SUBTIDAL SURVEY FOR THE PRESENCE OF OYSTER REEFS IN PORTIONS OF RARITAN BAY, ARTHUR KILL, AND THE HACKENSACK RIVER OF THE HUDSON RIVER ESTUARY

A Final Report of the Tibor T. Polgar Fellowship Program

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Bugenhagen, E. and T. Medley. 2016. Subtidal Survey for the Presence of Oyster Reefs in Portions of Raritan Bay, Arthur Kill, and the Hackensack River of the Hudson River Estuary. Section III: 1- 23 pp. *In* S.H. Fernald, D.J. Yozzo and H. Andreyko (eds.), Final Reports of the Tibor T. Polgar Fellowship Program, 2014. Hudson River Foundation.

ABSTRACT

Eastern oyster (*Crassostrea virginica*) reefs historically occurred throughout the lower Hudson River Estuary (HRE). As a result of anthropogenic pollution and overharvesting during the early 1900s, oyster reefs in the HRE suffered and the population has not yet recovered. Currently, small populations of intertidal oysters have been documented to exist in the HRE. Their presence in the intertidal zone leads to the hypothesis that oysters may also occur in subtidal areas. The goal of this project was to locate subtidal oyster reefs that may exist naturally in the estuary. The study area was focused on the Arthur Kill into western Raritan Bay and northward into the lower Hackensack River. The subtidal survey was conducted by examining the seafloor using a Klein 3900 dual frequency side scan sonar to delineate areas of hard bottom which could be characterized as a subtidal reef or an area that could support an oyster population. Areas of interest were then further investigated using a Video Ray Pro 4 remote operated vehicle to visually determine and characterize the bottom habitat. All data was imported into ArcGIS to visually depict the data. A living subtidal oyster reef was not identified in the study area by means of the underwater methods used; however locations with hard bottom that may support an oyster reef were identified. As part of a shoreline survey of intertidal oysters, single oysters were found on the shores of South Amboy (Raritan Bay), Perth Amboy (Arthur Kill) and Secaucus (Hackensack River). Outside of the study area, a subtidal reef partially exposed during low tide was identified in the East River.

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INTRODUCTION

Eastern oyster (*Crassostrea virginica*) reefs historically occurred throughout the lower Hudson River Estuary (HRE). Historical maps indicate that oyster beds still existed in Jamaica Bay, Raritan Bay, Newark Bay, Upper New York Bay and parts of the Arthur Kill and East River as late as c. 1910 (Metropolitan Sewerage Commission 1912). The New York oyster fishery declined and then ended by the 1930s because of sewage and industrial contamination reducing oyster stocks and rendering the consumption of the remaining oysters detrimental to human health. The current extent of remnant oyster populations in the HRE is poorly documented.

Oysters serve as positive ecosystem engineers and as biological indicators of ecosystem health. Oysters and oyster reefs contribute both biologically and physically to the estuarine ecosystem. Oyster reefs develop as multiple generations settle one upon another and the resulting vertical structure can protect shorelines from wave action. These reefs also provide an important habitat for fish, invertebrates, and macroalgae throughout their distribution (Lenihan and Peterson 1998). These benefits along with their filtering capacity warrant the restoration of oysters to estuaries. In areas like the Chesapeake Bay and Delaware Bay, the maintenance and restoration of oyster reefs is also critical to a commercial fishery. For the HRE, interest in the restoration of oysters is due to their biological importance as filter feeders and for their potential role in protecting shorelines during storm events, as well as their role in maintaining biodiversity within the estuary.

The goal of this study was to locate subtidal oyster reefs that may exist naturally in the estuary. Previous work has identified small populations of living intertidal oysters

in the lower Hackensack River, East River and Hudson River (Medley 2010). Their presence in these intertidal zones suggests that subtidal reefs may exist. It is known that the shell remains of historic oyster reefs still exist buried under sediment. Geophysical mapping conducted on the Hudson River bottom in a five-mile stretch north of the Tappan Zee Bridge imaged oyster beds covering 30% of the river bottom (Carbotte et al. 2004). Live, young oysters were reported to be occasionally recovered during sampling of these fossil oyster beds (Carbotte et al. 2004). More recently, in this same location, an estimated 200,000 oysters were discovered during the analysis of the impact of dredging for the replacement of the Tappan Zee Bridge (Risinit 2013). The Meadowlands Environmental Research Institute also identified five locations in the lower Hackensack River where subtidal oysters were captured during a fish survey (Bragin et al. 2005).

The U.S. Army Corps of Engineers and the Port Authority of NY/NJ has developed the Hudson-Raritan Estuary Comprehensive Restoration Plan (CRP) in conjunction with the New York New Jersey Harbor Estuary Program (USACE et al. 2009). This plan develops guidelines for ecosystem restoration within the estuary, to be utilized by organizations associated with the HRE. One of the eleven Target Ecosystem Characteristics in this plan is to establish oyster reefs. Local organizations such as the Hudson River Foundation and the NY/NJ Baykeeper have undertaken oyster restoration projects to attempt to reestablish this species. Permitting for these restoration projects has been limited by the New York Department of Environmental Conservation and New Jersey Department of Environmental Protection due to health concerns with potential consumption of oysters illegally harvested from restricted waters and the costs of policing

illegal harvesting and monitoring restoration projects. The potential negative impact that the illegal poaching of oysters in contaminated waters could have on the reputation of the otherwise harvestable New Jersey shellfish has led to a ban of oyster gardening and restoration projects in New Jersey waters designated as contaminated (NJDEP 2010). Therefore, reestablishment of the eastern oyster in the HRE may benefit from research focused on the habitat of existing wild oyster populations and the identification of available habitat that can support oyster settlement and future recruitment.

This study examined the benthos of the lower HRE to locate and visualize subtidal oyster populations, and provide insight into restoration efforts of this important species. Side scan sonar was used to survey the study area, as it was the simplest and most efficient method of surveying the study site.

METHODS

Study Area

The subtidal survey area included the entire stretch of the Arthur Kill from Raritan Bay to Newark Bay and the lower Hackensack River. The presence of intertidal oysters suggests that subtidal reefs may also exist in the Hudson River and East River, but the study area was limited due to the restricted time frame and funding of this research project. Dredged channels are present within the interior portions of the study area and were therefore excluded from the analysis.

Intertidal Survey

An intertidal survey of the HRE was conducted to reconfirm the presence of oysters existing in the intertidal zone of previous areas identified in 2006 and 2007 (Medley 2010) and additional intertidal areas surrounding the present subtidal study area. Sampling dates coordinated with spring tides when the lowest water levels would be expected. Exposed shorelines were walked approximately from one hour before low tide until one hour after low tide. In compliance with restrictions listed in collection permits from the New York City Department of Parks and Recreation (NYCDPR), one oyster was collected per every ten oysters found on NYCDPR properties along the East River. For areas on the New Jersey side of the HRE, no such permit restriction existed and all oysters found were collected.

Subtidal Survey

The subtidal side scan sonar survey was conducted over three sampling periods, beginning on 6/4/2014 in the Hackensack River near Laurel Hill County Park, Secaucus, NJ and continuing down the Hackensack River into Newark Bay. The survey continued in Raritan Bay and the lower Arthur Kill on 7/10/2014. On 7/31/14, a final effort was made to further delineate Raritan Bay and return to areas of interest within the Arthur Kill. The Urban Coast Institute of Monmouth University's 27 foot, *R/V Seahawk* was utilized as the research platform for conducting the subtidal survey. Data was collected using a Klein 3900 dual frequency side scan sonar towfish deployed approximately 2 meters below the vessel. A 30m coverage range was set to either side of the vessel, with a depth of 3-30m. Vessel speed and position were monitored using GPS, with a constant

speed of 4-6 knots during sampling to maintain uniformity. Qualitative substrate samples were collected with a petite Ponar grab sampler at areas of interest on hard and soft substrate throughout the study area to confirm bottom type. Sonar records were reviewed using Sonarwiz software, developed by Chesapeake Technology and used to locate areas of interest to further investigate using a remote operated vehicle (ROV) or a Splashcam drop camera. Sonar records were integrated into ArcGIS 10.1 in order to visualize benthic habitat differences.

Bottom types were characterized by the substrate that was found during grab sampling, as well as analyzing sonar and video records. Hard substrate such as rocks and scattered shell was classified as Hard Bottom/Scattered Shell. Soft substrate such as sand or mud was classified as Soft Bottom; these areas would not support a subtidal oyster population. Dredged areas were marked as Channeled, as these areas would be regularly disturbed. Areas that were scanned, but were not of interest for video analysis or grab sampling were designated as Searched/Unclassified.

Figure 1. Intertidal locations where oysters can be found in the Hudson River Estuary.

RESULTS

The intertidal survey re-confirmed the existence of oysters in the previously identified areas of the Hackensack River (HK), Macneil Park (MN), Soundview Park (SV) along the East River, Orchard Beach Lagoon (OB) in western Long Island Sound and the Hudson River at Alpine, NJ (AP) as shown in Figure 1. In addition to these areas, oysters were found in the East River at Castle Hill Park (CH), Bronx, NY, Little Bay Park (LB), Queens, NY, Raritan Bay Riverfront Park in South Amboy (SA) and the Perth Amboy waterfront (PA) in New Jersey (Figure 1). Specifically, four living oysters were found in the Hackensack River location, one at Raritan Bay Riverfront Park and one at the Perth Amboy waterfront. In addition to these living oysters, several recently dead oysters, indicated by both valves remaining attached, were also found at HK, SA and PA. All areas of the East River, with the exception of Little Bay Park, yielded a high abundance of oysters (50+) during each survey event.

Intertidal oysters were found attached to small rocks, other living oysters and bivalves or remaining shells of such. At Soundview Park (SP) and Castle Hill (CH), they were also found attached to tires and other debris. Oysters were collected at NYCDPR properties in the East River by taking one oyster per every ten found. The overall abundance of oysters in these locations was estimated to be, at a minimum, the number of oysters collected multiplied by ten; however, the actual abundance of oysters is likely much greater in these locations since the goal at the time of collection was to collect no more than 50 oysters during each survey event. The CH location particularly contained a visual abundance of oysters that could be seen both exposed in the intertidal zone and submerged in the subtidal zone (Figure 2).

Figure 2. Portions of a subtidal reef exposed at Castle Hill Park, Bronx NY

Table 1. Intertidal Survey Locations and Number of Oysters collected in the Hudson River Estuary.

Location	Oysters Collected	Date Sampled	Coordinates
Hackensack River, NJ (HK)	4	5/23/2014	40°45'47" N, -74°05'13"W
Raritan Bay Waterfront Park, NJ (SA)	1	5/27/2014	40°28'46" N, -74°16'05"W
Perth Amboy, NJ (PA)	1	6/12/2014	40°30'36" N, -74°15'39"W
Soundview Park, NY (SV)	55	6/16/2014	40°48'35" N, -73°51'46"W
Orchard Beach Lagoon, NY (OB)	65	6/16/2014	40°52'03" N, -73°48'03"W
Alpine, NJ (AP)	21	6/19/2014	40°56'54" N, -73°55'06"W
Macneil Park, NY (MN)	64	7/15/2014	40°47'39" N, -73°51'06"W
Little Bay Park, NY (LB)	32	7/15/2014	40°47'23" N, -73°47'29"W
Castle Hill Park, NY (CH)	91	7/15/2014	40°48'44" N, -73°50'54"W

The subtidal survey did not locate a subtidal oyster reef. Figure 2 shows areas of hard bottom with scattered shell along the western Staten Island shoreline. Video validation in this area depicted scattered oyster shell. Some appeared as entire valves with the potential of being a living oyster, but no oysters were collected by ponar grab sampling. Areas immediately adjacent to SA also consisted of scattered shell, but on a softer bottom. The area immediately adjacent to PA was viewed and showed no evidence of hard substrate or shell.

The subtidal scan in the upper part of the study area did not locate an area of interest to investigate further using video validation (Figure 3). Large rocks could be seen along the eastern

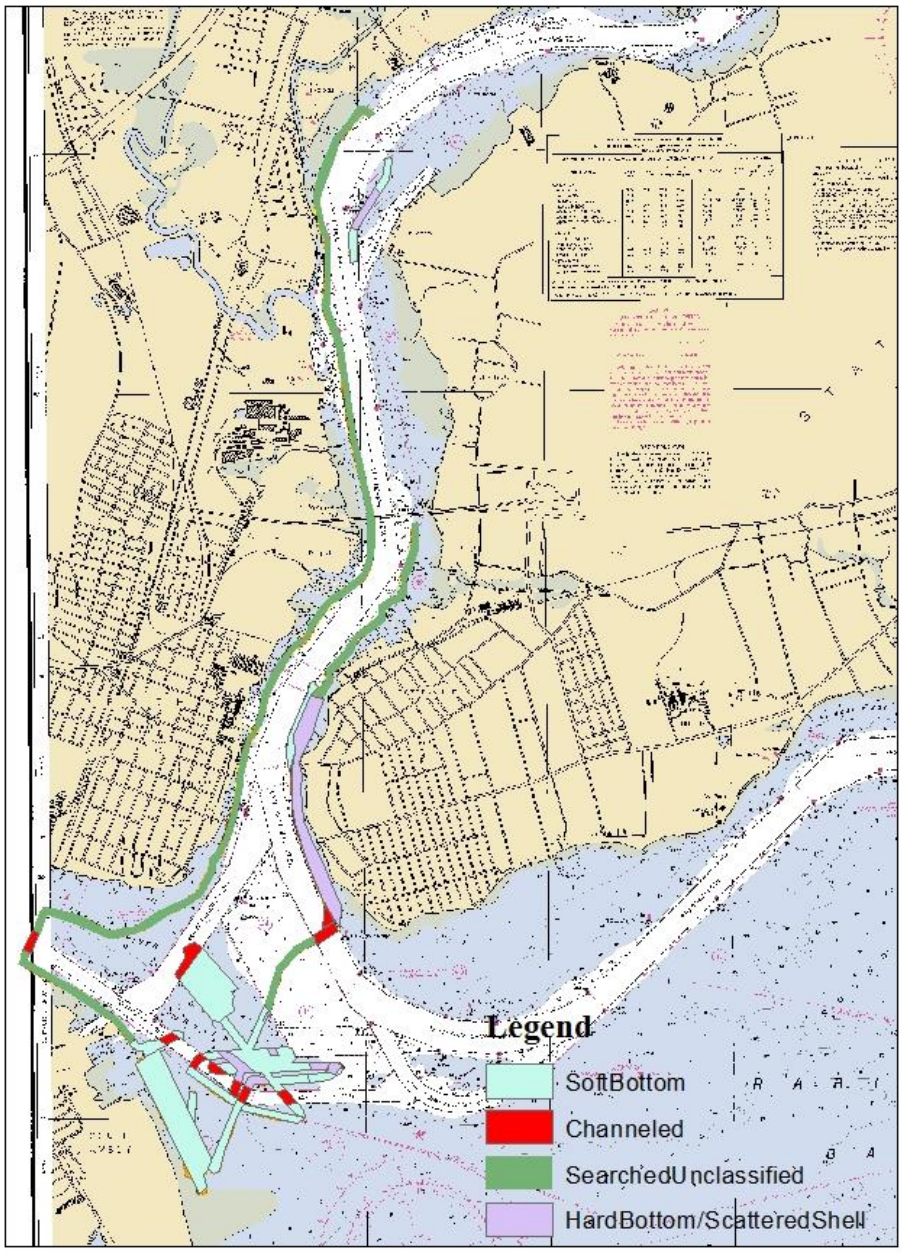

Figure 3. Side scan sonar survey area and delineated bottom types of western Raritan Bay and the Arthur Kill

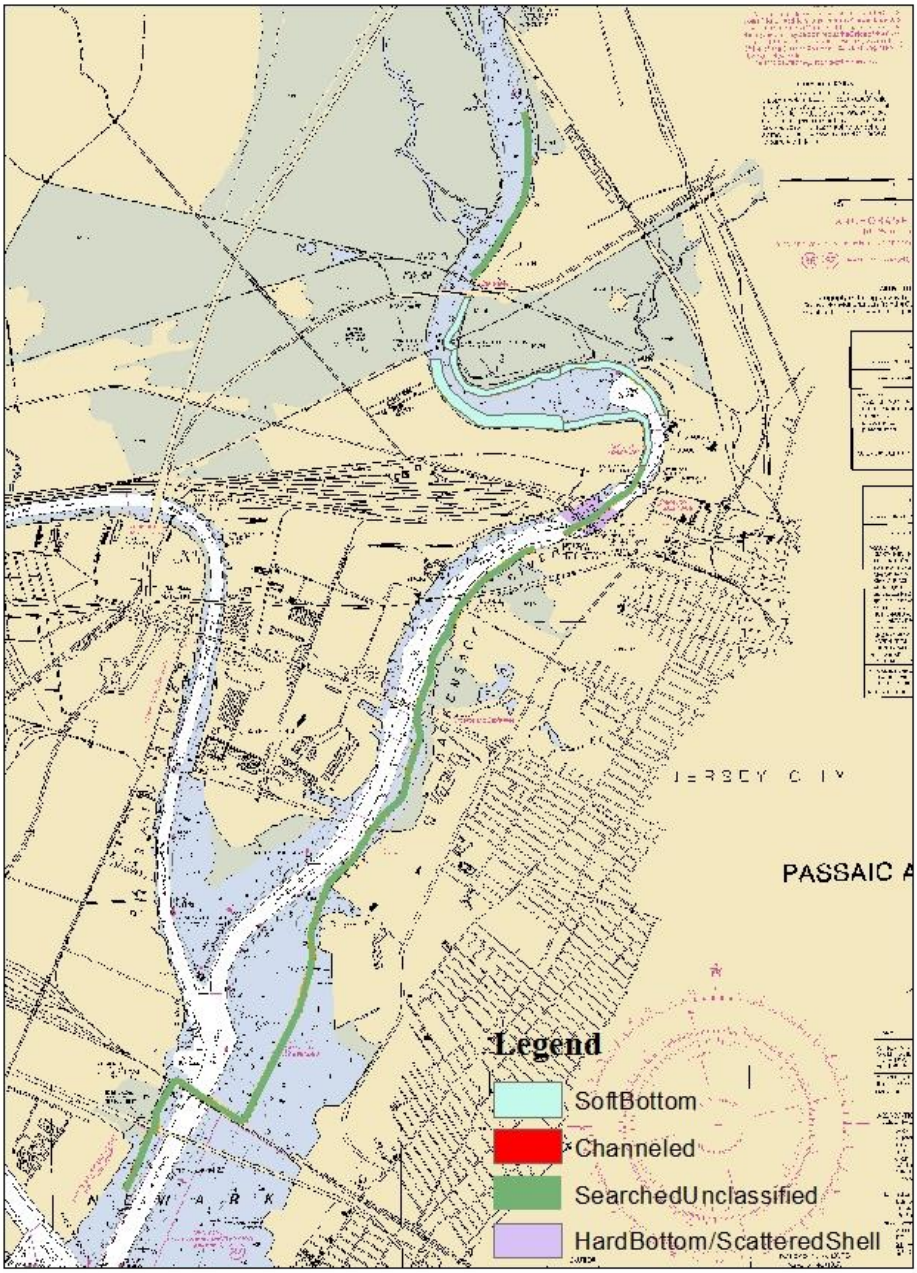

Figure 4. Side scan sonar area and delineated bottom types of the Hackensack River and Newark Bay

Hackensack River shoreline and parts of Newark Bay, but the subtidal substrate in these areas consisted mostly of soft bottom and debris.

Table 2. Subtidal Bottom Type Spatial Data

Bottom Types	Area surveyed (m^2)	% of Survey
Channeled	98866	3.85
HardBottom/ScatteredShell	243928	9.50
Soft Bottom	1036007	40.35
Searched/Unclassified	1189036	46.30

DISCUSSION

The Eastern oyster can be found in both the intertidal and subtidal zones of estuaries along the East Coast of the United States. At the latitude of the HRE, intertidal areas are not ideal for oyster survival due to mortality associated with ice exposure during the winter, so it was expected that the general abundance would be low and individual oysters were more likely to be found instead of intertidal reefs along the shorelines. The identified intertidal locations are geographically separated throughout the estuary which indicates that oyster larvae are present and are distributed to settling sites via tides and currents.

The one living intertidal oyster found in Raritan Bay was large (117.5 mm H x79.6 mm L) and round in shape which indicates that it grew singly on a hard bottom. The discovery of this oyster, along with another living oyster and several recently dead

oysters in the SA and PA locations, suggested that a potential reef could be found in the upper portion of Raritan Bay and the subtidal survey was expanded to include this area. This portion of the HRE is where a mile long oyster bed known as "The Great Beds" once existed (MacKenzie 1990). However, although scattered oyster shell was identified by ROV, no living subtidal oyster reefs were found.

The subtidal bottom type analysis identified substrate that could support subtidal oyster populations (Figure 2). While the percentage of hard substrate and scattered shell was relatively small, the fact that these areas are present within the HRE is supportive of future oyster restoration or natural recruitment (Table 2). The portion of the sonar record that was unclassified (unverified by ROV), 46% of the entire area surveyed, denotes substrate that would not likely support an oyster population. Large portions of these areas are located near channels that are dredged regularly, disturbing the surrounding bottom habitat. The southeastern side of the Arthur Kill had the most scattered shell and isolated individual oysters found subtidally. This area is located within the pilot location for a proposed "Living Breakwaters" project to be built along the southern shore of Tottenville (Rizzi 2014). The project plans to utilize oysters to construct breakwaters to protect the shores of Staten Island from storm damage.

The waters of the HRE are divided between New York and New Jersey and all oyster restoration projects require approval by the appropriate state regulatory agencies. The "attractive nuisance" that the restoration of oyster reefs will potentially create, requires the State(s) to police the reefs to prevent poaching and public consumption of the oysters (Yozzo et al. 2004); this limits permit approvals. In June 2010, the New Jersey Department of Environmental Protection, under a new administration, banned existing

and future research-related gardening of commercial shellfish in waters classified as contaminated. These include portions of Raritan Bay, the Arthur Kill, Hackensack River and Hudson River. The state's intent is to minimize potential negative impacts to New Jersey's shellfish industry in non-prohibited waters that could result in public illness due to consumption of shellfish raised in prohibited waters for research of educational projects. The NY/NJ Baykeeper was granted an exception to conduct an oyster restoration project at the Naval Weapons Station Earle in Sandy Hook Bay because that location is continuously supervised by the United States Navy.

With the present restrictions on introduction of live oysters, the future of oyster restoration in the New Jersey waters of the HRE may be limited to encouraging the settlement of existing wild larvae by placing suitable habitat for attachment. The most ideal location for such placement would be in an area where wild oysters are already established. In addition to having adapted to local environmental stresses, the existing populations may have established tolerances to two known protozoan oyster diseases endemic in *C. virginica* throughout much of its range, *Perkinsus marinus*, better known as "Dermo" disease and *Haplosporidium nelsoni*, MSX disease (Coen and Luckenbach 2000). These diseases, along with over-fishing and habitat destruction, are devastating oyster fisheries in the mid-Atlantic region and are hindering efforts in oyster restoration and aquaculture (MacKenzie 1996; Yu and Guo 2006). On a global scale, it was recently estimated that 85% of oyster reef ecosystems have been lost due to disease and overharvesting (Beck et al. 2011) putting additional pressure on preserving wild populations of oysters.

Despite contaminated waters and concerns regarding public consumption by state regulatory agencies, this study confirms that wild oysters occur in the Hudson-Raritan Estuary. The subtidal survey results indicate that there is ample substrate to support oyster restoration and natural recruitment. Although subtidal surveying of the East River was not feasible as part of this study, the results of the intertidal survey and the relative abundance of live oysters collected strongly suggest that subtidal reefs may be present in this area. The partial subtidal reef exposed at Castle Hill Park, Bronx, NY (CH) during the intertidal survey is evidence that subtidal reefs likely exist but have yet to be identified.

ACKNOWLEDGEMENTS

I would like to thank the members of the Polgar Fellowship committee of the Hudson River Foundation for providing funding for this study. I thank the staff of the Monmouth University School of Science and Department of Biology, specifically Dr . Tiffany Medley for giving me the opportunity to conduct this research. A special thanks goes to James Nickels of the Urban Coast Institute for providing equipment access as well as assisting in data acquisition and interpretation. Thanks also go to Helena Andreyko, David Yozzo and Sarah Fernald for recommendations on revising this manuscript.

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