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## Oyster Bed Mapping in the Great Bay Estuary, 2012-2013

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# Oyster Bed Mapping in the Great Bay Estuary, 2012-2013

A Final Report to  
The Piscataqua Region Estuaries Partnership and  
New Hampshire Department of Environmental Services

Submitted by  
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June 26, 2013



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## Executive Summary

Six major oyster beds (reefs) in New Hampshire are mapped periodically to assess wild oyster populations in the Great Bay Estuary. Data on the spatial extent of the beds are combined with density and other measures to estimate the abundances of live oysters. The first objective of the present project was to determine the spatial extent of these six oyster beds, and to compare the 2012/2013 data with previous mapping efforts. A second objective was twofold: to map the extent of live oyster bottom at selected recent oyster restoration sites, and to map areas where oyster beds have been known to occur historically but not recently. Towed underwater video methods, as used in previous oyster mapping efforts in New Hampshire, were used for this project. All recorded video was classified into three categories: "reef" (>20% shell cover and live oysters visible); "sparse shell" (<20% shell cover); and "non-reef" (no shell or live oysters). Only the "reef" category was used to construct the polygons that represented oyster beds. The "sparse shell" category was mainly used to identify potential restoration areas (see below).

Two of the natural beds (Nannie Island [2012: 32.4 ac] and Oyster River [2012: 1.6 ac]) had similar total bottom area coverage compared to most previous mapping efforts. Three beds (Adams Point [2012: 15.9 ac], Squamscott River [2012: 7.7 ac] and Woodman Point [2012: 15.4 ac]) had substantially greater area coverage compared to previous surveys. In all three cases, however, the increases were likely due to additional adjacent areas being surveyed. In contrast to the others, the Piscataqua River bed appears to have substantially decreased in bottom area coverage (2012: 7.0 ac) compared to previous surveys.

Selected oyster restoration sites were also video surveyed in 2013 to determine bottom area coverage that could be considered "reef" and therefore considered as part of the overall oyster resource in New Hampshire. Restoration sites in the Lamprey River, Oyster River (3 sites), and at Fox Point in Little Bay were imaged. Due to poor image quality, full bottom area coverage could not be determined for any of the sites. Nonetheless, substantial areas of at least "sparse shell" bottom, and live oysters in some areas were recorded at all sites. These restoration sites as well as additional sites are scheduled for video surveying and quantitative sampling in 2013.

The third focus of the project was to survey areas where oyster beds historically occurred. Of the four general areas surveyed, live oyster reefs were found in two areas: Lamprey River (0.9 ac) and mid-Great Bay (35.2 ac). In sum, these two areas represent a major addition to the known live oyster bottom in the state. Moreover, these findings strongly suggest that live oyster reefs may be in other areas where oysters have not been known to exist in recent years.

Overall, this project has added substantially to our knowledge of where live oysters occur in New Hampshire as well as the total bottom area coverage. A total of 120 acres of bottom area classified as "reef" was mapped. Additionally, the extent (perhaps 100 ac or more) of bottom area that had sparse shell but apparently few or no live oysters in mid-Great Bay bed and in the Nannie Island/Woodman Point area is important because these areas represent excellent oyster restoration opportunities. However, they will need to be mapped in more detail to sufficiently design future projects.

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## Introduction

The major live oyster beds (or reefs) in New Hampshire are mapped periodically in order to assess wild oyster populations in the Great Bay Estuary. Data on the spatial extent of the beds are combined with density and other measures provided by the New Hampshire Fish and Game Department (NHF&G) to estimate the abundances of live oysters (PREP 2013). NHF&G annually samples six major beds designated as: Adams Point, Nannie Island, Oyster River, Piscataqua River, Squamscott River and Woodman Point (Fig. 1). The first objective of the present project was to determine the spatial extent of these six oyster beds, and to compare the 2012 data with previous mapping efforts.

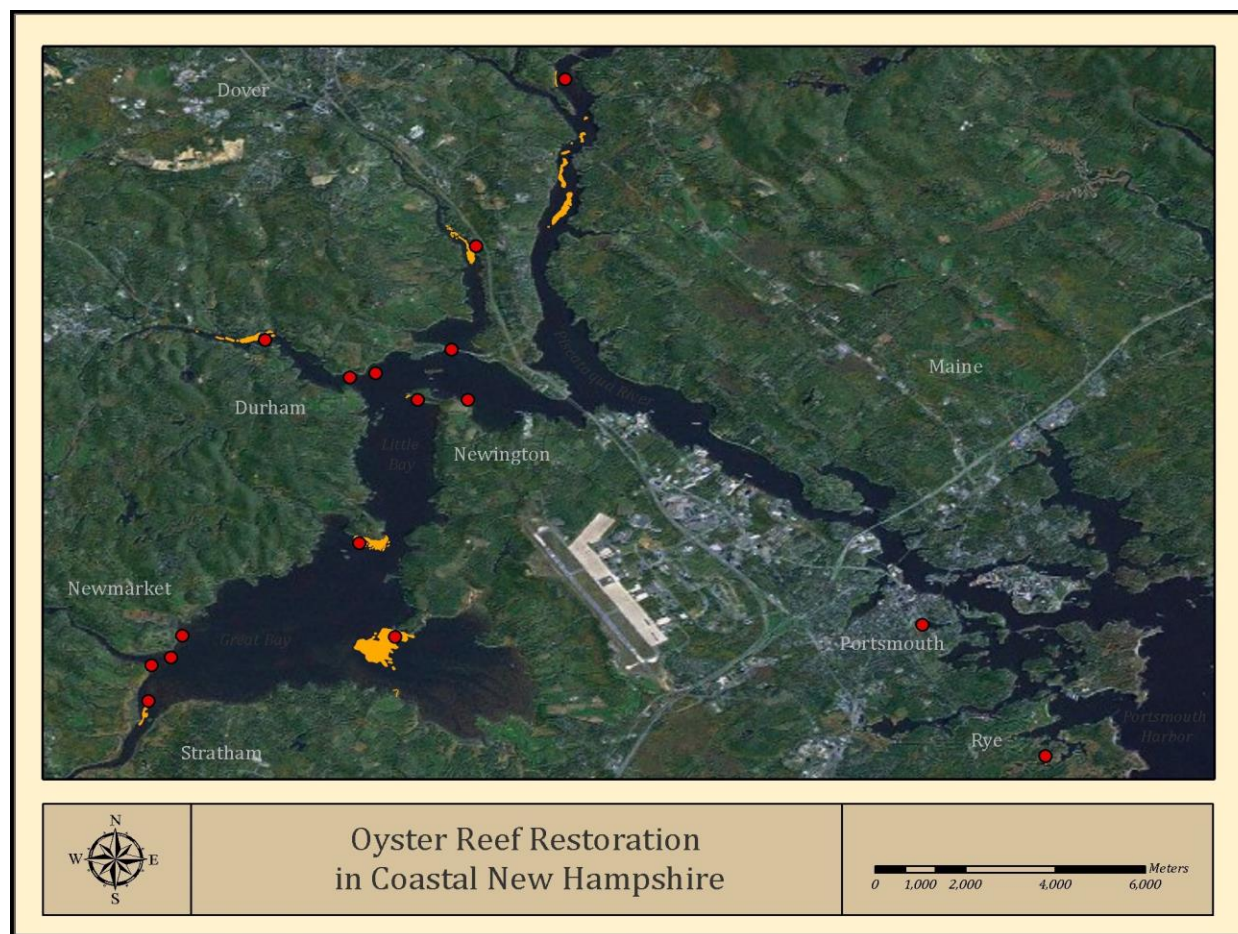


Fig. 1. General locations of major oyster restoration projects since 2000 (red circles) in relation to six major natural oyster beds (yellow polygons).

Some historical maps of oyster beds in New Hampshire show oysters in areas where they no longer exist, or at least where they have not been documented recently. The extent of these historical beds were summarized in Odell et al. (2006; see Fig. 2 below). In 2011, a substantial live oyster bed was found at the mouth of the Lamprey River where oysters had been known to occur historically but not recently. Thus, there may be live oysters in other areas where they previously existed but are thought to no longer exist. There is a need to re-visit as many of these areas as possible in order to better characterize the oyster resources in the state, and to design future restoration projects. There

is also a need to determine the boundaries of some of the oyster restoration projects that have been conducted since 2000. Therefore, the second objective of the present project was to map as many of the areas as practical where available information indicated live oysters historically occurred in the Great Bay Estuary, and where major recent restoration projects have been completed (Fig. 2).

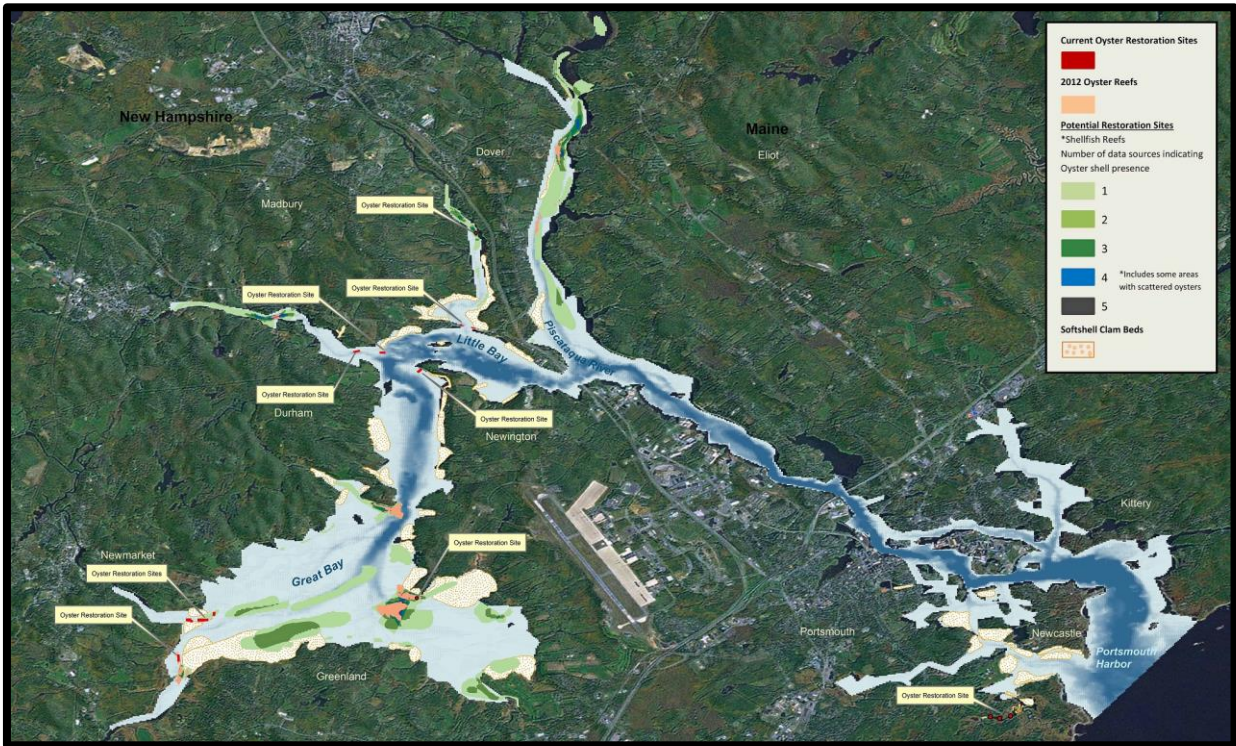


Fig. 2. Locations where live oysters (green to blue polygons) were shown on historical maps; note color coding to show the number of historical maps where each bed was shown, thus giving an estimate of accuracy), and major recent oyster restoration projects (revised from Odell et al. 2006) (also see Fig. 1).

## Methods

Towed underwater videography was used to map the six major oyster beds in the Great Bay Estuary system that are regularly sampled by NHF&G (Objective 1; see above), and historical beds and major restoration areas (Objective 2; Table 1). Methods used in previous surveys (Grizzle and Brodeur 2004; Grizzle and Ward 2009) and as described in detail in Grizzle et al. (2008) were used in the present project. Briefly, a video system consisting of a SeaViewer model 550 color camera was deployed in towed mode on a sled with imagery continuously recorded onto a digital video recorder along multiple transects across each mapping area and extending beyond the boundaries of where live oysters were observed (Fig. 3). A Garmin 76CSx GPS unit was used with WAAS mode activated and horizontal position data recorded near-continuously along each shiptrack and overlaid onto the video imagery. A minimum of five transects were traversed along the major axis of each mapping area with 5 to 20 m distance between transects. All imagery was reviewed in the laboratory and classified into one of two categories: “non-reef” (<20% shell cover, no live oysters visible) and “reef” (>20% shell cover and potentially [based on video imagery] live oysters).



Fig. 3. Towed underwater video system showing major components (see text for details).

It was not possible to determine how many historical reef areas (Fig. 2) and recent major restoration areas (Fig. 1) could be mapped within time and budget constraints. Thus, a prioritized listing of the areas that were proposed for surveying was developed (Table 1).

Table 1. Prioritized listing (most important first) of potential study areas for 2013 oyster mapping.

Site	Category	Potential Size (acres)	Comments
Lamprey River	New & Restored	> 2	Restored area constructed in 2011
Mid-Great Bay	New	> 50	Shown on some historical maps
W Great Bay	New	?	Reportedly harvested in 1960s and 1970s
SE Great Bay	New	?	Shown on some historical maps
Oyster River (3 sites)	Restored	> 2	Three restoration projects (2009-2011)
Little Bay/Fox Pt.	Restored	1	Restored in 2009
Salmon Falls River	New & Restored	?	Restoration project in 2000; natural reef never mapped
Coheco River	New	?	Oysters found in early 2000s, not mapped



## Results and Discussion

Objective 1: Map six major natural reefs (2012 mapping). The six major oyster reefs mapped in the present study had been mapped several times in past years to determine the areal coverage of “shell bottom.” For the present study, the aim was to provide data that could as directly as possible be compared to previous surveys. It was decided that those bottom areas that had >20% shell cover (and some live oysters visible in the video) would be classified as “reef” (see above), thus being comparable to previous efforts where “shell bottom” was determined; Table 2 summarizes bottom area coverage of “reef” for the present study (highlighted in yellow) with prior efforts for the six major natural beds mapped (see Appendix A for metadata). Because of differences in methods used for the different studies, including what qualified as “shell bottom,” it is not possible to accurately infer changes in bottom area over time. Some reasonable conclusions, however, can be drawn on an individual reef basis.

The Adams Point reef area appears to have increased substantially compared to the 2001 survey (Table 2). Most of the increase, however, is likely due to a new area being surveyed in 2012 southeast of the main portion of the reef (Fig. 4). Previous video surveys (e.g. Grizzle et al. 2008b) had not imaged this area due to water depth or other reasons. A portion of this “new” area had dense cover by live oysters, and had the overall appearance

of a healthy reef. Based mainly on the contiguous nature of the new area with previously mapped portions of the reef, it seems likely that this area had just been overlooked in previous surveys.



Fig. 4. Polygon for Adams Point reef based on video imagery recorded on October 8, 2012. Circle indicates bottom area probably not mapped in previous recent surveys (see Appendix A for metadata).

Table 2. Summary statistics for six major natural oyster reefs regularly sampled by NHF&G comparing previous (beginning in 1997) and present (2012) areal coverages of “shell bottom” (see text for details).

Reef	Data Collection (year)	Acres	Hectares	Source(s)	Comments
Adams Point	1997	4.0		Langan (1997)	
	2001	13.1		NHF&G (2002)	
	2004-2006	5.7		Grizzle et al. (2008b)	
	2012	15.9		(this report)	New area surveyed eastward of previous mapping efforts.
Nannie Island	1997	37.3		Langan (1997)	
	2001	24.7		NHF&G (2002)	
	2004-2006	35.7		Grizzle et al. (2008b)	Medium and high density
	2012	32.4		(this report)	
Oyster River	1997	1.8		Langan (1997)	
	2001	1.7		NHF&G (2002)	
	2004-2006	2.5		Grizzle et al. (2008b)	
	2012	1.4		(this report)	
Piscataqua River	1997	12.8		Langan (1997)	
	2003	12.5		Grizzle and Brodeur (2004); Grizzle et al. (2008a)	High density
	2012	7.0		(this report)	
Squamscott River	1997	1.7		Langan (1997)	
	2003	1.9		Grizzle and Brodeur (2004); Grizzle et al. (2008a)	High density
	2012	7.7		(this report)	New areas surveyed compared to previous mapping efforts.
Woodman Point	1997	6.6		Langan (1997)	
	2001	7.3		NHF&G (2002)	
	2004-2006	6.1		Grizzle et al. (2008b)	Medium and high density
	2012	15.4		(this report)	New area surveyed westward of previous mapping efforts.

The Nannie Island reef area mapped in 2012 was similar to that for 1997, but substantially less than that reported by NHF&G for 2001 (Table 2). As noted above, all previous mapping efforts differed in methods used and/or how “reef” or “shell bottom” area was defined. Thus, direct comparisons are not possible. Our previous studies on this reef using sonar methods and towed video (as in 2012) did not quantify bottom area coverage, but comparisons of the resulting polygons (see Figs. 13 and 15 in Grizzle et al. 2008b) indicate similar overall shape and size to that for 2012 (Fig. 5). Thus, although live oyster densities have varied substantially in recent years, we suggest that the total areal coverage by live oysters on the Nannie Island reef probably has not changed substantially in the recent past.



Fig. 5. Polygon for Nannie Island reef based on video imagery recorded on November 19, 2012 (see Appendix A for metadata).

The reported Oyster River reef area coverage has only varied minimally since 1997 (Table 1). The shape of the reef, however, apparently has varied in the recent past. Previous video surveys had indicated live oyster bottom in the same overall area but no obvious “non-reef” area in the middle portion, as was found in the present survey (Fig. 6). Thus, it seems reasonable to conclude that the Oyster River reef may have decreased somewhat in size since the last survey in 2001. (See Objective 2 section below for discussion of restoration areas.)



Fig. 6. Natural reef in Oyster River and two restoration areas based on video imagery recorded on November 15, 2012 (see Appendix A for metadata).

All previous surveys of the Piscataqua River reef reported much higher bottom area coverage compared to the present (2012) survey (Table 1). The general area mapped in the present survey was similar to that in previous surveys, and similar video methods were used (Grizzle and Brodeur 2004; Grizzle et al. 2008a). Also, the overall shape of the reef area was similar in 2012 in those areas where live oysters and >20% shell cover occurred (Fig. 7). Thus, it seems reasonable to conclude that the Piscataqua River reef has decreased substantially in areal coverage since the most recent previous survey was conducted (2003).



Fig. 7. Polygon for Piscataqua River reef based on video imagery recorded on November 6, 2012 (see Appendix A for metadata).

The Squamscott River reef and the Woodman Point reef appear to have increased dramatically in size compared to previous surveys (Table 2). However, in both cases additional areas were imaged in 2012 compared to previous video surveys, thus making direct comparisons difficult.

The additional areas surveyed in the Squamscott River were mainly in an uncharted channel east of the main navigational channel where previous surveys had occurred (Fig. 8).



Fig. 8. Polygon for Squamscott River reef based on video imagery recorded on October 10, 2012 (see Appendix A for metadata).

When considering only those areas imaged in previous video mapping efforts, the overall shape and size of the polygons differ somewhat. For example, the area of the Squamscott reef south of the railroad trestle is larger than reported previously, but the northern area is smaller (compare Fig. 8 herein with Fig. 3 in Grizzle et al. 2008a).

In contrast, those areas of the Woodman Point reef video mapped previously are similar in shape and size to the 2012 survey. The additional areas surveyed for the Woodman Point reef were west of the extension of a rocky outcrop from the land north of the reef southward into the Great Bay (Fig. 9). Previous surveys (Grizzle et al. 2008b) had stopped at this point. During the present survey, the mapping was continued west of the outcrop and a substantial areal coverage of live reef was discovered. Areal coverage of this portion of the overall reef alone was approximately six

acres. If this “new” area is subtracted from the total areal coverage given in Table 2, then the 2012 data are similar to previous recent surveys.

Therefore, for both the Squamscott River and Woodman Point reefs we suggest that their bottom area coverage has probably remained relatively stable in recent years, and the additional reported coverage (Table 2) is a result of a more comprehensive survey in 2012 compared to previous efforts.



Fig. 9. Polygon for Woodman Point reef based on video imagery recorded on October 10, 2012 (see Appendix A for metadata).

Objective 2: Map historical natural reefs and selected restoration sites (2013 mapping). Bottom areas where oyster reefs historically occurred and selected recent oyster restoration sites were mapped to provide a more comprehensive assessment of New Hampshire’s oyster resources as well as to identify areas for future restoration efforts (Objective 2; Table 1). Six of the eight target areas listed in Table 1 were mapped. As noted above, there was no way to accurately determine how much mapping could be accomplished within time and budgetary constraint. Although it is anticipated that the remaining areas listed in Table 2 will be surveyed later in 2013, we conclude that the results presented herein represent full completion of the present project. Each of the six target areas mapped in 2013 is discussed separately below in the order listed in Table 1.

The Lamprey River survey area included a “new” natural reef that was thought to no longer exist, and two separate restoration areas (Fig. 10). Qualitative sampling on the natural reef indicated a substantial amount of vertical structure as well as some large (>100 mm shell height) individuals and multiple year classes on some clusters. The reef surface was also very hard and appeared to be quite thick, indicating many years of shell accretion. This is likely the historical reef known to have been in existence for decades. The restoration areas shown in Figure



Fig. 10. Polygons for natural Lamprey River reef and two restoration areas based on video imagery recorded on June 19, 2013 (see Appendix B for metadata).

10 were constructed in 2011 by deposition of a base layer of dead mollusc (mostly surf clams) followed by scattered live oyster spat-on-shell produced by remote setting. Most of the “reef” areas shown represent some combination of surf clam shell and live oysters from the spat-on-shell put out as part of the restoration process and naturally recruited oysters.

The natural oyster reef shown on some historical maps (Fig. 2; also see Odell et al. 2006) in the channel area of middle and western Great Bay was found to be extensive, with “reef” (>20% shell and live oysters visible) area covering 35.2 acres (Fig. 11; Appendix B). The general area also included a substantial amount of sparse shell bottom, mostly consisting of dead oyster shell. The extent of live oyster reef in this area was surprising. Moreover, the extent of sparse shell bottom extending away from the main reef at both ends (east and west) likely indicated the historical spatial extent of this reef. This spatial arrangement of features—a central area of dense live oysters with adjacent areas of sparse mostly dead shell—suggests excellent conditions for future oyster restoration projects. Additionally, the same general situation exists in the nearby Nannie Island/Woodman Point reef area. Therefore, a map showing these conditions as well as the most recent available (from 2012) map of eelgrass was produced to illustrate the extent of potential oyster restoration sites for central Great Bay (Fig. 11). Although more detailed mapping of each of the six potential oyster restoration areas would be needed to adequately design each project, we estimate that >100 acres of bottom area likely represents excellent oyster restoration opportunities.

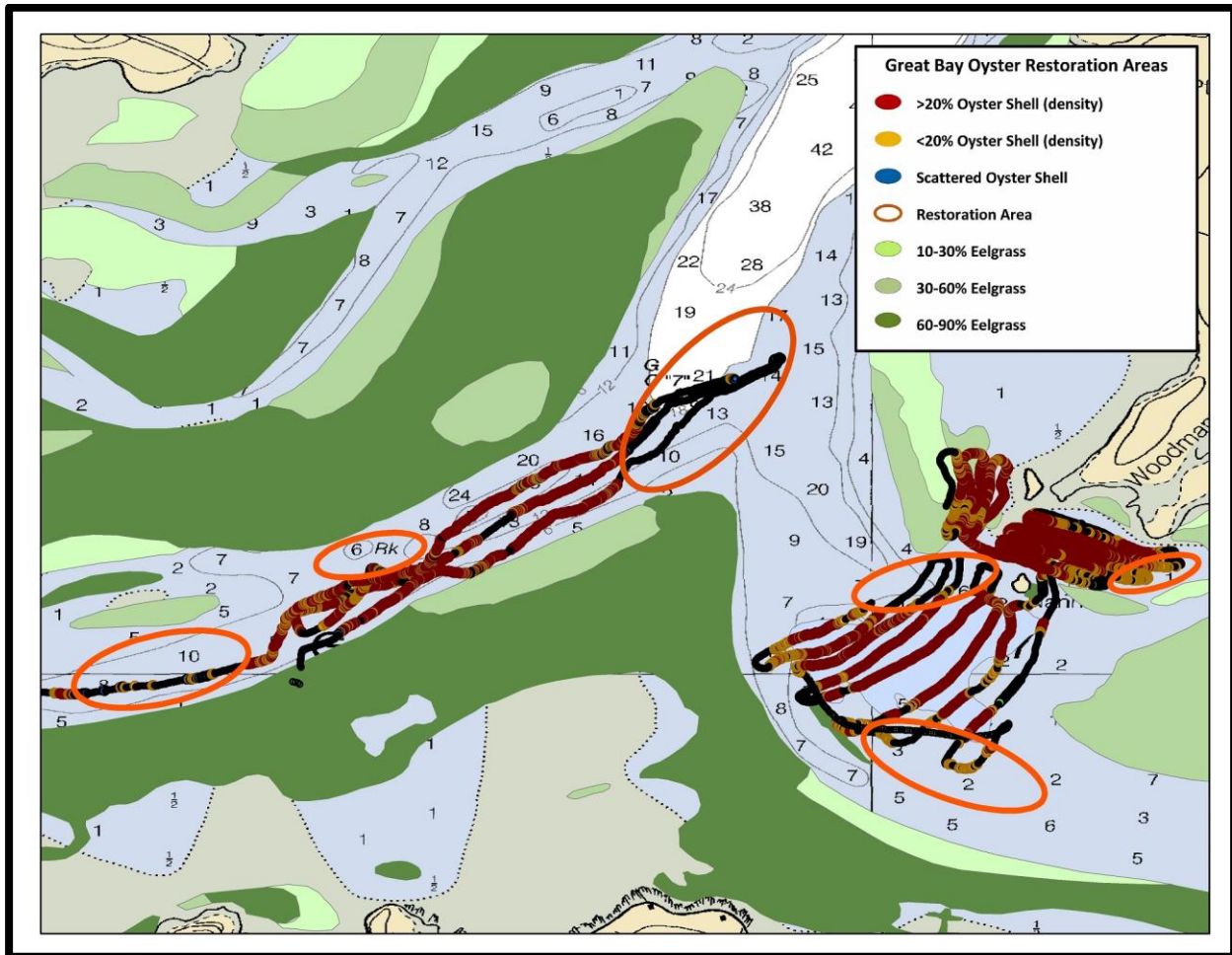


Fig. 11. Composite map showing potential oyster restoration areas (orange polygons) in Great Bay based on 2012 classified video shiptracks and recent (201x) mapping of eelgrass on bathymetric chart base map (water depth in feet).

The general area of a historical natural oyster bed in southeastern Great Bay at the mouth of the Winnicut River (see Fig. 2 above) was surveyed by navigating a zig-zag pattern out of the River and probing the bottom with a PVC pipe to determine bottom type (Fig. 12). The entire area consisted of muddy substrate, very soft in many places. Shell material was only encountered in a few areas near mid-channel just south of Pierce Point, and included shell material beneath several centimeters of bottom sediment. No “hard bottom” was encountered.



Fig. 12. Shiptracks recorded on June 19, 2013 showing area in southeastern Great Bay where oyster reef occurred historically.

This overall combination of conditions suggests that the reef may have been buried during a storm or other event involving substantial sediment transport. We have observed a similar situation in the Bellamy River at an oyster restoration site. Thus, we conclude that most likely this reef no longer exists.

In addition to the natural reef in the Oyster River, two oyster restoration sites were mapped in 2013. The first area was adjacent to the natural reef, and the second was near the mouth of the Oyster River (Fig. 13; also see Fig. 6 above). Both were constructed by deposition of a base layer of dead



Fig. 13. Polygons showing extent of “shell bottom” at two oyster restoration sites in the Oyster River based on video imagery recorded on June 19, 2013 (See Appendix B for metadata).

mollusc (mostly surf clams) followed by scattered oyster spat-on-shell produced by remote setting. The video imagery indicated some combination of surf clam shell and live oysters in both areas. The video imagery confirmed the presence of abundant mollusc shell base material as well as live oysters in both areas. The base shell in most areas had a thin coating of silt, and some appears to have been substantially buried. Macroalgae had colonized the shell in many areas, and crabs and other invertebrates were visible in the imagery. These areas are scheduled for quantitative sampling and additional characterization by video and other methods in 2013.

The final restoration site mapped in 2013 was at Little Bay/Fox Point, which was constructed in 2010 (Fig. 14). This area was chosen for restoration because most of the site was on natural rocky bottom, and adjacent to a natural oyster reef that had not been previously mapped or sampled. Unfortunately, the video imagery recorded in 2013 was of poor quality in most areas. The entire area covered by the shiptracks shown in Figure 14 was rocky bottom with substantial macroalgal patches, and live oysters were observed in many areas. This area is scheduled for more video imaging and quantitative sampling in 2013.



Fig. 14. Polygon for oyster restoration site in Little Bay at Fox Point based on video imagery recorded on June 19, 2013 (see Appendix B for metadata).

In addition to the target survey areas listed in Table 1, a “new” natural reef was discovered in 2012 while using towed video to survey a potential restoration site in the Piscataqua River. This reef is south of the known Piscataqua River reef regularly sampled by NHF&G, but it is within the overall area of the upper Piscataqua River that historically had natural beds (Fig. 2). This “new” reef covered a bottom area of 3.9 acres, and represents a significant addition to the known natural oyster beds in New Hampshire (Fig. 15). A 1.5-acre area adjacent to and east of the natural bed is scheduled for construction/restoration in summer 2013. The restoration area will represent an addition onto the natural reef, likely in an area that historically was live oyster reef. The restoration area is scheduled for quantitative sampling and video mapping in 2013 and 2014.



Fig. 15. Polygon for natural Piscataqua (South) River reef based on video imagery recorded on November 6, 2012 (see Appendix B for metadata).



## Synthesis and Recommendations

The present study substantially expands the total bottom area coverage and overall distribution of known “oyster bottom” in New Hampshire. Figure 16 is an overview map showing both natural and restored oyster beds—defined as >20% shell cover and some live oysters observed in the video imagery—mapped in the present study. In sum, these areas total 120 acres. The major additions compared to previous surveys were two “new” beds, one in mid-Great Bay (35.2 ac) and one at the mouth of the Lamprey River (0.9 ac), that were known to occur historically but had not been surveyed in recent decades.

These findings have management implications that need to be addressed in order to sufficiently characterize New Hampshire’s oyster resources. For example, how should the “new” beds be considered in light of current management goals for increasing oyster abundances? These findings also suggest that more surveys should be done in other areas where oyster beds had occurred historically.

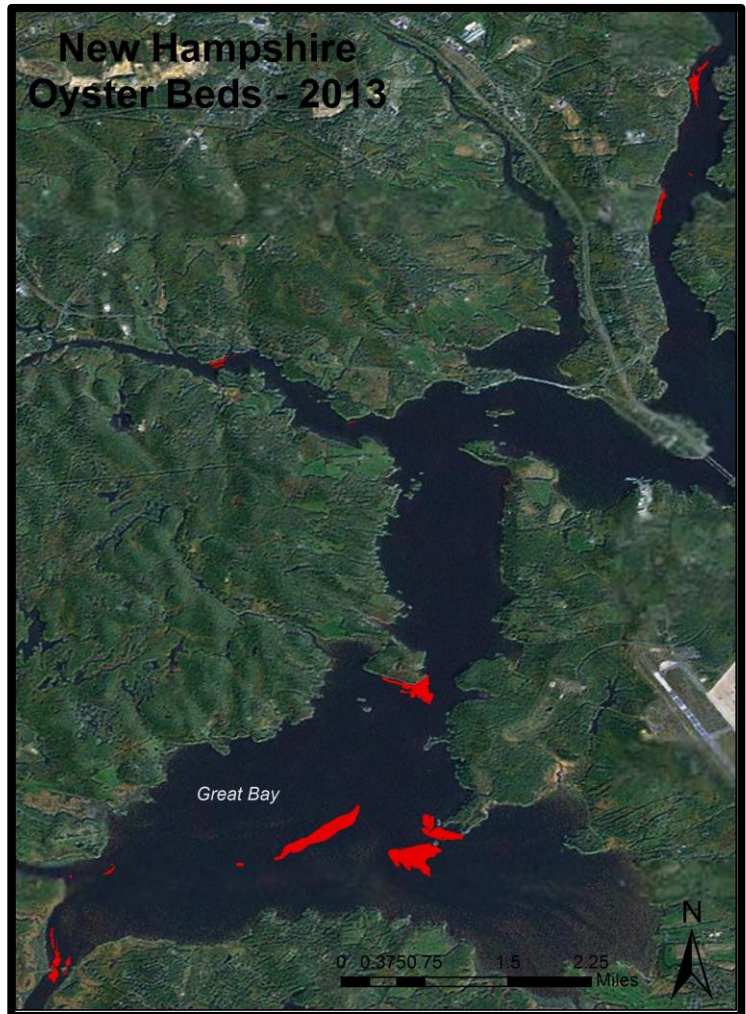


Fig. 16. Natural and restored oyster reefs mapped in the present project (red polygons).

A final important finding was the extent (perhaps 100 ac or more) of bottom area that had sparse shell but apparently few or no live oysters in several areas adjacent to the “new” mid-Great Bay bed and the Nannie Island/Woodman Point area. These areas may represent excellent oyster restoration opportunities, but they will need to be mapped in more detail to sufficiently design future projects.

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## Appendix A – Metadata for six monitored (NHF&G) oyster beds mapped in 2012

### Adams Point Oyster Bed



#### Tags

United States, North East, New Hampshire, Great Bay, Adams Point, Oyster Reef, *Crassostrea virginica*, Eastern Oyster, Oyster, Underwater Video, Seaviewer, Density

#### Summary

Dr. Ray Grizzle and staff, at UNH's Jackson Estuarine Laboratory used underwater video to determine the boundaries of areas with at least 20% coverage by oyster shell and some live oysters on seven known oyster beds in the Great Bay Estuary, New Hampshire. The underwater video was classified and an ArcGIS polygon shapefile was created for each oyster bed. The project was funded by the Piscataqua Region Estuaries Partnership (PREP) and work was completed in 2012.

#### Description

At each site surveyed, a SeaViewer model 550 color video camera was deployed in towed mode on a sled with video imagery continuously recorded onto a digital video recorder. Garmin 76CSx and 541s GPS units were used with WAAS mode activated, with horizontal position data (advertised positional accuracy: 3 m) recorded near-continuously along each shiptrack. The imagery was viewed in real-time to locate areas with significant amounts of oyster shell and live oysters. When oysters were encountered, the extent of the oyster bottom in that area was delineated by navigating multiple parallel transects. All imagery was later reviewed in the laboratory and classified into the category of: "high density" oysters (>20% cover by shell and some live oysters visible). This provided near-continuous classification of the seafloor along each shiptrack. The Adams Point Oyster Bed polygon is 15.9 acres.

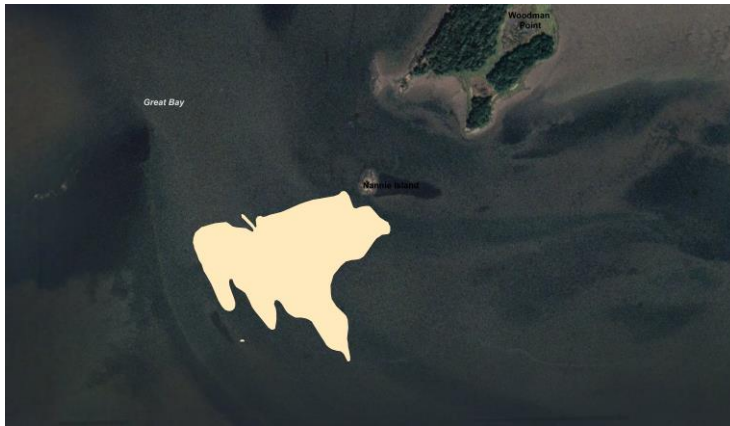
#### Credits

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#### Access and use limitations

There are no access and use limitations for this item.

## Nannie Island Oyster Bed



### Tags

United States, North East, New Hampshire, Great Bay, Nannie Island, Oyster Reef, Crassostrea virginica, Eastern Oyster, Oyster, Underwater Video, Seaviewer, Density

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Dr. Ray Grizzle and staff, at UNH's Jackson Estuarine Laboratory used underwater video to determine the boundaries of areas with at least 20% coverage by oyster shell and some live oysters on seven known oyster beds in the Great Bay Estuary, New Hampshire. The underwater video was classified and an ArcGIS polygon shapefile was created for each oyster bed. The project was funded by the Piscataqua Region Estuaries Partnership (PREP) and work was completed in 2012.

### Description

At each site surveyed, a SeaViewer model 550 color video camera was deployed in towed mode on a sled with video imagery continuously recorded onto a digital video recorder. Garmin 76CSx and 541s GPS units were used with WAAS mode activated, with horizontal position data (advertised positional accuracy: 3 m) recorded near-continuously along each shiptrack. The imagery was viewed in real-time to locate areas with significant amounts of oyster shell and live oysters. When oysters were encountered, the extent of the oyster bottom in that area was delineated by navigating multiple parallel transects. All imagery was later reviewed in the laboratory and classified into the category of: "high density" oysters (>20% cover by shell and some live oysters visible). This provided near-continuous classification of the seafloor along each shiptrack. The Nannie Island Oyster Bed polygon is 32.4 acres.

### Credits

Citation Information: Dr. Ray Grizzle and Krystin Ward, University of New Hampshire. Address: 85 Adams Point Road, Durham, NH 03801 Email: ray.grizzle@unh.edu. kward@unh.edu Publication Date: 20121217 Title: Nannie Island Oyster Bed\_2012 Primary Organization: Piscataqua Region Estuaries Partnership (PREP) Contact: Phil Trowbridge Phone: 603-271-8872 Email: Pthrowbridge@des.state.nh.us

### Access and use limitations

There are no access and use limitations for this item.

## Oyster River Oyster Bed



### Tags

United States, North East, New Hampshire, Great Bay, Oyster River, Oyster Reef, *Crassostrea virginica*, Eastern Oyster, Oyster, Underwater Video, Seaviewer, Density

### Summary

Dr. Ray Grizzle and staff, at UNH's Jackson Estuarine Laboratory used underwater video to determine the boundaries of areas with at least 20% coverage by oyster shell and some live oysters on seven known oyster beds in the Great Bay Estuary, New Hampshire. The underwater video was classified and an ArcGIS polygon shapefile was created for each oyster bed. The project was funded by the Piscataqua Region Estuaries Partnership (PREP) and work was completed in 2012.

### Description

At each site surveyed, a SeaViewer model 550 color video camera was deployed in towed mode on a sled with video imagery continuously recorded onto a digital video recorder. Garmin 76CSx and 541s GPS units were used with WAAS mode activated, with horizontal position data (advertised positional accuracy: 3 m) recorded near-continuously along each shiptrack. The imagery was viewed in real-time to locate areas with significant amounts of oyster shell and live oysters. When oysters were encountered, the extent of the oyster bottom in that area was delineated by navigating multiple parallel transects. All imagery was later reviewed in the laboratory and classified into the category of: "high density" oysters (>20% cover by shell and some live oysters visible). This provided near-continuous classification of the seafloor along each shiptrack. The Oyster River Oyster Bed polygon is approximately 1.4 acres.

### Credits

Citation Information: Dr. Ray Grizzle and Krystin Ward, University of New Hampshire. Address: 85 Adams Point Road, Durham, NH 03801 Email: ray.grizzle@unh.edu. kward@unh.edu Publication Date: 20121217 Title: Oyster River Oyster Bed\_2012 Primary Organization: Piscataqua Region Estuaries Partnership (PREP) Contact: Phil Trowbridge Phone: 603-271-8872 Email: Pthrowbridge@des.state.nh.us

### Access and use limitations

There are no access and use limitations for this item.

## Piscataqua River Oyster Bed



### Tags

United States, North East, New Hampshire, Great Bay, Piscataqua River, Oyster Reef, *Crassostrea virginica*, Eastern Oyster, Oyster, Underwater Video, Seaviewer, Density

### Summary

Dr. Ray Grizzle and staff, at UNH's Jackson Estuarine Laboratory used underwater video to determine the boundaries of areas with at least 20% coverage by oyster shell and some live oysters on seven known oyster beds in the Great Bay Estuary, New Hampshire. The underwater video was classified and an ArcGIS polygon shapefile was created for each oyster bed. The project was funded by the Piscataqua Region Estuaries Partnership (PREP) and work was completed in 2012.

### Description

At each site surveyed, a SeaViewer model 550 color video camera was deployed in towed mode on a sled with video imagery continuously recorded onto a digital video recorder. Garmin 76CSx and 541s GPS units were used with WAAS mode activated, with horizontal position data (advertised positional accuracy: 3 m) recorded near-continuously along each shiptrack. The imagery was viewed in real-time to locate areas with significant amounts of oyster shell and live oysters. When oysters were encountered, the extent of the oyster bottom in that area was delineated by navigating multiple parallel transects. All imagery was later reviewed in the laboratory and classified into the category of: "high density" oysters (>20% cover by shell and some live oysters visible). This provided near-continuous classification of the seafloor along each shiptrack. The Piscataqua River Oyster Bed polygon is 7.7 acres.

### Credits

Citation Information: Dr. Ray Grizzle and Krystin Ward, University of New Hampshire. Address: 85 Adams Point Road, Durham, NH 03801 Email: ray.grizzle@unh.edu. kward@unh.edu Publication Date: 20121217 Title: Piscataqua River Oyster Bed\_2012 Primary Organization: Piscataqua Region Estuaries Partnership (PREP) Contact: Phil Trowbridge Phone: 603-271-8872 Email: Pthrowbridge@des.state.nh.us

### Access and use limitations

There are no access and use limitations for this item.

## Squamscott River Oyster Bed



### Tags

United States, North East, New Hampshire, Great Bay, Squamscott River, Oyster Reef, *Crassostrea virginica*, Eastern Oyster, Oyster, Underwater Video, Seaviewer, Density

### Summary

Dr. Ray Grizzle and staff, at UNH's Jackson Estuarine Laboratory used underwater video to determine the boundaries of areas with at least 20% coverage by oyster shell and some live oysters on seven known oyster beds in the Great Bay Estuary, New Hampshire. The underwater video was classified and an ArcGIS polygon shapefile was created for each oyster bed. The project was funded by the Piscataqua Region Estuaries Partnership (PREP) and work was completed in 2012.

### Description

At each site surveyed, a SeaViewer model 550 color video camera was deployed in towed mode on a sled with video imagery continuously recorded onto a digital video recorder. Garmin 76CSx and 541s GPS units were used with WAAS mode activated, with horizontal position data (advertised positional accuracy: 3 m) recorded near-continuously along each shiptrack. The imagery was viewed in real-time to locate areas with significant amounts of oyster shell and live oysters. When oysters were encountered, the extent of the oyster bottom in that area was delineated by navigating multiple parallel transects. All imagery was later reviewed in the laboratory and classified into the category of: "high density" oysters (>20% cover by shell and some live oysters visible). This provided near-continuous classification of the seafloor along each shiptrack. The Squamscott River Oyster Bed polygon is 7.7 acres.

### Credits

Citation Information: Dr. Ray Grizzle and Krystin Ward, University of New Hampshire. Address: 85 Adams Point Road, Durham, NH 03801 Email: ray.grizzle@unh.edu. kward@unh.edu Publication Date: 20121217 Title: Squamscott River Oyster Bed\_2012 Primary Organization: Piscataqua Region Estuaries Partnership (PREP) Contact: Phil Trowbridge Phone: 603-271-8872 Email: Pthrowbridge@des.state.nh.us

### Access and use limitations

There are no access and use limitations for this item.

## Woodman Point Oyster Bed



### Tags

United States, North East, New Hampshire, Great Bay, Woodman Point, Oyster Reef, Crassostrea virginica, Eastern Oyster, Oyster, Underwater Video, Seaviewer, Density

### Summary

Dr. Ray Grizzle and staff, at UNH's Jackson Estuarine Laboratory used underwater video to determine the boundaries of areas with at least 20% coverage by oyster shell and some live oysters on seven known oyster beds in the Great Bay Estuary, New Hampshire. The underwater video was classified and an ArcGIS polygon shapefile was created for each oyster bed. The project was funded by the Piscataqua Region Estuaries Partnership (PREP) and work was completed in 2012.

### Description

At each site surveyed, a SeaViewer model 550 color video camera was deployed in towed mode on a sled with video imagery continuously recorded onto a digital video recorder. Garmin 76CSx and 541s GPS units were used with WAAS mode activated, with horizontal position data (advertised positional accuracy: 3 m) recorded near-continuously along each shiptrack. The imagery was viewed in real-time to locate areas with significant amounts of oyster shell and live oysters. When oysters were encountered, the extent of the oyster bottom in that area was delineated by navigating multiple parallel transects. All imagery was later reviewed in the laboratory and classified into the category of: "high density" oysters (>20% cover by shell and some live oysters visible). This provided near-continuous classification of the seafloor along each shiptrack. The Woodman Point Oyster Bed polygon is 15.4 acres.

### Credits

Citation Information: Dr. Ray Grizzle and Krystin Ward, University of New Hampshire. Address: 85 Adams Point Road, Durham, NH 03801 Email: ray.grizzle@unh.edu. kward@unh.edu Publication Date: 20121217 Title: Woodman Point Oyster Bed\_2012 Primary Organization: Piscataqua Region Estuaries Partnership (PREP) Contact: Phil Trowbridge Phone: 603-271-8872 Email: Pthrowbridge@des.state.nh.us

### Access and use limitations

There are no access and use limitations for this item.



## Appendix B – Metadata for “new” and restored oyster beds mapped in 2012-2013

### Mid-Great Bay Oyster Bed



#### Tags

United States, North East, New Hampshire, Great Bay, Oyster Reef, *Crassostrea virginica*, Eastern Oyster, Oyster, Underwater Video, Seaviewer, Density

#### Summary

Dr. Ray Grizzle and staff, at UNH's Jackson Estuarine Laboratory used underwater video to determine the boundaries of areas with at least 20% coverage by oyster shell and some live oysters on seven known oyster beds in the Great Bay Estuary, New Hampshire. The underwater video was classified and an ArcGIS polygon shapefile was created for each oyster bed. The project was funded by the Piscataqua Region Estuaries Partnership (PREP) and work was completed in 2013.

#### Description

At each site surveyed, a SeaViewer model 550 color video camera was deployed in towed mode on a sled with video imagery continuously recorded onto a digital video recorder. Garmin 76CSx and 541s GPS units were used with WAAS mode activated, with horizontal position data (advertised positional accuracy: 3 m) recorded near-continuously along each shiptrack. The imagery was viewed in real-time to locate areas with significant amounts of oyster shell and live oysters. When oysters were encountered, the extent of the oyster bottom in that area was delineated by navigating multiple parallel transects. All imagery was later reviewed in the laboratory and classified into the category of: “high density” oysters (>20% cover by shell and some live oysters visible). This provided near-continuous classification of the seafloor along each shiptrack. The Mid-Great Bay Oyster Bed polygon is 35.16 acres.

#### Credits

Citation Information: Dr. Ray Grizzle and Krystin Ward, University of New Hampshire. Address: 85 Adams Point Road, Durham, NH 03801 Email: ray.grizzle@unh.edu. kward@unh.edu Publication Date: 20121217 Title: Great Bay Oyster Bed\_2012 Primary Organization: Piscataqua Region Estuaries Partnership (PREP) Contact: Phil Trowbridge Phone: 603-271-8872 Email: Pthrowbridge@des.state.nh.us

#### Access and use limitations

There are no access and use limitations for this item.

## Lamprey River Oyster Bed



### Tags

United States, North East, New Hampshire, Great Bay, Lamprey River, Oyster Reef, *Crassostrea virginica*, Eastern Oyster, Oyster, Underwater Video, Seaviewer, Density

### Summary

Dr. Ray Grizzle and staff, at UNH's Jackson Estuarine Laboratory walked the perimeter of this oyster reef marking waypoints with a handheld Garmin 76Cx GPS unit. The reef was sampled by hand using oyster tongs to confirm that live oysters are present. Work was completed in 2012. Underwater video was used in 2013 to determine oyster density. We used underwater video to determine the boundaries of areas with at least 20% coverage by oyster shell and some live oysters on eight known oyster beds in the Great Bay Estuary, New Hampshire. The underwater video was classified and an ArcGIS polygon shapefile was created for each oyster bed. The project was funded by the Piscataqua Region Estuaries Partnership (PREP) and work was completed in 2013.

### Description

This natural oyster reef at the mouth of the Lamprey River was surveyed using a handheld Garmin 76Cx GPS unit at low tide. Oyster tongs were also used to sample oyster density. The Lamprey River Oyster Bed polygon is 0.9 acre.

### Credits

Citation Information: Dr. Ray Grizzle and Krystin Ward, University of New Hampshire. Address: 85 Adams Point Road, Durham, NH 03801 Email: ray.grizzle@unh.edu. kward@unh.edu Publication Date: 20121217 Title: Lamprey River Oyster Bed\_2012 Primary Organization: Piscataqua Region Estuaries Partnership (PREP) Contact: Phil Trowbridge Phone: 603-271-8872 Email: Pthrowbridge@des.state.nh.us

### Access and use limitations

There are no access and use limitations for this item.

## Oyster River Oyster Bed



### Tags

United States, North East, New Hampshire, Great Bay, Oyster River, Oyster Reef, *Crassostrea virginica*, Eastern Oyster, Oyster, Underwater Video, Seaviewer, Density

### Summary

Dr. Ray Grizzle and staff, at UNH's Jackson Estuarine Laboratory used underwater video to determine the boundaries of areas with at least 20% coverage by oyster shell and some live oysters on eight known oyster beds in the Great Bay Estuary, New Hampshire. The underwater video was classified and an ArcGIS polygon shapefile was created for each oyster bed. The project was funded by the Piscataqua Region Estuaries Partnership (PREP) and work was completed in 2012.

### Description

At each site surveyed, a SeaViewer model 550 color video camera was deployed in towed mode on a sled with video imagery continuously recorded onto a digital video recorder. Garmin 76CSx and 541s GPS units were used with WAAS mode activated, with horizontal position data (advertised positional accuracy: 3 m) recorded near-continuously along each shiptrack. The imagery was viewed in real-time to locate areas with significant amounts of oyster shell and live oysters. When oysters were encountered, the extent of the oyster bottom in that area was delineated by navigating multiple parallel transects. All imagery was later reviewed in the laboratory and classified into the category of: "high density" oysters (>20% cover by shell and some live oysters visible). This provided near-continuous classification of the seafloor along each shiptrack. The Oyster River Oyster Bed polygon is approximately 1.6 acres.

### Credits

Citation Information: Dr. Ray Grizzle and Krystin Ward, University of New Hampshire. Address: 85 Adams Point Road, Durham, NH 03801 Email: ray.grizzle@unh.edu. kward@unh.edu Publication Date: 20121217 Title: Oyster River Oyster Bed\_2013 Primary Organization: Piscataqua Region Estuaries Partnership (PREP) Contact: Phil Trowbridge Phone: 603-271-8872 Email: Pthrowbridge@des.state.nh.us

### Access and use limitations

There are no access and use limitations for this item.

## Oyster River Restored Area



### Tags

United States, North East, New Hampshire, Great Bay, Oyster River, Oyster Reef, Crassostrea virginica, Eastern Oyster, Oyster, Underwater Video, Seaviewer, Density

### Summary

Dr. Ray Grizzle and staff, at UNH's Jackson Estuarine Laboratory used underwater video to determine the boundaries of areas with at least 20% coverage by oyster shell and some live oysters on eight known oyster beds in the Great Bay Estuary, New Hampshire. The underwater video was classified and an ArcGIS polygon shapefile was created for each oyster bed. The project was funded by the Piscataqua Region Estuaries Partnership (PREP) and work was completed in 2013.

### Description

At each site surveyed, a SeaViewer model 550 color video camera was deployed in towed mode on a sled with video imagery continuously recorded onto a digital video recorder. Garmin 76CSx and 541s GPS units were used with WAAS mode activated, with horizontal position data (advertised positional accuracy: 3 m) recorded near-continuously along each shiptrack. The imagery was viewed in real-time to locate areas with significant amounts of oyster shell and live oysters. When oysters were encountered, the extent of the oyster bottom in that area was delineated by navigating multiple parallel transects. All imagery was later reviewed in the laboratory and classified into the category of: "high density" oysters (>20% cover by shell and some live oysters visible). This provided near-continuous classification of the seafloor along each shiptrack. The Oyster River Restored Oyster Bed polygon is 0.14 acre.

### Credits

Citation Information: Dr. Ray Grizzle and Krystin Ward, University of New Hampshire. Address: 85 Adams Point Road, Durham, NH 03801 Email: ray.grizzle@unh.edu. kward@unh.edu Publication Date: 20121217 Title: Oyster River Restored\_2013 Primary Organization: Piscataqua Region Estuaries Partnership (PREP) Contact: Phil Trowbridge Phone: 603-271-8872 Email: Prowbridge@des.state.nh.us

### Access and use limitations

There are no access and use limitations for this item.

## Piscataqua (South) River Oyster Bed



### Tags

United States, North East, New Hampshire, Great Bay, Piscataqua River, Oyster Reef, *Crassostrea virginica*, Eastern Oyster, Oyster, Underwater Video, Seaviewer, Density

### Summary

Dr. Ray Grizzle and staff, at UNH's Jackson Estuarine Laboratory used underwater video to determine the boundaries of areas with at least 20% coverage by oyster shell and some live oysters on seven known oyster beds in the Great Bay Estuary, New Hampshire. The underwater video was classified and an ArcGIS polygon shapefile was created for each oyster bed. The project was funded by the Piscataqua Region Estuaries Partnership (PREP) and work was completed in 2012.

### Description

At each site surveyed, a SeaViewer model 550 color video camera was deployed in towed mode on a sled with video imagery continuously recorded onto a digital video recorder. Garmin 76CSx and 541s GPS units were used with WAAS mode activated, with horizontal position data (advertised positional accuracy: 3 m) recorded near-continuously along each shiptrack. The imagery was viewed in real-time to locate areas with significant amounts of oyster shell and live oysters. When oysters were encountered, the extent of the oyster bottom in that area was delineated by navigating multiple parallel transects. All imagery was later reviewed in the laboratory and classified into the category of: "high density" oysters (>20% cover by shell and some live oysters visible). This provided near-continuous classification of the seafloor along each shiptrack. The Piscataqua River (South) Oyster Bed polygon is 3.9 acres.

### Credits

Citation Information: Dr. Ray Grizzle and Krystin Ward, University of New Hampshire. Address: 85 Adams Point Road, Durham, NH 03801 Email: ray.grizzle@unh.edu. kward@unh.edu Publication Date: 20121217 Title: Piscataqua (South) River Oyster Bed\_2012 Primary Organization: Piscataqua Region Estuaries Partnership (PREP) Contact: Phil Trowbridge Phone: 603-271-8872 Email: Pthrowbridge@des.state.nh.us

### Access and use limitations

There are no access and use limitations for this item.

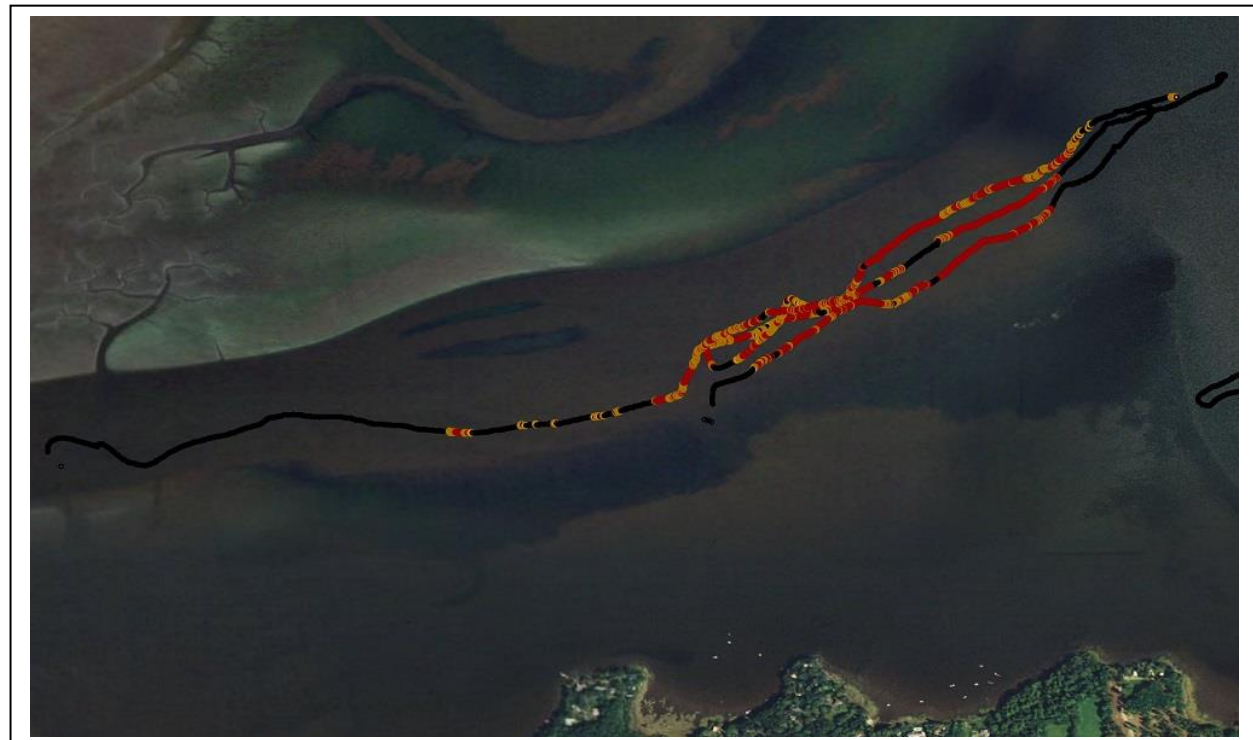
## Appendix C – Shiptracks for towed video mapping of oyster beds in Appendices A and B

For all figures below: black outlined open circles="non-reef" (no shell or live oysters) or no visibility; red circles="reef" (>20% shell cover, live oysters); yellow circles="sparse shell" (<20% shell cover); green=eelgrass

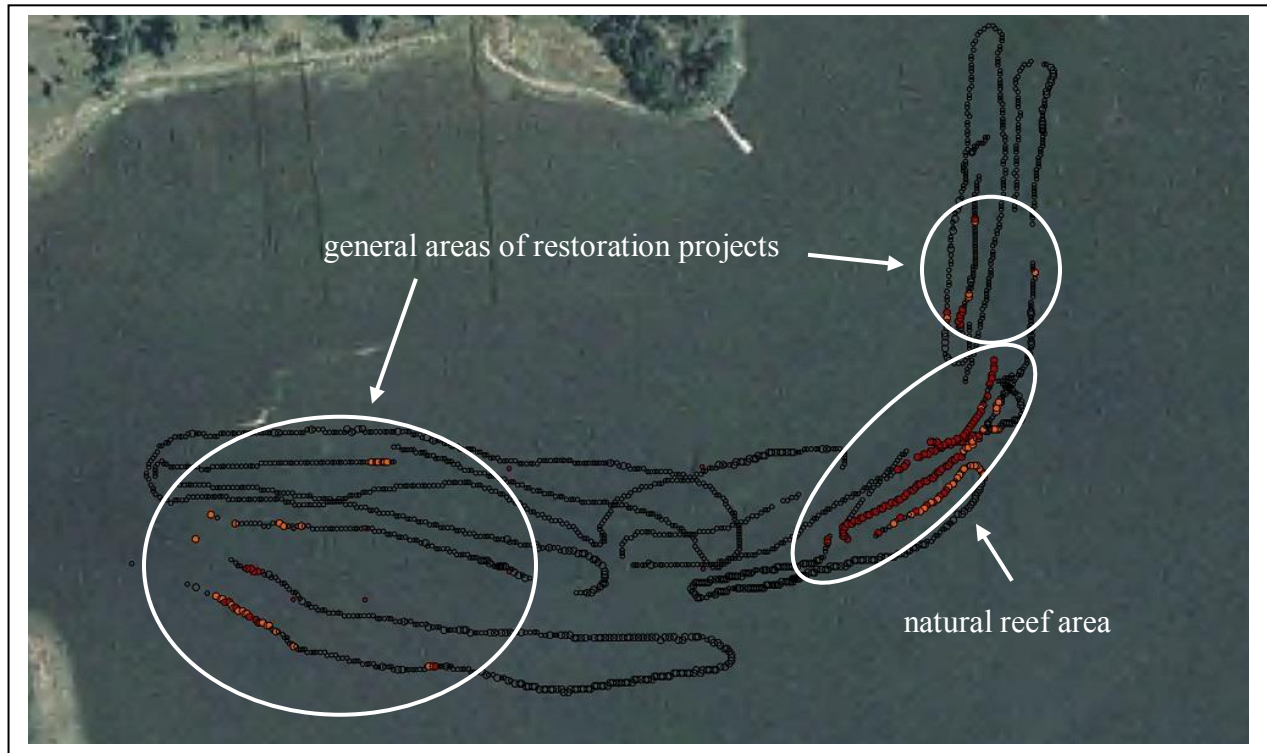
### Adams Point



### Middle and Western Great Bay



Lamprey River



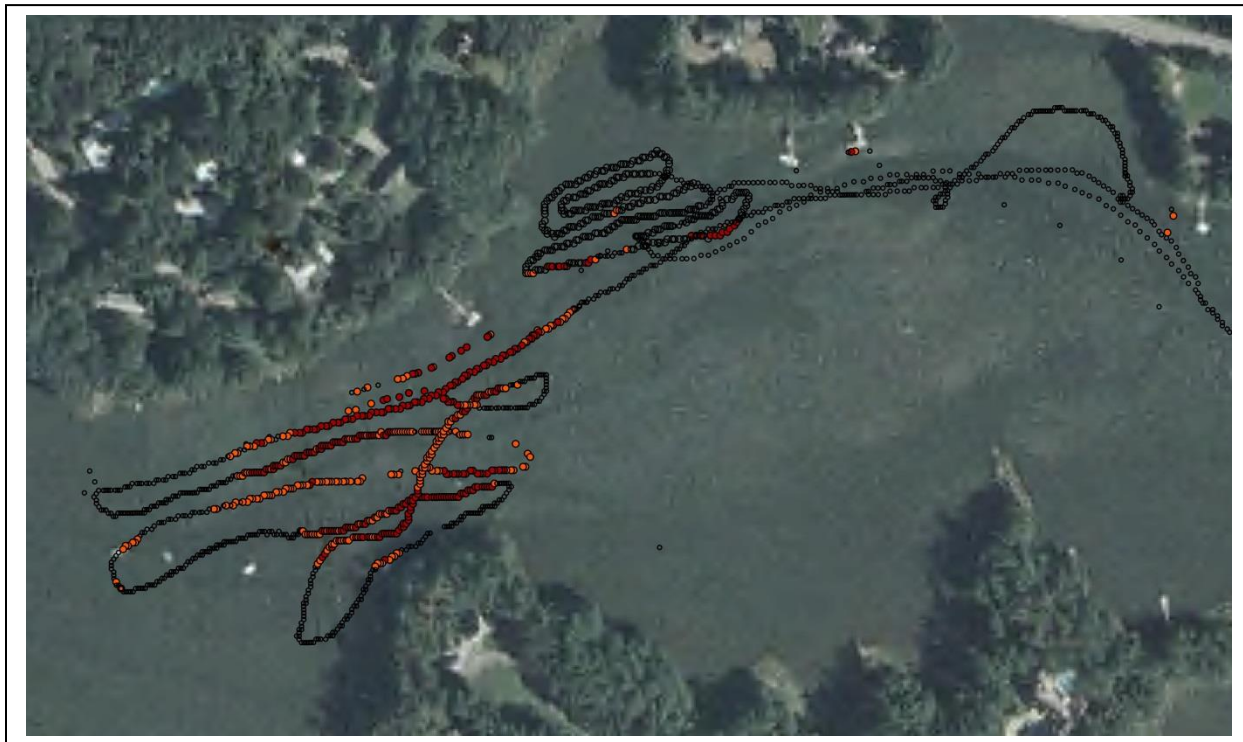
Little Bay/Fox Point



Nannie Island and Woodman Point



Oyster River





Piscataqua River and Piscataqua (South) River



Squamscott River

