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Oyster Reef Mapping in the Great Bay Estuary, New Hampshire - 2003, Grizzle, R

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OYSTER (*CRASSOSTREA VIRGINICA*) REEF MAPPING IN THE GREAT BAY ESTUARY, NEW HAMPSHIRE - 2003

A Final Report to

The New Hampshire Estuaries Project

Submitted by

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Executive Summary

In New Hampshire, the locations, sizes, and shapes of the major oyster, *Crassostrea virginica*, reefs have been determined using a variety of techniques. The most recent survey occurred in 2001 when four (Nannie Island, Woodman Point, Adams Point, and Oyster River) of the six largest reefs were mapped using a combination of acoustic sounders, videography, and quadrat sampling. The present project required mapping the boundaries in order to determine the size of the remaining two major reefs in the Great Bay Estuary: Squamscott River and Piscataqua River. Underwater videography was used in the present study to determine the boundaries of these two reefs.

Continuous video imagery was acquired along three or four parallel transects spanning the longest axis of each reef and seven to ten transects perpendicular to them. At approximately 90 points for the Squamscott reef and 115 points for the Piscataqua reef, stationary (for 3 to 5 seconds) video imagery was taken within the overall matrix of transects. Concurrently and synchronized with respect to time with the imaging, DGPS output was logged at 0.5 second intervals to provide geo-referencing of all the imagery. Stills taken from each stationary imagery site were assigned a classification of "non-reef" (<10% bottom coverage by oyster shells), "low density reef" (10% to 50% coverage by oyster shells), or "high density reef" (>50% coverage by oyster shells). The classification types were then plotted on the base map and polygons were constructed manually, drawing each boundary line approximately midway between bottom type classes. Areas of polygons for "high density reef" and "low density reef" were determined by ArcView for each of the reefs. One representative still image from each stationary video site was assembled in a systematic grid overlaid on the overall imaging area to provide a photomontage of bottom images for each reef.

The video imagery was of sufficient quality to allow classification of "shell bottom" into two density classes: "low" (10% to 50% bottom coverage by oyster shell) and "high" (>50% bottom coverage by oyster shell). If it is assumed that "low" and "high" density oyster shell coverage reflect oyster reef bottom, the Piscataqua reef had an areal extent of 19.9 acres (Fig. 6) and the Squamscott reef covered 3.9 acres (Fig. 7). If only "high density" bottom represents oyster reef bottom, the Piscataqua reef covered 12.5 acres and the Squamscott 1.9 acres. If it is assumed that at least the high density areas would have been considered oyster reef bottom in previous studies, then areal coverages from the present study compare well with recent previous surveys suggesting that total bottom areal coverage may not have changed appreciably for either reef since the 1990s.

The use of underwater videography for routine monitoring of oyster reefs is in the early development stages. At this time, we think it can be recommended that video be considered as a tool for routine inspection of reefs, and to better design the traditional sampling programs based on quadrat sampling. Our laboratory recently was awarded a 2-year NH Sea Grant project to develop a general protocol for routine monitoring of oyster reefs. This research will consider underwater video along with several acoustics techniques and quadrat sampling.

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Introduction

The shapes and sizes of the major oyster (*Crassostrea virginica*) reefs ("beds") in New Hampshire have been determined using a variety of techniques. Langan (1997) used a combination of tonging and diver observations, coupled with buoys located by differential GPS, to map the boundaries of most of the major reefs shown in Figure 1. In 2001, four of these reefs (Nannie Island, Woodman Point, Adams Point, and Oyster River) were again mapped using different combinations of acoustic sounders, videography, and quadrat sampling (Smith 2002; Grizzle et al. 2003). The present project required mapping the boundaries in order to determine the size of the remaining two major reefs in the Great Bay Estuary: Squamscott River and Piscataqua River (Fig. 1). Underwater videography was used in the present study to determine the boundaries of these two reefs. The overall purpose of the present project was to complete the more recent (2001) mapping effort so that NHEP will have information on areal coverage of the six oyster reefs regularly monitored by NH Fish and Game Department (Trowbridge 2002).

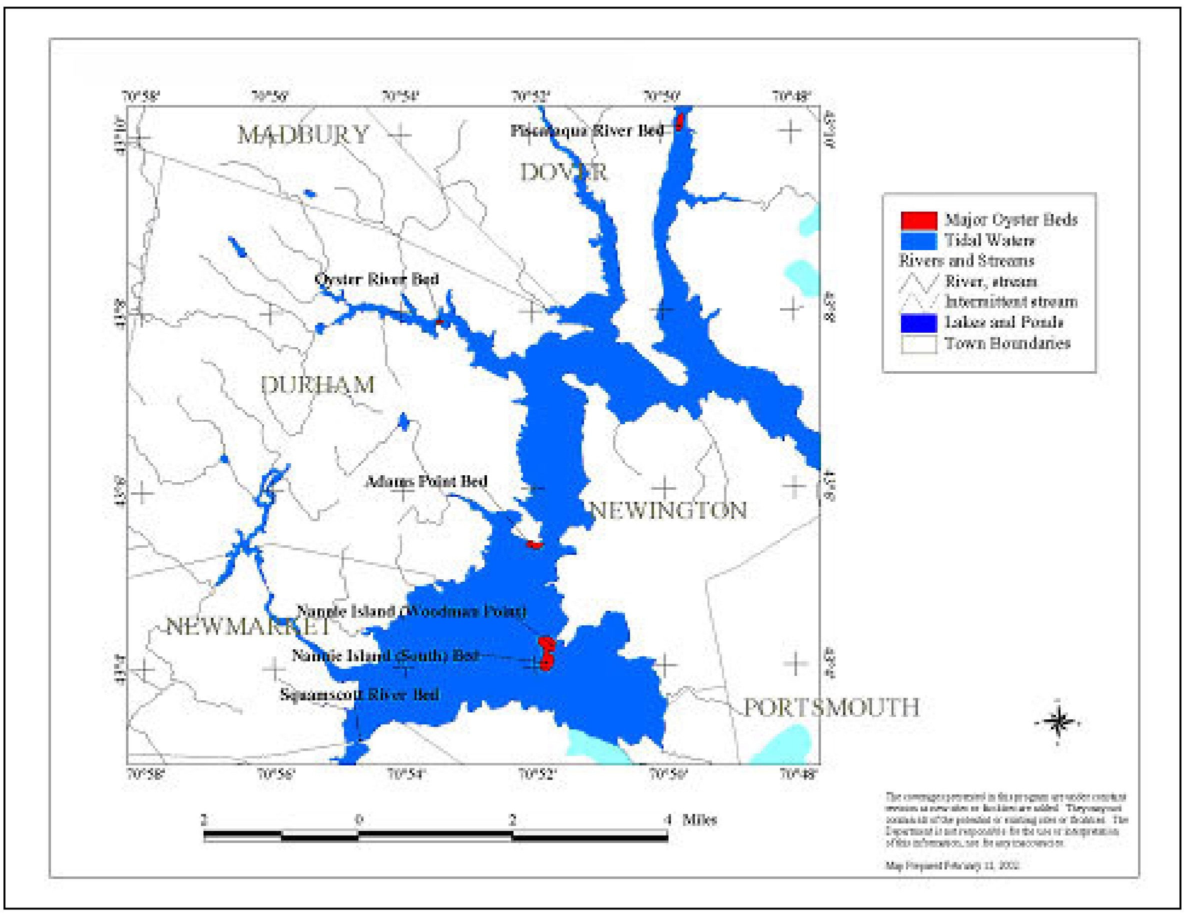

Figure 1. Six major oyster reefs in the Great Bay Estuary, including the two study reefs at Squamscott River and Piscataqua River (from Trowbridge 2002).

Project Goals and Objectives

The objectives of this project were to map the two study reefs, determine their areal coverages, and compare the new data with data from previous studies (as summarized in Langan 1997). Four deliverables were required: (1) Two ArcView-compatible GIS-based maps of the Squamscott River and Piscataqua River oyster reefs, (2) two photomontages constructed from 50+ stills extracted from video imagary of each reef, (3) documentation/metadata for the GIS file, and (4) copies of all video imagery.

Methods

The methods used in the present study were similar to and based on recommendations made by Smith (2002). The intent was to provide data on reef boundaries for the two study reefs that would be comparable to the four reefs mapped in 2001.

Field

Continuous video imagery was acquired along three or four parallel transects spanning the longest axis of each reef and seven to ten transects perpendicular to them (Figs. 2 and 3). Each transect extended 20+ meters in both directions beyond the actual boundary of the reef, yielding a crisscrossing pattern providing complete video coverage of the reef and allowing accurate determination of reef boundaries. At approximately 90 points for the Squamscott reef and 115 points for the Piscataqua reef, stationary (for 3 to 5 seconds) video imagery was taken within the overall matrix of transects (Figs. 2 and 3). Concurrently and synchronized with respect to time with the imaging, DGPS output was logged at 0.5 second intervals to provide geo-referencing of all the imagery. The Squamscott River reef was visited on 6 and 7 October 2003, and approximately 1.5 hr of video imagery was recorded on the 7th. The Piscataqua River reef was visited on 8 October 2003, and approximately 2 hr of imagery was recorded.

Image processing

Stills taken from each stationary imagery site were assigned a classification of "non-reef" (<10% bottom coverage by oyster shells), "low density reef" (10% to 50% coverage by oyster shells), or "high density reef" (>50% coverage by oyster shells). The classification types were then plotted on the base map and polygons were constructed manually, drawing each boundary line approximately midway between bottom type classes. Areas of the polygons for "high density reef" and "low density reef" were determined by ArcView for each of the reefs. One representative still image from each stationary video site was assembled in a systematic grid overlaid on the overall imaging area (Figs. 2 and 3) to provide a photomontage of bottom photographs for each reef.

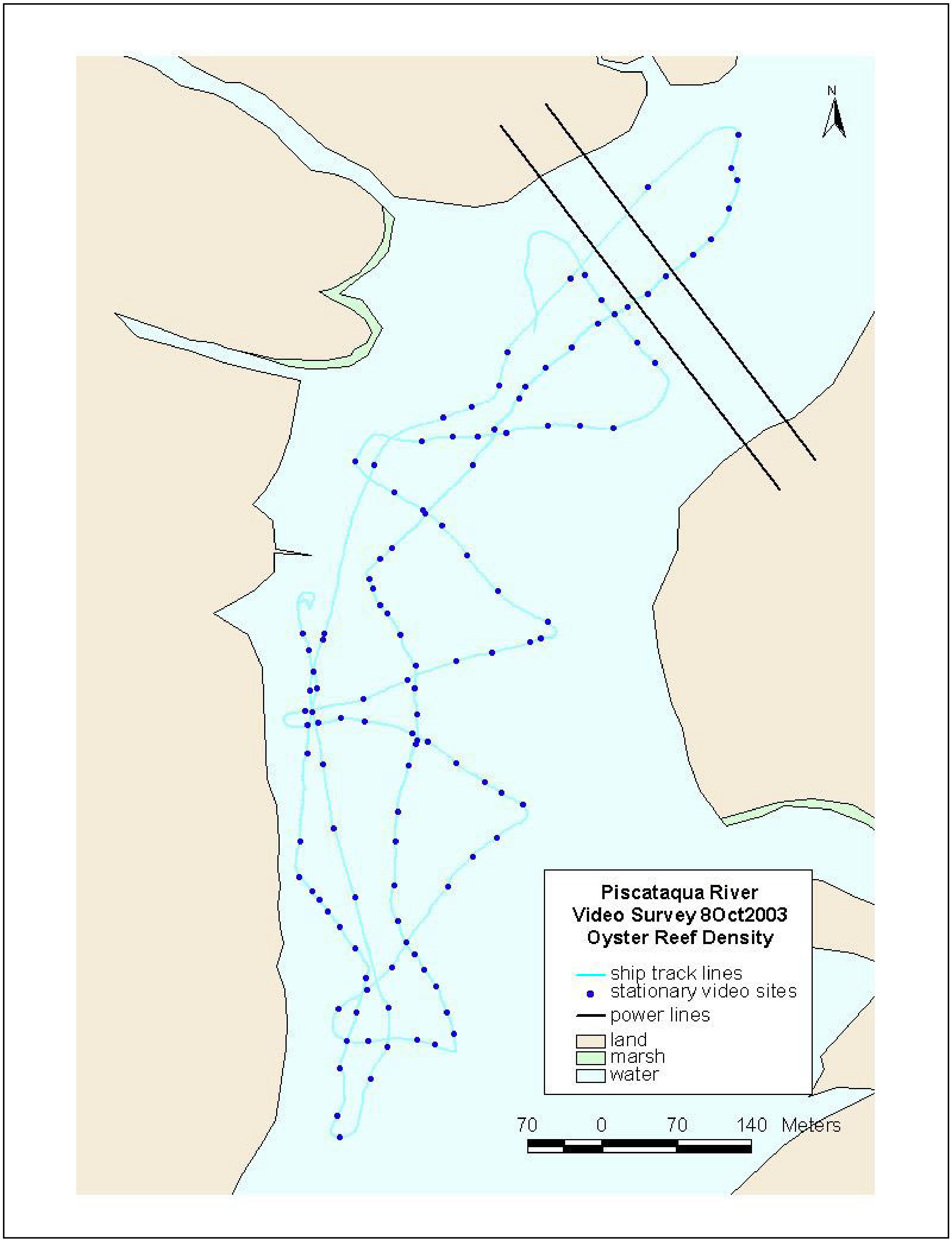

Figure 2. Ship track lines for video survey of Piscataqua River oyster reef.

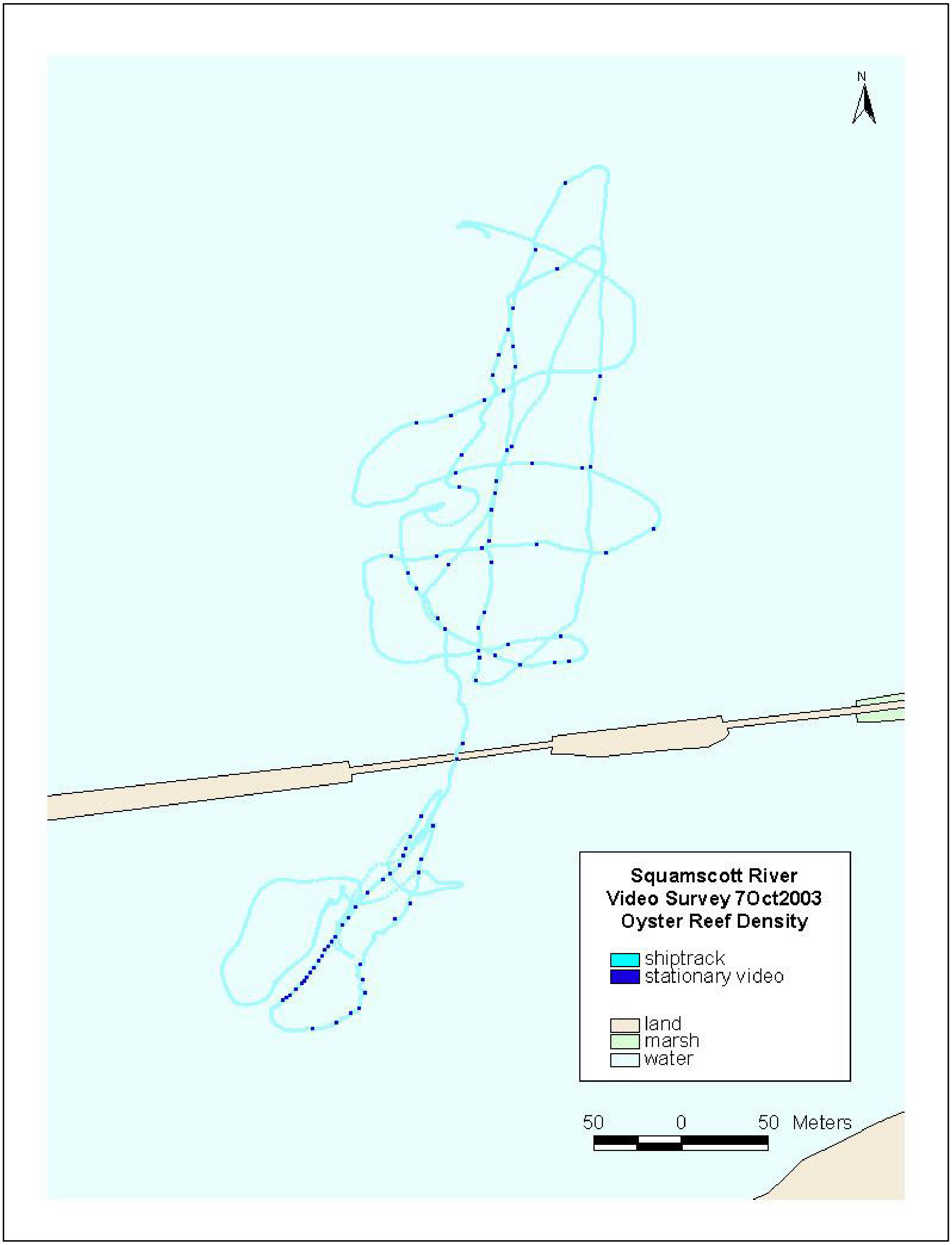

Figure 3. Ship track lines for video survey of Squamscott River oyster reef.

Results and Discussion

The Piscataqua River reef (considering both "low" and "high" density classes; see discussion below) has an irregular shape and is aligned approximately with the main channel, occupying nearly all of the subtidal portion of the river along the reef's southern half but tapering to the northwestern side of the channel along its northern half (Figs. 4-6). It extends a total linear distance of about 1000 m along its major axis, varying in width from 50 m to 200 m. The Squamscott reef also only occurs subtidally and along the main channel, with its overall shape reflecting channel morphology (Fig. 7). It extends 150 m south of the railroad bridge and in that portion has a relatively uniform width of 30 to 40 m. It extends 250 m north of the bridge and in this area varies from 20 m to 100 m wide.

The video imagery was of sufficient quality to allow classification of "shell bottom" into two density classes: "low" (10% to 50% bottom coverage by oyster shell) and "high" (>50% bottom coverage by oyster shell). If it is assumed that "low" and "high" density oyster shell coverage reflect oyster reef bottom, the Piscataqua reef had an areal extent of 19.9 acres (Fig. 6) and the Squamscott reef covered 3.9 acres (Fig. 7). If only "high density" bottom represents oyster reef bottom, the Piscataqua reef covered 12.5 acres and the Squamscott 1.9 acres.

It is not possible to directly compare data from the two density classes to previous surveys because different methods were used. However, it seems reasonable to assume that at least the high density areas would have been considered oyster reef bottom in previous studies. Based on this assumption, areal coverages from the present study compare well with data in Langan (1997), suggesting that total bottom areal coverage may not have changed appreciably for either reef since the 1990s (Table 1).

Table 1. Recent historical data on oyster reef bottom areal coverages (acres) compared to present study. All pre-2003 data from Langan (1997). Note that 2003 data give "low" and "high" density measurements (see text).

Reef Location	1991	1993	1997	2003	
				"Low Density"	"High Density"
Piscataqua River	12.3	12.3	12.8	7.4	12.5
Squamscott River	-	-	1.7	2.0	1.9

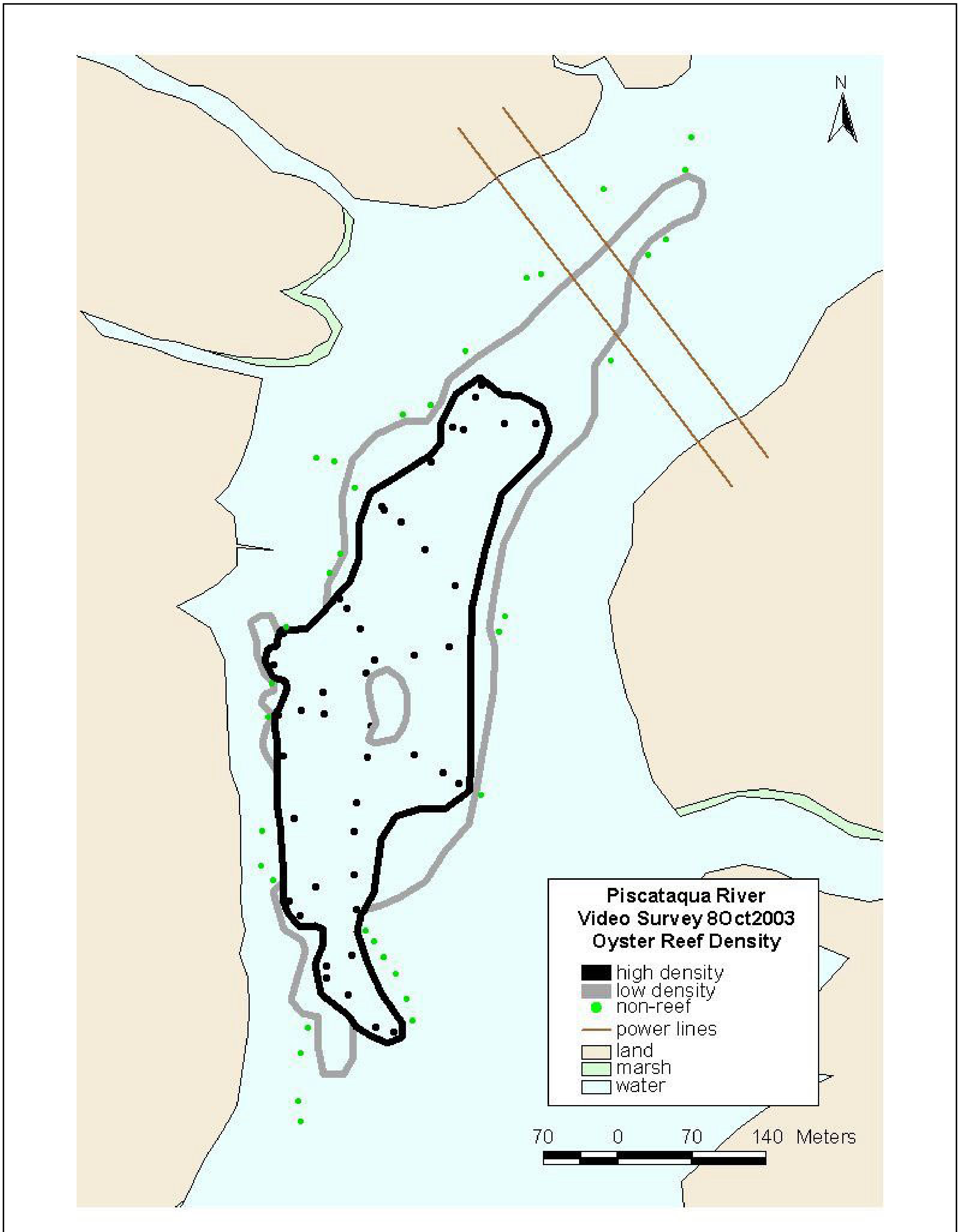

Figure 4. Piscataqua River reef showing high density, low density, and non-reef bottom types as determined using stationary video at each marked site (black, gray and green dots).

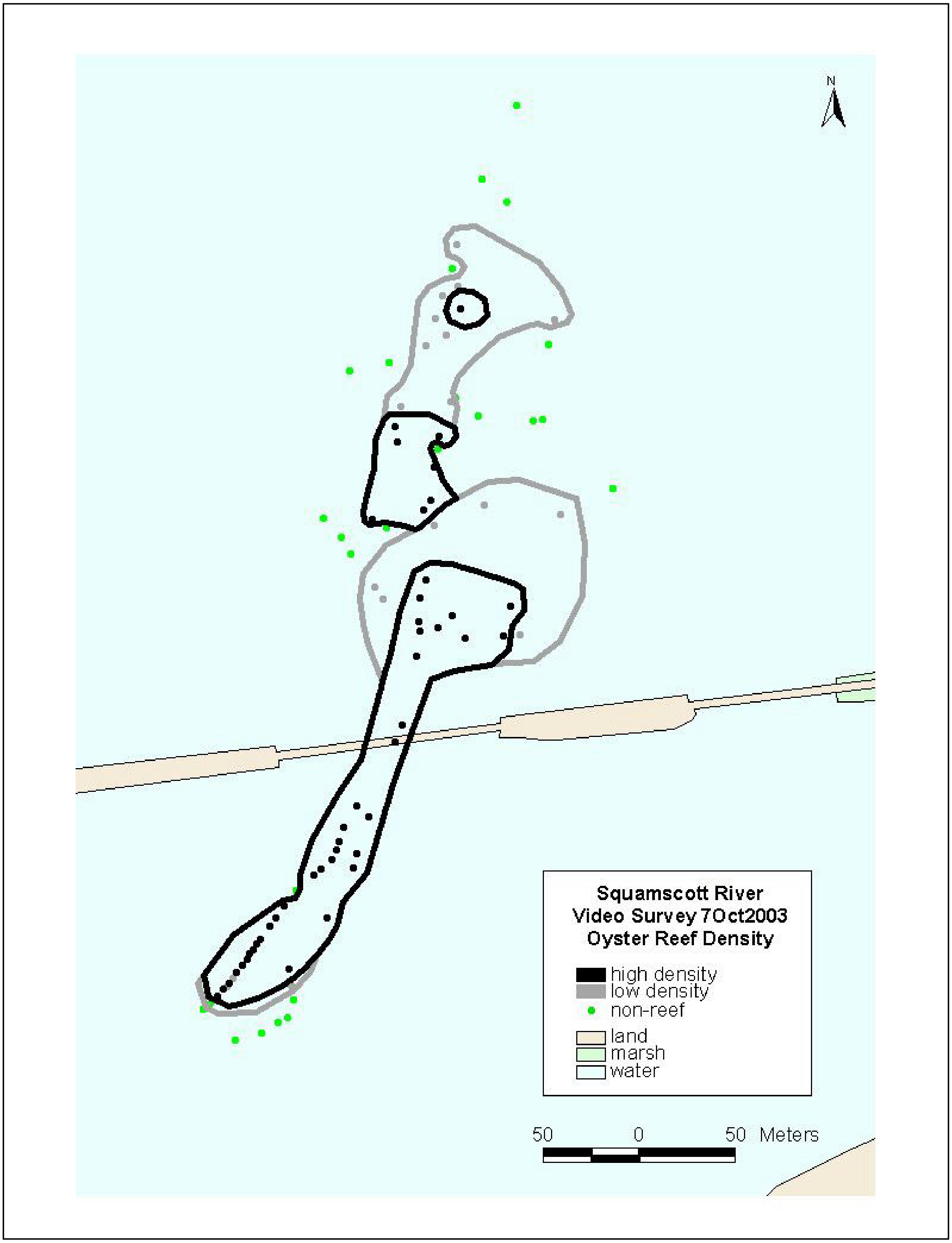

Figure 5. Squamscott River reef showing high density, low density, and non-reef bottom types as determined using stationary video at each marked site (black, gray and green dots).

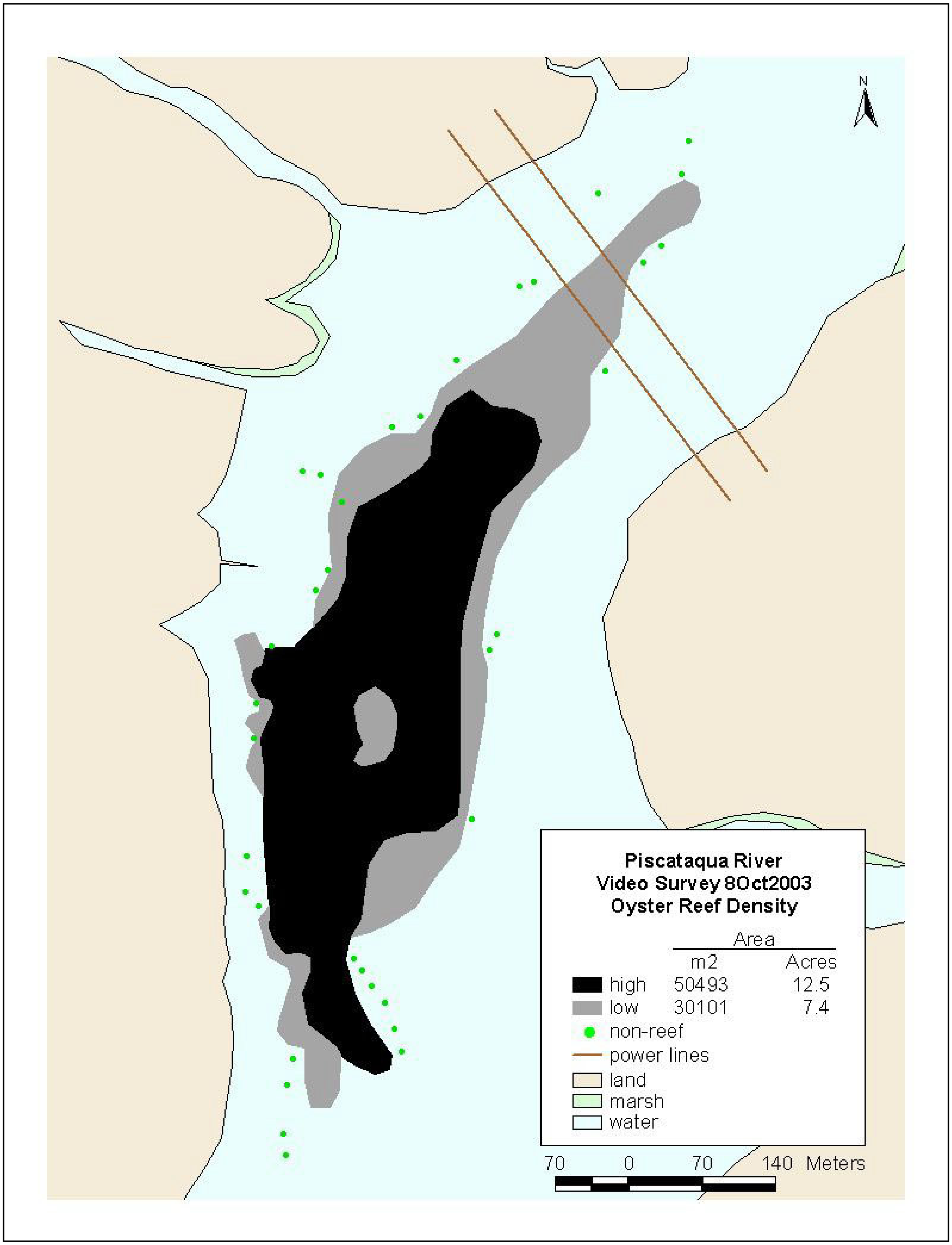

Figure 6. Piscataqua River oyster reef showing high and low density areas as shaded polygons (compare to Fig. 4 and see text for details on density measurements).

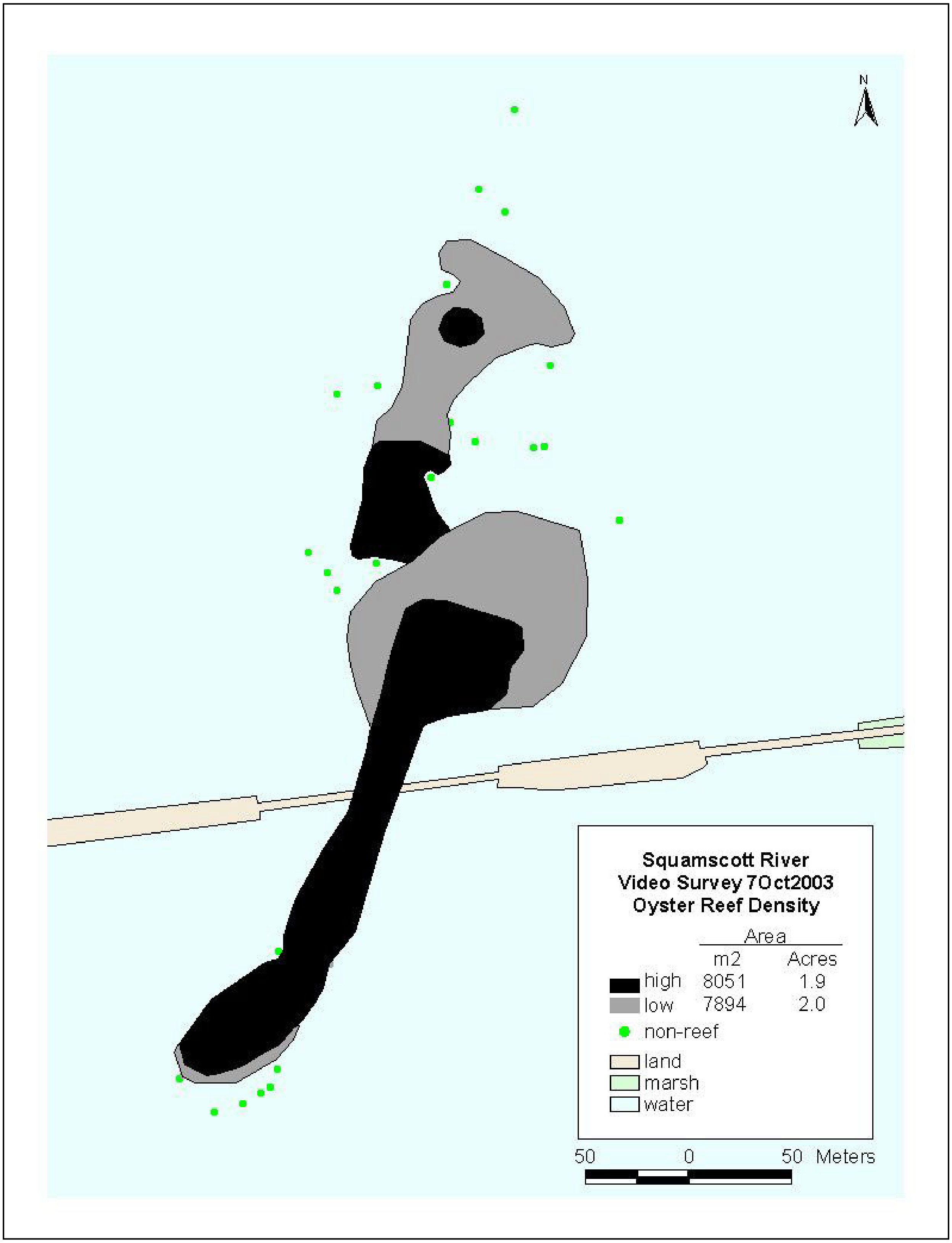

Figure 7. Squamscott River oyster reef showing high and low density areas as shaded polygons (compare to Fig. 5 and see text for details on density measurements).

Photomontages were also constructed for each of the study reefs to provide photographic representation of reef characteristics (Figs. 8 and 9). This is a new kind of assessment and presentation method being developed by our laboratory (Smith 2002; Grizzle et al. 2003). Although not one of the objectives of the present study, a preliminary assessment of the photomontages from the two study reefs shows some obvious differences that are related to reef health, and might be useful for future monitoring programs.

For example, there were dramatic differences in vertical relief and shell densities when comparing the two reefs. In both high and low density areas, the Piscataqua reef consisted mainly of individual shells lying on one valve scattered across the bottom, and it was difficult to differentiate between empty valves and live oysters. In contrast, many areas of the Squamscott reef consisted of vertically oriented, dense clusters of obviously (based on valve gape and/or visible movements) live oysters. Careful inspection of the photomontages presented herein (Figs. 8 and 9) shows some of these differences, but they were readily evident in the raw video imagery. Also, Grizzle et al. (2003) present data comparing quadrat counts and shell counts from other video imagery on NH reefs, and suggest that video imagery may have the potential to quantify differences in densities of live and dead oysters.

Conclusions

Data on total reef bottom areal coverages measured in the present study compare well with previous surveys, and suggest that there have been no major changes in this respect since the 1990s in the two study reefs. The use of continuous underwater video along transects to determine reef areal coverage provided spatial resolution on the scale of a few meters for reef boundaries, probably resulting in more accurate information on reef shape than was available from previous studies. The use of video also provided information on reef structure and health not previously available, and it is potentially useful for future monitoring programs.

Recommendations (for future work or management strategies)

The use of underwater videography for routine monitoring of oyster reefs is in the early development stages. At this time, we think it can be recommended that video be considered as a tool for routine inspection of reefs, and to better design the traditional sampling programs based on quadrat sampling.

The present study and earlier work (Smith 2002, Grizzle et al. 2004) have demonstrated some potentially fruitful directions for further research. We know that imagery of sufficient quality readily yields information on shell density and size, relative numbers of live oysters, vertical structure, and spatial variations across the reef on a scale of meters. However, the full potential for underwater video and how it might fit into a comprehensive and cost-effective program of routine monitoring remains to be determined. Our laboratory recently was awarded a 2-year NH Sea Grant project to develop a general protocol for routine monitoring of oyster reefs. This research will consider underwater video along with several acoustics techniques and quadrat sampling.

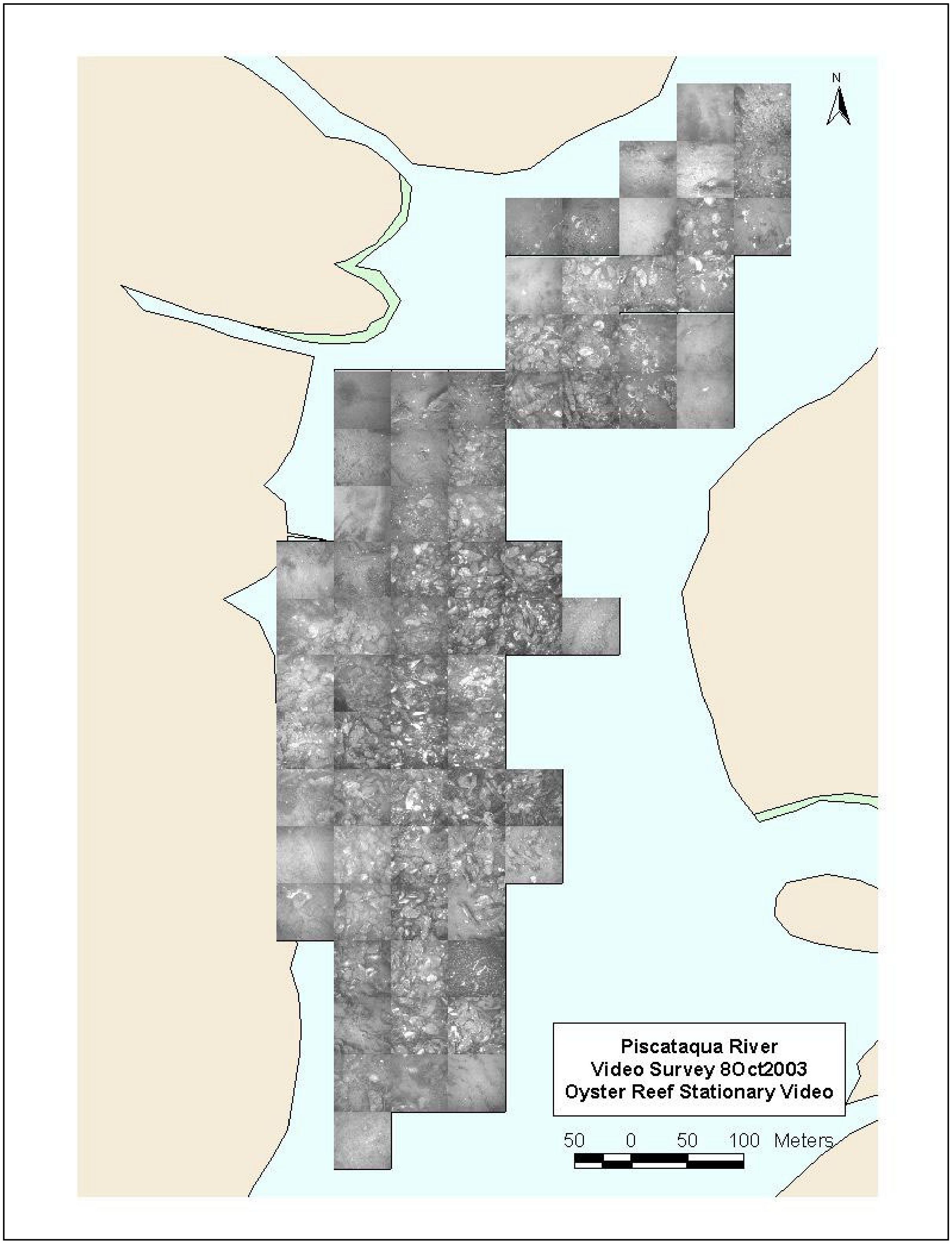

Figure 8. Piscataqua River reef photomontage based on stationary video imagery. Each individual photo is about 0.5 x 0.5 m, and each corresponds to one of the stationary video sites shown in Figure 2.

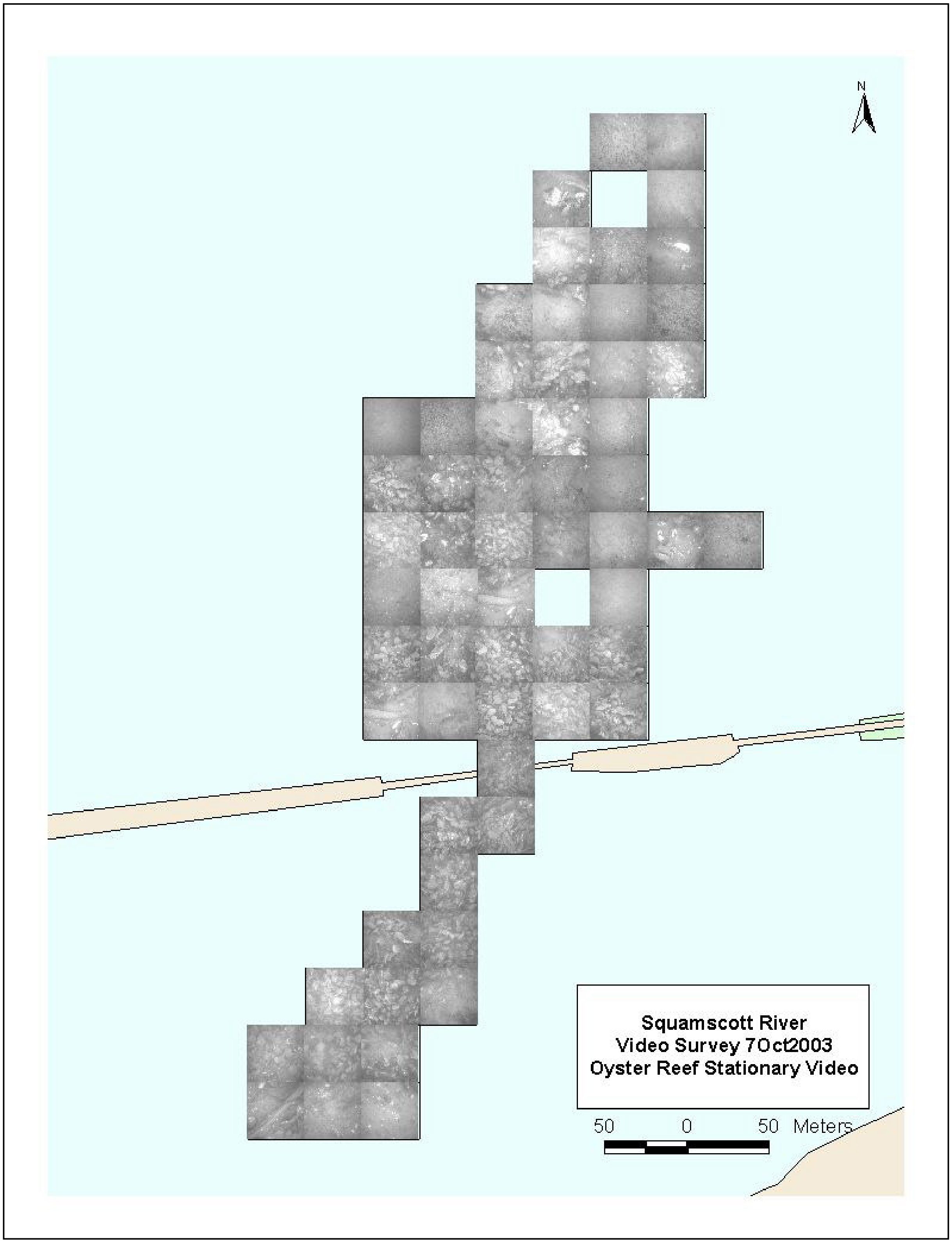

Figure 9. Squamscott River reef photomontage based on stationary video imagery. Each individual photo is about 0.5 x 0.5 m, and each corresponds to one of the stationary video sites shown in Figure 3.

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Appendix A - QA Procedures

The accuracy of the maps produced by the present study were assessed by visiting 11 sites on the Piscataqua reef and 27 sites on the Squamscott reef using latitude and longitude read directly from the ArcView map files. At each site, a 0.25 m^2 area of the bottom was thoroughly worked using oyster tongs to remove as much bottom material as practical. All live oysters retrieved were measured (shell height to nearest mm using calipers) and counted, and all empty valves were counted. The resulting data were compared to the mapped classification ("high density reef," "low density reef," and "non-reef") for each of the sites as an assessment of the accuracy (i.e. ground-truthing) of the video-derived bottom classes.

A total of 11sites were sampled on both reefs in areas mapped as "high density reef", and live oysters were found at all 11 sites (Table A1 below). Live oysters also were collected from 10 of the 12 sites in areas mapped as "low density reef." In contrast, live oysters were only collected from 4 of the 15 "non-reef" sites. These data indicate that the mapping process used in the present study was probably highly accurate for oyster bottom in general, including areas designated as high (100% of sampled sites with live oysters) and low (83% of sampled sites with live oysters) densities. It also indicates that live oysters were found in some areas adjacent to mapped "reef" areas but in most cases only at very low densities.

Table A1. Raw tong data from Piscataqua and Squamscott oyster reefs. H = high density reef area, L = low density reef, N = non-reef.

Piscataqua River Oyster Density - 7 July 2004

approximate tong area = 0.25 m^2

Sample #	Density	# Oysters	# Empty shells
1	H	12	9
2	H	12	9
3	H	21	15
4	L	3	4
5	L	15	15
6	L	15	10
7	N	2	5
8	N	0	0
9	N	0	0
10	N	2	1
11	N	3	2

Squamscott River Oyster Density - 6 July 2004

approximate tong area = 0.25 m^2

Sample #	Density	# Oysters	# Empty shells
1	H	18	4
2	H	15	5
3	H	1	1
4	H	26	1
5	H	34	5
6	H	21	13
7	H	9	2
8	H	10	6
9	L	29	12
10	L	10	0
11	L	3	5
12	L	22	4
13	L	4	0
14	L	24	6
15	L	0	0
16	L	0	0
17	L	11	11
18	N	0	0
19	N	0	0
20	N	18	4
21	N	0	0
22	N	0	0
23	N	0	0
24	N	0	0
25	N	0	0
26	N	0	0
27	N	0	0