIC MAPPING AND GIS AIDED OYSTER RESTORATION

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INTRODUCTION

The name Chesapeake is derived from the native Powhatan word “chesepiooc” translated as “Great Shellfish Bays”. Over the past 150 years, over harvesting, disease, and pollution contributed to the momentous decline in abundance of the native Eastern Oyster, *Crassostrea virginica.* Funding for native oyster restoration directed through the NOAA Chesapeake Bay Office (NCBO) has increased 300 fold since 1995. As funding has increased, so have the resources employed to ensure the highest probability for successful restoration projects. The NCBO Habitat and Characterization Mapping Program (HCMP) is partnering with private, public, and academic restoration interests to provide acoustic characterizations of bay seafloor for assessing the quality of substrate for restoration, enhancing oyster bar monitoring activities, and supporting bay-wide integrated assessment of living resources and their interrelationship with benthic habitat features. Mapping projects supporting the restoration of *C. virginica* have centered on the Chester River on the eastern shore of Maryland. The integration of acoustic data collected as bathymetry, side scan sonar imagery, and rugosity measurements results in the delineation of the seafloor into zones of similar geologic characteristics. The delineation of seafloor at higher resolution than was previously available has enabled restoration managers to more precisely place and locate resources lending to improvements in oyster survivability and monitoring efficiency and techniques. As the HCMP continues to support native oyster restoration in both Maryland and Virginia, a catalog of targeted tributary assessments will grow, ultimately contributing to the more holistic and comprehensive assessment of the entire Chesepiooc.

BACKGROUND

In 1994, the Oyster Recovery Partnership formed to accomplish the goals incorporated in the 1993 Maryland Oyster Roundtable Action Plan generated to address the sharp decline in *C. virginica*. The Chesapeake Bay Office was approached by the Oyster Recovery Partnership (ORP) in 2004 to provide technical mapping support to their native oyster restoration program. The ORP identified three oyster restoration activities for evaluation and support. These activities included resource planting vessel tracking, locating and delineation of completed projects as well as existing oyster bottom for future restoration site selection, and the characterization of that bottom to enhance monitoring and population assessments. Although oyster restoration activities have taken place through-out the bay, the ORP has focused a large proportion of their efforts in two river systems. The Chester and Choptank Rivers are two mesohaline systems in the central eastern shore of Maryland. Historic oyster bars exist in large numbers in both these rivers, however gaining access to these or any public oyster bottom in either Maryland or Virginia is a delicate partnership entered into with the local watermen. The watermen of the Chester and Choptank have agreed to let oyster restoration take place by closing areas to traditional harvest and opening bottom for restoration activities. This paper discusses the three restoration activities evaluations and actions.

VESSEL TRACKING/POSITIONING

The backbone of any mapping project is the positioning of data relative to a defined geodetic system. Acoustic mapping relies on accurate and frequent positioning of vessels. A frequent problem for the ORP post restoration planting was the inability of research divers to locate the planted shell in extremely low visibility conditions. Corner coordinates were produced to delineate the project boundary however, the planting vessel neither was recording and therefore transferring its trackline data nor was the software present to process and report on the project. During a planting (Figure 1), NCBO observed how little of the bottom was actually covered within the given corner coordinates. Therefore ORP, with the support of NCBO, integrated data acquisition software on its planting vessel to provide real time vessel tracking with Differential Global Positioning System (DGPS) positions (Figure 2). A process was created that allowed the near real-time reporting (Figure 3) of project status as well as the ability to adapt on the fly if conditions required deviating from the plan. This action alone has saved time and effort for post-restoration dive monitoring but has not provided managers and scientist with a clear picture of the restoration on the seafloor.

Figure 1. Oyster planting vessel

Figure 2. Data acquisition station

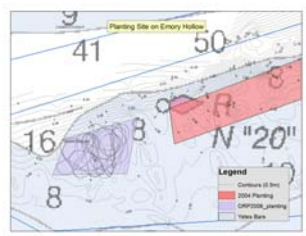

Figure 3. Post planting report

SITE LOCATING AND SELECTION METHODS

The NCBO Habitat Characterization and Mapping Program team was approached by our partner at the Oyster Recovery Partnership to survey the East Neck Bay oyster bar at the mouth of the Chester River to identify the most suitable bottom for a spat on shell planting. This restoration site would be designated as a sanctuary protecting the planting from future harvest. Charted soundings provided little in the way of bathymetric features to approach the survey and so additional data was needed. We downloaded the bathymetric dataset used to compile the chart and were able to establish the extents of a prominent shoal that cut across the historic bar boundary. With the survey area determined, the team set out to collect side scan sonar data to provide the high resolution two-dimensional imagery over the area. A side scan sonar emits a time series sound pulse across two channels, one port and one starboard of the towfish. The intensity of the return signal is captured with the receive array of each transducer. The image displays that time series of intensities across a grey-scale spectrum. For this image, the high intensity returns, darker imagery, depicts either hard or coarse sediment bottom. Low intensity returns, lighter imagery, correspond to either soft or fine sediment bottom. The imagery yielded promising data that potentially identified a hard, shell bottom (Figure 4). Following the side scan survey, we conducted the bathymetric survey across the shoal to better define the morphology of the feature as well as acoustically class the types of bottom. The bathymetry data was collected with a single beam echosounder emitting sonar pulses across a 200 kHz transducer. The return signal is split between the echosounder and an acoustic seabed classification system (ASCS). The echosounder processes the signal and transfers the resultant sounding to the acquisition software where it is integrated with position data according to time. The ASCS catalogs the return signal by echo waveform and integrates position data into the data stream. Post processing of each data stream yields attributed text files of position data that are modeled in a GIS. Three dimensional bathymetric models permit high resolution imagery to be draped over the surface providing a valuable interpretive tool. The GIS takes the interpolated point data of seabed class and produces a raster feature class of bottom type for analysis (Figure 5). Through the combined analysis of side scan imagery, bathymetric modeling and seabed classification, the team identified the bottom substrate most suitable for the restoration site (Figure 6). The high point provides refuge from all but the most severe anoxic conditions. The shell bottom provides evidence that this area is less susceptible to sedimentation and documents a historic precedence for oyster survivability.

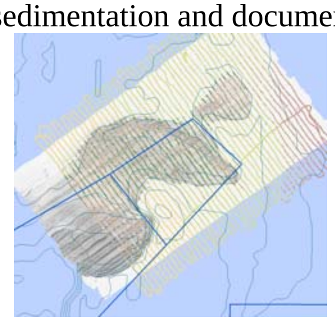

Figure 4. Side scan imagery

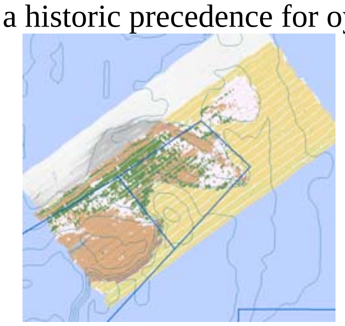

Figure 5. Seabed class data

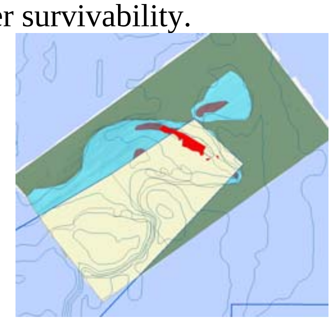

Figure 6. GIS Analysis for suitable bottom

OYSTER MONITORING SUPPORT METHODS

A fundamental aspect of habitat mapping is the verification of remotely sensed data. As an ORP partner, The University of Maryland Marine Estuarine Environmental Science (MEES) program Paynter Lab is responsible for monitoring an increasing number of restoration sites around the Maryland Chesapeake Bay. The lab approached NCBO HCMP to ask whether acoustic mapping could assist their monitoring program by being able to identify oyster bottom that included shell, lightly sedimented shell, and heavily sedimented shell from the rest of the bay bottom habitat. An approximately three mile reach of the Chester River encompassing six historic oyster bars was selected for the project. During the summer and fall of 2006, the HCMP collected high resolution side scan sonar imagery; sub-bottom profile, bathymetric, acoustic seabed and video transect data across this reach of the Chester River. The single beam acoustic class data was selected as the initial layer for answering the lab's question. The processing software conducts a Principle Components Analysis (PCA) of the edited waveforms and through a clustering routine provides the user the opportunity to select the number of classes to display. We selected six classes with the goal of correlating the predominant physical components of river bottom to each class. This dataset was interpolated into a grid to generate a raster polygon feature class of the six classes (Figure 7). Using this feature class, ten points were selected per class inside the historic oyster bar boundaries up to a depth of 25 feet to dive on. During the fall, the lab divers described the bottom within a 1-meter quadrat around each of these points using the attributes of depth of sediment penetration, primary, secondary and tertiary components of the bottom. The primary bottom descriptions used included shell hash, half shell, sand, mud, and silt (Figure 8).

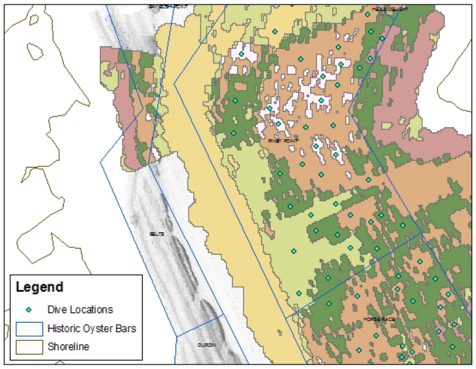

Figure 7. Interpolated acoustic class polygons

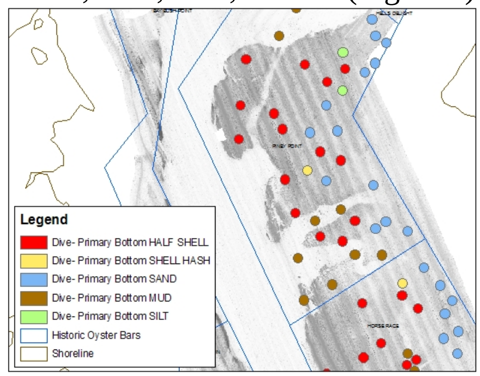

Figure 8. Diver bottom descriptions on side scan imagery

OYSTER MONITORING SUPPORT ANALYSIS

The single beam acoustic bottom classes were evaluated first with the primary bottom descriptions from the dives. The initial analysis supported general trends across the fine sediment classes and the very coarse shell bottom. However, the sample scales for acoustic data and diver descriptions differed greatly with respect to the variability of the oyster bottom between the coarse shell and sand ranges. Furthermore, forcing bottom descriptions into discrete categories is problematic as nature rarely provides such distinct facies change. We conducted additional GIS analyses across the matrix of available data layers. The side scan sonar imagery, multiple iterations of the single beam acoustic class data and side scan acoustic classes derived in a similar manner were each referenced against the diver descriptions for primary bottom type and depth of sediment penetration, and the video transect data. The most frequent method of analyzing the point dive data against the acoustic class data was to clip points from acoustic classes within a specific buffer around each dive location. Frequency histograms of classes provided one method of determining whether a good correlation existed for a given description. It became apparent that within the context of each analysis, strong correlations could be made for some classes but not all the classes. The next step was to create additional classes of diver descriptions by combining primary bottom types with depth of sediment penetrations and primary bottom types with secondary bottom types. This resulted in more bottom descriptions than there were acoustic classes available for comparison, often with points overlapping from the combinations. As well, correlations could be drawn between these combinations and the acoustic classes, some stronger than others. Regardless of the number of combinations for analysis, variations across the acoustic class data persisted. One conclusion that can be drawn is that with each additional level of analysis, we looked more closely than the previous. What did not change was the fact that the acoustic classification system was forcing a narrow band of classifications across an extremely variable bottom. Evaluating the video transects across acoustic facies change revealed similar findings to the bottom descriptions. These findings continued to show obvious correlations with some classes and less obvious correlations to others. With each finding the conclusions that: sampling scale plays a part in data correlation and adjustments to the automated method of cataloguing acoustic classes need to be made, were strengthened. We followed this path to manually adjust acoustic class data, splitting acoustically similar classes, not necessarily where the automated routine did, but where through ground truth data we determined the seafloor to be geologically different. The most notable geologic variations occurred on the oyster bars in areas where shell exists in a variety of conditions: whole oysters, half shells, fragmented shell, and shell gravel with a combination of shell to sand and silt ratios. Against this manually adjusted class data, acoustic facies shifted slightly in some areas and changed the classification of the bottom in others. The correlations of the newly classed bottom against the dive descriptions of primary bottom were stronger, but not perfect.

CONCLUSIONS

There is no “silver bullet” software package for developing an acoustic habitat map. Evaluating a single data layer can be beneficial to the pursuit of developing such a scheme; however, it is the combined analysis of multiple acoustic source data that is the preferred method for drawing such a map. This data and these techniques are currently being used to enhance monitoring of native oyster restoration sites and will be included in the redevelopment of native oyster population assessments surveys across the state.

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