Permit Application for Artificial Reef Development – Yarmouth MA

Submitted by:
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Town of Yarmouth
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Proposal for Yarmouth Artificial Reef Permit Application

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List of Attachments for ENF

1. Copy of Environmental Notification Form Application
2. Copy of Project narrative including Figures and Appendices

List of Agencies and persons receiving the ENF

1. MEPA Office (2 copies)
   Secretary Richard K. Sullivan, Jr.
   Executive Office of Energy and Environmental Affairs (EEA)
   Attn: MEPA Office
   100 Cambridge Street, Suite 900
   Boston, MA 02114

2. Department of Environmental Protection Boston Office
   Commissioner's Office
   One Winter Street
   Boston, MA 02108

3. DEP Southeastern Regional Office
   Attn: MEPA Coordinator
   20 Riverside Drive
   Lakeville, MA 02347

4. DEP Southeast Region Cape Cod Office
   3195 Main St.
   Barnstable, MA 02630

5. Applicable Massachusetts DOT District Office District #5
   Attn: MEPA Coordinator
   Box 111
   1000 County Street
   Taunton, MA 02780

6. Massachusetts Historical Commission
   The MA Archives Building
   220 Morrissey Boulevard
   Boston, MA 02125

7. Massachusetts Department of Transportation
   Public/Private Development Unit
   10 Park Plaza
   Boston, MA 02116

8. Cape Cod Commission
   3225 Main Street
   Barnstable, MA 02630

9. DCR
   Attn: MEPA Coordinator
   251 Causeway St. Suite 600
   Boston MA 02114

10. Coastal Zone Management
    Attn: Project Review Coordinator
    251 Causeway Street, Suite 800
    Boston, MA 0211

11. Conservation Commission
    Town of Yarmouth
    1146 Route 28
    South Yarmouth, Massachusetts 02664-4492

12. Division of Marine Fisheries (South Shore)
    Attn: Environmental Reviewer
    1213 Purchase Street - 3rd Floor
    New Bedford, MA 02740-6694

13. Natural Heritage and Endangered Species Program
    Commonwealth of Massachusetts
    Route 135
    Westborough MA 01581

List of Municipal and Federal Permits required

Local
Notice of intent (filed)

State
WPA NOI (filed)
Chapter 91 license
401 Water Quality Certification

Federal
Army Corps of Engineers General Permit (GP)

Yarmouth Artificial Reef Project Proposal

Introduction

The creation of artificial reef habitat has been employed by many coastal states as an effective method of increasing fisheries productivity, augmenting fisheries habitat, and enhancing local recreational fisheries (Ditton et al. 2002; Figley 2004). The Division of Marine Fisheries (DMF) has an established artificial reef program designed to provide an operational framework for responsible long-term management of artificial habitats that provide benefits to fisheries resources. Nantucket Sound is an area of limited hard bottom habitat relative to other coastal regions of Massachusetts. Bugley and Carr (1994) reviewed the status of artificial structures in Nantucket Sound and found many of the once plentiful shipwrecks were deteriorating, resulting in an overall loss of relief and habitat value. Public interest in developing artificial reefs in the region has grown over concerns that the amount of available structured fish habitat along southern Cape Cod is diminishing.

Yarmouth is the site of the first permitted artificial reef site in Massachusetts. Developed in 1978 by the Town of Yarmouth Department of Natural Resources, the 127-acre site is located 2.2 miles south of the mouth of the Bass River (Figure 1). The reef units built for this site consist of 3 to 5 tires ballasted with concrete and strapped together in bundles. Approximately 1,500 units were deployed in 1978 and an additional 1,000 units in 1994 totaling 2,500 units. Since its creation, this site has become one of the most frequented recreational fishing areas off the Yarmouth coast.

These supporting materials are provided to further describe the proposed methods for selection and placement of materials at the location identified in Notice of Intent (NOI) file # SE 083-1921 issued by the Department of Environmental Protection (DEP) on 3/23/12. The deployment of new reef material proposed for this location are for expanding and maintaining an artificial reef to provide benefits to marine resources by providing shelter for cryptic marine vertebrate and invertebrate species in a location that is otherwise limited in structural complexity. This project will also provide near-shore fishing for anglers in Nantucket Sound. This document addresses seven specific issues: 1) Assessment of current on-site conditions 2) proposed project size 3) dispersion of materials on-site 4) volume of new materials construction impacts 6)monitoring and 7) alternatives analysis.

1. Site Assessment

In 2009 and 2010, DMF conducted a site assessment to examine the capacity of the Yarmouth reef site to accept additional reef materials. DMF contracted American Underwater Search and Survey (AUSS) to perform a sidescan sonar survey of the Yarmouth tire reef site in August 2009. From this survey, a mosaic image was generated to characterize differences in surficial substrate and to locate materials deployed during previous permitting rounds. Visual analysis of image data generated from the survey was used to identify the locations of vertical relief within the permitted area. Diver surveys along 100m transects were conducted to verify the composition of surficial substrate and to qualitatively assess species diversity of macroinvertebrates and vertebrates. These data were used to characterize the current condition of the reef and to assess the feasibility of deploying additional artificial reef materials on site. Transect locations were selected from areas of interest identified in the visual analysis of the sidescan image data (Figure 2).

Site Assessment Results

Sidescan sonar survey

Sidescan survey coverage was achieved for ninety-five percent of the targeted area. Different shades of gray depicted on the sidescan survey image are an indication of different sediment characteristics. Lighter shaded areas represent the presence of softer sediments relative to other darker shaded areas on the image. Verification of the surficial substrate composition was assessed using diver surveys along 100m transects.

Surficial substrate composition

Divers quantified substrate composition data along both sides of a 4m x 100m transect line out to a distance of 2 meters. Larger substrate types were visually classified according to categories defined by Wentworth (1922 – Wentworth scale) and verified using rulers. Finer substrates were categorized as sand, mud, or silt. Primary (area contained >50% of sediment type), secondary (area contained 10-50% of sediment type) and underlying (subsurface sediments) sediment types were recorded at 10m intervals. Surficial substrate composition results are displayed in Figure 3.

Reef Materials on-site

To assess the density of reef materials on site, a point layer was generated in GIS by marking the presence of sonar "shadows" depicted in the sidescan mosaic image (Figure 4). Points were added to a map to indicate areas where structures are present, however these data are limited because areas containing multiple tire units cannot be differentiated from areas containing single units, only areas where materials are present. Thus, the number of targets identified in this analysis was only used for estimating the density of materials and not as an indication of the actual quantity of materials present within the permitted area. Visual image analysis identified 719 different targets within the site (Table 1).

Species presence and relative abundance

Divers quantified all fish species, motile invertebrates, and select sessile macroinvertebrates along each transect line. Species observations was totaled from both divers to determine relative abundance along a transect. Survey totals for observed fish species are depicted in Table 2 and Figure 5. Survey totals for observed invertebrate species are depicted in Table 3 and Figure 6.

Table 1. Number of targets (reef units) identified

Area	# of targets identified	%
NE	259	36
NW	325	45.2
SE	40	5.6
SW	95	13.2
Total	**719**	**100**

Table 2. Fish data

	Transect							
Fish (count)	T1	T2	T3	T4	T5	T6	T7	Totals
Black sea bass	63	1	144	88	25	78	88	487
Scup	223	5	134	11	1	7	20	401
Blue Runner	27	0	152	0	0	0	0	179
Cunner	10	3	27	0	7	0	0	47
Lesser amber jacks (juv.)	5	0	20	0	0	0	0	25
Tautog	5	14	2	0	0	0	0	21
Spotfin butterfly	0	0	5	0	0	0	0	5
Winter flounder	0	0	0	0	0	2	1	3
Summer flounder	0	0	1	0	0	2	0	3
Butter fish	3	0	0	0	0	0	0	3
Northern sea robin	0	0	0	0	0	0	1	1
Total number of fish species per transect	7	4	8	2	3	4	4	11
Total number of fish per transect	336	23	485	99	33	89	110	1175

Table 3. Invertebrate data

	Transect							
Invertebrate (count)	T1	T2	T3	T4	T5	T6	T7	Totals
Hermit crabs	0	0	0	0	134	155	299	588
Cliona celata (yellow sponge)	16	5	13	24	1	7	2	68
Tufted bryazoan	0	0	9	0	0	0	0	9
Slipper shells (*cripedula* sp.)	0	0	0	0	0	8	0	8
Busycon + Buccinum (whelks)	0	1	0	0	2	0	1	4
Blue mussel	0	2	0	0	0	0	0	2
Homarus americanus	0	0	1	0	0	0	0	1
Libinia emarginata (spider crab)	0	0	0	0	0	1	0	1
Metridium sp. (anemonies)	1	0	0	0	0	0	0	1
Quahog	0	0	0	1	0	0	0	1
Total number of invertebrate species per transect	2	3	3	2	3	4	3	10
Total number of invertebrates per transect	17	8	23	25	137	171	302	683

Land Containing Shellfish

This site lies within an area designated as habitat suitable for shellfish, specifically *Argopecten irradians* (Atlantic bay scallop) and *Mercenaria mercenaria* (hard clam), according to data published by DMF and MassGIS (Figure 7). This information includes areas where shellfish have been observed since the mid-1970's, but may not currently support any shellfish. Therefore, these designations represent potential rather than actual shellfish habitat areas. This factor was addressed by collecting information during transect surveys on the actual presence of all shellfish species. Two shellfish species, hard clam (N=1) and *Mytilus edulis* (blue mussel) (N=2) were observed over all seven transects.

Site Assessment Summary
Surficial substrate composition is relatively uniform throughout the site, consisting primarily of sand. The northern extent of the site contains the highest density of deployed materials. There are several areas where structure density is low, particularly in the southeast quadrant. Some softer sediment occurs in the deeper portion of the southwest quadrant and settling of tire units into the substrate was observed. However, it should be noted that many of these materials have been onsite for 20 years or more and continue to provide fish habitat.

Eleven different fish species were recorded during the survey (Table 2). Black sea bass and scup were the dominant species found throughout the permit site, with the highest numbers of these species observed where the concentration of tire reef structures was the highest. Both species were the only fish species observed along all transects. Transect locations with the highest recorded concentrations of tire units (transects 1 and 3) contained more fish species and higher fish count totals than transects where lower or no concentrations of tires were observed. Two fish species, Winter flounder (n=3) and Northern sea robin (n=1) were observed only along transects where no tire units were recorded.

Ten different invertebrate species were recorded during the survey (Table 3). Small areas (<$2ft^2$) containing high concentrations (>50 individuals per ft^2) of hermit crabs were observed at locations along three transects (T5, T6, T7). *Cliona celata* (yellow sponge) was the only invertebrate species observed along all transects and ranked second in occurrence among all invertebrate species. Four invertebrate species (Quahog, lobster, spider crab, and anemone) were observed on only one occasion during transect sampling.

Although this site has been identified as suitable shellfish habitat for two shellfish species, low numbers of shellfish were observed during transect surveys. The deployment of new materials on site in accordance with the method of material deployment proposed in this narrative is not expected to have a significant impact on shellfish habitat or abundance.

The Yarmouth artificial reef site continues to act as valuable fisheries habitat and has remained relatively stable and functional for over 30 years. Local recreational anglers actively use this site throughout the recreational season and were observed during all phases of data collection. Areas within the permitted site with low concentrations of materials are capable of supporting additional reef materials of similar vertical relief and structural complexity. Deployment of new materials to the site should target the underdeveloped areas identified in this report. Settlement of materials can be expected to occur over time, and must be considered when selecting new materials for deployment on site. The addition of new reef material to the site shall be in accordance with the "Guidelines for Marine Artificial Reef Materials, Second Edition" (ASMFC 2004), the National Artificial Reef Plan (NOAA 2007), the Massachusetts Artificial Reef plan (Rousseau 2008), and follow the materials and design criteria outlined in Appendix A.

2. Proposed Project Size

In addition to identifying several patch reef areas that support an array of structure-dependent vertebrate and invertebrate marine species, the site assessment identified large areas on-site where no reef materials were present. Reef materials currently deployed on-site consist of approximately 2500 tire units deployed during two previous permits in or around 1978 and 1995. To calculate the approximate footprint of these materials, a tire unit is conservatively estimated based on photographs (See Appendix B) of tire unit arrays pre- deployment at 3ft x 3ft = $9ft^2$. The total footprint of all tire units is approximately $22500ft^2$, or 0.5 acres in area (0.4% of the total site area). With an approximate 3ft vertical profile for each unit, the total estimated volume of deployed materials is 67,500 ft^3.

This proposed project will place a cap on the amount of new materials that may be deployed to 9.5 acres ($413{,}820ft^2$) of area, or 8% of the total surface of the permitted site. Deploying new material within these limits will provide additional environmental benefits to structure-oriented marine resources in an area of limited structured habitat, maintain a substantial amount of undisturbed area on-site, and afford additional opportunities for near-shore anglers.

3. Dispersion of Materials

To determine appropriate options for dispersing new materials, a literature review was undertaken to define optimal densities for patch reef development and a plan for the distribution of new materials was formulated based the an assessment of the current distribution of materials. Peer reviewed information on optimal material densities for patch reef development is limited and varies substantially depending upon location. In general, artificial reefs of smaller sizes are utilized by more fish because of a higher perimeter to area ratio (Ambrose and Swarbrick, 1989). Interstitial spaces are important for maintaining trophic relationships between reef inhabitants and the surrounding fauna. Hueckel et al. (1989) found that bottom development consisting of a ratio of one part reef material for every two parts of undisturbed bottom was optimal when mitigating for habitat loss using artificial reefs. Based on this information, this project proposes an arrangement of materials utilizing a 1:2 ratio (33% coverage) of new material to natural bottom.

Concentrations of tire units
Sidescan sonar image analysis identified 719 different locations where vertical relief is present (Figure 4). The distribution of these materials is highly variable (see distribution of red dots in Figure 4), with higher concentrations of materials found within the northern sections of the permitted site. To assess the viability of utilizing the proposed 1:2 ratio of materials to open space for further site development, a map of the site was divided into quadrants (NE, NW, SE, and SW) containing 10m x 10m grid blocks (Figure 8). The grid system serves three purposes. First, it facilitates the identification of areas within each quadrant where high concentrations of materials already exist. Next, it allows for the calculation of the number of grid blocks within each quadrant that are available to receive new materials. Lastly, it provides a mechanism to plan and monitor material deployment in order to maintain the proposed 1:2 ratio throughout the entire reef site. Figure 9 summarizes the assessment of existing materials and provides a breakdown of area availability for new materials within each quadrant, by 10m x 10m block and by total acreage. Examples of potential organized and random configurations within a 10m x 10m grid for different material types are depicted in Figures 12 – 15.

4. Volume of New Reef Materials

The type of and source for new materials for this site have not been determined. This project is designed to take advantage of low or no cost clean materials approved under the "Guidelines for Marine Artificial Reef Materials, Second Edition" (ASMFC 2004), the National Artificial Reef Plan (NOAA 2007), and the Massachusetts Artificial Reef plan (Rousseau 2008). Two primary categories of materials have been used in the development of artificial reefs in U.S. coastal waters – 1) materials of opportunity and 2) designed/constructed reef units (*Guidelines for Marine Artificial Reef Materials, Second Edition*, ASMFC 2004). To maximize opportunities to acquire materials for deployment this proposal examines both materials of opportunity and engineered structures. Examples of clean materials include concrete culverts, concrete sewage dry well (honeycomb), natural rock, or manufactured units such as "Reef Balls" or other similar structures. Tire units are no longer considered approved materials.

New deployments of designed reef structures
There is a considerable amount of variation in shape and size among various types of designed reef structures (See Figure 10). To estimate the approximate area and volume of an array of different designs, the footprint of an individual unit was calculated by squaring the longest base length. Base dimensions for specific designs vary, but the base dimension of a unit generally increases as vertical dimension increases to maintain structural stability. To maintain a minimum 24' depth clearance over the reef site, new materials are limited to a maximum height of six feet. Table 4 lists the estimated area and volume for a range of designed structures with up to six feet of vertical relief. Using this method we were able to determine the number of units of various sizes needed to cover the proposed 9.5 acre (413,820 ft^2) area.

New deployments of consolidated materials

Consolidated materials consist of clean debris, quarried stone or other approved materials of opportunity. (see Appendix B). To estimate the approximate quantity of materials ranging from 3’ to 6’ of vertical relief, a 1:2 ratio of material to natural bottom was used to calculate the available area within a single 10m x 10m block.

Table 4. Estimated area and volume for a range of designed reef structures

Structure size (l x w)	Footprint (ft^2)	Volume (ft^3)	# units / acre	Total # units / 9.5 acres
3ft x 3ft	9	27	4,840	45,980
4ft x 4ft	16	64	2,722	25,864
5ft x 5ft	25	125	1,742	16,552
6ft x 6ft	36	216	1,210	11,495

This value is multiplied by the number of blocks available in each quadrant (see table in Figure 9). Base dimensions for specific designs and material types vary, but in general the base dimension of a unit increases as vertical dimension increases. To maintain a minimum 24’ clearance over the reef site, new materials are limited to a maximum height of 6’. Table 5 estimates area and volume for a vertical range of consolidated designs. Using these calculations, a volume of material needed to cover 9.5 acres within the permitted area can be determined.

Table 5. Maximum area and volume for consolidated and prefabricated materials.

			NW = 199		NE = 264		SW = 304		SE = 365		Total = 1132	
Max Vertical relief (ft)	1:2 Max area (ft^2) per block (l x w)*.33	Volume per block (ft^3)	(ft^2) per quadrant NW	(ft^3) per quadrant NW	(ft^2) per quadrant NE	(ft^3)per quadrant NE	(ft^2) per quadrant SW	(ft^3) per quadrant SW	(ft^2) per quadrant SE	(ft^3)per quadrant SE	Total area (ft^2)	Total volume (ft^3)
3	359	1,077	71,441	214,323	94,776	284,328	109,136	327,408	131,035	393,105	406,388	1,219,164
4	359	1,436	71,441	285,764	94,776	379,104	109,136	436,544	131,035	524,140	406,388	1,625,552
5	359	1,795	71,441	357,205	94,776	473,880	109,136	545,680	131,035	655,175	406,388	2,031,940
6	359	2,154	71,441	428,646	94,776	568,656	109,136	654,816	131,035	786,210	406,388	2,438,328

5. Construction impacts

Clean materials will be deployed during daylight hours via floating barge. DMF recommends time of year (TOY) work windows for coastal alteration projects impacting important marine species and habitats. The time of year with the least amount of disruptive impacts to marine species in Nantucket Sound can vary by species. The preferred construction window for minimizing impacts is expected to be from October through January.

6. Monitoring

Representatives from DMF and the Town of Yarmouth Department of Natural Resources will verify that materials to be deployed meet the criteria for approved artificial reef materials as outlined in the MA Artificial Reef Plan, The National Artificial Reef Plan, and the Guidelines for Marine Artificial reefs (ASMFC 2004) and any other conditions specified through permitting. This document provides options that address configurations, volumes, and dispersal of both consolidated materials and designed reef structures. Although each material type has been addressed separately in this proposal, scenarios employing both types of materials on-site may occur. In order to track the progress of site development, a log of the amount and type of materials being deployed and coordinates identifying the location of the deployed material will be recorded for every trip. Representatives from DMF and the Town of Yarmouth Department of Natural Resources will verify that materials deployed on-site follow the deployment specifications outlined herein. DMF will conduct annual inspections of the reef to verify that the reef materials have remained structurally stable, in place, pose no threat to navigation, and shall immediately report any problems found during the inspections.

DMF is also interested in exploring other monitoring opportunities to address specific fisheries management decisions for important commercial and recreational species that utilize this site during on or more stage of their life history.

7. Alternatives Analysis

Alternatives to the site location, material types and the distribution of materials on site were considered for this project. The option of developing a second artificial reef site in state waters within the Yarmouth town boundaries was considered. The site assessment of the existing tire reef, outlined in this narrative, demonstrates the current site exhibits suitable substrate characteristics. Structure materials have remained on site and continue to function as habitat for marine fish and invertebrate species. The location is marked on NOAA chart and materials deployed on site are estimated to occupy less than 1% of the total footprint within the permitted area. All these factors point to the current reef site location as the better option for reef development, and for avoiding impacts to other areas and existing habitat types in Yarmouth.
Material options for this project were extensively evaluated, as tires are no longer considered appropriate materials for artificial reef structures. Although materials for this proposal have yet to be defined, a range of alternative materials was identified in an attempt to replicate the structured habitats created by materials previously deployed on-site. This range is based on the experience of the DMF artificial reef program in developing other artificial reef sites and other DMF mitigation projects designed to enhance hard bottom habitats. The options outlined herein considered materials of opportunity, potential hazards to navigation, and the options available for deploying materials.

Several alternatives for distributing materials on site were examined during the development of this proposal. For deployment purposes, aggregating large quantities of materials in a single location is an easy and economically efficient method. The alternative method proposed herein is designed to create an array of patch habitats similar to those created during the deployment of tire structures. The deployment of tires relied on a broadcast method for deployment, whereas the alternative method proposed will rely more extensively on GIS to direct materials to areas with low or no concentrations of existing structures. This approach will minimize impacts of construction activities to larger areas while creating a dispersed array of additional patch habitats on site.

References

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Yarmouth Artificial Reef Permit
List of Figures

Figure 1. Locus map.

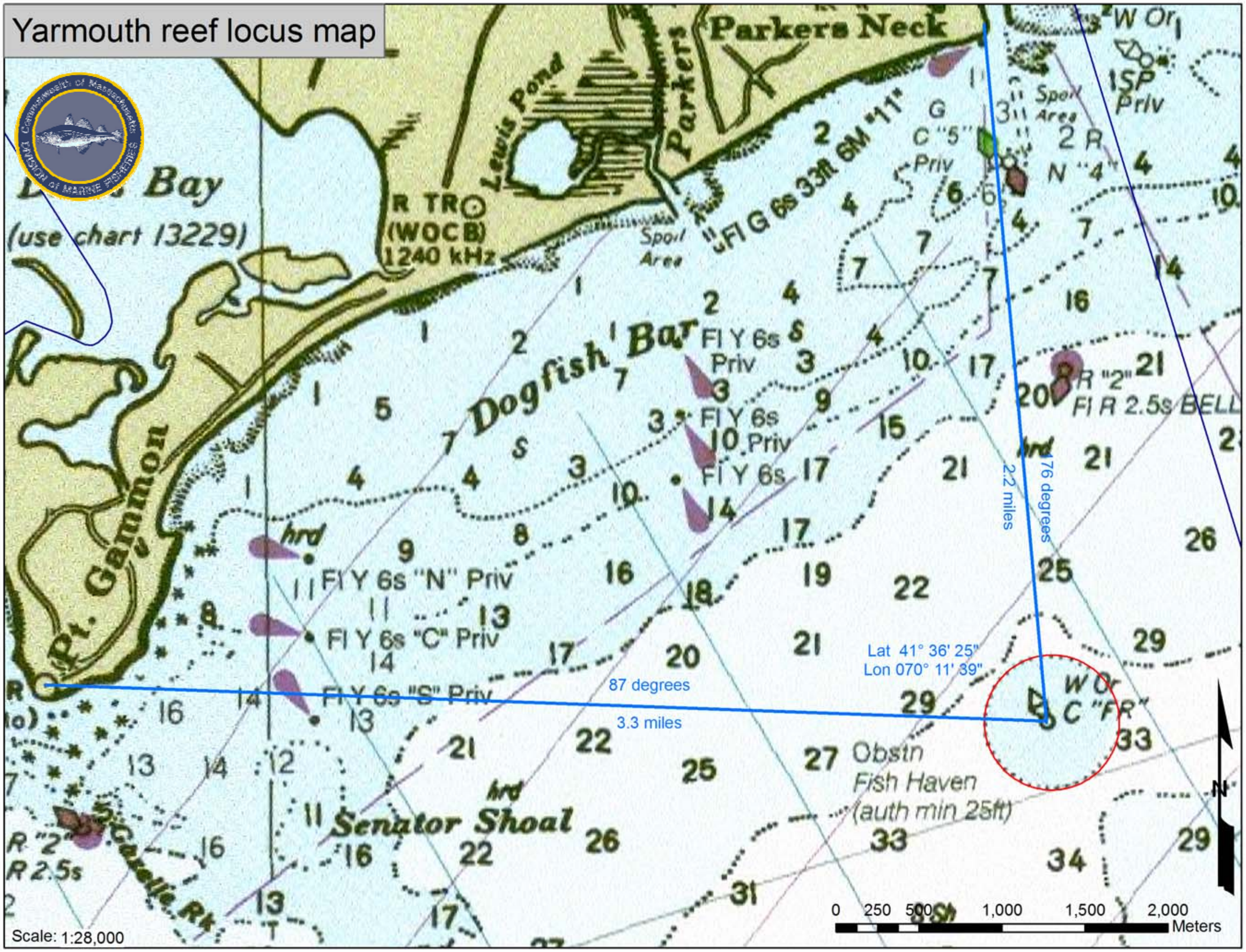
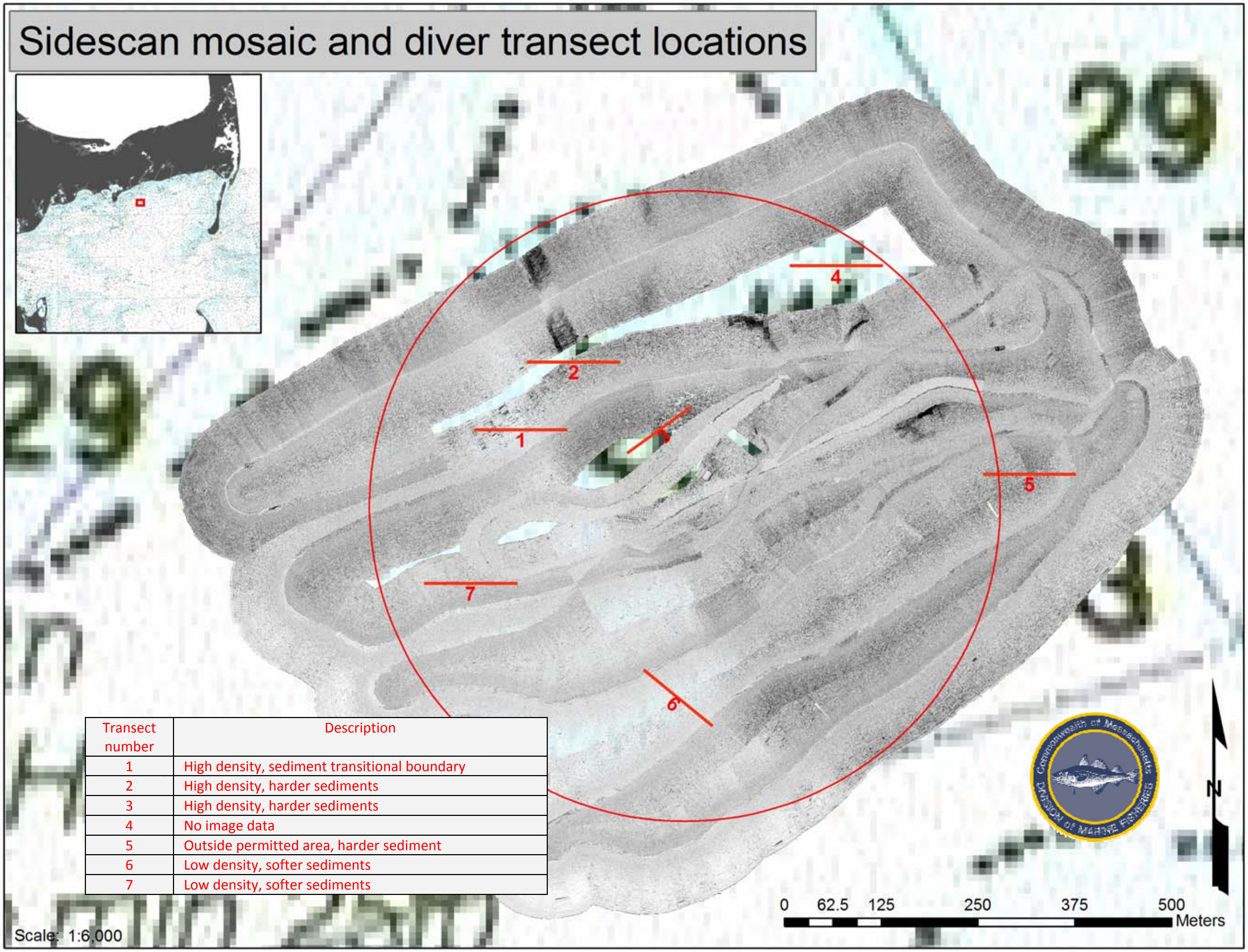


Figure 2. Sidescan sonar mosaic image and locations of diver transects.



Transect number	Description
1	High density, sediment transitional boundary
2	High density, harder sediments
3	High density, harder sediments
4	No image data
5	Outside permitted area, harder sediment
6	Low density, softer sediments
7	Low density, softer sediments

Figure 3. Surficial substrate results.

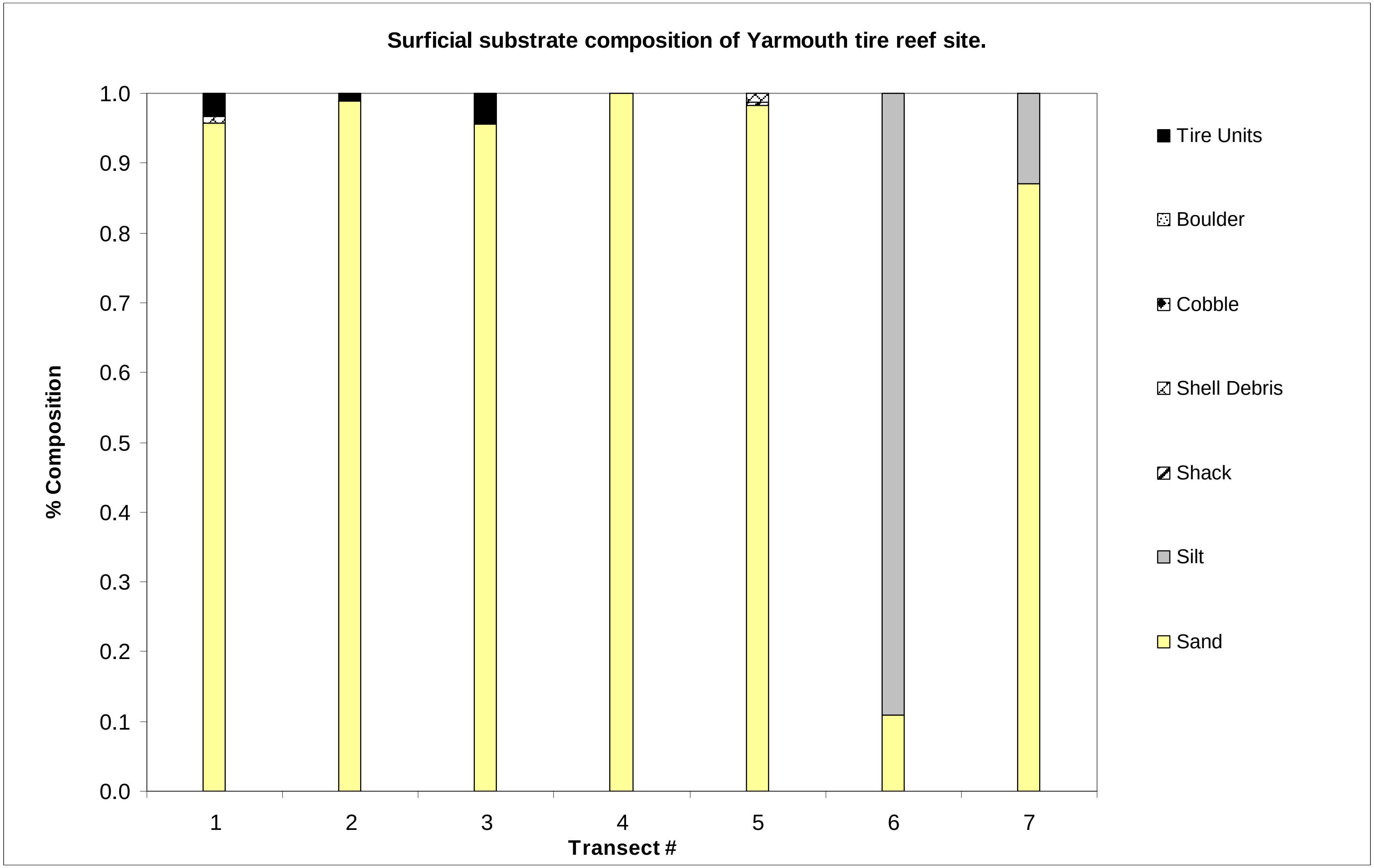


Figure 4. Visual assessment of sidescan sonar survey data.

Sidescan Mosaic image zoomed to 1:600 scale (A) with areas of relief identified and marked (B) and displayed at 1:6000 scale (C).

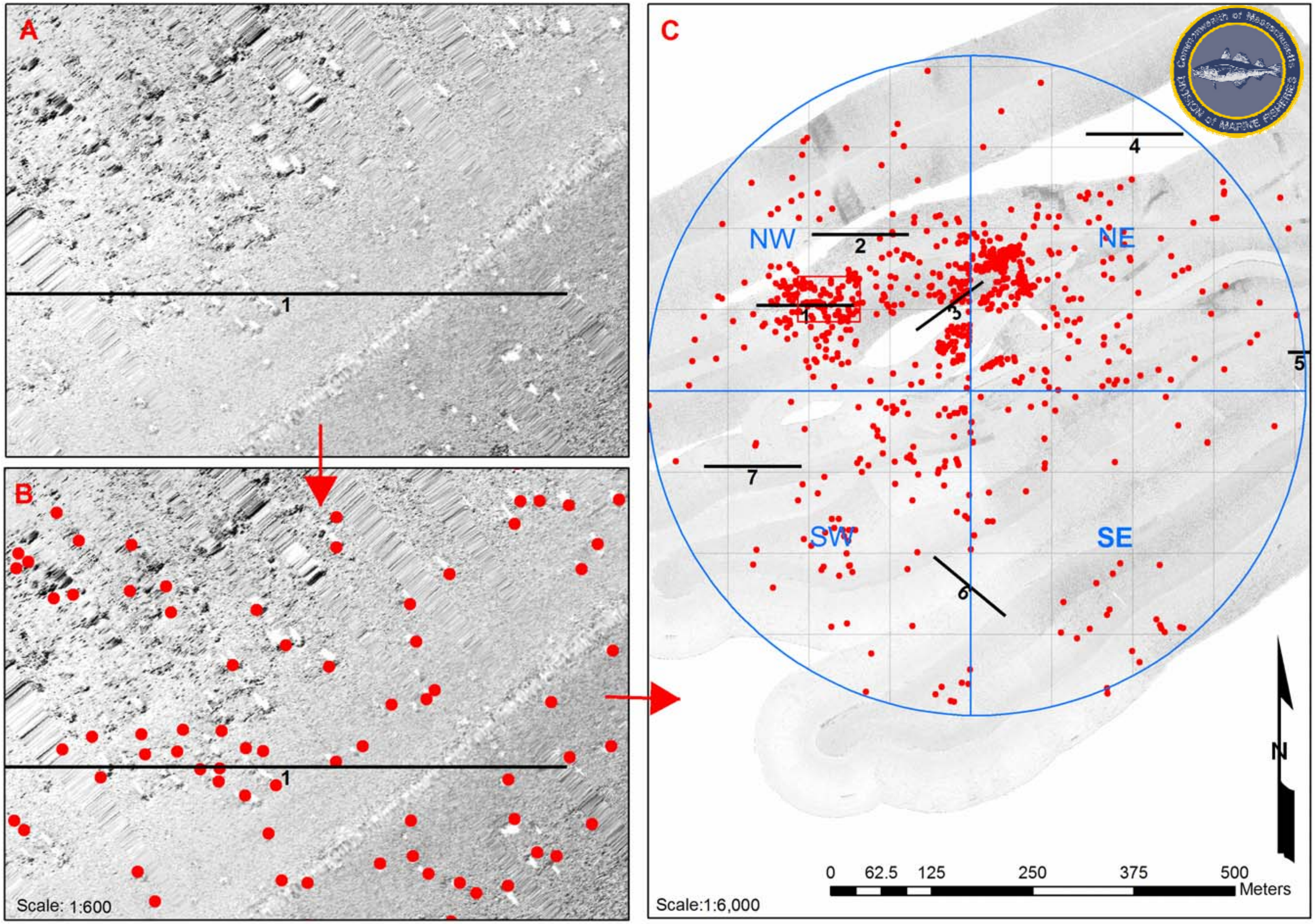


Figure 5. Fish counts by transect.

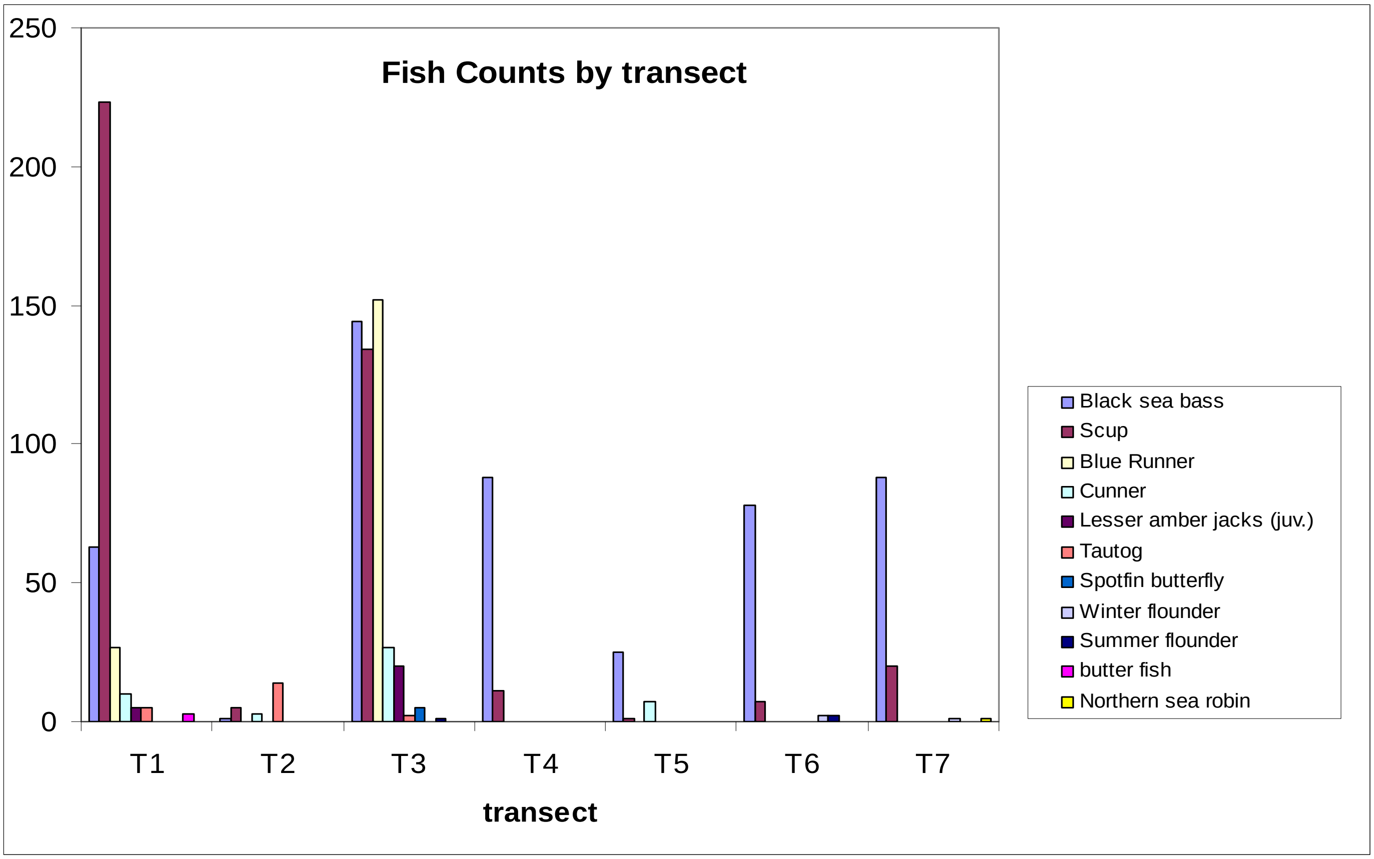


Figure 6. Invertebrate counts by transect.

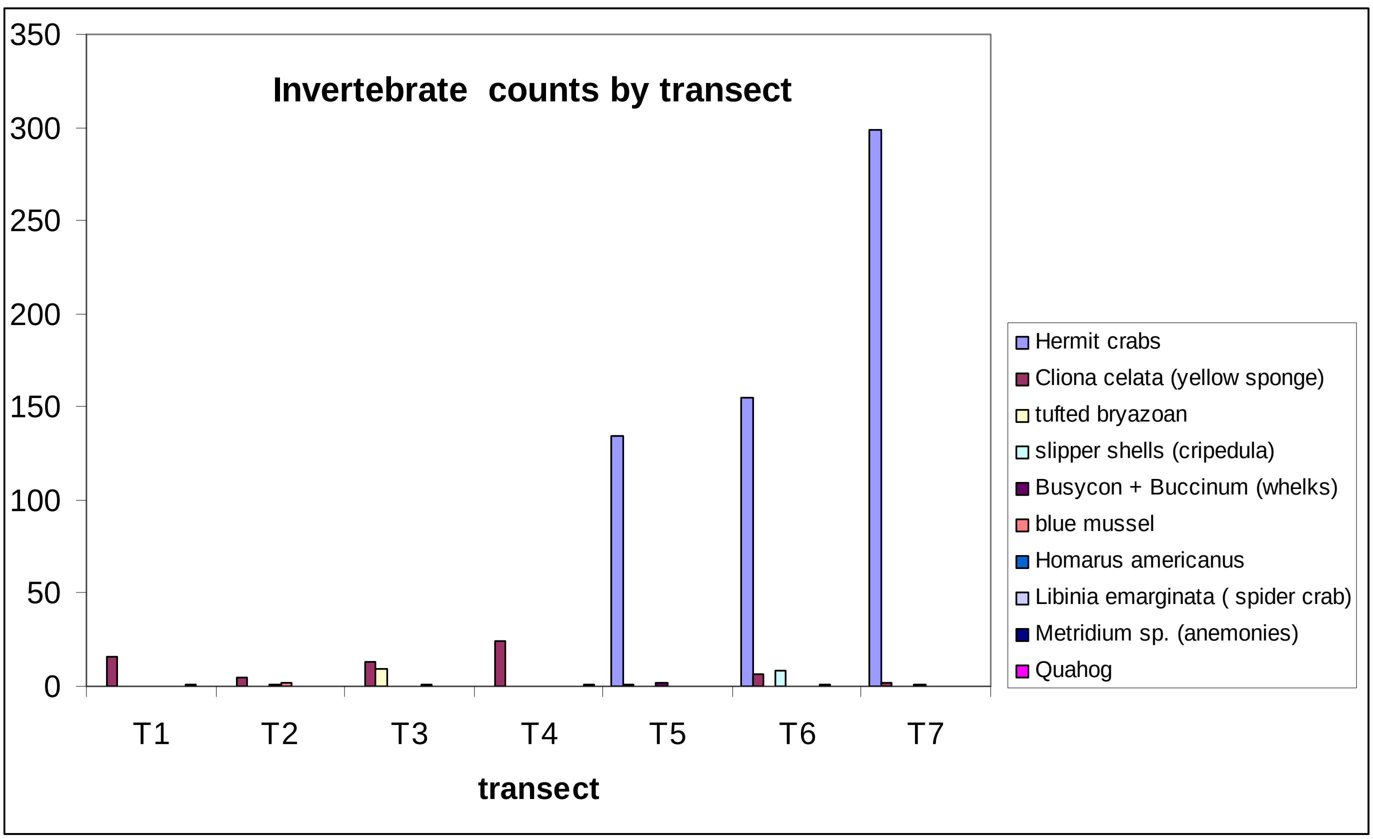


Figure 7. Land Containing Shellfish (from MASSGIS shellfish suitability data layer).

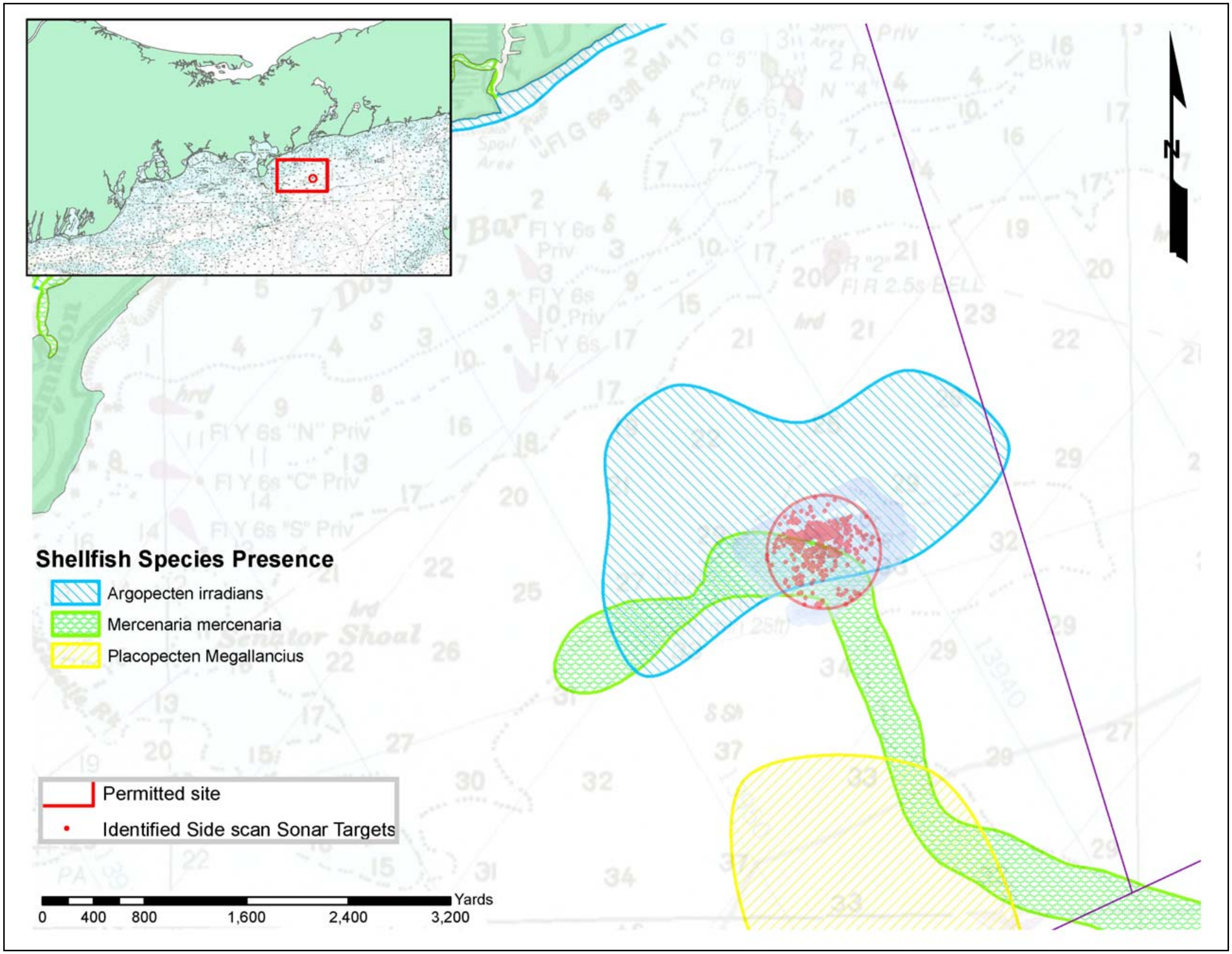


Figure 8. Yarmouth reef site divided into quadrants containing 10m x 10m grids.

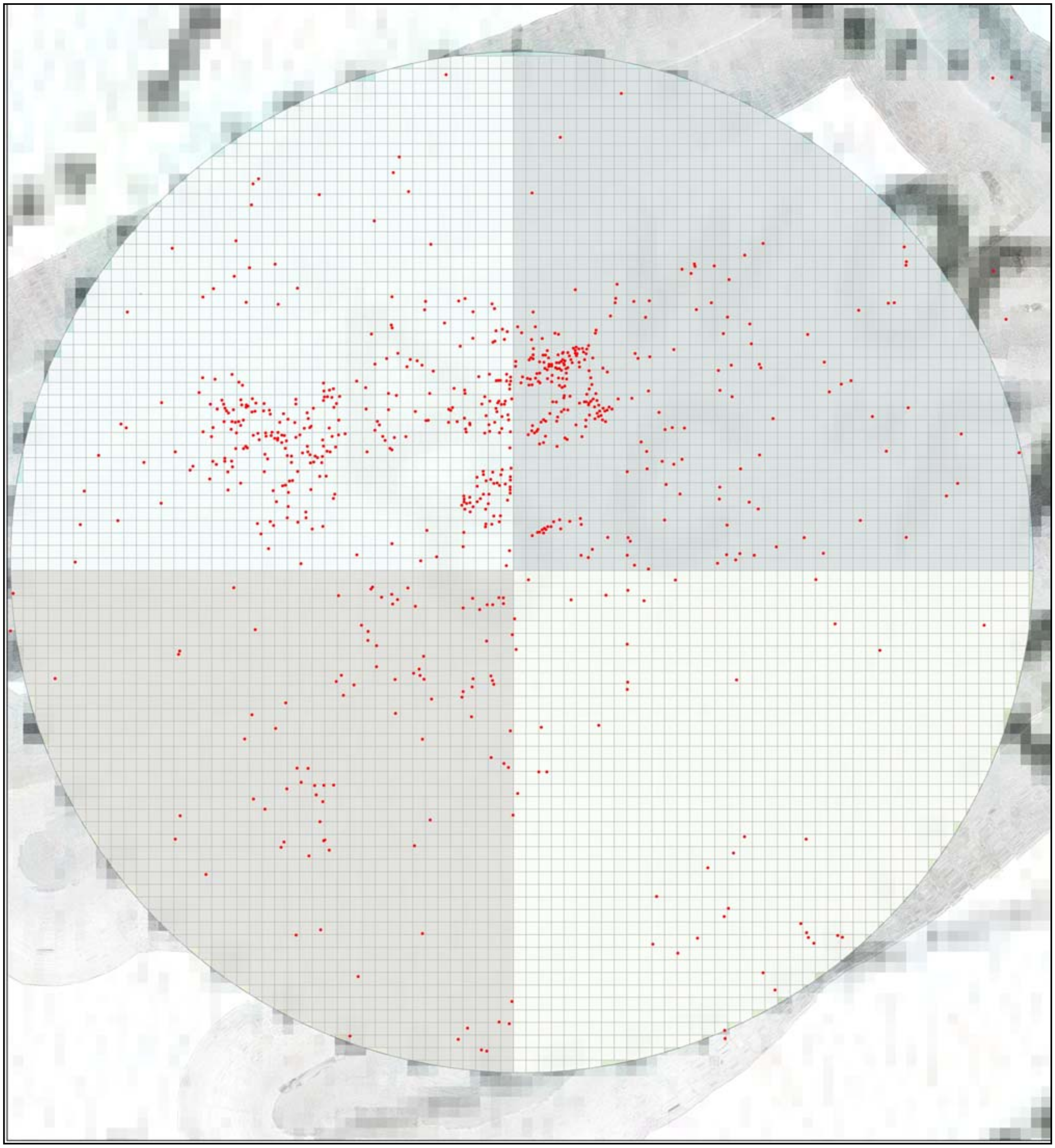
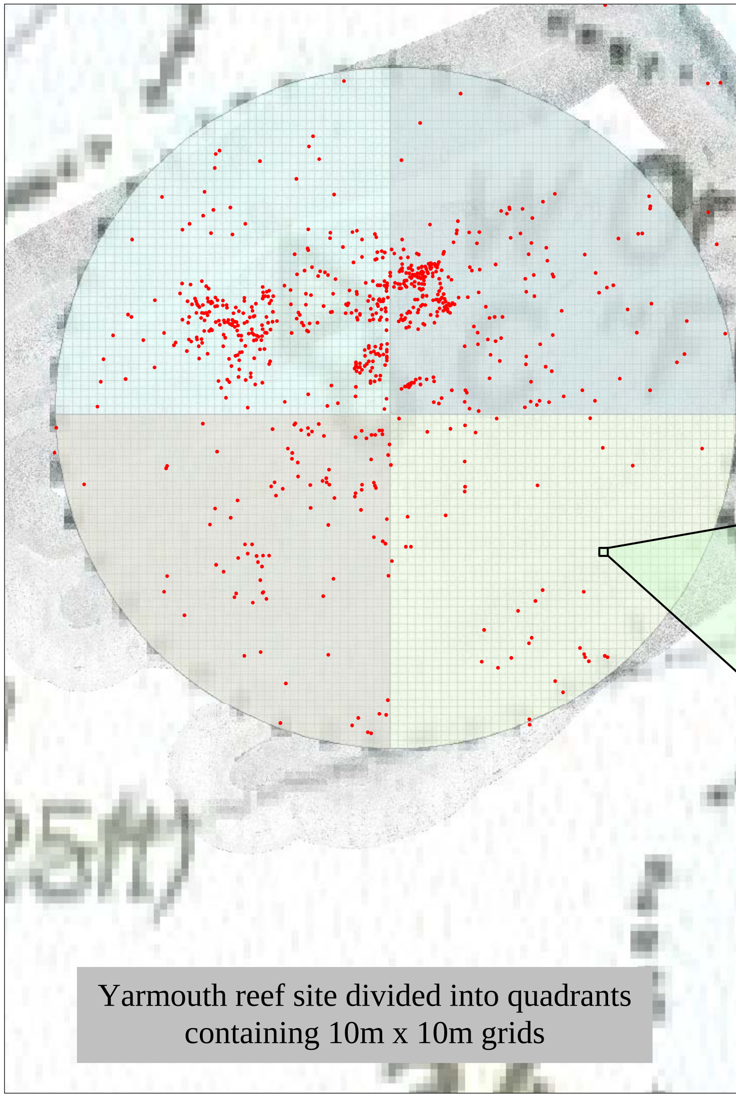


Figure 9. Reef site divided into quadrants containing 10m x 10m block.

Quadrant	Acres	# of 10m x 10m Blocks	# of Developable Blocks within quadrant (1:2 ratio of total area)	Blocks containing structures	Blocks no structures	Blocks Available for new materials	Acreage for development (Blocks Available * acreage)	Total Acreage material coverage using targeted 1:2 ratio of material to space (33%)
NE	33.43	1350	419	155	1195	264	6.5	2.2
NW	32.12	1300	403	204	1096	199	4.9	1.7
SE	32.12	1300	403	38	1262	365	9.0	3.1
SW	30.79	1246	386	82	1164	304	7.5	2.6
Total	128.5	5196	1611	479	4717	1132	28.0	9.5

One 10m x 10m block = $100m^2$ = 0.0247 acres
Areas where structures are present were identified using sidescan sonar survey
Blocks along the circumference of the perimeter containing <$50m^2$ of bottom surface were discarded from the assessment, resulting in an uneven number of blocks per quadrant.
1:2 ratio for dispersion of material based on study by *Hueckel et al.* (1989).



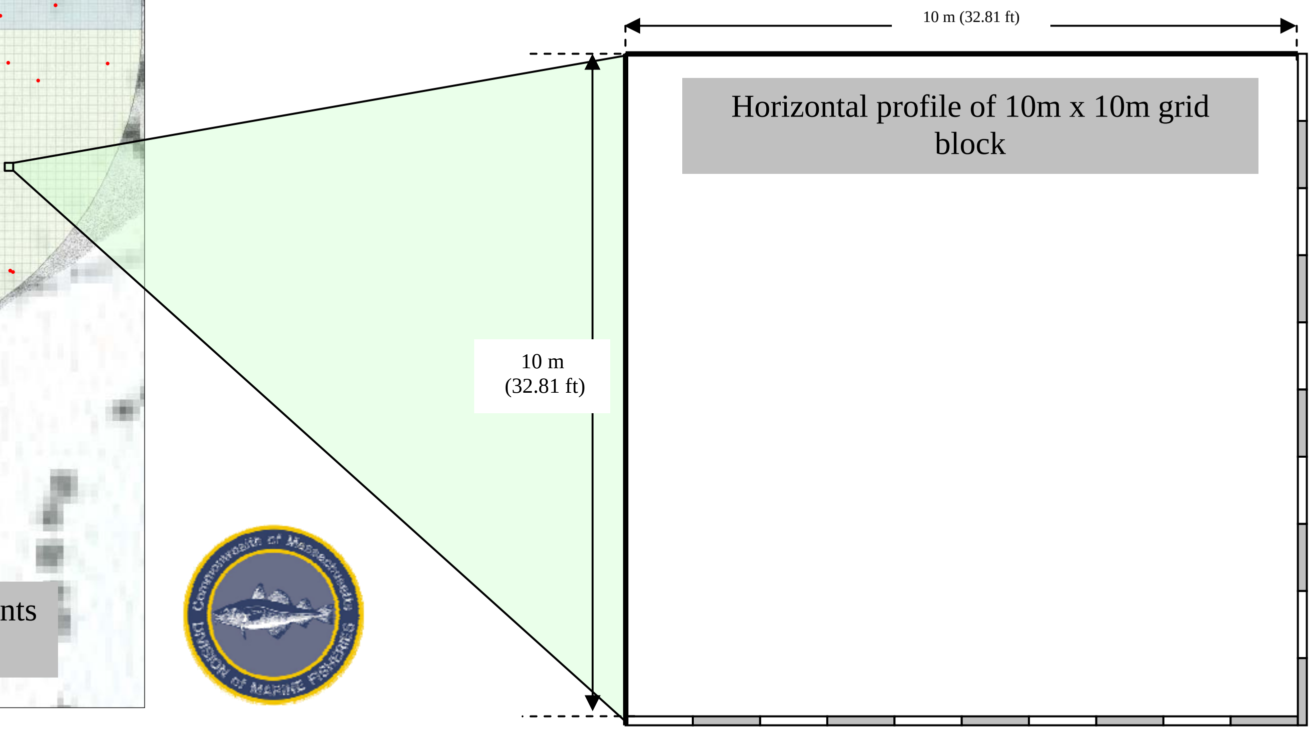
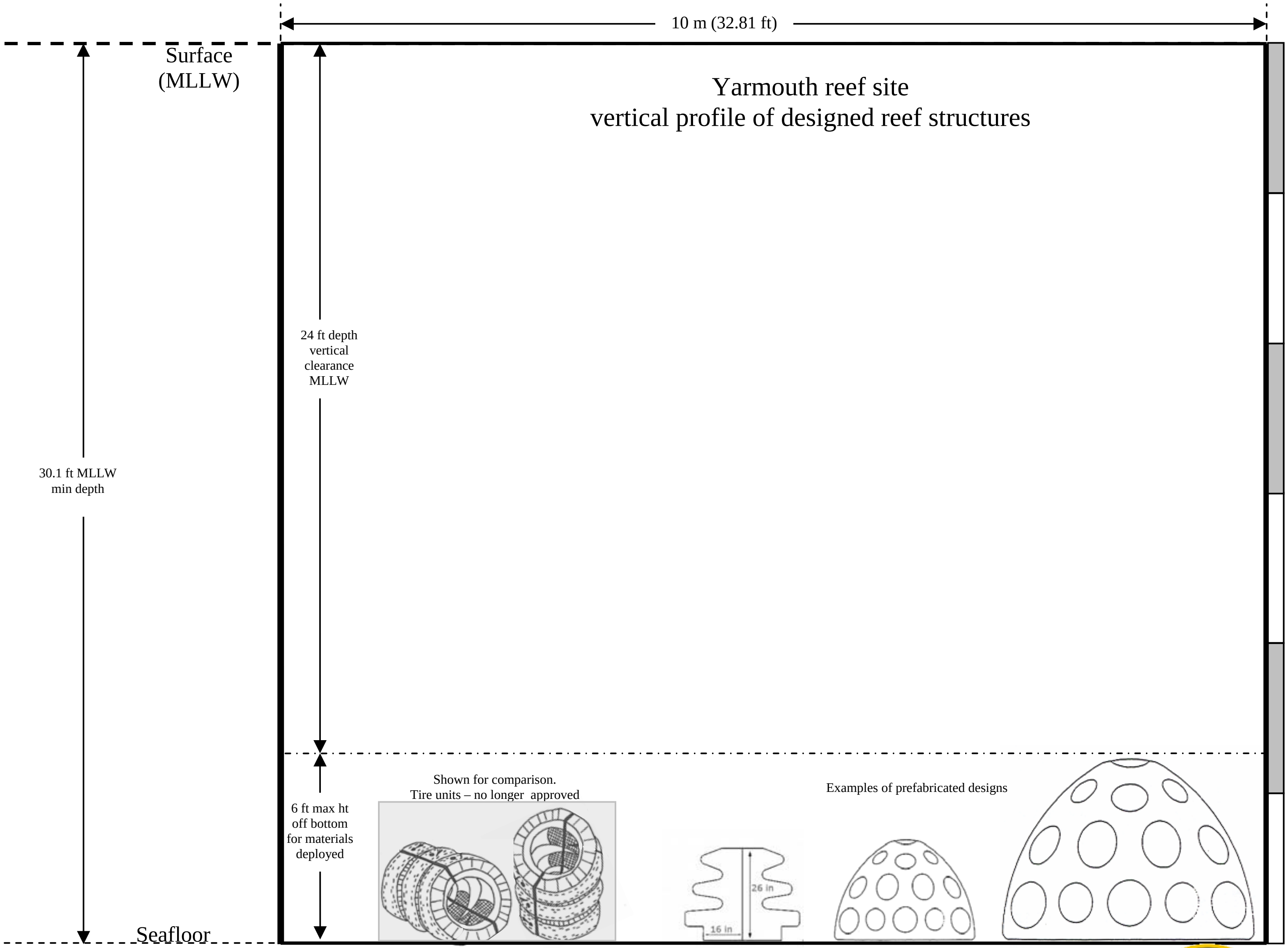
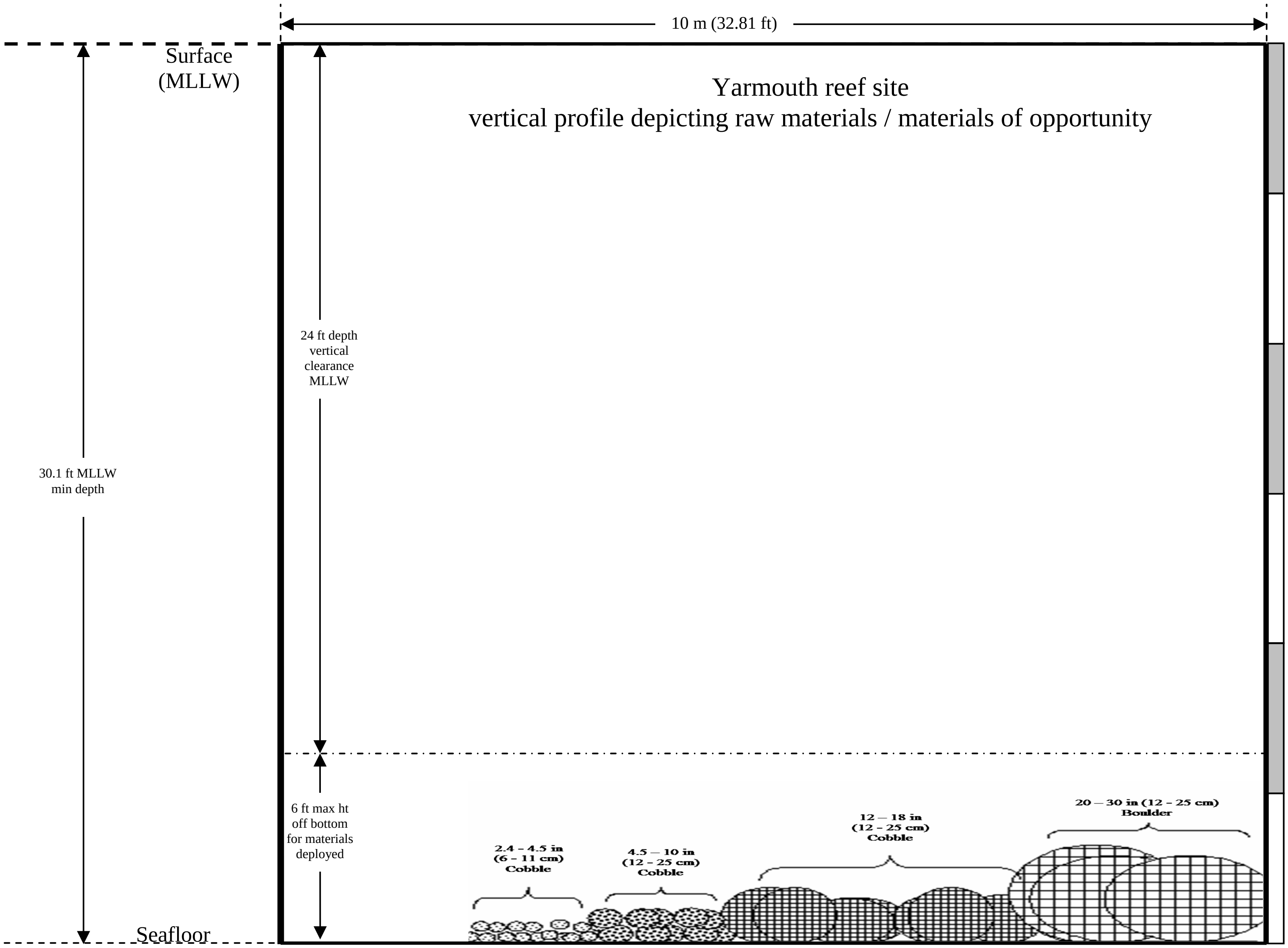


Figure 10. Vertical profile of various designed reef structures.



Prefabricated reef units not drawn to scale. Actual prefabricated material sizes can vary. Prefabricated unit images represent examples of different reef material options and are not an endorsement of any particular product or manufacturer.

Figure 11. Vertical profile of various consolidated materials.



Materials not drawn to scale. Actual material sizes will vary. Material images represent examples of different reef material options and are not an endorsement of any particular manufacturer.

Figure 12. Example of organized dispersion of designed reef structures within a 10m x 10m grid using a 1:2 ratio of new materials to existing bottom.

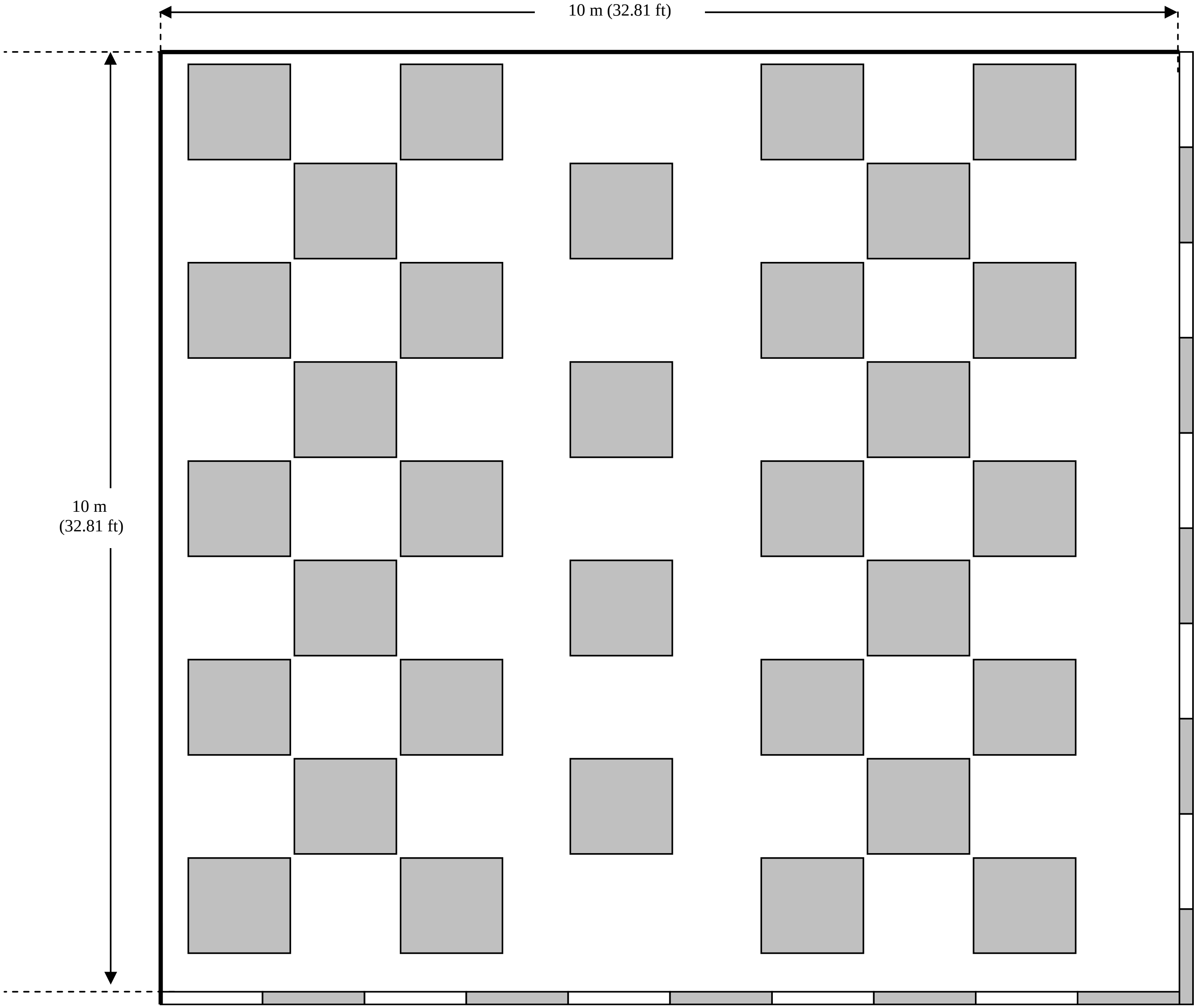


Figure 13. Example of random dispersion of designed reef structures within a 10m x 10m grid using a 1:2 ratio of new materials to existing bottom.

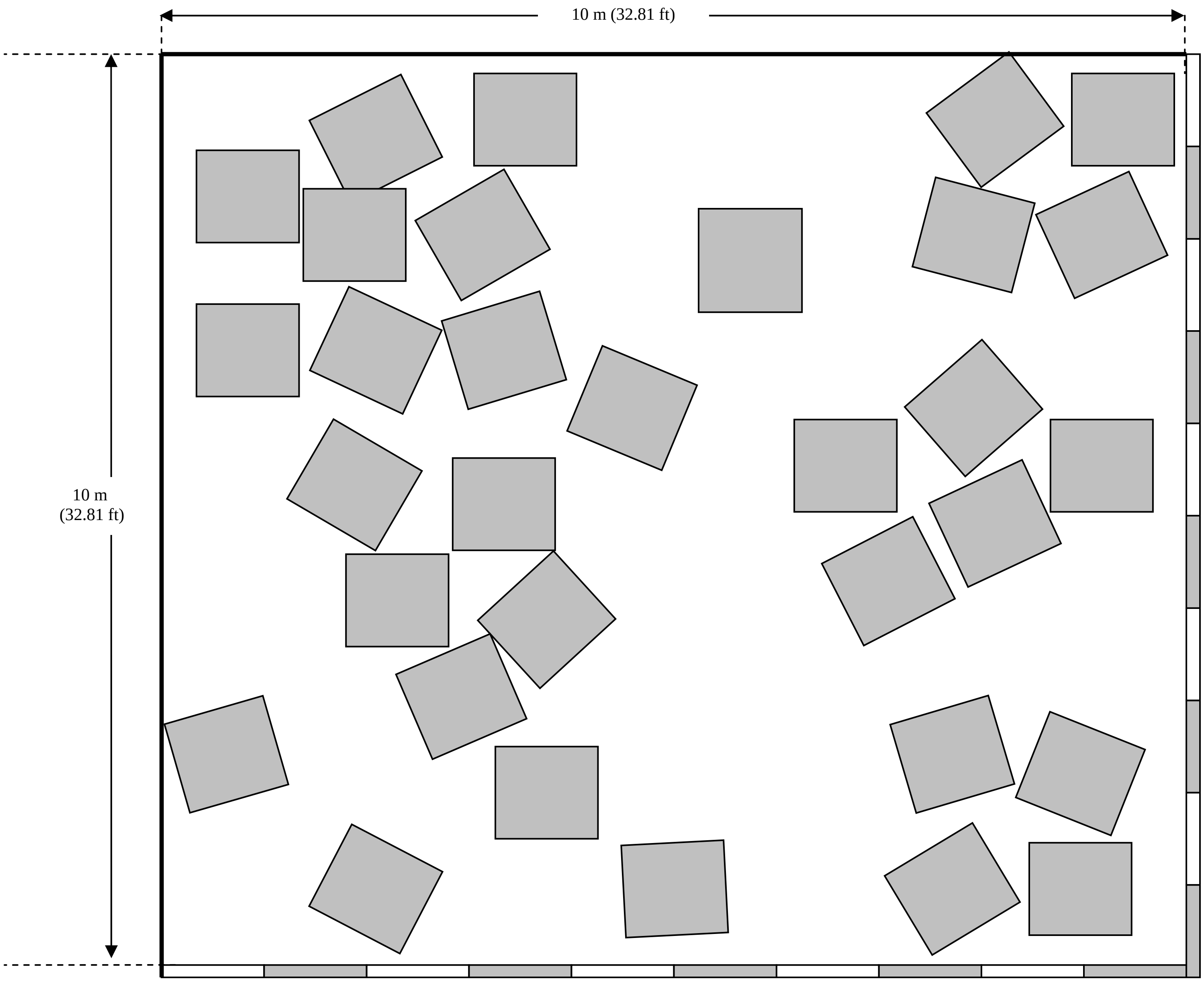


Figure 14. Example of organized dispersion of consolidated materials within a 10m x 10m grid using a 1:2 ratio of new materials to existing bottom.

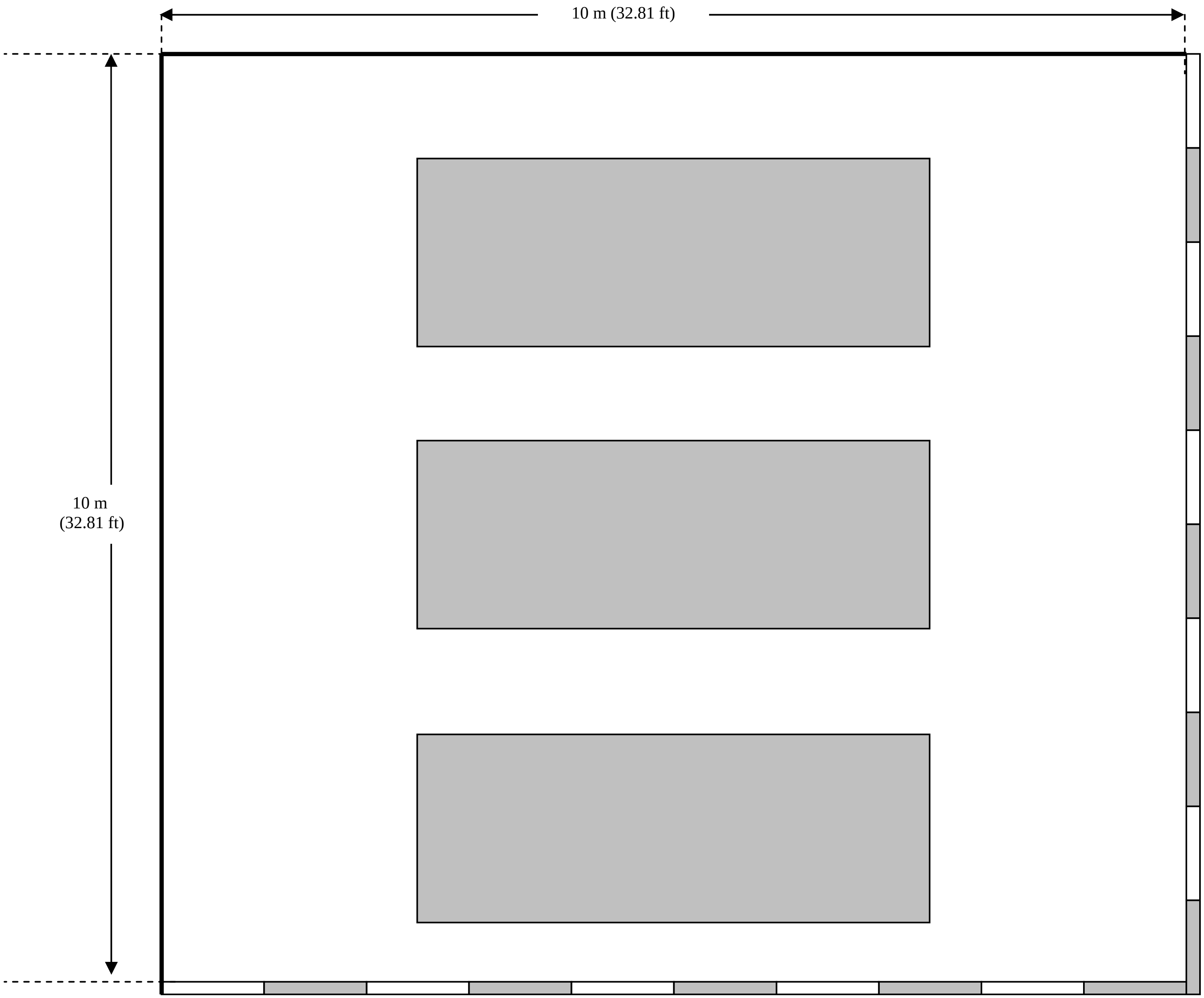


Figure 15. Example of random dispersion of consolidated materials within a 10m x 10m grid using a 1:2 ratio of new materials to existing bottom.