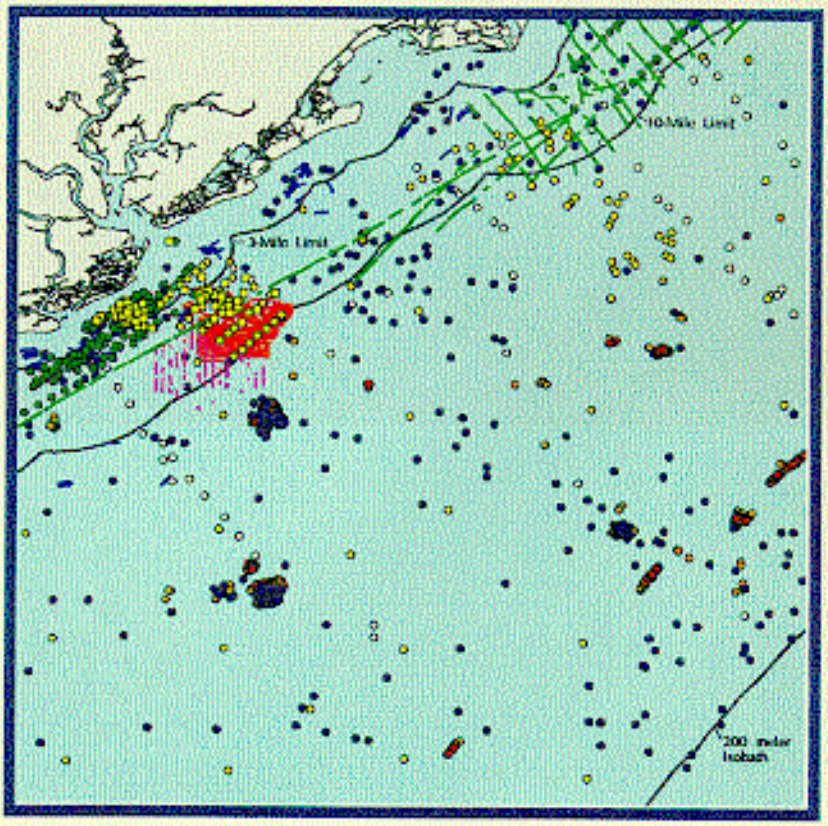
Spatial Analysis of Bottom Habitats and Sand Deposits on the Continental Shelf off South Carolina

prepared by

A.S. Bury and R.F. Van Dolah



Final Report

South Carolina Task Force on Offshore Resources
a cooperative program with the
State of South Carolina
and the
Minerals Management Service

Final Report

Spatial Analysis of Bottom Habitats and Sand Deposits on the Continental Shelf off South Carolina

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Office of International Activities and Marine Minerals
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Executive Summary

In July of 1992, the State of South Carolina entered a cooperative agreement with the Minerals Management Service (MMS). This agreement began a five-year program to evaluate the sand, mineral and hard-bottom resources that exist on the coastal shelf. During the first year, an interagency "Task Force on Offshore Resources" was formed to evaluate and summarize historical information available for the South Carolina coastal zone. This effort resulted in an extensive database that was further evaluated during the second year of the program. This report describes the GIS analysis completed on the offshore database as conducted by the South Carolina Department of Natural Resources (SCDNR).

During the second year, the survey area boundary was expanded to include all data from the shoreline to approximately 80 km (50 mi) offshore to coincide with the 200-m isobath. Previous efforts had focussed primarily on the nearshore zone, from the shoreline out to 16 km (10 mi) offshore. In addition, data from the nearshore zone mapping effort conducted by CCU were added to the database. These efforts provided high resolution seismic-reflection and vibracore data that could be used to directly enhance the GIS analysis of sediment thickness, mean grain size and percent sand. For more information on the data used in this effort, see Van Dolah et al. (1994a, 1994b) and Gayes and Donovan-Ealy (1995).

The database compiled in the second year was analyzed in detail for bottom-type and sediment characteristics. With respect to bottom-type characteristics, most records indicating the presence of hard-bottom habitat are found in the deeper waters of the shelf, greater than 10 mi from shore. However, dense patches of hard-bottom habitat do occur within 3 mi of the coast in the Grand Strand area, and within 5 mi of the coast off Charleston. It is possible that additional reef

habitat is present along other sections of South Carolina's coastline, but records providing information on bottom type are sparse in these areas.

The bottom-type data identifying locations of reef habitat were overlaid on a detailed bathymetric database provided by the National Ocean Survey (NOS) to determine if areas of relief may be used to extend areas of known hard-bottom reef habitat artificially. The results suggested that our ability to extrapolate the distribution of reef habitat does not appear to improve by overlaying bottom-type data on NOS bathymetry. This is due to limitations in the bathymetric file and the bottom-type data, both of which did not have a dense enough spatial array of data points.

Areas identified as sand-bottom habitats were further characterized with respect to sediment thickness, mean grain size and percentage of sand where data were available. The sparseness of data made accurate sediment volume calculations impossible, so sediment thickness was analyzed instead. In the span from Hunting Island to Charleston Harbor, several areas show thick sediment deposits (>1 m) within 10 mi of shore. The large number of records showing the presence of thick sediment from Bulls Bay to Winyah Bay indicate that this region may provide suitable sand sources for nourishment purposes, but the coastline along this section is largely unpopulated and therefore not in need of nourishment. In the more populated Grand Strand area, only a few areas within 10 mi of the beach show evidence of sediment thickness greater than 1 m in depth.

Database records containing information on sand composition and grain size show that most records within 10 mi of the beach have >90% sand. Outside 10 mi, percent-sand data points are sparse and widely distributed. Mean grain size data are generally very sparse for most of the South Carolina coastal zone. Where data are available, most of the records show an average sand grain size that should be suitable for beach nourishment purposes.

To be useful for beach nourishment, sand deposits must be near enough to an eroding beach to be mined economically. Within a 5-mi buffer zone from each eroding beach, the most appropriate locations to mine sand are those that have a sufficient depth of sediment, a mean grain size compatible with the erosional beach, a high percentage of sand and no hard-bottom reef habitat. Because either no data exist or samples have not been fully analyzed, there are only a few locations at which MMS-INTERMAR database records overlap with all of the appropriate characteristics. Most of these records are found in the area from Pawleys Island to Myrtle Beach, and in an area approximately 3 mi from shore off the Stono Inlet near Folly Beach.

Locating the best sites to mine sand was limited by the database, which had gaps in bottom type and sediment information. Future data acquisition efforts to fill these gaps should focus on collecting the specific data type that is lacking off each erosional beach.

Introduction

The South Carolina coastline is a popular destination for tourists. According to the South Carolina Department of Parks, Recreation and Tourism (1995), 70% of the state's 12.3 billion dollars of annual tourism revenue is generated along the coast. As well as attracting tourists, the beaches play an important role in protecting coastal properties from storms. However, over half the state's 90 miles of developed beaches are seriously eroding, threatening both residential and resort communities (Kana and Snyder, 1991).

To protect and restore South Carolina's beaches, the South Carolina General Assembly passed the Beachfront Management Act (BMA) of 1988 (amended in 1990). This Act mandates the development of a "comprehensive, long-range beach management plan" for the state's coastline, and the development of local beach management plans. Where feasible, the BMA promotes nourishment projects as one means of beach restoration. However, each nourishment project provides only temporary relief from the effects of erosion, requiring multiple nourishment projects to maintain a beach over a long period of time. Ultimately, this will require access to large quantities of sand.

A potential source for much of the nourishment material is the nearshore coastal shelf. As a result of previous nourishment projects, some sand deposits on the nearshore coastal shelf have been identified. In general, however, information on the location, size, and character of sand deposits off South Carolina is insufficient. Additionally, the effects of removing sand from these deposits on the coastal sand budget, and the consequences to living marine resources, are not well understood.

To address these concerns, the State of South Carolina initiated a cooperative program with

the Minerals Management Service, Office of International Activities and Marine Minerals, in July of 1992. One major goal of this five-year program is to evaluate the state's sand, mineral and hard-bottom resources on the coastal shelf, with emphasis on the zone extending form the shoreline out to approximately 16 km (10 mi) offshore. A final report for Year I, which contains a comprehensive database of sand, mineral and hard-bottom resources, was completed by Van Dolah, et al. (1994a).

The data compiled from Year I became available for distribution in April 1994, but detailed graphical and statistical analysis of these data was still required. In addition, the database needed to be augmented in critical areas identified in Year I. Considering these needs, the Task Force established the following objectives for Year II:

(1) Conduct a detailed analysis of the nearshore data collected during the first year using a Geographic Information System (GIS) to map the location and extent of known mineral and biological resources,

(2) Begin a phased mapping effort of the nearshore zone where renourishment is needed and data are lacking,

(3) Continue studies to determine historical shoreline movements and future beach renourishment needs for the South Carolina coastline, and

(4) Update the Year I database and add newly acquired data, particularly Year II generated data, into the database.

This report compiles the results of work completed for Objective 1. Specific objectives of the analysis were to map:

(1) the location and continuity of reef habitats that should be avoided in any offshore mining operation,

(2) the extent, volume, location, and characteristics of potential sand sources and mineral deposits where sufficient data were available, and

(3) areas where additional data collection is required to characterize bottom resources.

Methods

Data Integration

The data analyzed in the second year include the entire database created during the first year of the program, data from other federal and state programs for areas located further offshore, and some new seismic and vibracore data collected during the summer of 1994 near Folly Beach (Gayes and Donovan-Ealy, 1995). The new data were compiled into the existing database using the same methodologies identified by Van Dolah, et al. (1994a). To prepare for spatial analysis, all data sets were integrated into a common data format within the GIS. The integration process entailed downloading data from the database in ASCII format, converting the ASCII files into ARC/INFO coverages, then converting the coverages into a useful projection.

Although the data were compiled from many different sources, all of the records contained latitude and longitude coordinates. If a data record had beginning and ending latitude/longitude coordinate pairs, the record represented a line. If a data record had only a single latitude/longitude pair, the record represented a point. Some point locations represented data obtained from a larger area (e.g., a trawl path that may have been longer than 1 km), but no end coordinates were available for representation of these points as a line. Accordingly, records containing point and line coordinates, and their attributes, were downloaded from the database in ASCII format. The ASCII data files were then converted into Arc/Info GIS files. These GIS files, which were in a latitude/longitude coordinate system, were subsequently converted into an Albers Equal Area projection in units of meters. This projection is often used when mapping large regions where length and area measurements need to remain constant. It is also the same projection used by NOS and NOAA, making future data integration with these agencies easier.

Data Analysis

The lines and points in the database have various positional accuracies depending on the positioning system used during their creation. Most of the point and line records analyzed for this project were collected using LORAN-C positioning systems (Table 1). LORAN-C positions are only guaranteed to within ¼ mi of the true position (U.S. Dept. of Transportation, 1980), although in practice the position readings are usually better. Thus, all point and line data were buffered by ¼ mi (463 m) in the graphics presented in this report. This buffer represents the "worse case" positional accuracy that may occur for most of the data records.

Table 1: Positioning methods used in the MMS-INTERMAR database.

Position Method	Number of Records	Percentage of Total Records
LORAN-C	9445	92.2%
LORAN-A	587	5.7%
Mini Ranger Positioning System	55	0.5%
Dead Reckoning	30	0.3%
Range and Bearing	5	0.1%
None Identified	121	1.2%

After buffering each line and point, all of the data were combined to determine the most likely locations to mine sand. Final locations were derived by searching for records within 5 mi of an erosional beach, where sediment thickness was greater than 1 m, where there was no evidence of hard-bottom reef habitat, and where sediment characteristics included a very high percentage of sand (>90%) of a suitable grain size (2-4 phi).

Data Display

To enable the viewer to see all of the data in detail, the study area was divided into eight sub-zones (Figure 1). In all graphics depicting information on hard-bottom habitat, sediment type and sediment thickness, more desirable characteristics were given priority over less desirable characteristics. For instance, locations with a high percentage of sand were plotted over locations with a low percentage of sand where the data records were coincident. Similarly, locations of hard-bottom habitat were plotted over locations of no hard-bottom to highlight areas where sensitive habitats were present. As a reference, each item in the legend is arranged in the order it was plotted. The items at the bottom of the legend were plotted first and the items at the top were plotted last. Thus, if multiple data points occur in one area, only the last record to be plotted may be shown on the maps. The exceptions to this are the mean grain-size plots (Appendix C). Since the desirability of grain size is related to the grain size of the beach to be nourished, the most desirable grain size could not always be given priority. However, South Carolina beaches are usually fine-grained, so graphics of mean grain size were plotted giving priority to fine-grained sand (2-3 phi). Despite the plotting limitations, the graphics still provide information on the general character of hard-bottom resources and sand deposits in the area and are helpful for visualizing patterns. Users interested in viewing all records for a particular area should access the original database.

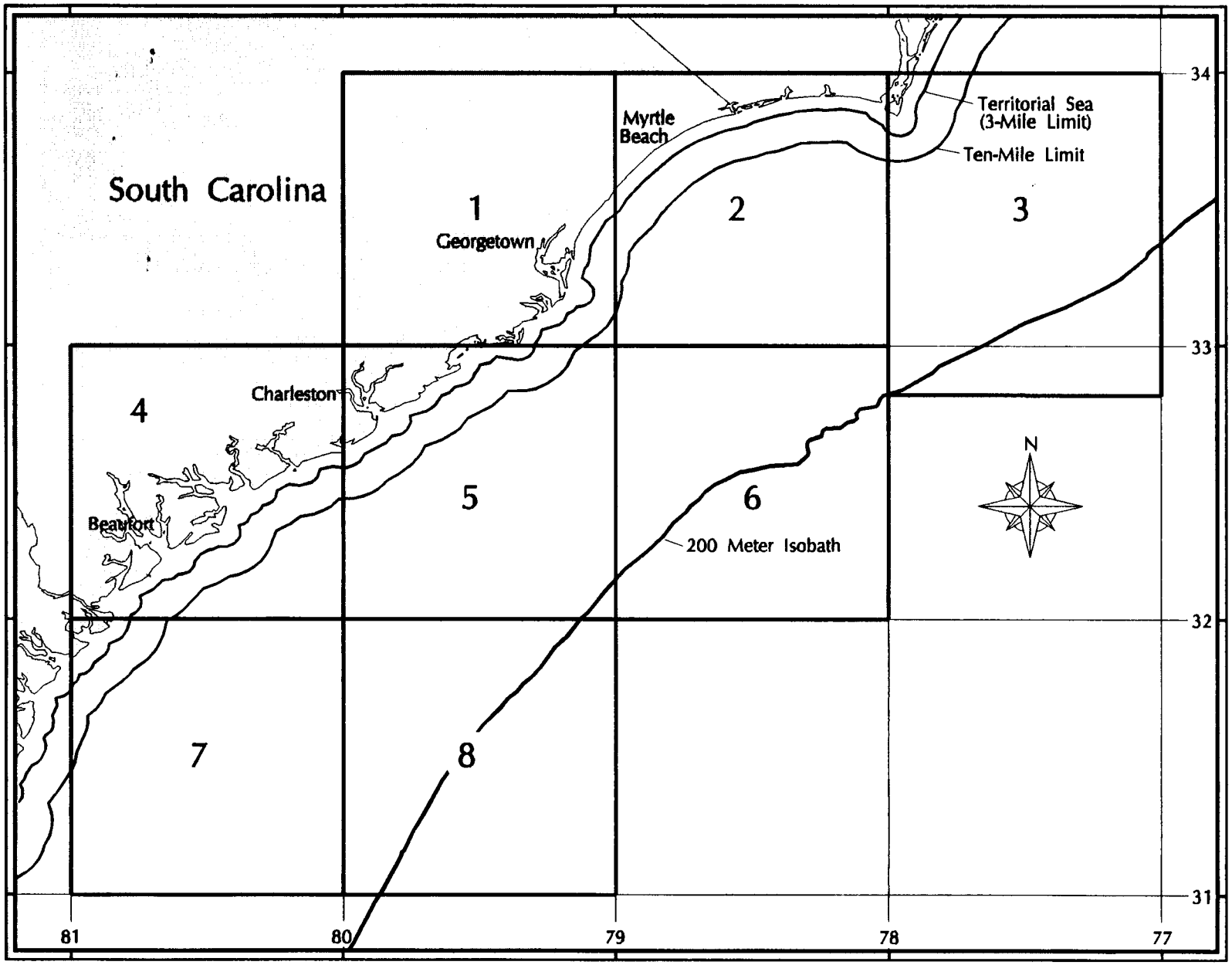


FIGURE 1: Survey area showing the eight subzones that were analyzed in detail.

Results and Discussion

The database evaluated for this study contains a total of 10,243 data records. The gear types most frequently used when collecting these data were trawls, vibracores, uniboom subbottom profilers, color closed circuit T.V. and sidescan sonar with closed circuit T.V. (Table 2). Analyses of these data for bottom-type and sediment characteristics are provided in the following sections. Complete information associated with each data record is being maintained by the SCDNR-Marine Resources Division.

Table 2. Types of gear included in the MMS-INTERMAR database.

Gear Type*	Gear Code	Frequency	Percentage
Dredge-Unknown	DR00	1	0.0%
Dredge-Orange Peel	DR01	3	0.11%
Dredge-Modified Pierce	DR02	12	0.4%
Trawl-3/4Yankee #35	FT01	13	0.5%
Trawl-Semi-Balloon	FT03	184	6.7%
Trawl-Falcon	FT04	366	13.3%
Trawl-1986 SEAMAP	FT05	33	1.2%
Vibracore	GR01	527	19.2%
Grap-Smith-McIntyre	GR02	42	1.5%
Grab-Campbell	GR03	1	0.0%
Grab-Peterson	GR05	131	4.8%
SCUBA Diver	SD01	46	1.7%
Sidescan Sonar	SS21	107	3.9%
Subbottom Profiler-3.5kHz	PR01	23	0.8%
Subbottom Profiler-Uniboom	PR02	599	21.8%
Closed circuit T.V. -Color	CC02	251	9.1%
Sidescan Sonar + Closed Circuit T.V.	0101	375	13.7%
No Gear Data	NULL	33	1.2%

*See Van Dolah et al. (1994a) for a complete description of gear types.

Distribution of Bottom-Type Data

Since mining operations result in the disturbance of bottom habitats, it is a critical need to identify the location and extent of hard-bottom reef habitats that would be adversely affected by these operations. Several of the larger data sources (Van Dolah et al., 1994a,b) provided a significant amount of information on reef habitats, but many of these data sources were compiled by concentrating sampling activities on known reef habitats. Consequently, caution should be used when interpreting the proportion of records coded as hard-bottom or possible hard-bottom habitat. Records are coded as possible hard-bottom where evidence of hard-bottom is present but not conclusive. Protocols for defining bottom type are described by Van Dolah, et al. (1994b).

The distribution of data records that provide information on bottom type (i.e., hard vs. sand bottom) is summarized in Figure 2 and presented in more detail in Appendix A. Most records indicating the presence of hard-bottom habitat are found in the deeper waters of the shelf, greater than 10 mi from shore. However, dense patches of hard-bottom habitat do occur within 3 mi of shore in the Grand Strand area, and within 5 mi of shore off Charleston. It is possible that additional reef habitat is present along other sections of the coast, but information on bottom type is sparse in these areas.

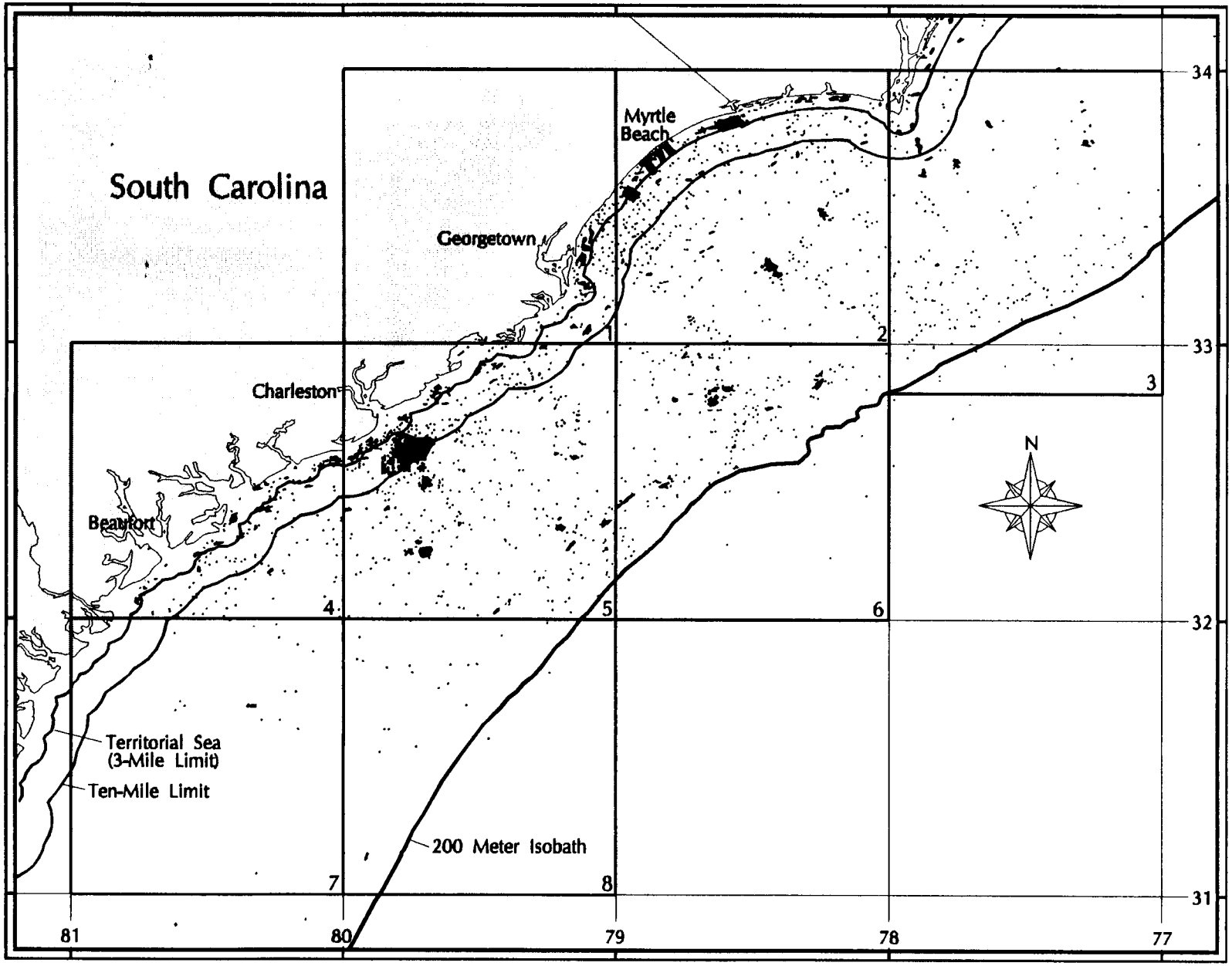


FIGURE 2: Distribution of records that have information on bottom-type. See Appendix A for additional information on areas 1-8.

Spatial Relationship between Hard-Bottom Habitats and Bathymetry

The hard-bottom data were overlaid onto a detailed bathymetric database provided by the National Ocean Survey (NOS) to determine if areas of relief may be used to artificially extend areas of known hard-bottom habitat. The NOS bathymetry data is the most current and detailed bathymetry available for the South Carolina shelf. However, due to the large size of the bathymetry file, evaluating all of the areas of interest was not possible. Instead, select areas were evaluated to test whether this overlay technique would be useful. The results of this analysis suggested that the spatial distribution of these data may not be sufficient to provide for an accurate extrapolation of bottom type. This is due to limitations in the bathymetric file and the bottom-type data, both of which did not have a dense enough spatial array of data points. Off Folly Beach, for instance, the bathymetry lattice is not dense enough to adequately define the subtle breaks in relief (1-2 m) created by low rock outcroppings (Figure 3). Even in an area where the change in slope was more pronounced (i.e., 0.2 - 4% slope in a distance of 500 m), such as near the 200 m isobath, there is still not a good correlation between changes in bottom slope and the location of hard-bottom and possible hard-bottom habitat (Figure 4). Thus, our ability to extrapolate the distribution of reef habitat does not appear to improve by overlaying bottom-type data on NOS bathymetry.

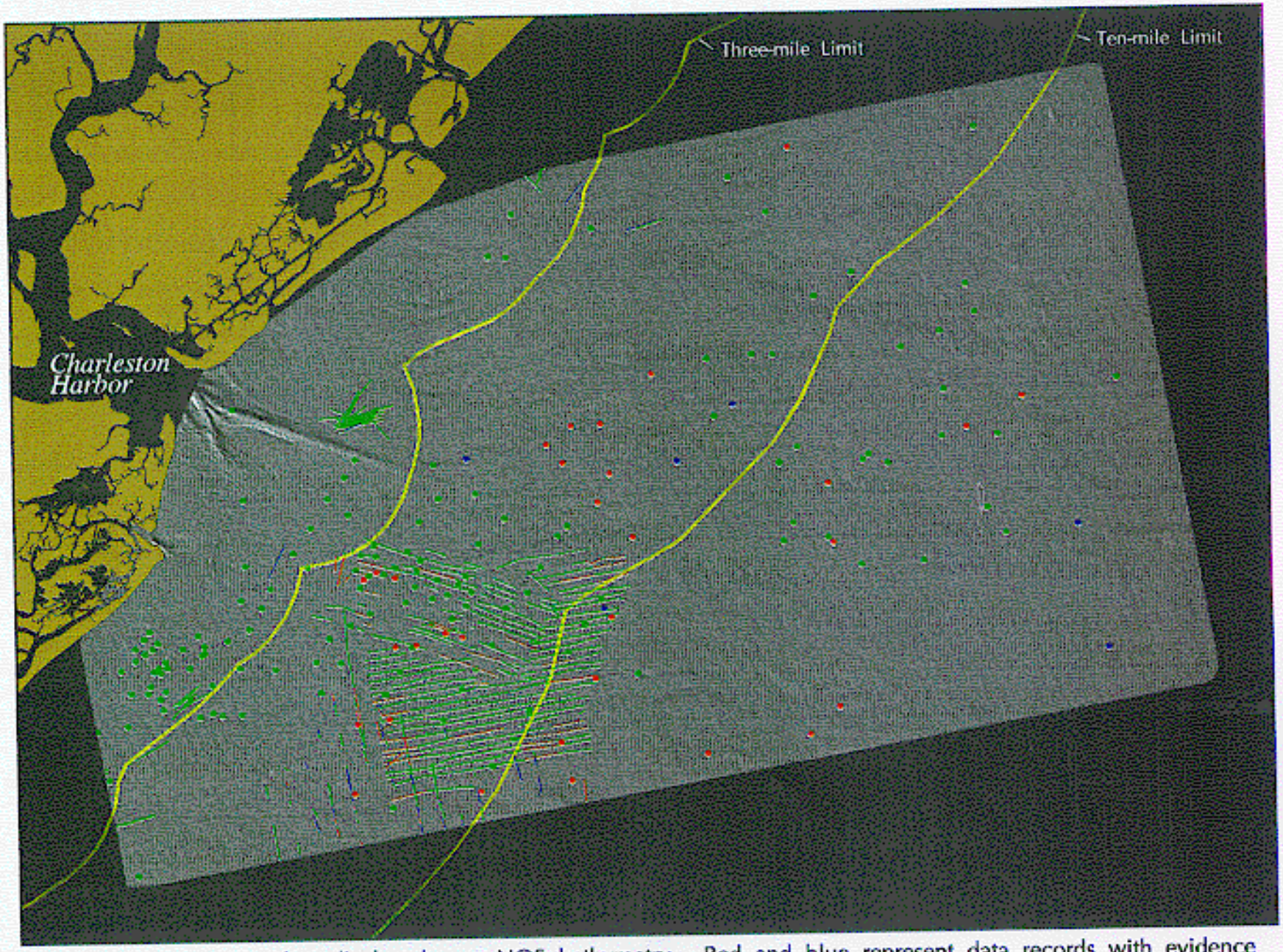


Figure 3: Bottom-type data displayed over NOS bathymetry. Red and blue represent data records with evidence of hard-bottom and possible hard-bottom reef habitat, respectfully. Green represents records with no hard-bottom reef habitat. The bathymetry corresponds to an area defined by 79.93° long, 32.55° lat (NE corner) and 79.32° long, 32.83° lat (SW corner).

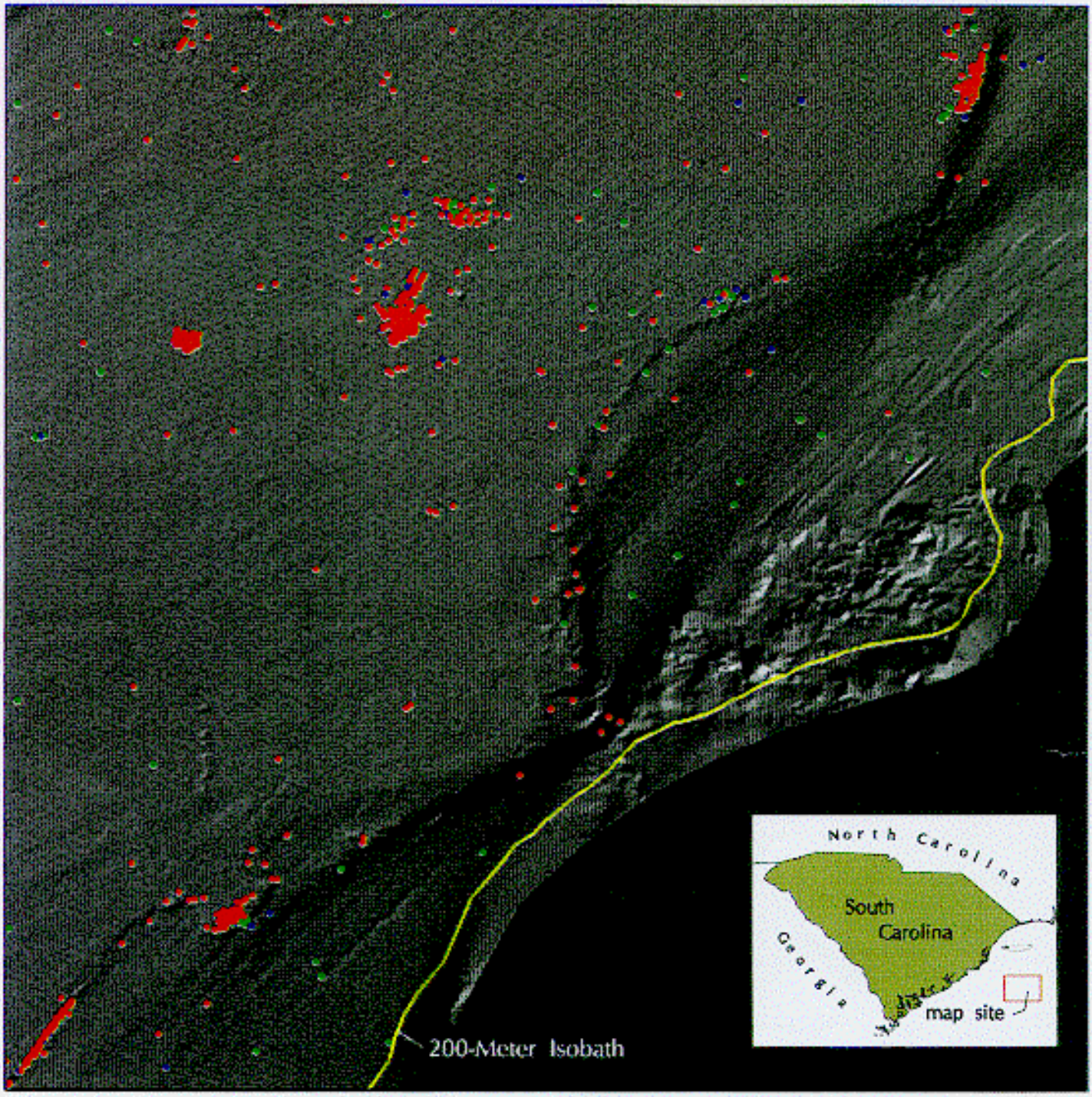


Figure 4: Bottom-type data displayed over NOS bathymetry. Red and blue represent data records with evidence of hard-bottom and possible hard-bottom reef habitat, respectfully. Green represents records with no evidence of hard-bottom reef habitat. The bathymetry corresponds to an area defined by 78.17° long, 32.88° lat (NE corner) and 79.00° long, 32.40° lat (SW corner

Analysis of Sand Deposits

Areas identified as sand-bottom habitat were further characterized with respect to sediment thickness, mean grain size and percentage of sand where data were available. Coastal Carolina University (CCU) identified the maximum thickness of surficial sediment (to the first subsurface reflector) from geophysical surveys for 853 survey points and line segments. However, sediment thickness has not yet been derived from vibracore samples. Considering the number of vibracore samples (527), this additional data on sediment thickness would greatly enhance the database. The sparseness of sediment thickness data made accurate sediment volume calculations impossible. Instead, sediment thickness is depicted (Figure 5). More detailed figures are presented in Appendix B. Discussions at Task Force meetings have indicated that sand mining should be limited to less than 3 m, whenever possible, to minimize biological impacts. Many records coded as having sand deeper than 3 m may not be suitable for mining to those depths, but they do suggest extensive sand deposits.

Figure 5 and Appendix B show several areas where sand is present at a suitable thickness for mining. In the coastal segment from Hunting Island to Charleston Harbor, there appears to be several areas where large sand deposits (>1 m in thickness) occur within 10 mi of shore. From Bulls Bay to Winyah Bay, most of the records indicate a sediment thickness of greater than 3 m. The large number of records showing the presence of thick sediment indicate that this region may provide suitable sand sources for nourishment purposes, but the coastline along this section is largely unpopulated and therefore not in need of nourishment. In the more populated Grand Strand area, only a few areas within 10 mi of the beach show evidence of sand sources greater than 1m thick. This may change once vibracore samples have been analyzed

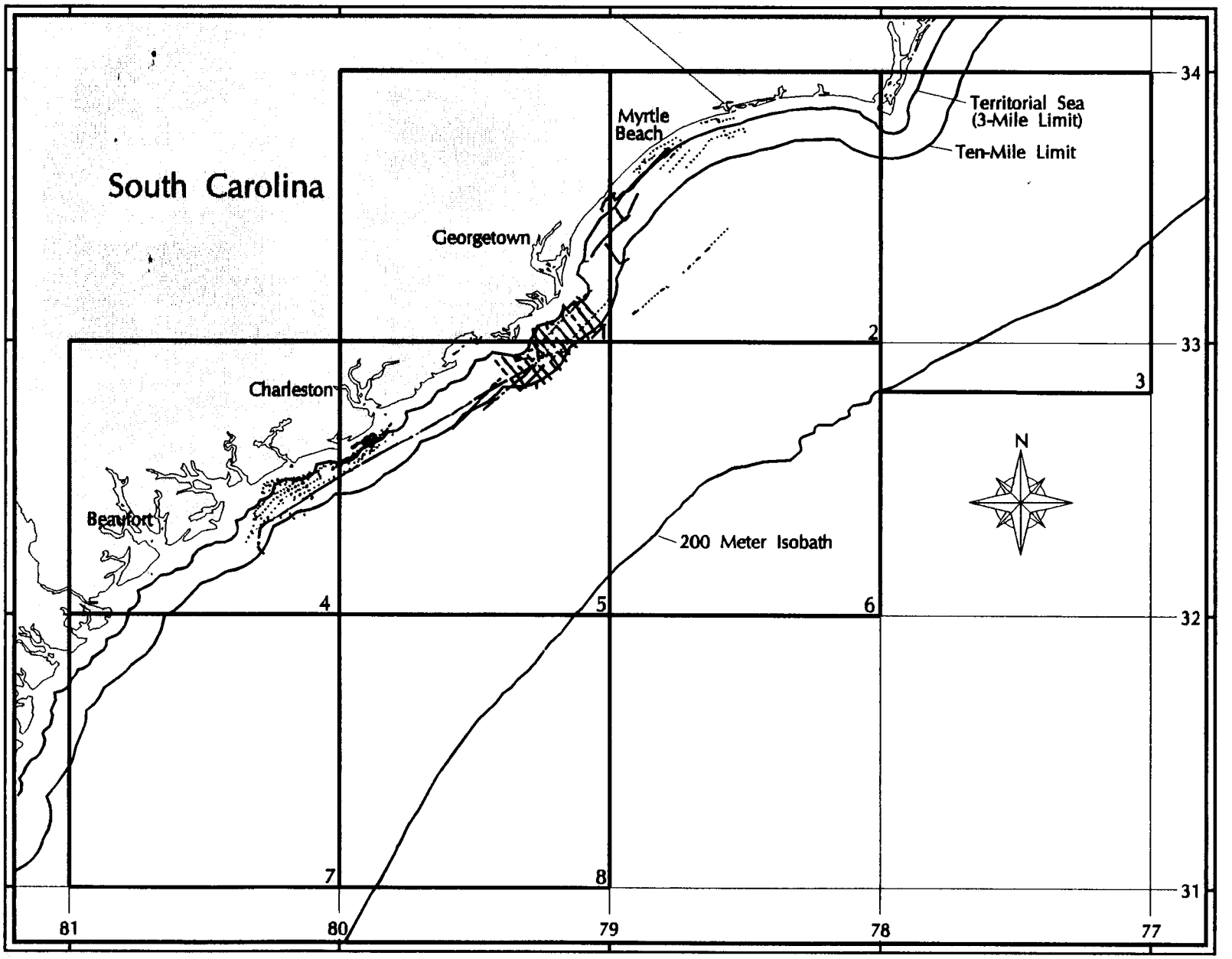


FIGURE 5: Distribution of records with information on maximum sediment thickness. See Appendix B for additional information on areas 1-8.

for thickness of sediment. The USACOE has already identified four large borrow areas that will provide sufficient sediment for nourishing the Grand Strand over the next 50 years.

CCU also determined mean grain size and percentage of sand for many of the sediment samples collected. Mean grain size records (751 points) are shown in Figure 6 and Appendix C. Percent sand records (884 points) are represented in Figure 7 and Appendix D. Sand deposits suitable for beach nourishment purposes should generally have less than 10% silt-clay content (>90% sand) and be of a grain size that is comparable to, or greater than, the sand on the beach to be nourished. Database records containing information on sand composition and grain size indicate that most records within 10 mi of the beach have >90% sand. Outside 10 mi, the data points are sparse and widely distributed. Mean grain size data are generally very sparse for most of the South Carolina coastal zone. Where data are available, most of the records indicate an average sand grain size that should be suitable for beach nourishment purposes.

To be useful for beach nourishment, sand deposits must be near enough to an eroding beach to be mined economically. Figure 8 depicts 3- and 5-mi buffer zones from each eroding beach along the South Carolina coastline. Within these buffer zones, the most appropriate locations to mine sand are those that have a sufficient thickness of sediment, a mean grain size compatible with the erosional beach, a high percentage of sand and no hard-bottom reef habitat. Because either no data exist or samples have not been fully analyzed, there are only a few locations at which MMS-INTERMAR database records overlap with all of the appropriate

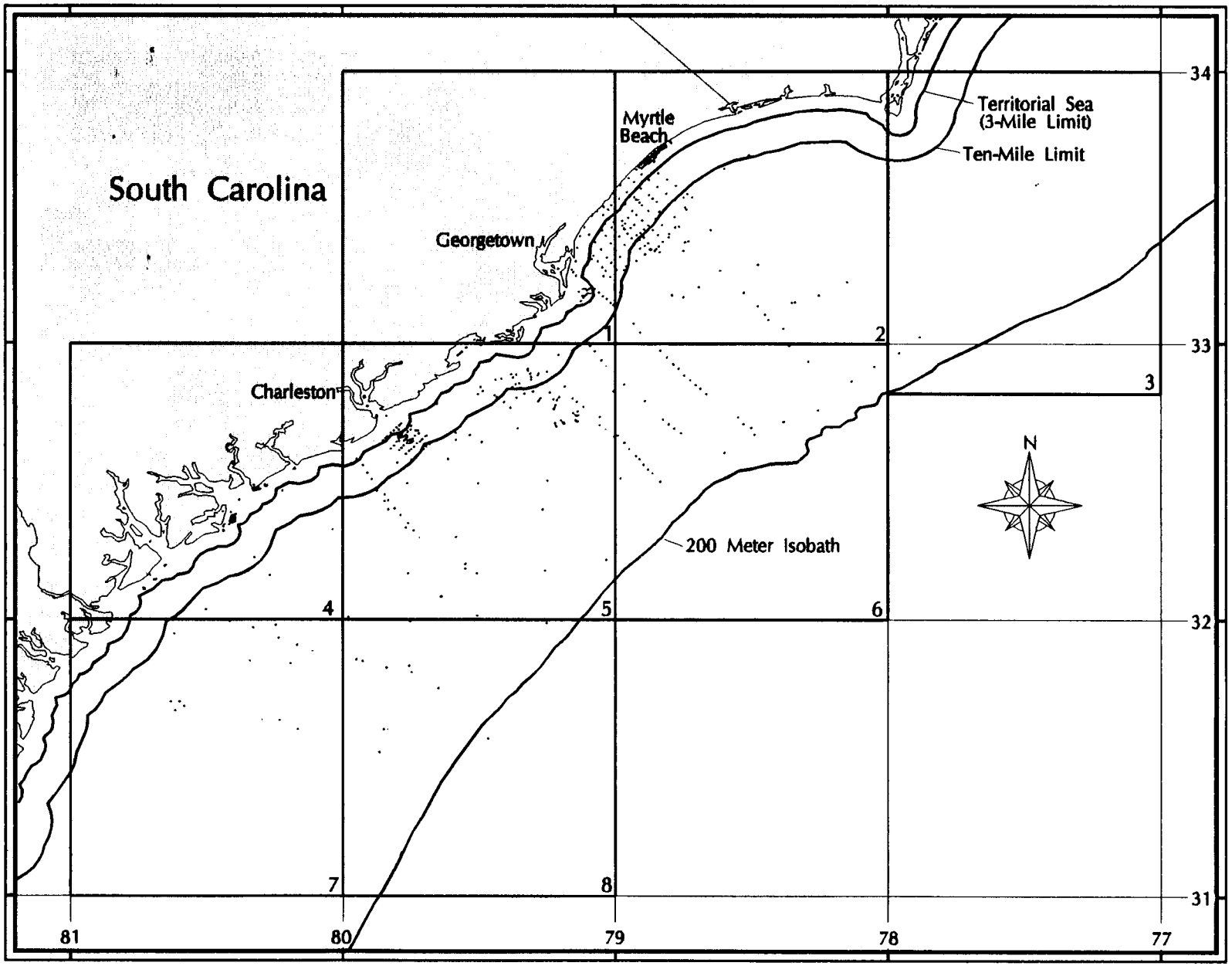
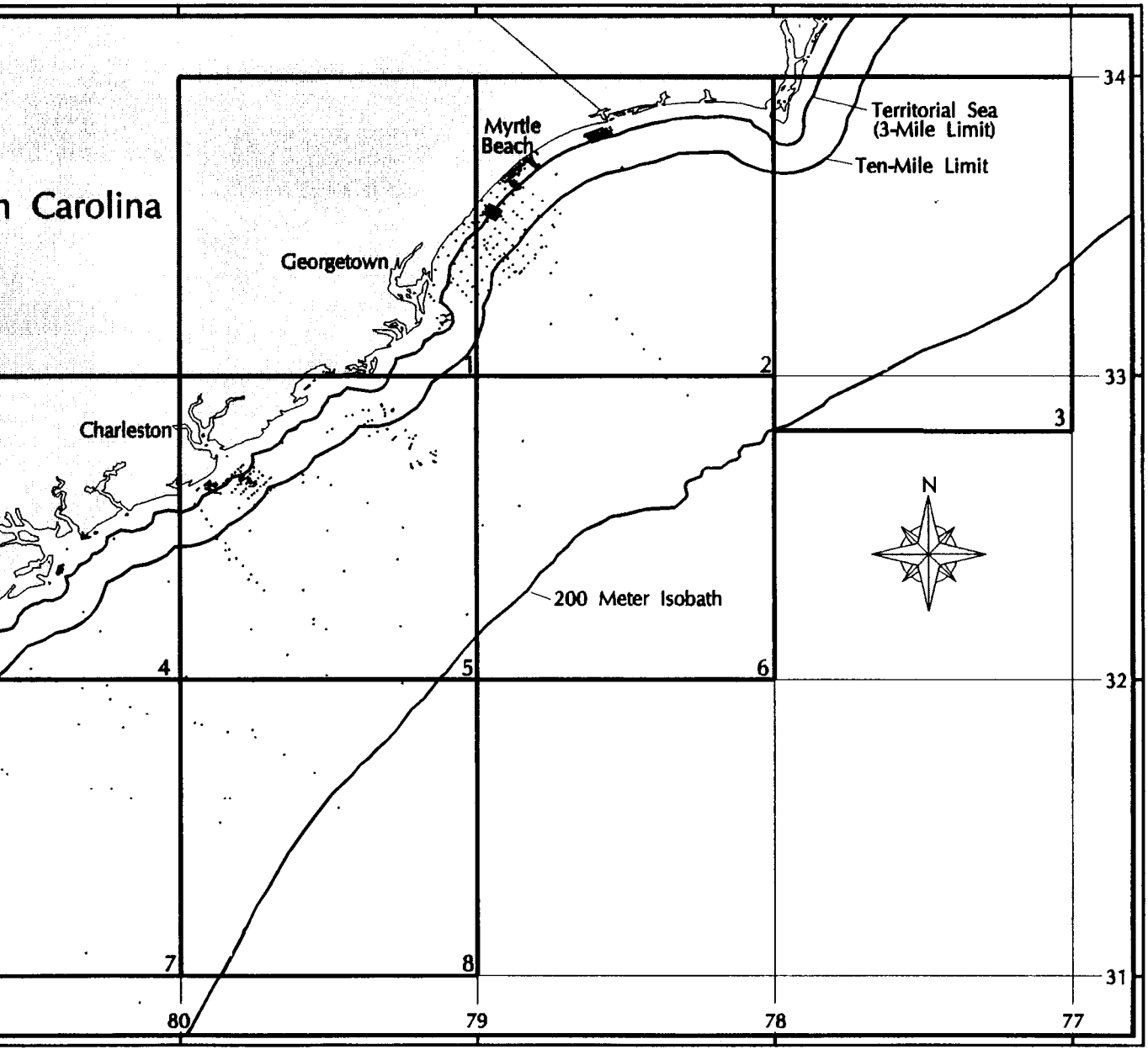
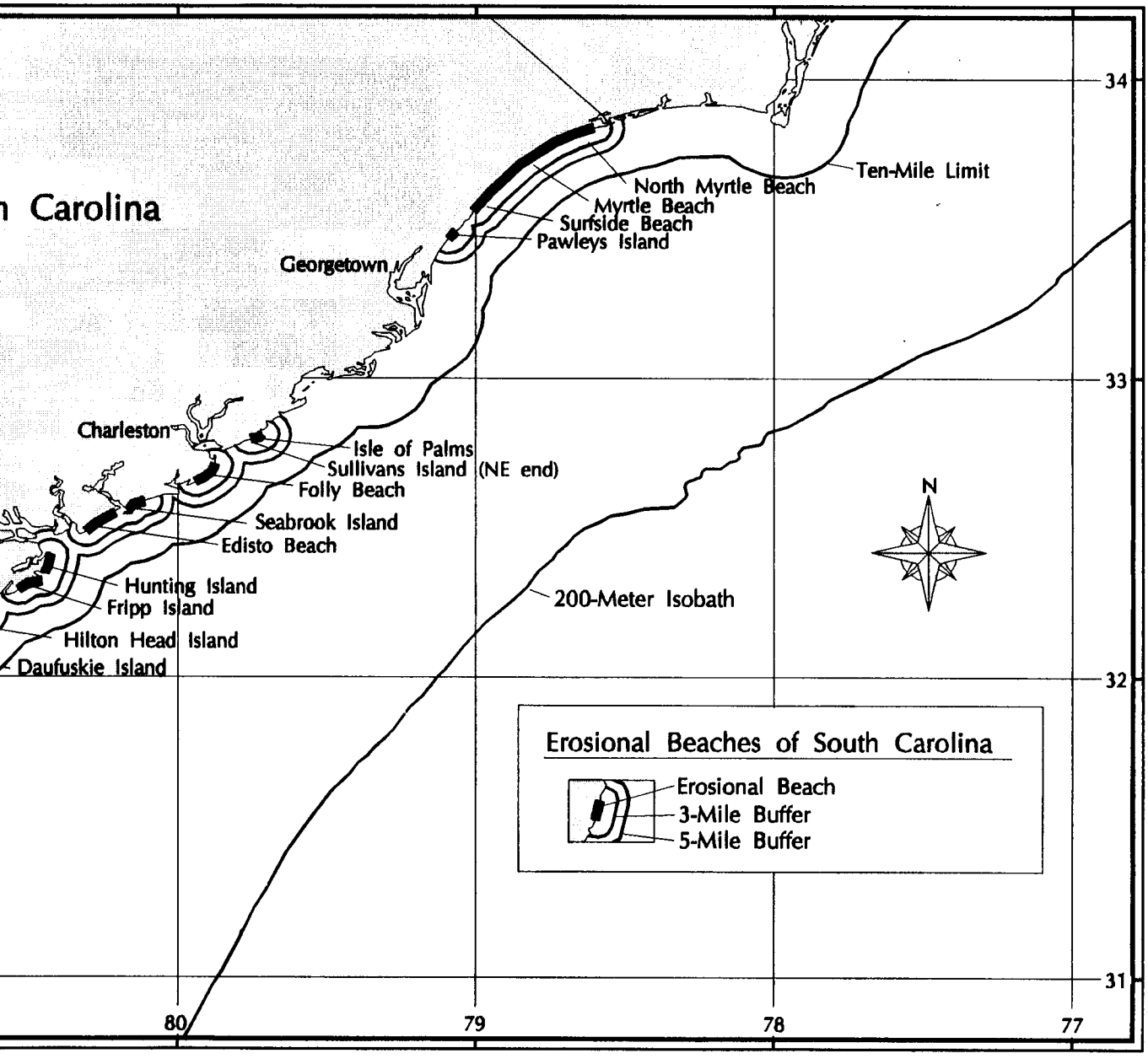


FIGURE 6: Distribution of records that have information on mean grain size. See Appendix C for additional information on areas 1-8.



ution of records that have information on percent sand. See Appendix D for additional information on areas 1-8.



al beaches along the coast of South Carolina

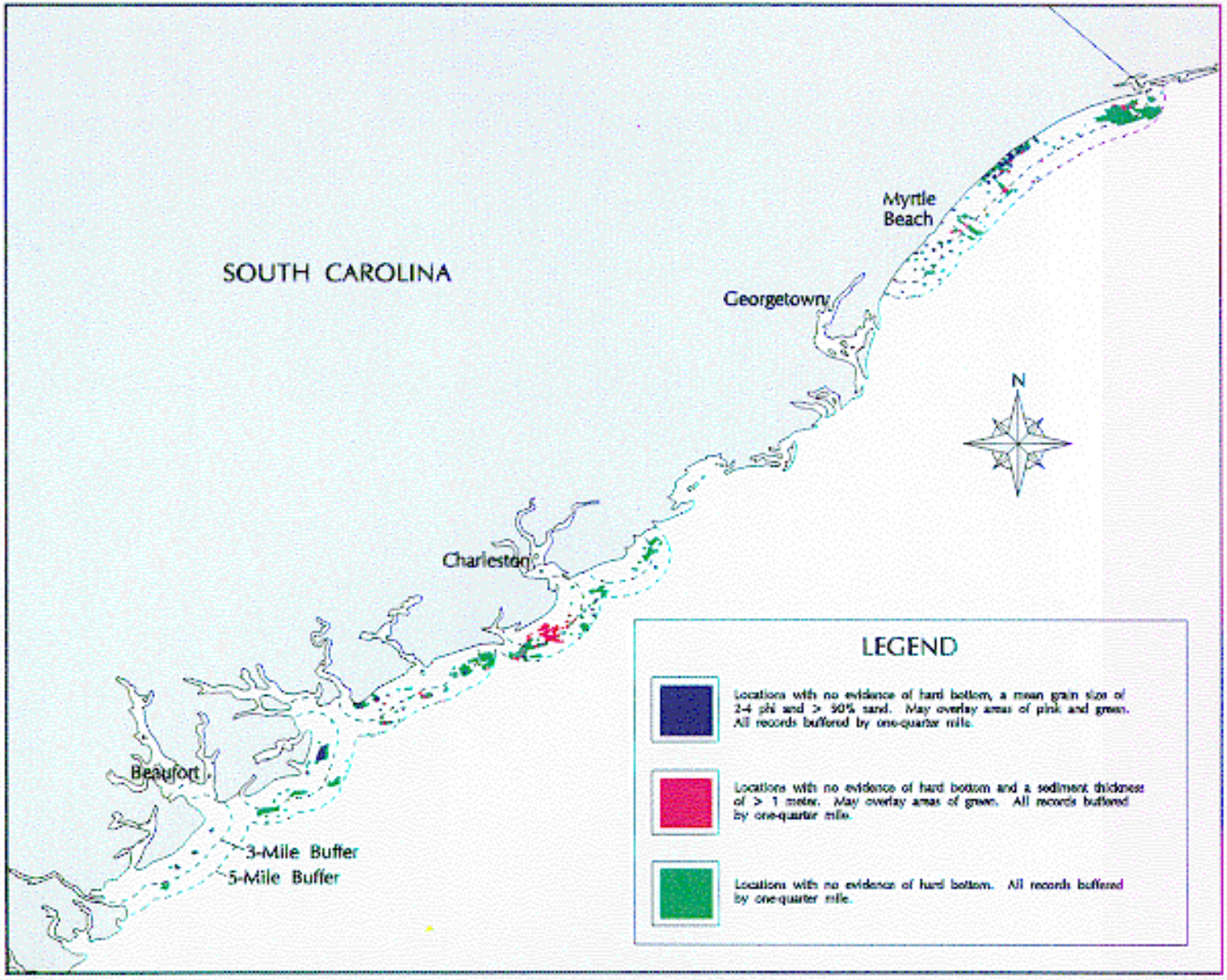


FIGURE 9: Analyses of records within three and five miles of erosional beaches that met certain criteria on bottom-type, sediment composition and sediment thickness.

alternative analyses of grain size, percent sand, sediment thickness and bottom type within 3 and 5 mi of erosional beaches. Since sand can only be mined where there is no hard-bottom habitat, all records with no evidence of hard-bottom habitat are buffered to ¼ mi, erased where they overlap with records containing evidence of hard-bottom habitat and shown in green. Records that meet these criteria and provide evidence that sediment is at least 1m thick are shown in pink. Records that meet the green criteria and show evidence of suitable sand-grain size and composition are shown in dark blue.

Potential Sites for Future Data Acquisition

When all of the data are displayed simultaneously (Figure 10 and Appendix E), it appears as though there is dense data coverage for the coastal zone off South Carolina. However, the usefulness of many records for the evaluation of sand suitability for beach renourishment is limited. This is because most records do not contain the attributes required for analysis of bottom type, sediment type and sediment thickness. To determine potential sites for future data acquisition, data records pertaining to bottom type, sediment type and sediment thickness must be viewed independently. For instance, Figure 5 shows large areas void of sediment thickness records north of Georgetown, between Charleston and Bulls Bay and south of Hunting Island. Figure 6 shows areas void of mean grain size records north of Myrtle Beach, between Charleston and Winyah Bay and south of Charleston with the exception of clusters at the mouth of St. Helena Sound. Figure 7 shows large areas void of percent sand records in a distribution similar to that of mean grain size, with the exception of percent sand records concentrated near Little River. Future data acquisition efforts should focus on collecting the particular data type that is lacking off each erosional beach.

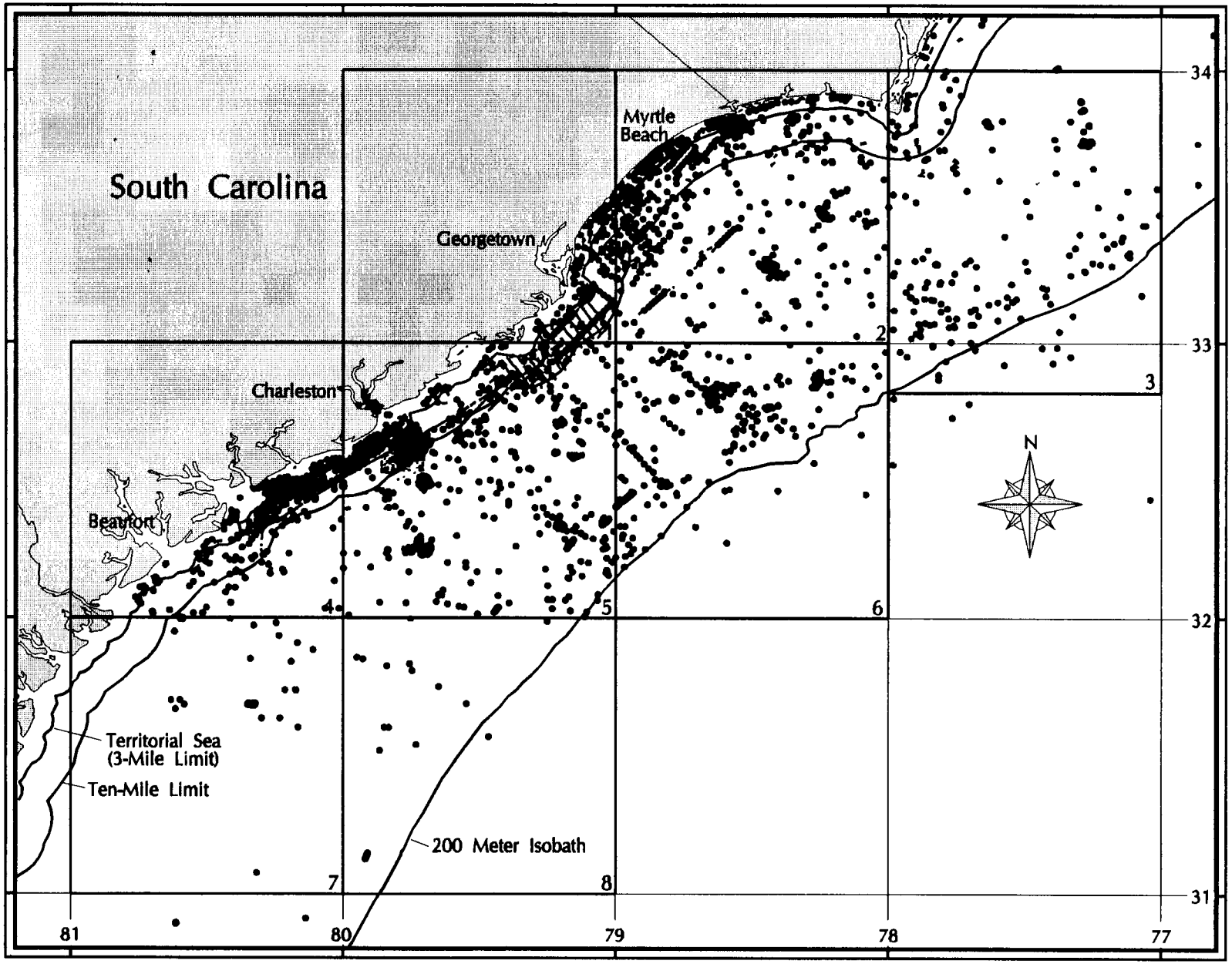


FIGURE 10: Distribution of records that have information on gear type. See Appendix E for additional information on areas 1-8.

Acknowledgments

We would like to thank several individuals who contributed significantly to the development of this report and associated databases.

Members of the Task Force who helped in developing the Task Force objectives and critically reviewing all aspects of the Year I and Year II accomplishments, who are not listed as authors on this report, include: Mitchell Colgan and Michael P. Katuna, University of Charleston; Millard Dowd, U.S. Army Corps of Engineers; M.R. DeVoe, South Carolina Sea Grant Consortium; Rob Dunlap and Sandy Padgett, SCDNR-Marine Resources Division; Bill Eiser, South Carolina Coastal Council; Paul Gayes and Pat Donovan-Ealy, Coastal Carolina University; Tony Giordano, Mineral Management Service; Mark Hansen, U.S. Geological Survey; Brenda Hockensmith, SCDNR-Water Resources Division; Roger Pugliese, South Atlantic Fishery Management Council; Mark Williams, SCDNR-Land Resources Division; Alan Zupan, South Carolina Geological Survey.

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Appendices

Appendix A: Bottom-type plots in areas 1-8 showing hard-bottom, possible hard-bottom, and no hard-bottom reef habitat where data exist.

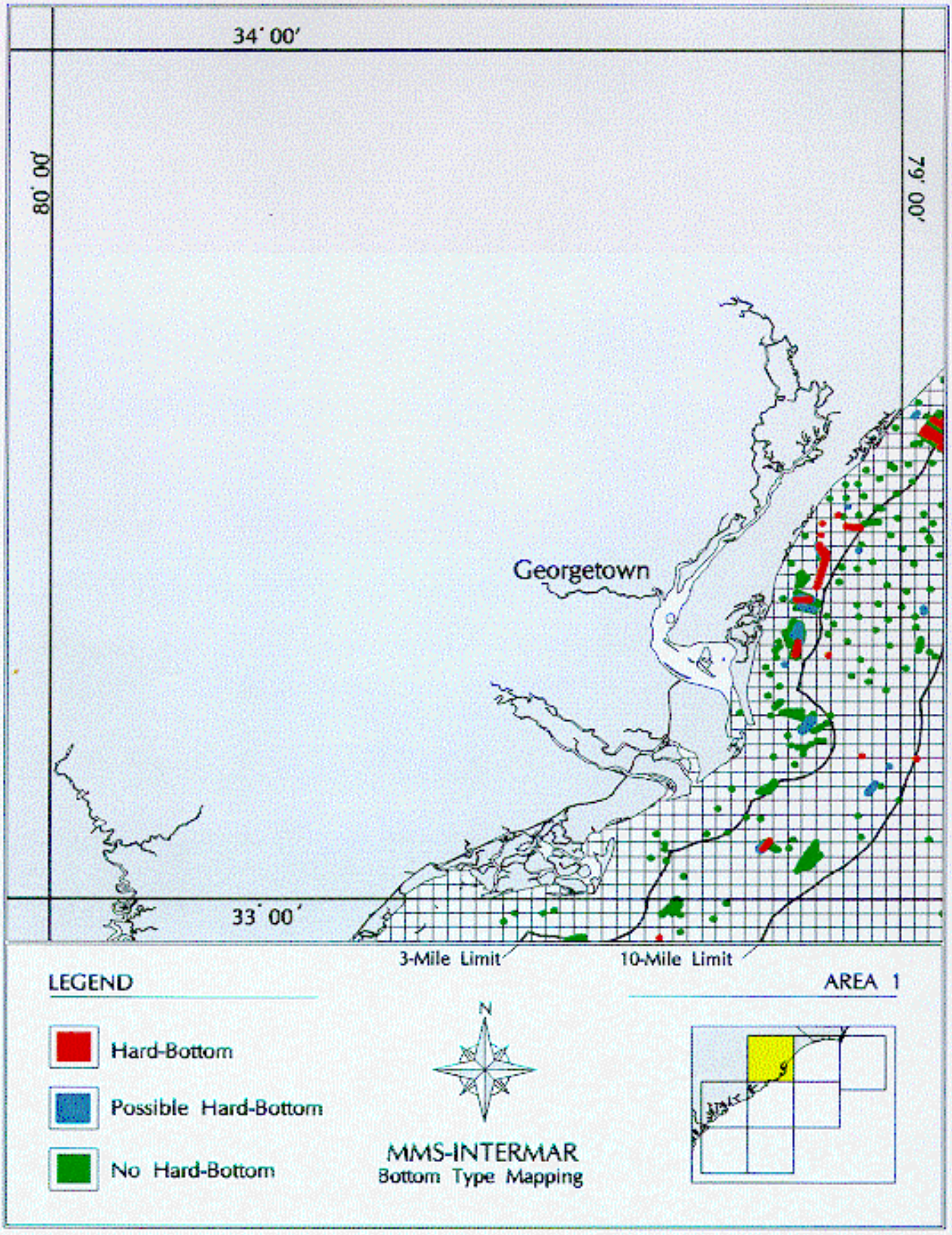
Appendix B: Plots showing maximum sediment thickness in areas 1-8 where data exist. Only Areas 1, 2, 4 and 5 contain data records with sediment thickness information.

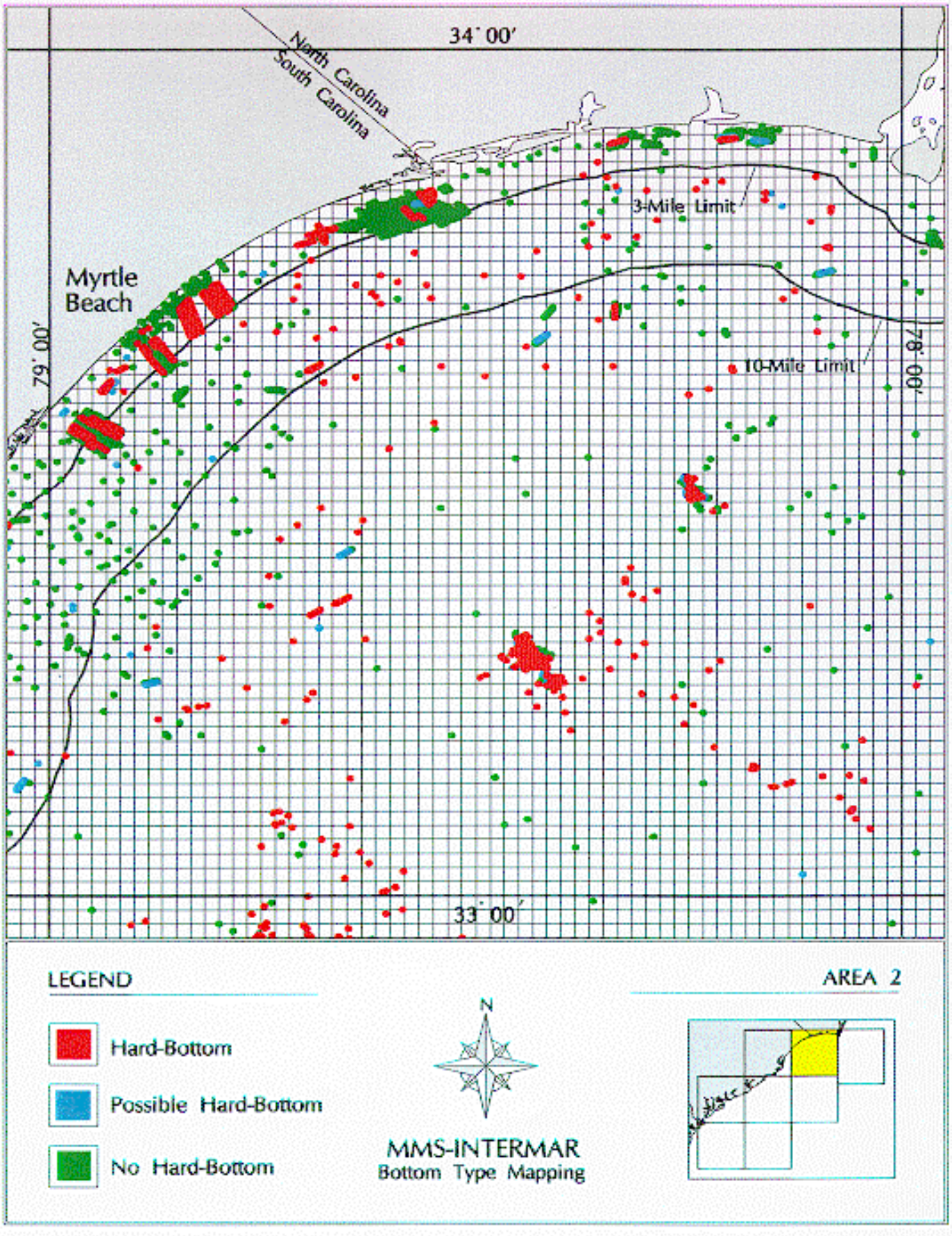
Appendix C: Plots showing mean grain size in areas 1-8 where data exist. Only Areas 1, 2, 4 and 5-8 contain data records with mean grain size information.

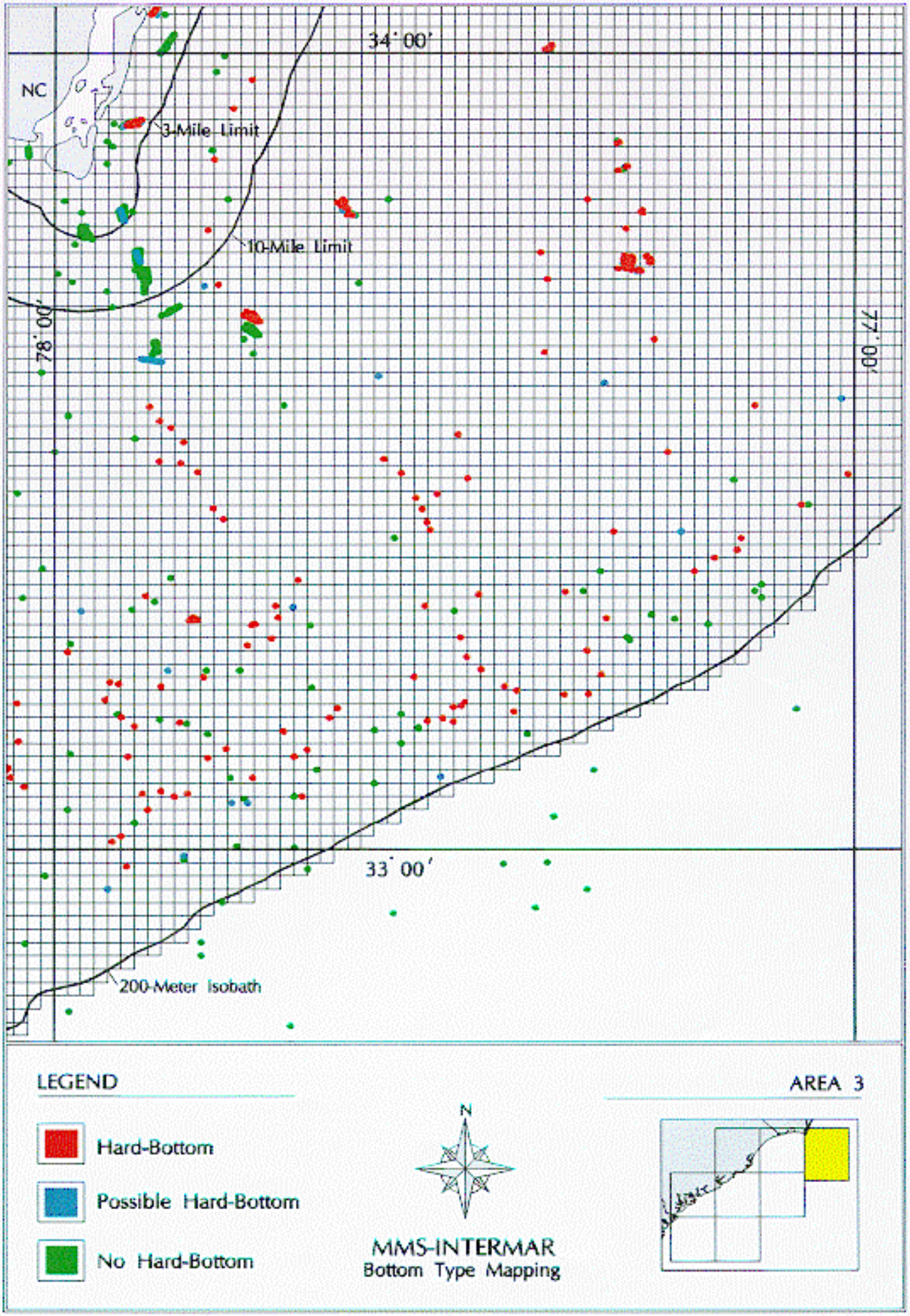
Appendix D: Plots showing percent sand in areas 1-8 where data exist. Only Areas 1, 2, 4 and 5-8 contain data records with percent sand information.

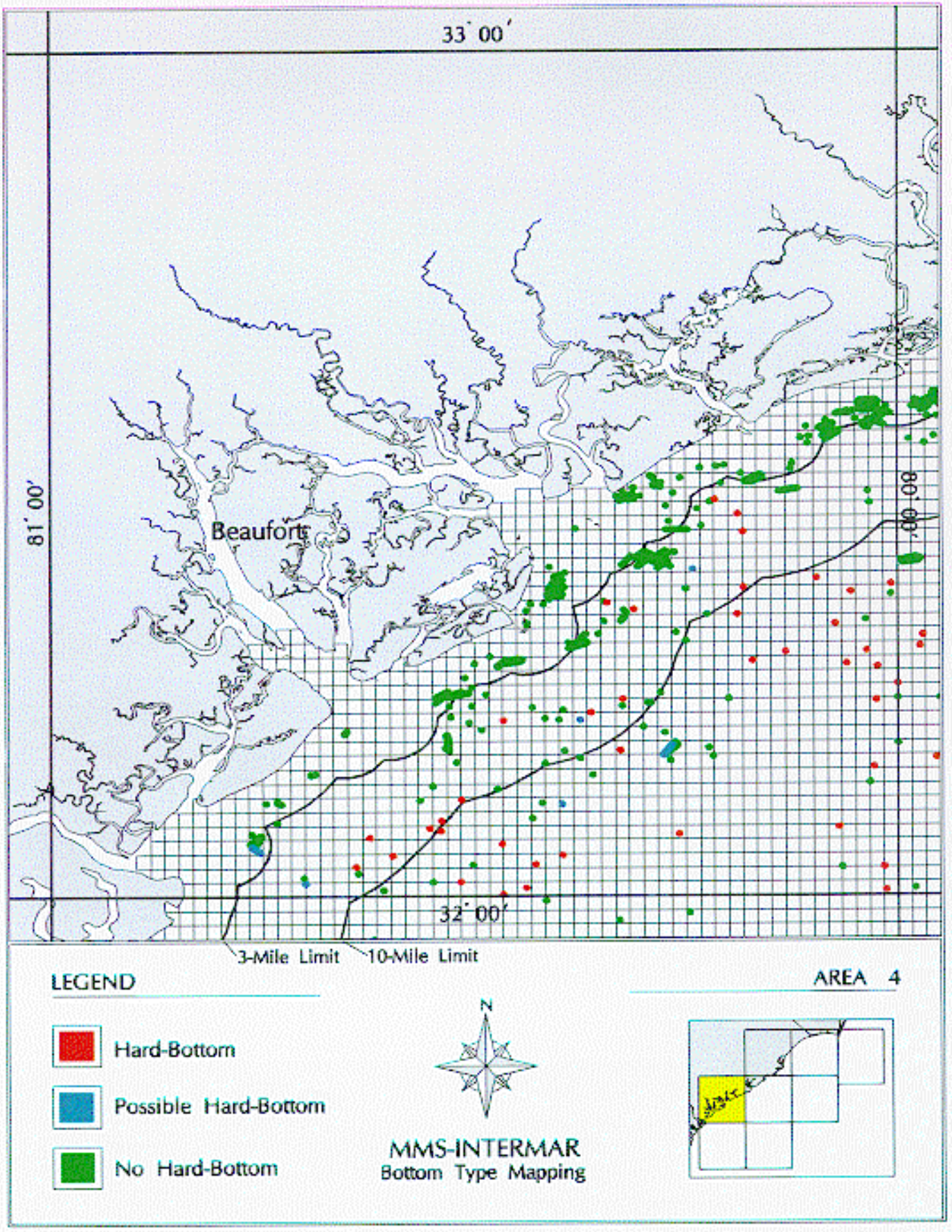
Appendix E: Plots showing gear type in areas 1-8 where data exist.

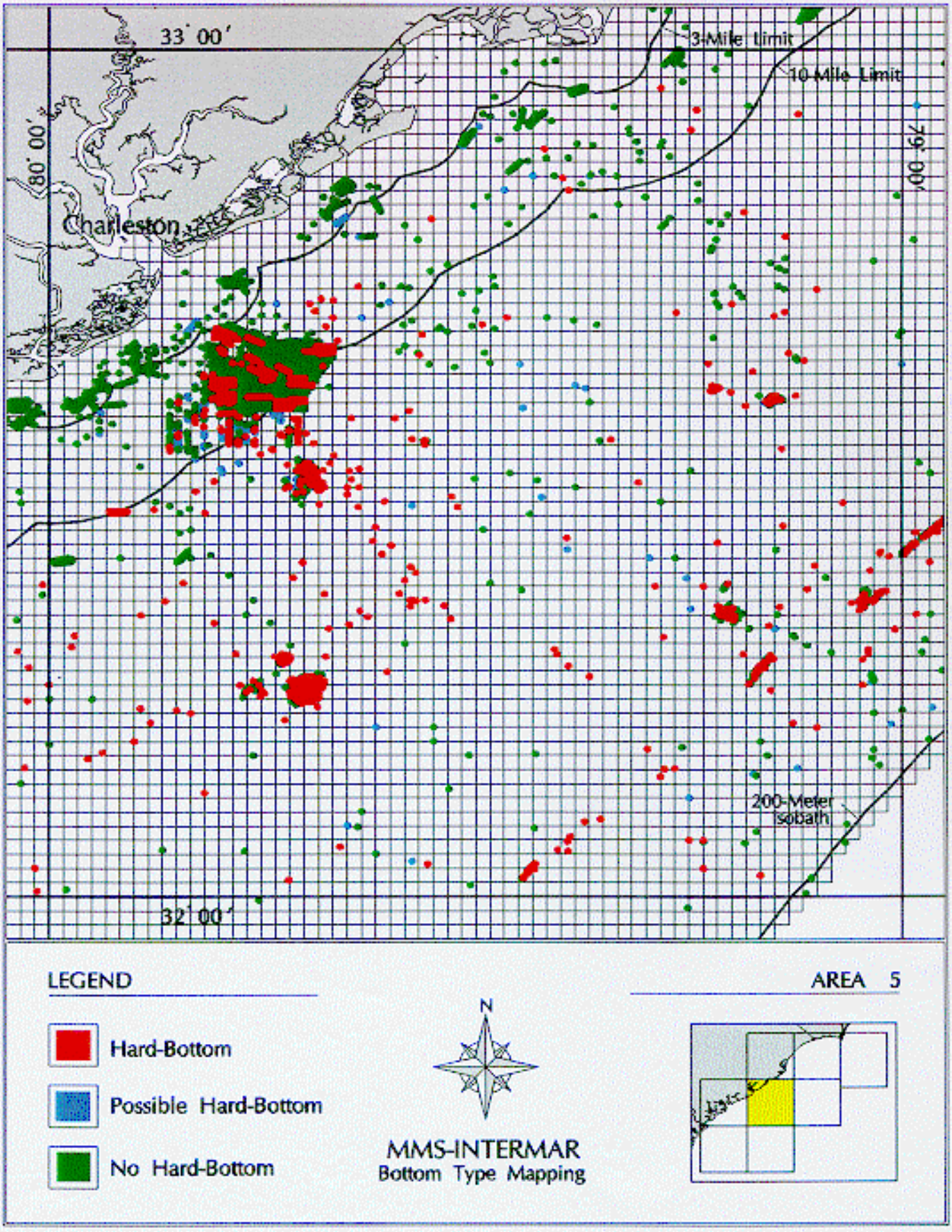
Appendix A: Bottom-type plots in areas 1-8 showing hard-bottom, possible hard-bottom, and no hard-bottom reef habitat where data exist.

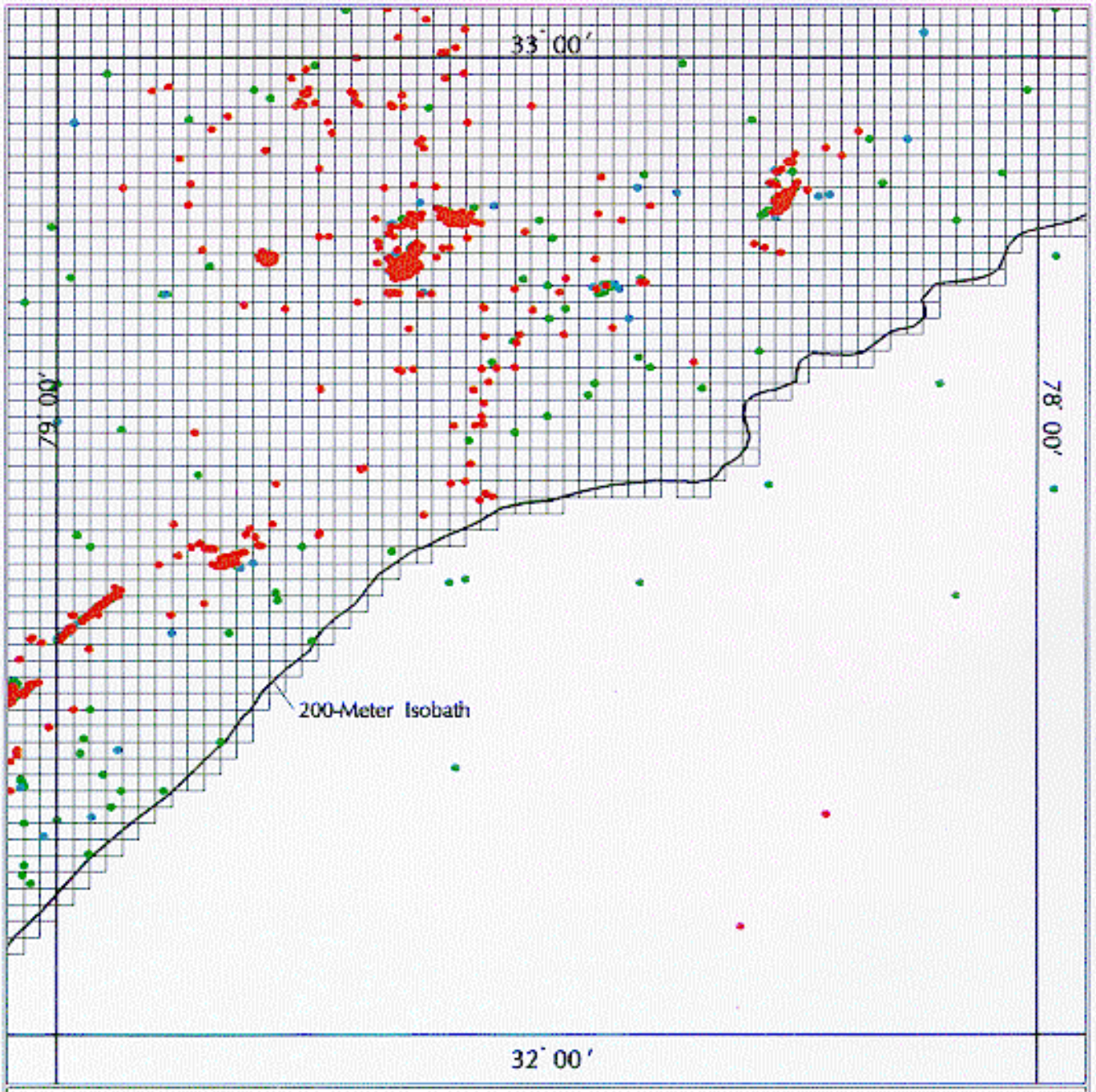

34° 00'
80° 00'
79° 00'
Georgetown
33° 00'
3-Mile Limit
10-Mile Limit
LEGEND
Hard-Bottom
Possible Hard-Bottom
No Hard-Bottom
N
MMS-INTERMAR
Bottom Type Mapping
AREA 1


34° 00′
North Carolina
South Carolina
3-Mile Limit
10-Mile Limit
Myrtle
Beach
79° 00′
78° 00′
33° 00′
LEGEND
Hard-Bottom
Possible Hard-Bottom
No Hard-Bottom
N
MMS-INTERMAR
Bottom Type Mapping
AREA 2


34° 00'
NC
3-Mile Limit
10-Mile Limit
78° 00'
77° 00'
33° 00'
200-Meter Isobath
LEGEND
Hard-Bottom
Possible Hard-Bottom
No Hard-Bottom
N
MMS-INTERMAR
Bottom Type Mapping
AREA 3


33° 00′
81° 00′
80° 00′
32° 00′
Beaufort
3-Mile Limit
10-Mile Limit
LEGEND
Hard-Bottom
Possible Hard-Bottom
No Hard-Bottom
N
MMS-INTERMAR
Bottom Type Mapping
AREA 4


33° 00′
80° 00′
79° 00′
32° 00′
Charleston
3-Mile Limit
10-Mile Limit
200-Meter Isobath
LEGEND
Hard-Bottom
Possible Hard-Bottom
No Hard-Bottom
N
MMS-INTERMAR
Bottom Type Mapping
AREA 5



LEGEND

Hard-Bottom

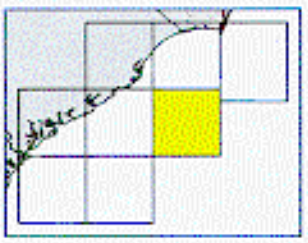
Possible Hard-Bottom

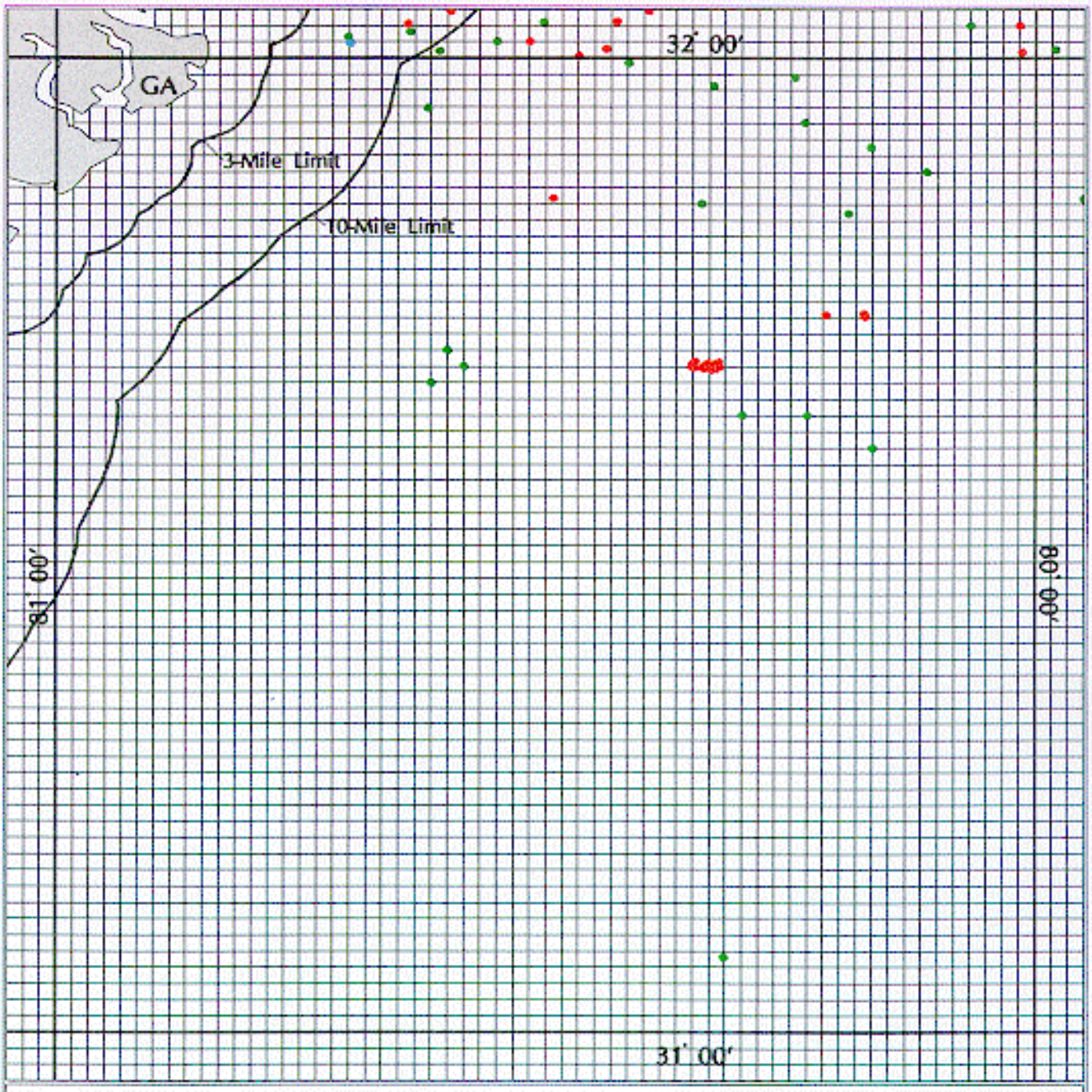
No Hard-Bottom

N

MMS-INTERMAR
Bottom Type Mapping

AREA 6





LEGEND

Hard-Bottom

Possible Hard-Bottom

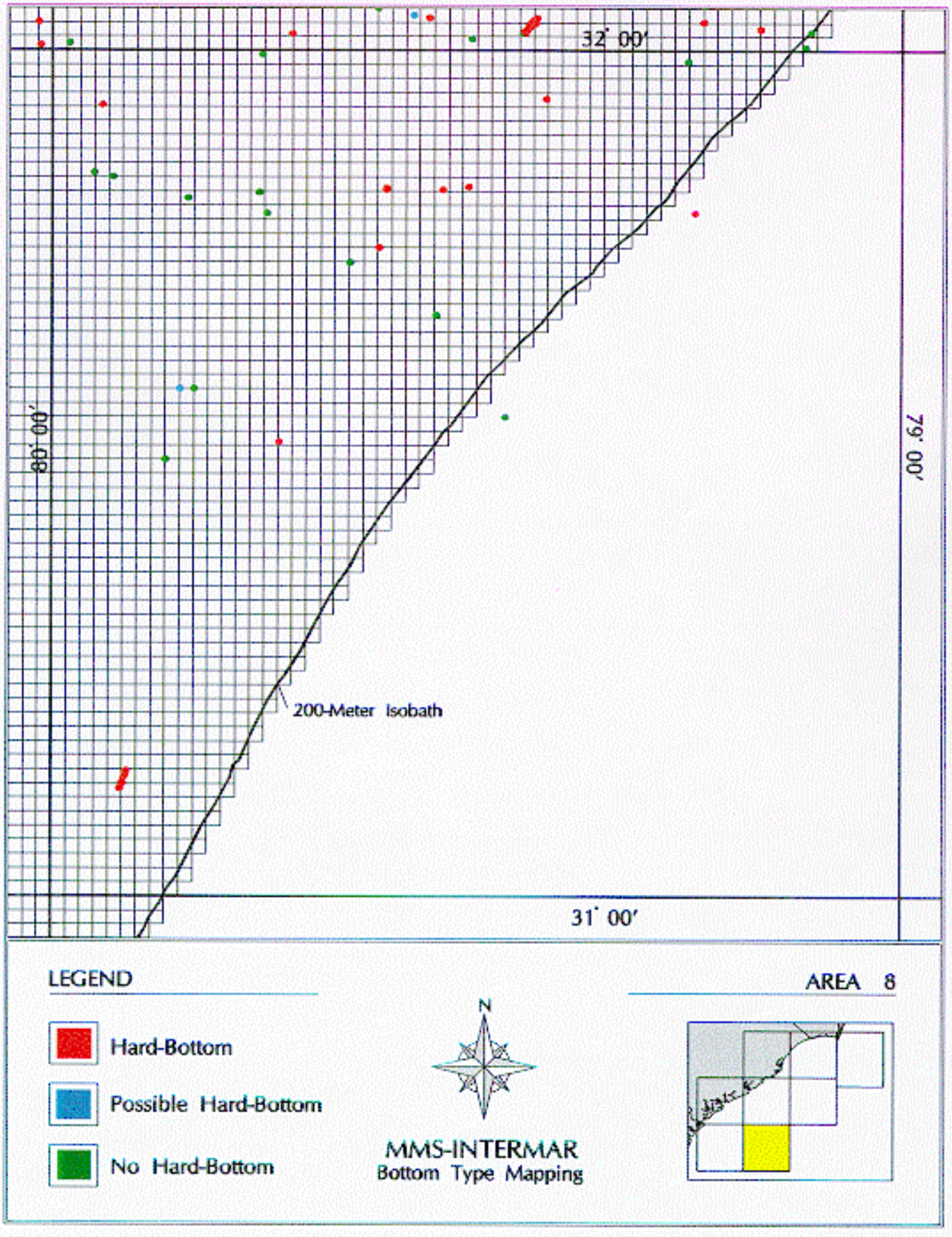
No Hard-Bottom

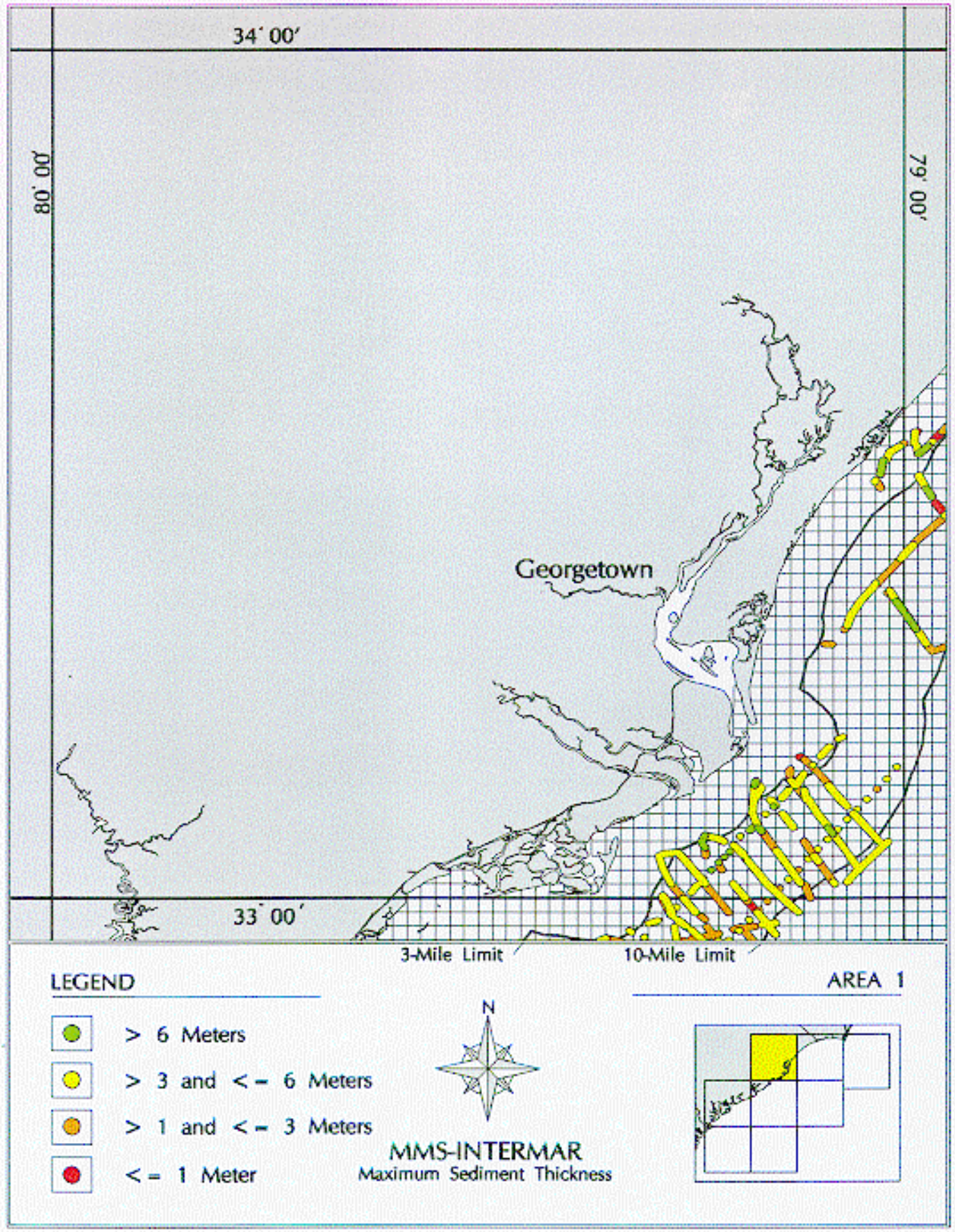
N

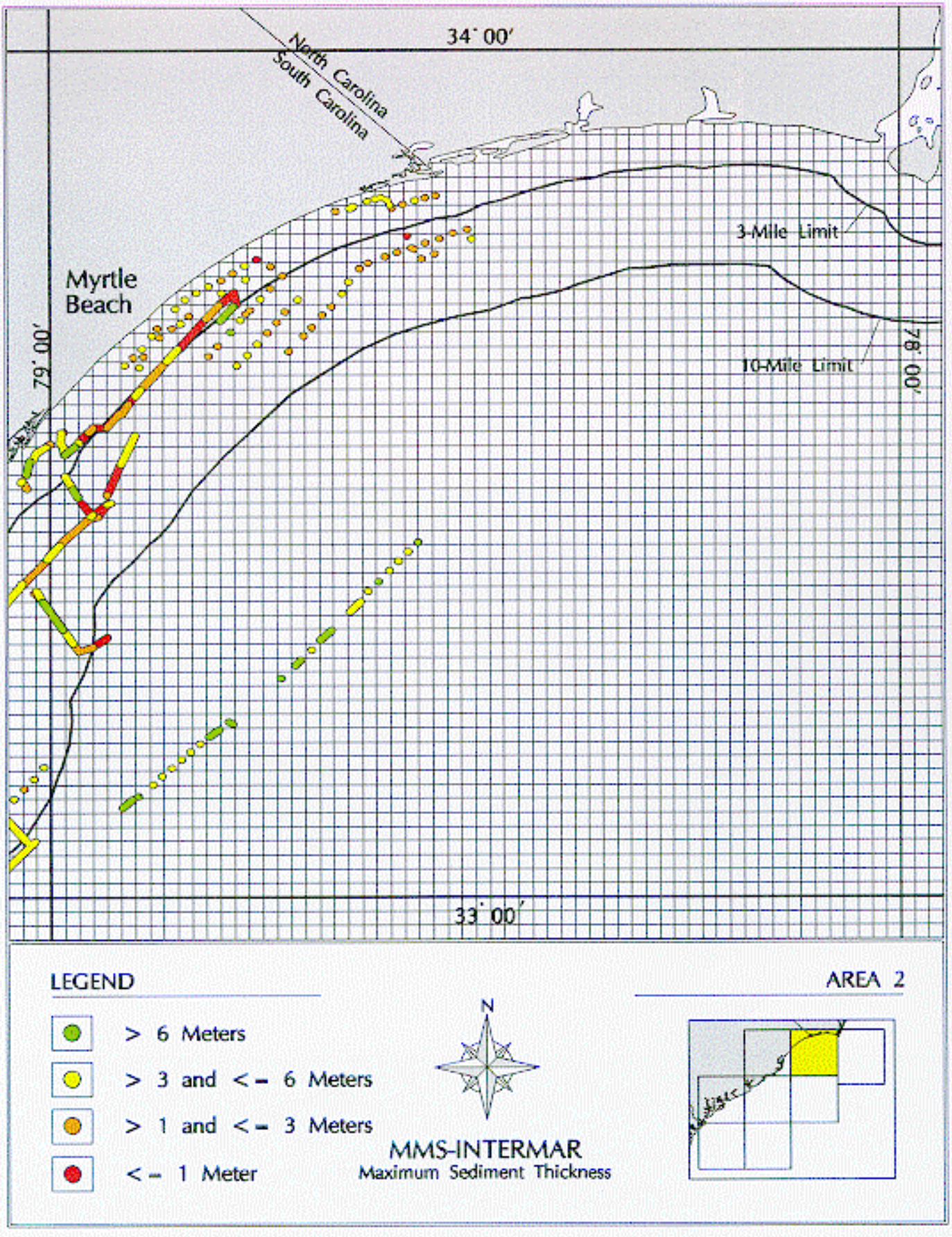
MMS-INTERMAR
Bottom Type Mapping

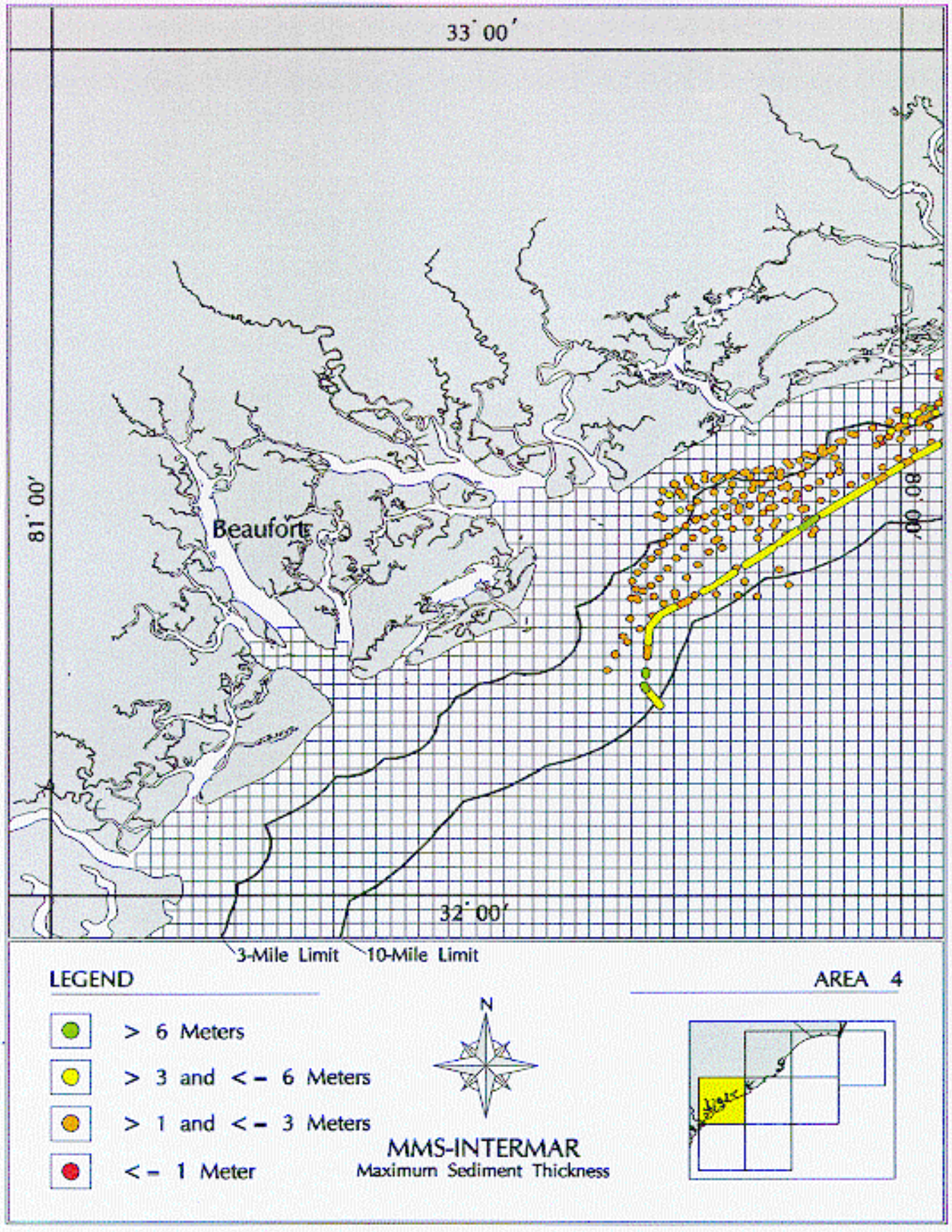
AREA 7

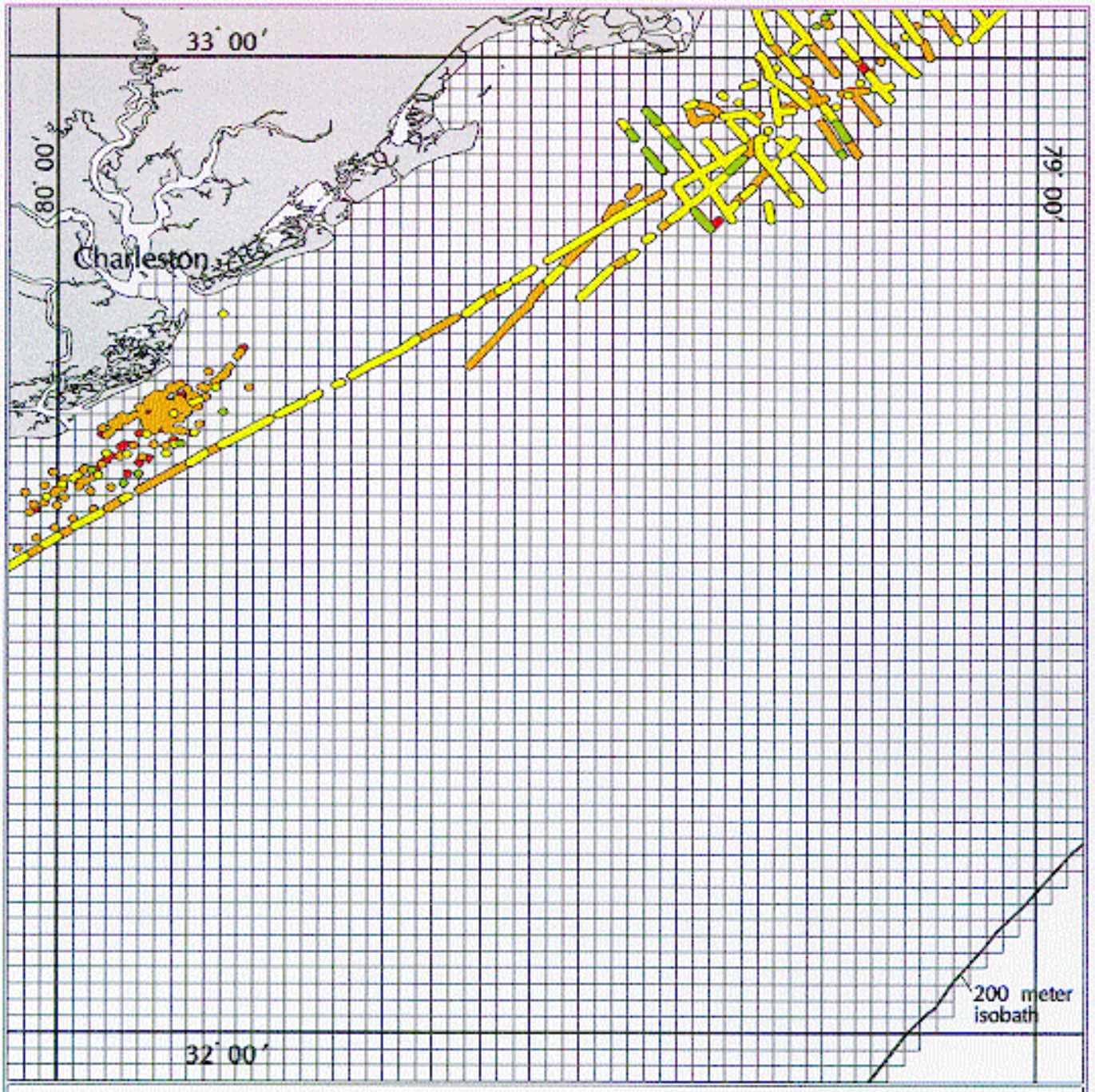
Appendix B: Plots showing maximum sediment thickness in areas 1-8 where data exist. Only Areas 1, 2, 4 and 5 contain data records with sediment thickness information.


32° 00'
80° 00'
79° 00'
200-Meter Isobath
31° 00'
LEGEND
Hard-Bottom
Possible Hard-Bottom
No Hard-Bottom
N
MMS-INTERMAR
Bottom Type Mapping
AREA 8


34° 00′
80° 00′
79° 00′
Georgetown
33° 00′
3-Mile Limit
10-Mile Limit
LEGEND
> 6 Meters
> 3 and <= 6 Meters
> 1 and <= 3 Meters
<= 1 Meter
N
MMS-INTERMAR
Maximum Sediment Thickness
AREA 1


34° 00′
North Carolina
South Carolina
3-Mile Limit
10-Mile Limit
Myrtle
Beach
79° 00′
78° 00′
33° 00′
LEGEND
> 6 Meters
> 3 and <= 6 Meters
> 1 and <= 3 Meters
<= 1 Meter
N
MMS-INTERMAR
Maximum Sediment Thickness
AREA 2


33° 00′
81° 00′
80° 00′
32° 00′
Beaufort
3-Mile Limit
10-Mile Limit
LEGEND
> 6 Meters
> 3 and <= 6 Meters
> 1 and <= 3 Meters
<= 1 Meter
N
MMS-INTERMAR
Maximum Sediment Thickness
AREA 4



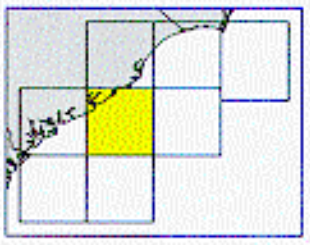
LEGEND

- > 6 Meters
- > 3 and <= 6 Meters
- > 1 and <= 3 Meters
- <= 1 Meter

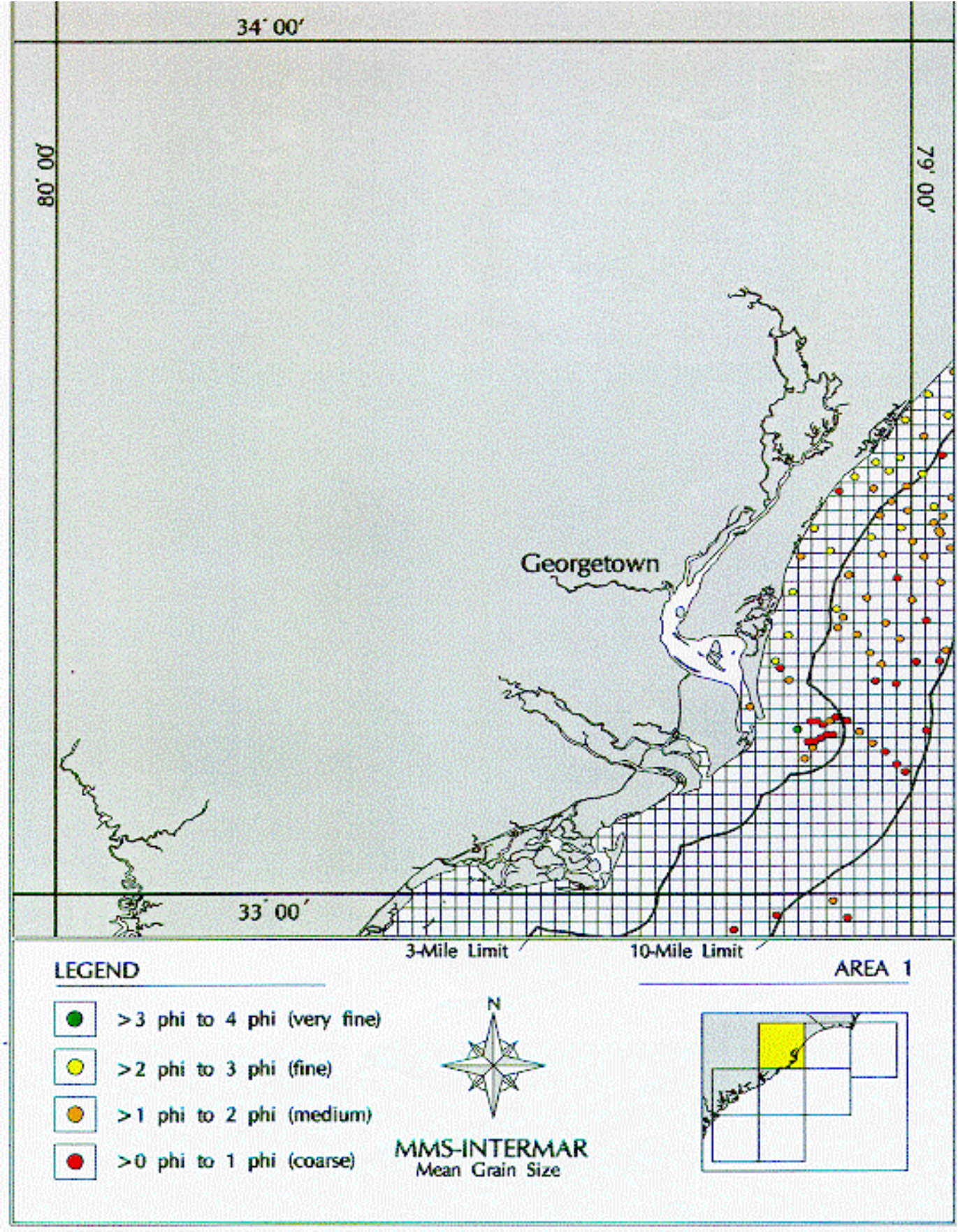
N

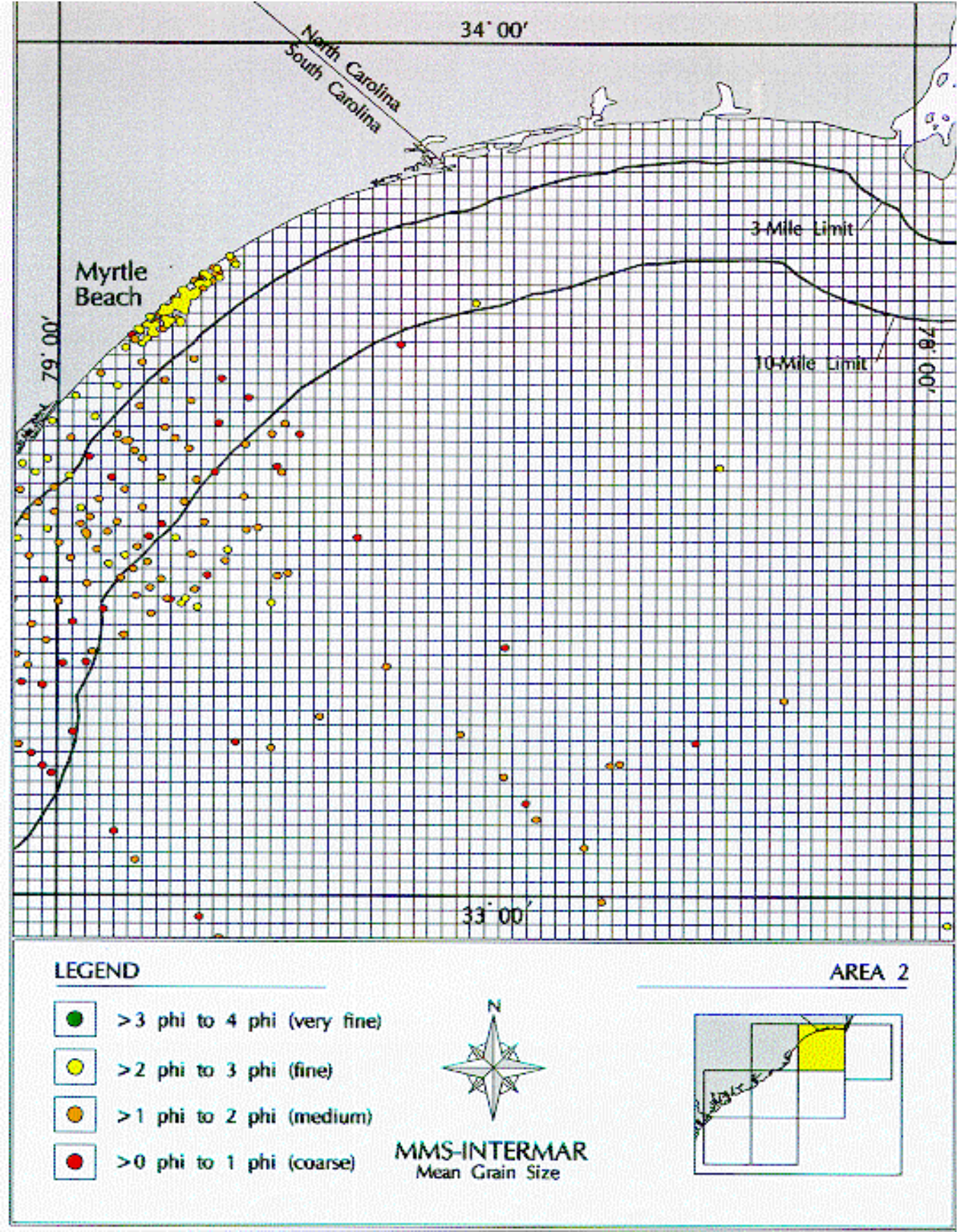
MMS-INTERMAR
Maximum Sediment Thickness

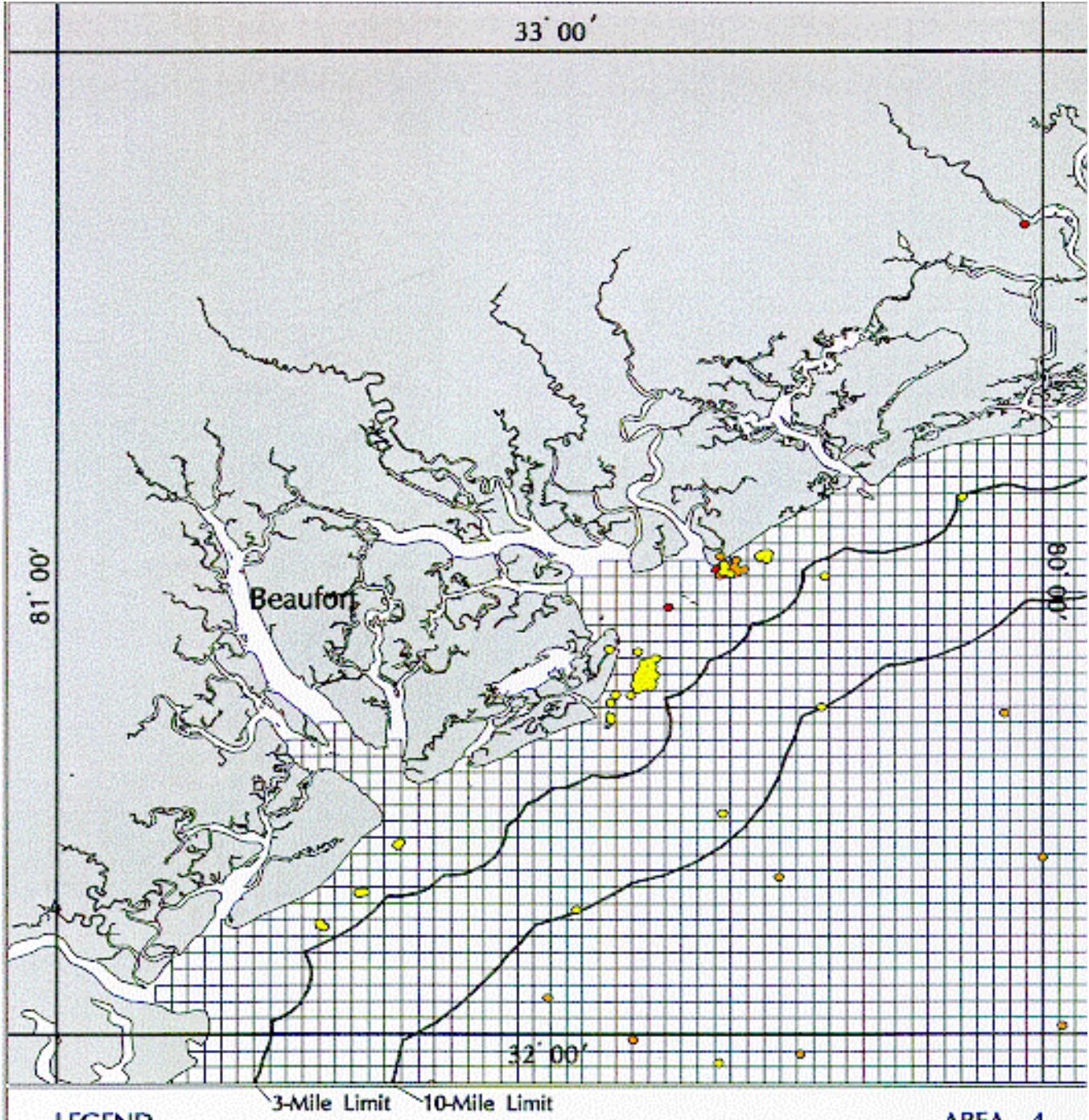
AREA 5



Appendix C: Plots showing mean grain size in areas 1-8 where data exist. Only Areas 1, 2, 4 and 5-8 contain data records with mean grain size information.


34° 00′
80° 00′
79° 00′
33° 00′
Georgetown
3-Mile Limit
10-Mile Limit
LEGEND
>3 phi to 4 phi (very fine)
>2 phi to 3 phi (fine)
>1 phi to 2 phi (medium)
>0 phi to 1 phi (coarse)
N
MMS-INTERMAR
Mean Grain Size
AREA 1


34° 00′
North Carolina
South Carolina
3-Mile Limit
10-Mile Limit
Myrtle Beach
79° 00′
78° 00′
33° 00′
LEGEND
>3 phi to 4 phi (very fine)
>2 phi to 3 phi (fine)
>1 phi to 2 phi (medium)
>0 phi to 1 phi (coarse)
N
MMS-INTERMAR
Mean Grain Size
AREA 2



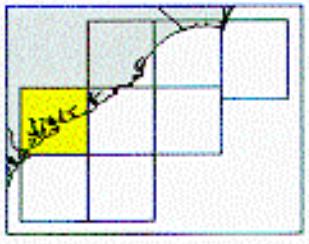
LEGEND

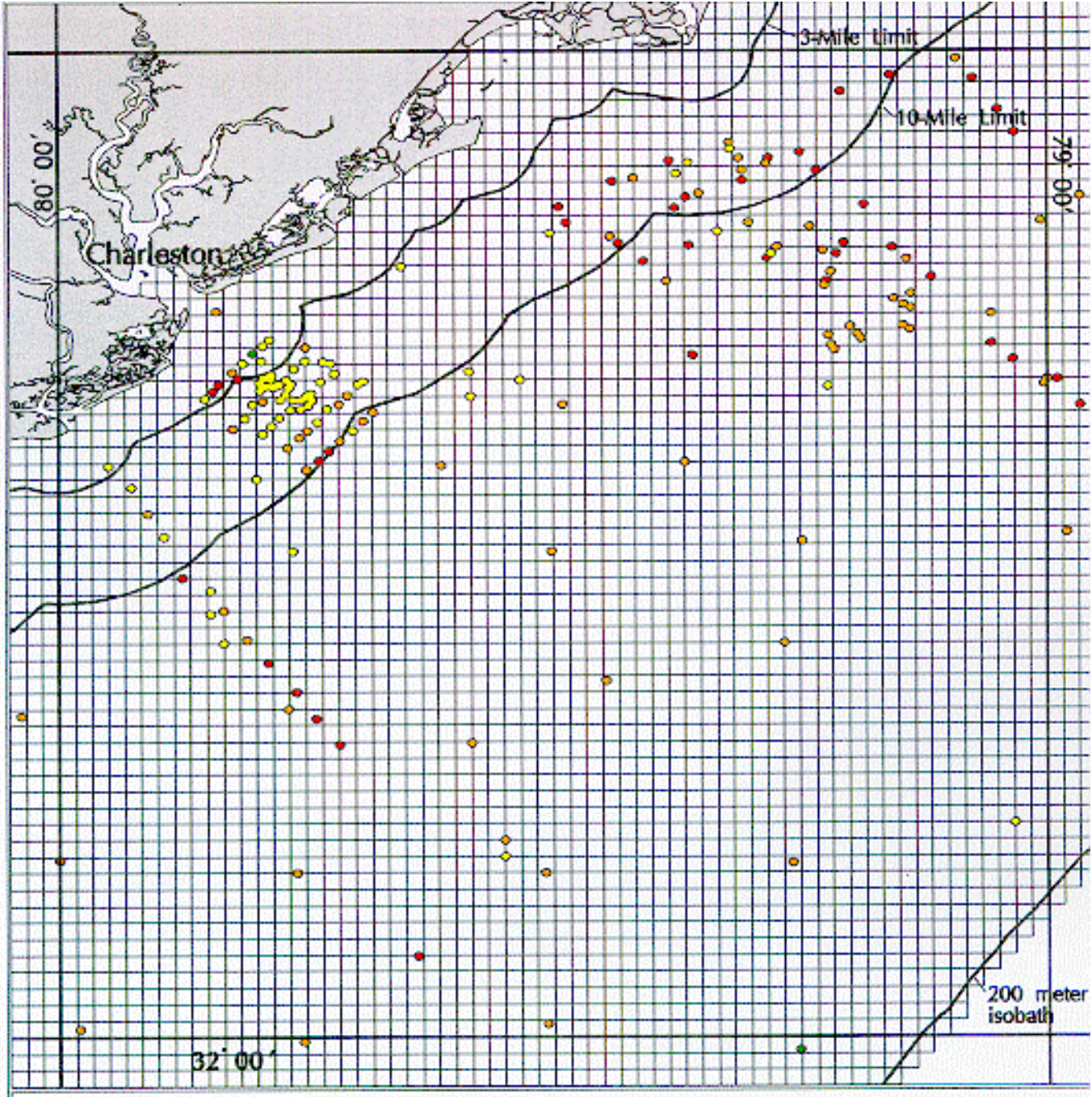
- >3 phi to 4 phi (very fine)
- >2 phi to 3 phi (fine)
- >1 phi to 2 phi (medium)
- >0 phi to 1 phi (coarse)

N

MMS-INTERMAR
Mean Grain Size

AREA 4





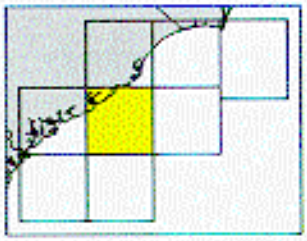
LEGEND

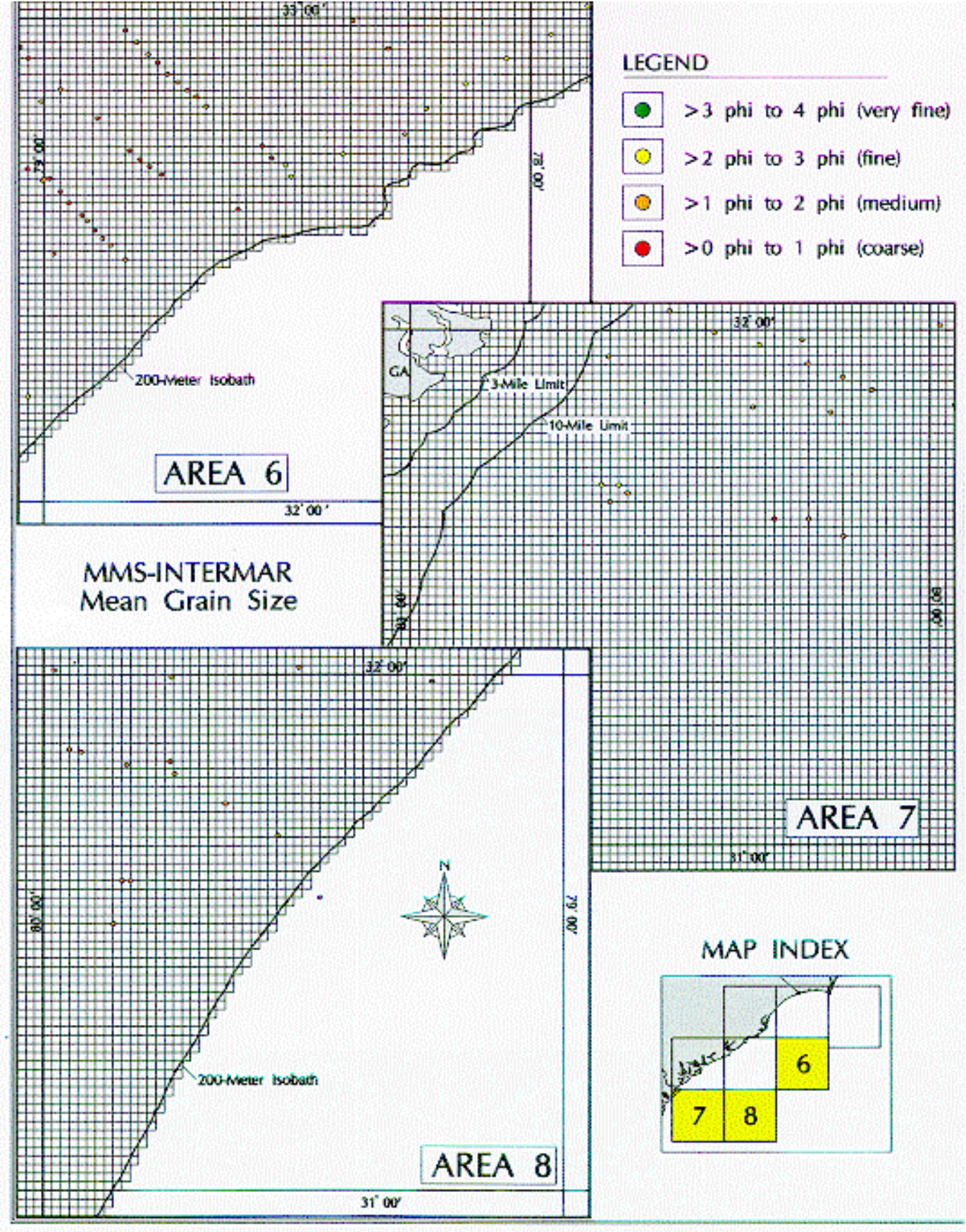
- >3 phi to 4 phi (very fine)
- >2 phi to 3 phi (fine)
- >1 phi to 2 phi (medium)
- >0 phi to 1 phi (coarse)

N

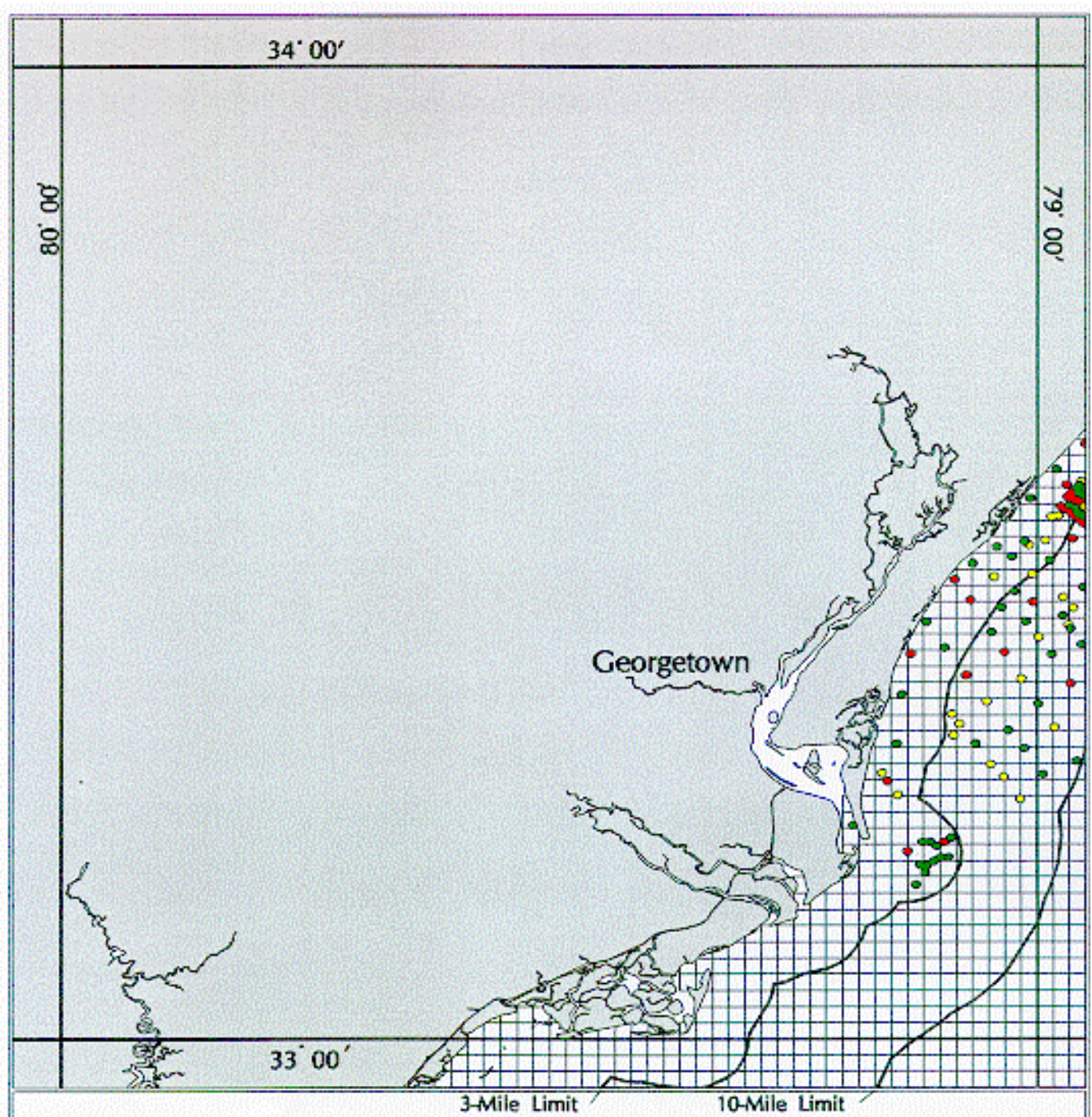
MMS-INTERMAR
Mean Grain Size

AREA 5




LEGEND
>3 phi to 4 phi (very fine)
>2 phi to 3 phi (fine)
>1 phi to 2 phi (medium)
>0 phi to 1 phi (coarse)
33° 00'
79° 00'
78° 00'
200-Meter Isobath
AREA 6
32° 00'
MMS-INTERMAR
Mean Grain Size
GA
3-Mile Limit
10-Mile Limit
32° 00'
80° 00'
AREA 7
31° 00'
32° 00'
N
80° 00'
79° 00'
200-Meter Isobath
AREA 8
31° 00'
MAP INDEX
6
7
8

Appendix D: Plots showing percent sand in areas 1-8 where data exist. Only Areas 1, 2, 4 and 5-8 contain data records with percent sand information.



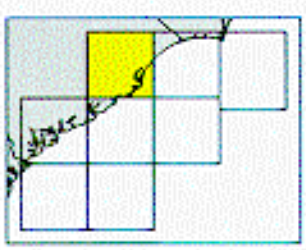
LEGEND

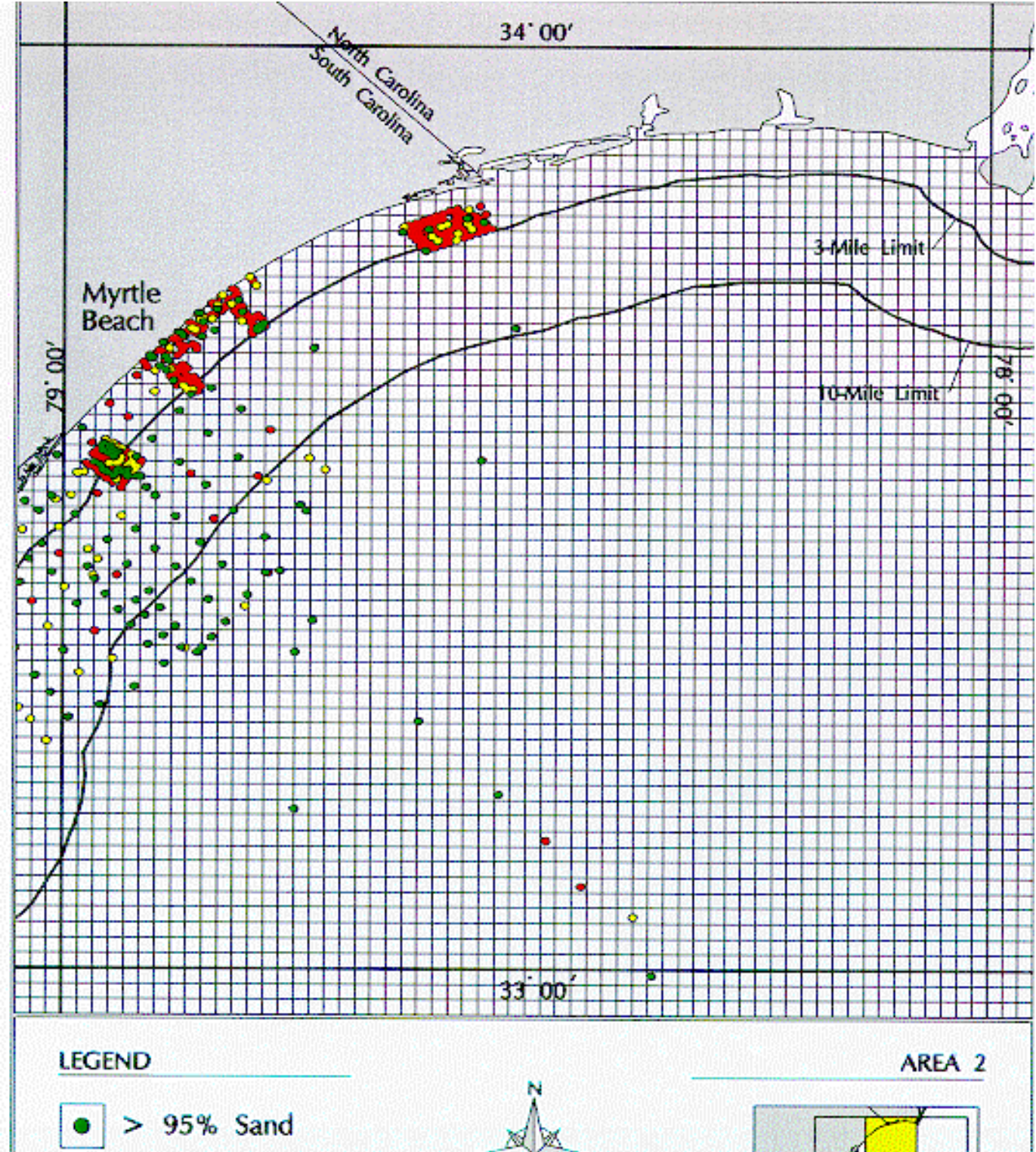
- > 95% Sand
- > 90% to 95% Sand
- <= 90% Sand

N

MMS-INTERMAR
Percent Sand

AREA 1





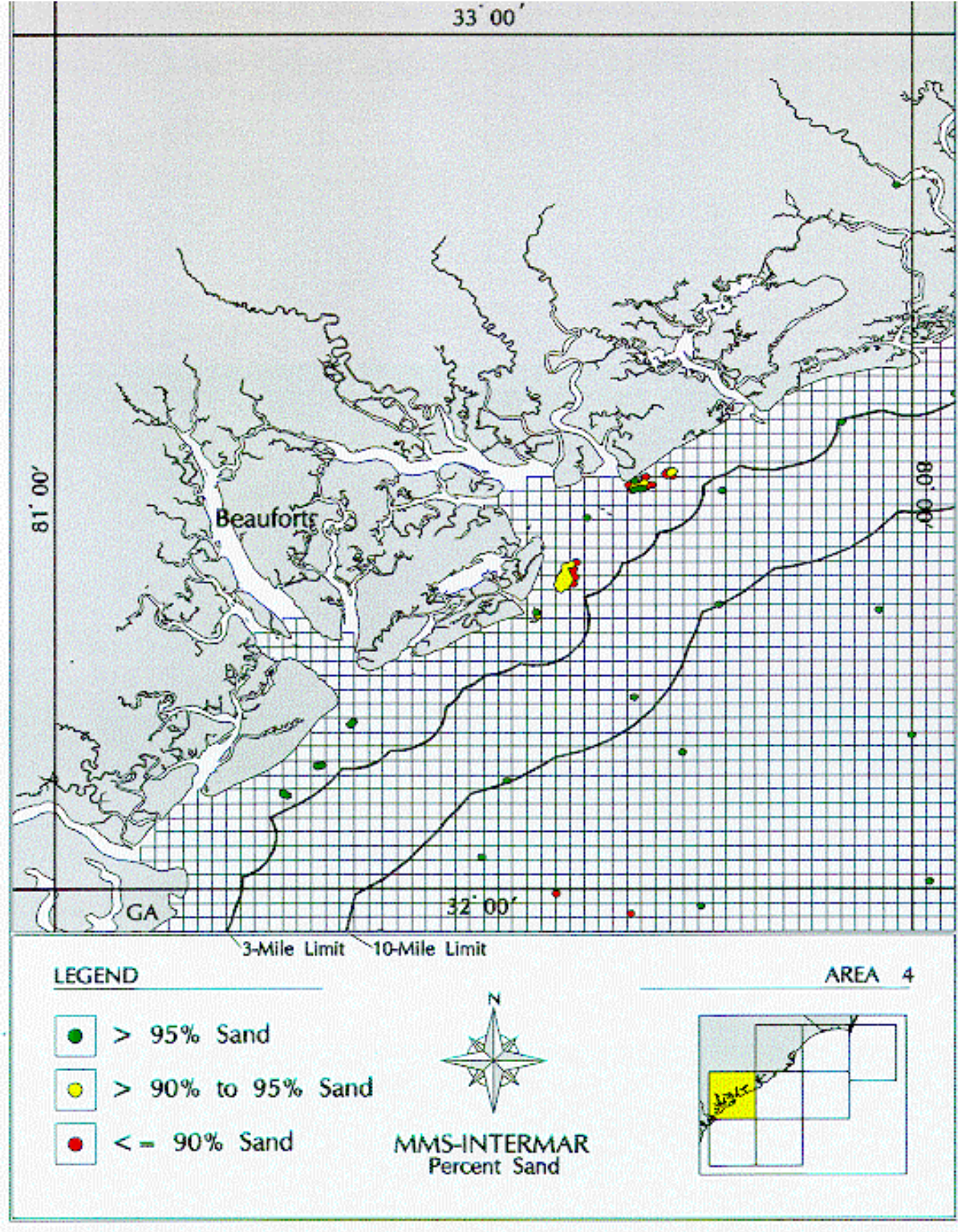
LEGEND

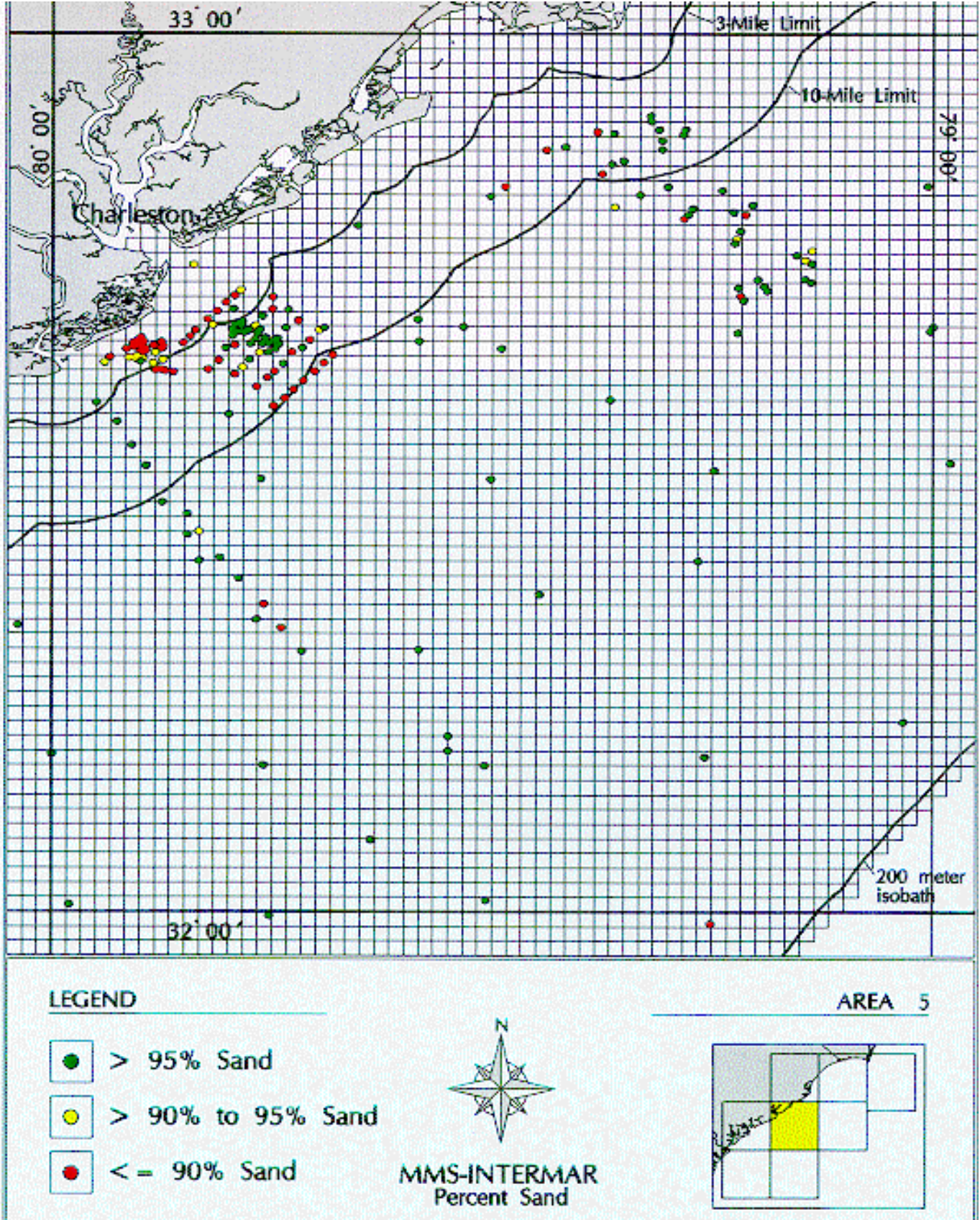
- > 95% Sand
- > 90% to 95% Sand
- <= 90% Sand

N

MMS-INTERMAR
Percent Sand

AREA 2


33° 00′
81° 00′
80° 00′
32° 00′
Beaufort
GA
3-Mile Limit
10-Mile Limit
LEGEND
> 95% Sand
> 90% to 95% Sand
<= 90% Sand
N
MMS-INTERMAR
Percent Sand
AREA 4



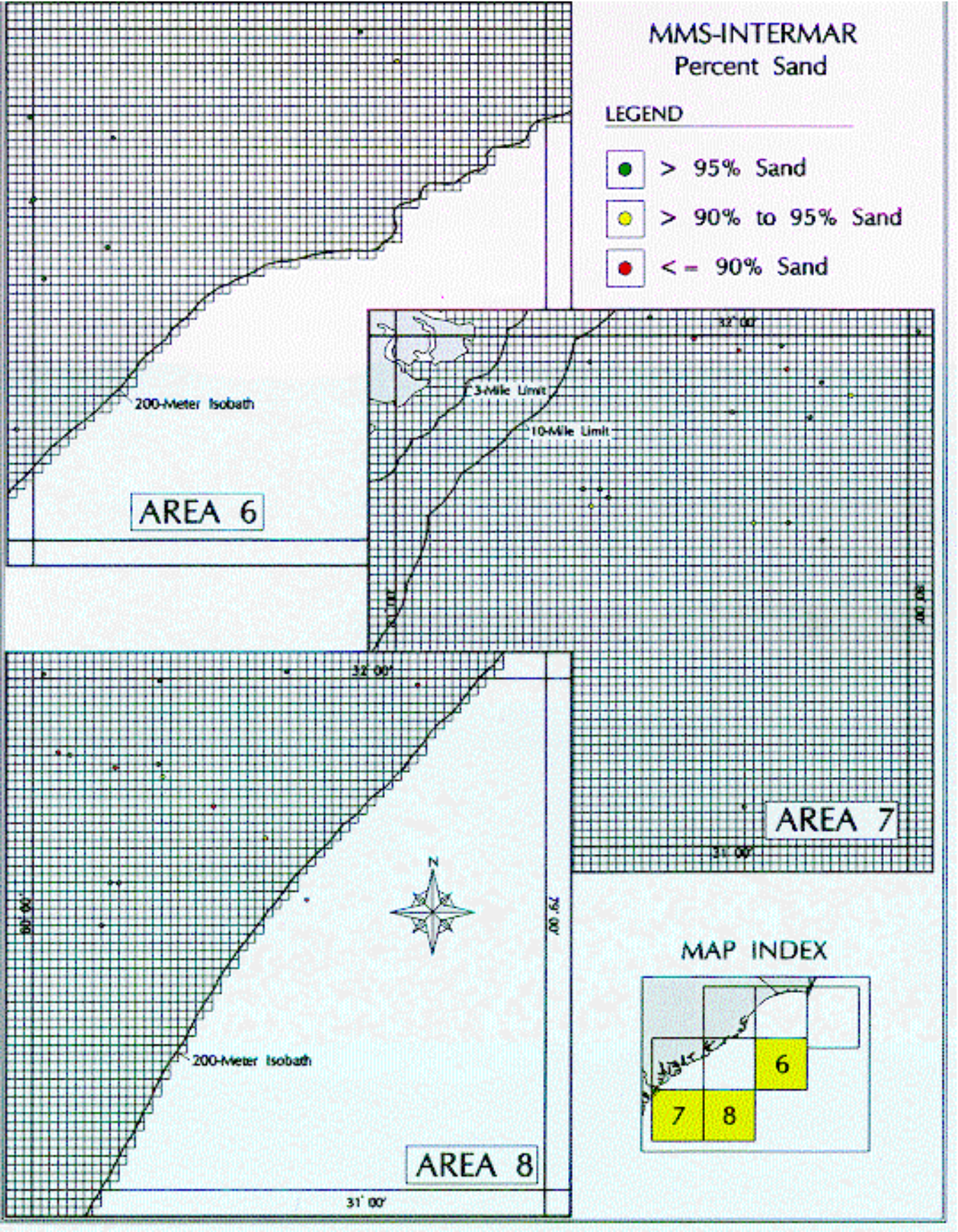
LEGEND

- > 95% Sand
- > 90% to 95% Sand
- <= 90% Sand

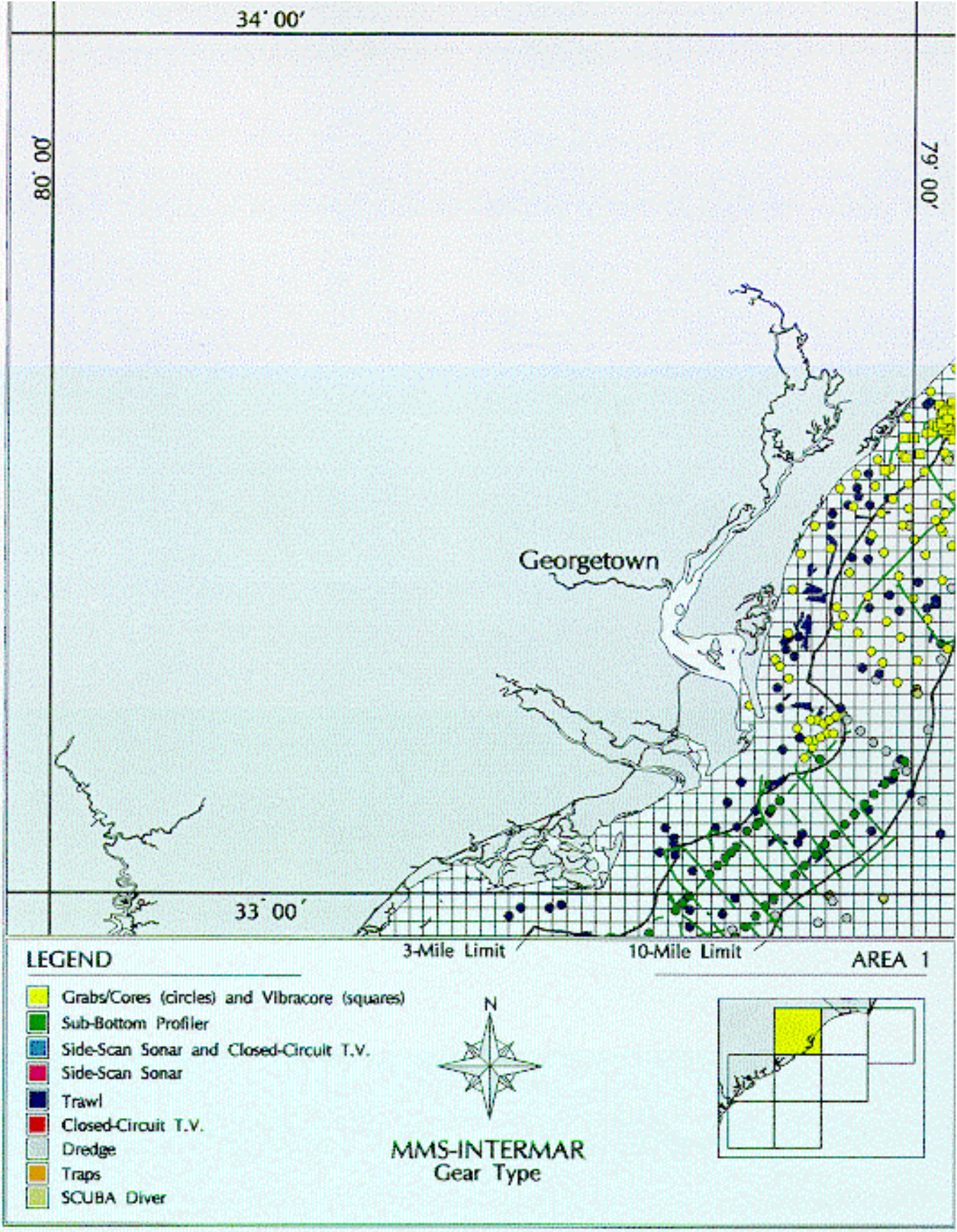
N

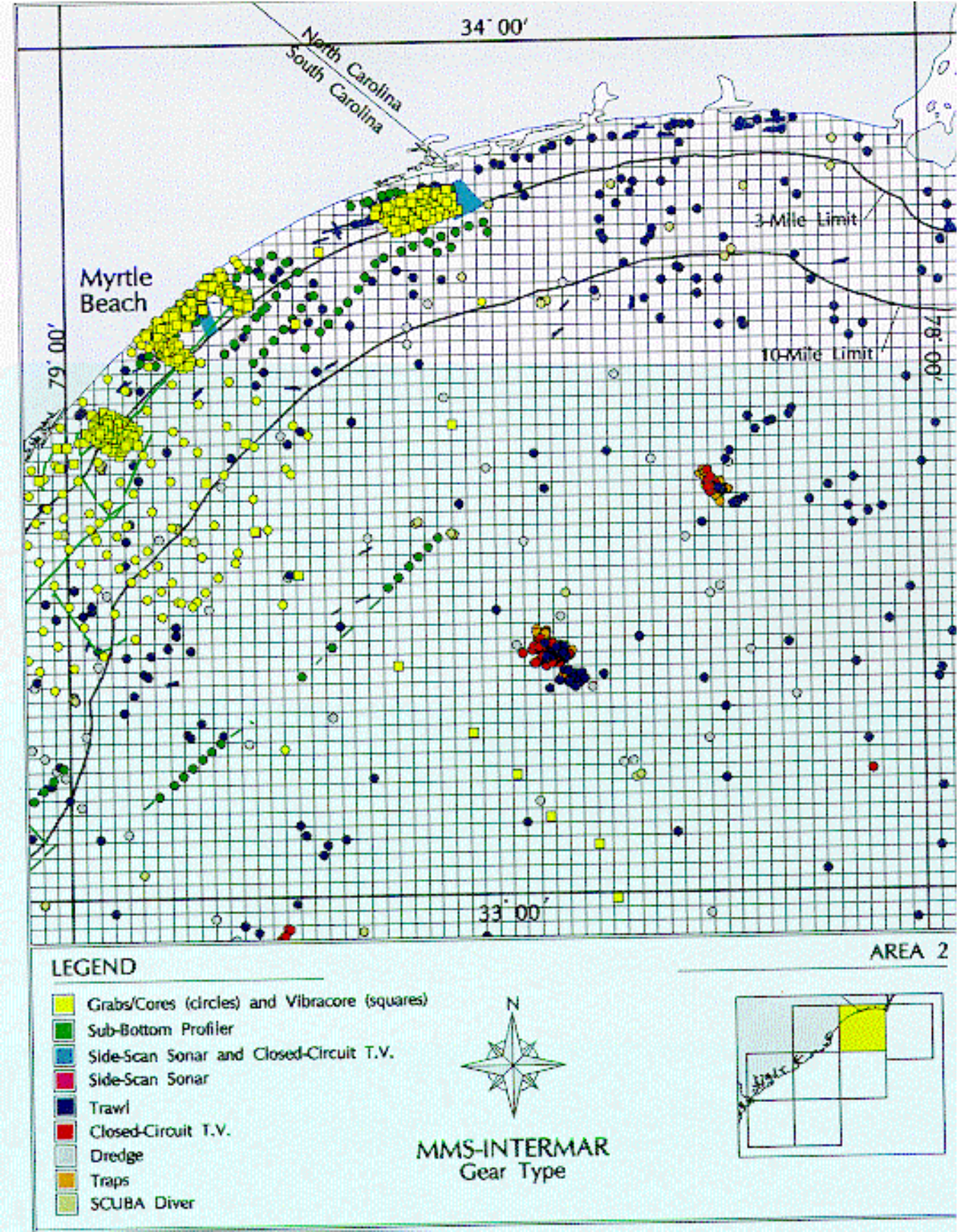
MMS-INTERMAR
Percent Sand

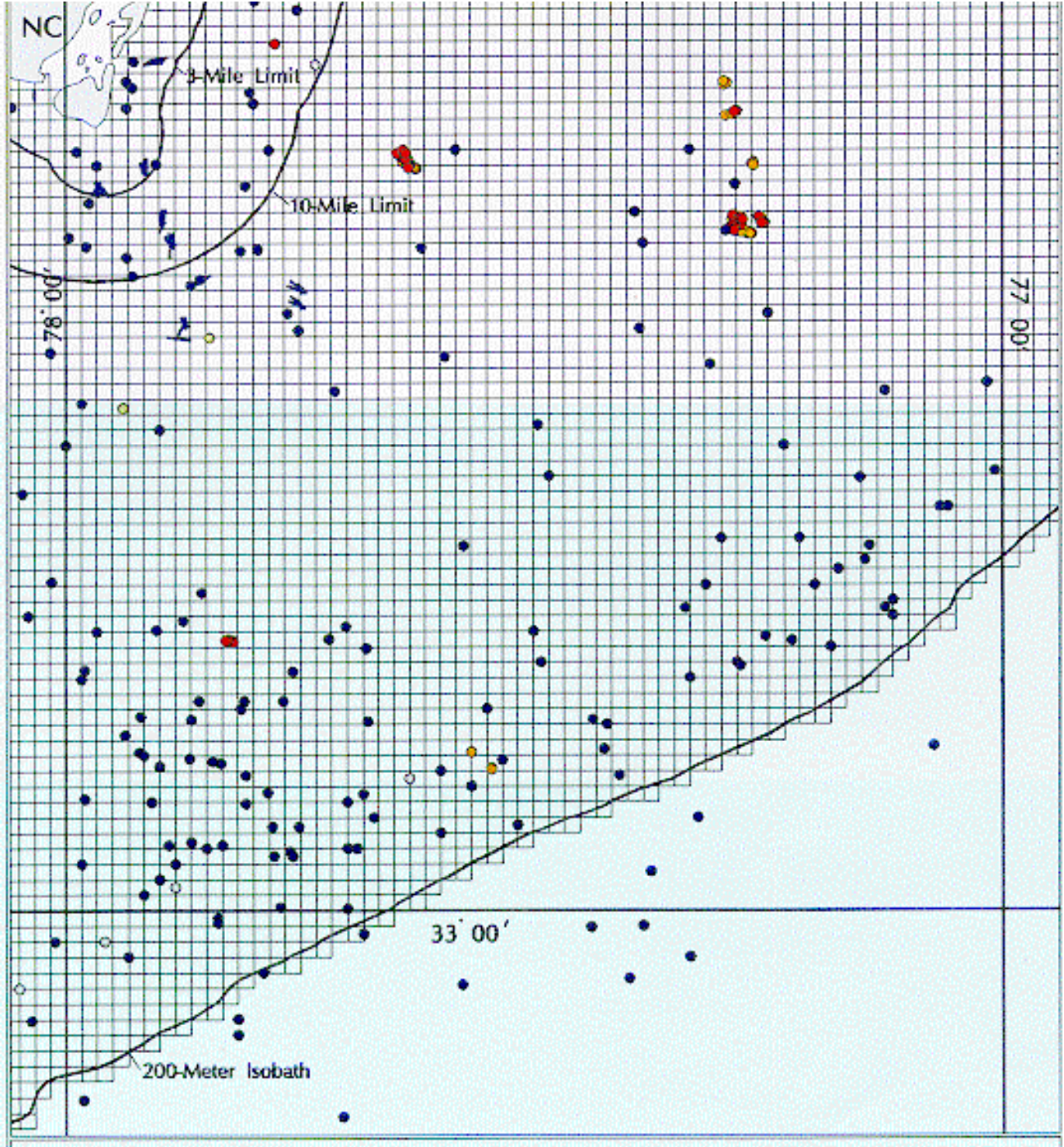
AREA 5


MMS-INTERMAR
Percent Sand
LEGEND
> 95% Sand
> 90% to 95% Sand
<= 90% Sand
200-Meter Isobath
AREA 6
3-Mile Limit
10-Mile Limit
32° 00'
80° 00'
AREA 7
31° 00'
N
79° 00'
200-Meter Isobath
AREA 8
MAP INDEX
6
7
8

Appendix E: Plots showing gear type in areas 1-8 where data exist.


34° 00′
80° 00′
79° 00′
Georgetown
33° 00′
3-Mile Limit
10-Mile Limit
AREA 1
LEGEND
Grabs/Cores (circles) and Vibracore (squares)
Sub-Bottom Profiler
Side-Scan Sonar and Closed-Circuit T.V.
Side-Scan Sonar
Trawl
Closed-Circuit T.V.
Dredge
Traps
SCUBA Diver
N
MMS-INTERMAR
Gear Type


34° 00′
North Carolina
South Carolina
3-Mile Limit
10-Mile Limit
Myrtle Beach
79° 00′
78° 00′
33° 00′
LEGEND
Grabs/Cores (circles) and Vibracore (squares)
Sub-Bottom Profiler
Side-Scan Sonar and Closed-Circuit T.V.
Side-Scan Sonar
Trawl
Closed-Circuit T.V.
Dredge
Traps
SCUBA Diver
N
MMS-INTERMAR
Gear Type
AREA 2

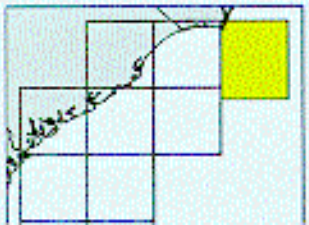


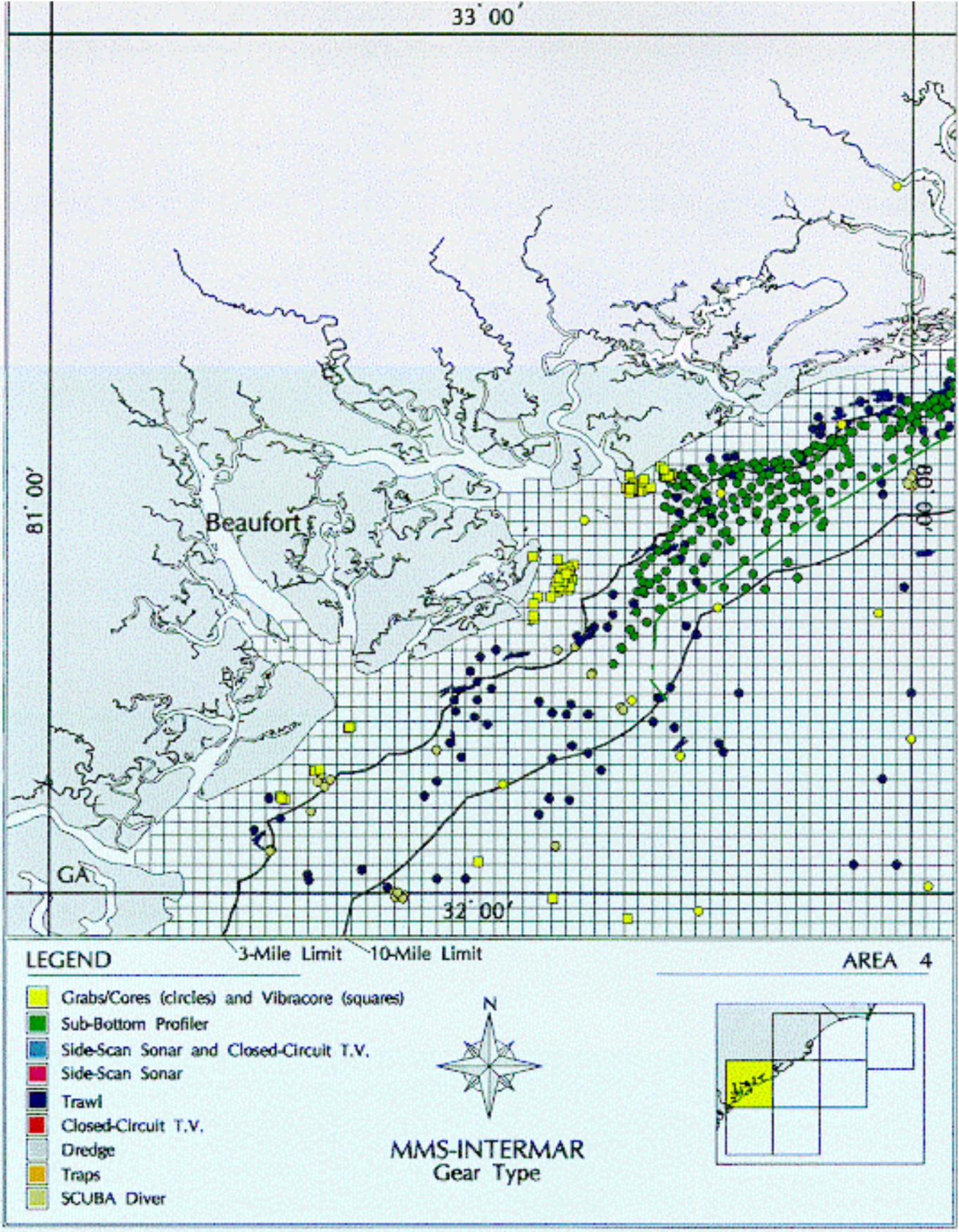
LEGEND

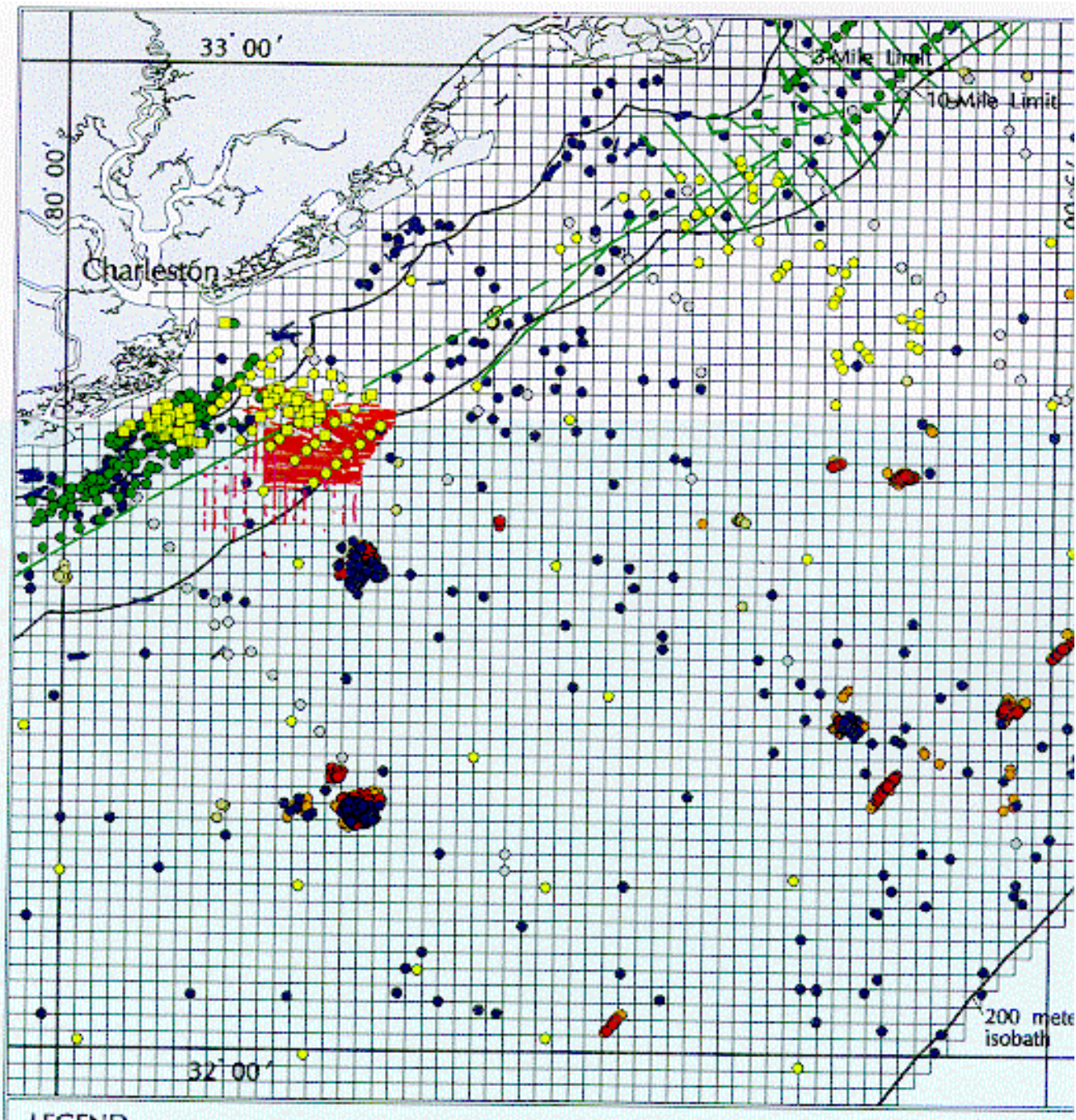
- Grabs/Cores (circles) and Vibracore (squares)
- Sub-Bottom Profiler
- Side-Scan Sonar and Closed-Circuit T.V.
- Side-Scan Sonar
- Trawl
- Closed-Circuit T.V.

N

AREA 3




33° 00′
81° 00′
80° 00′
32° 00′
Beaufort
GA
3-Mile Limit
10-Mile Limit
LEGEND
Grabs/Cores (circles) and Vibracore (squares)
Sub-Bottom Profiler
Side-Scan Sonar and Closed-Circuit T.V.
Side-Scan Sonar
Trawl
Closed-Circuit T.V.
Dredge
Traps
SCUBA Diver
N
MMS-INTERMAR
Gear Type
AREA 4



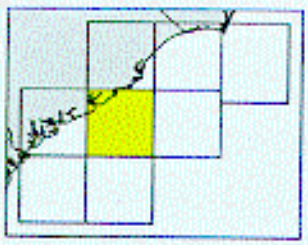
LEGEND

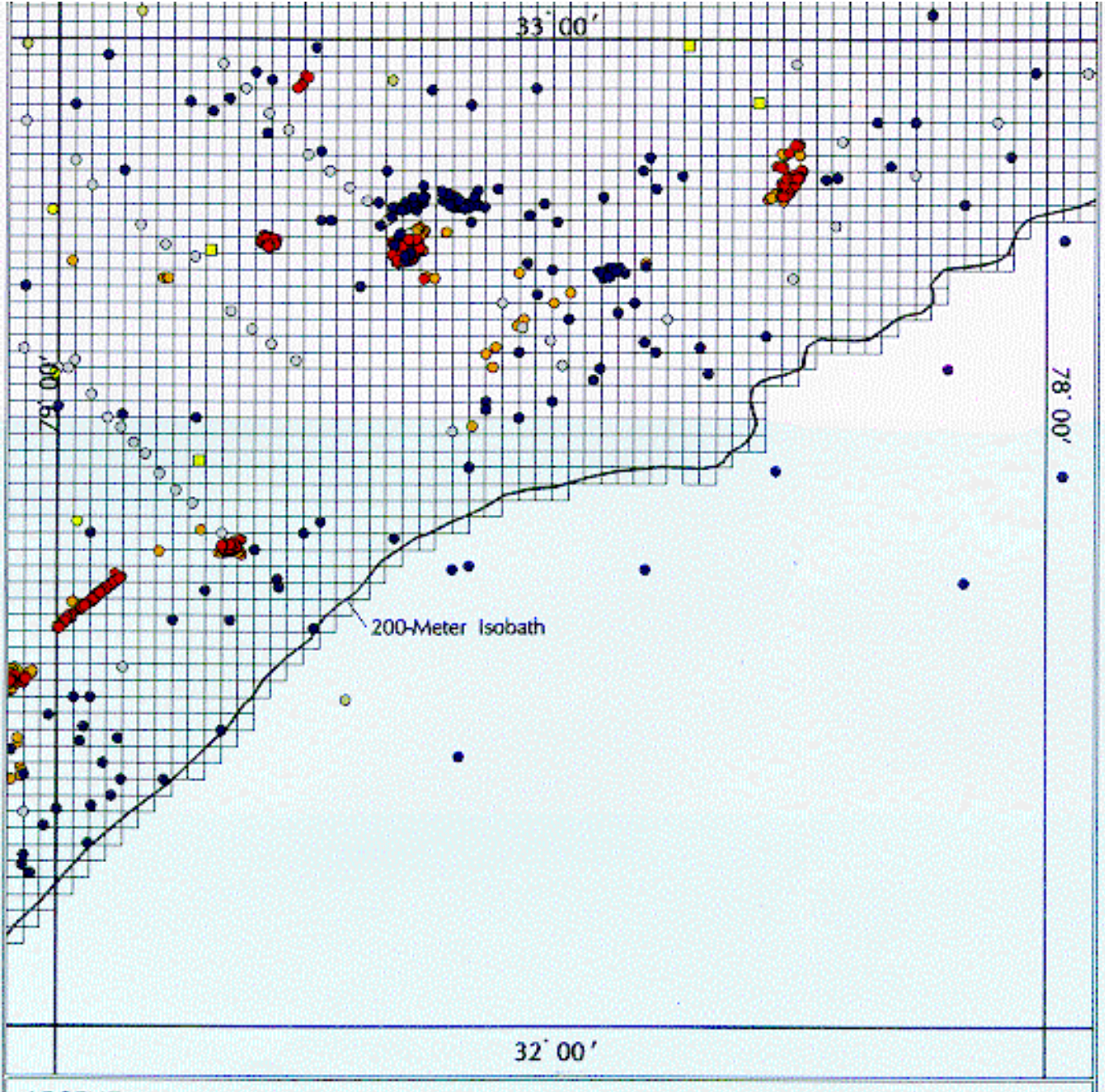
- Grabs/Cores (circles) and Vibracore (squares)
- Sub-Bottom Profiler
- Side-Scan Sonar and Closed-Circuit T.V.
- Side-Scan Sonar
- Trawl
- Closed-Circuit T.V.
- Dredge
- Traps
- SCUBA Diver

N

MMS-INTERMAR
Gear Type

AREA 5





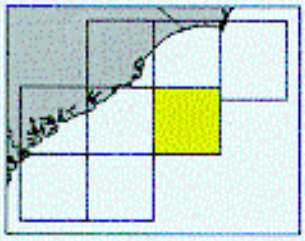
LEGEND

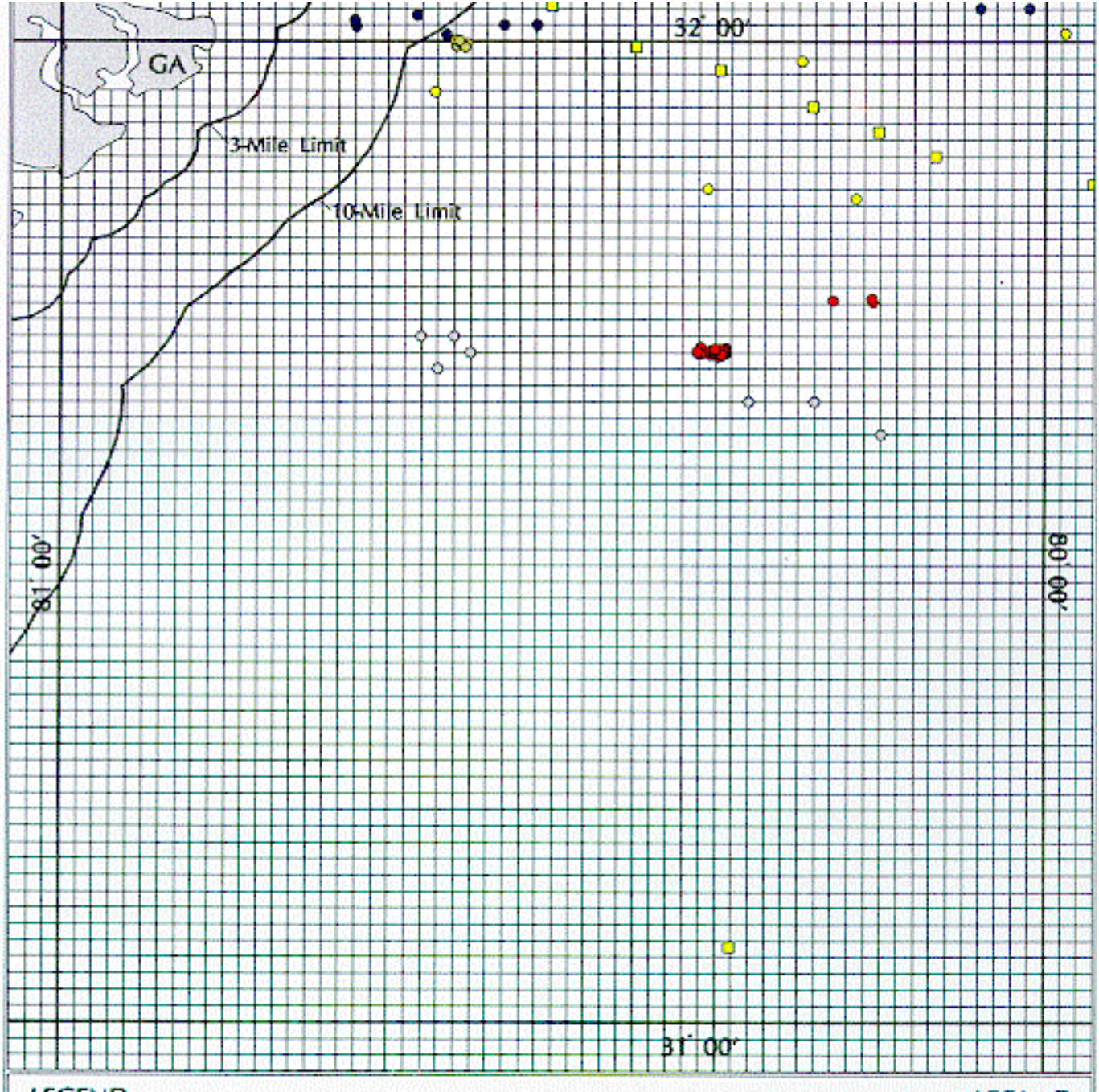
- Grabs/Cores (circles) and Vibracore (squares)
- Sub-Bottom Profiler
- Side-Scan Sonar and Closed-Circuit T.V.
- Side-Scan Sonar
- Trawl
- Closed-Circuit T.V.
- Dredge
- Traps
- SCUBA Diver

N

MMS-INTERMAR
Gear Type

AREA 6





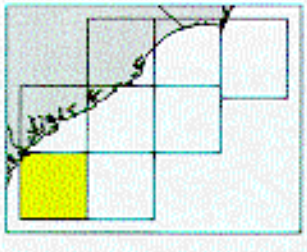
LEGEND

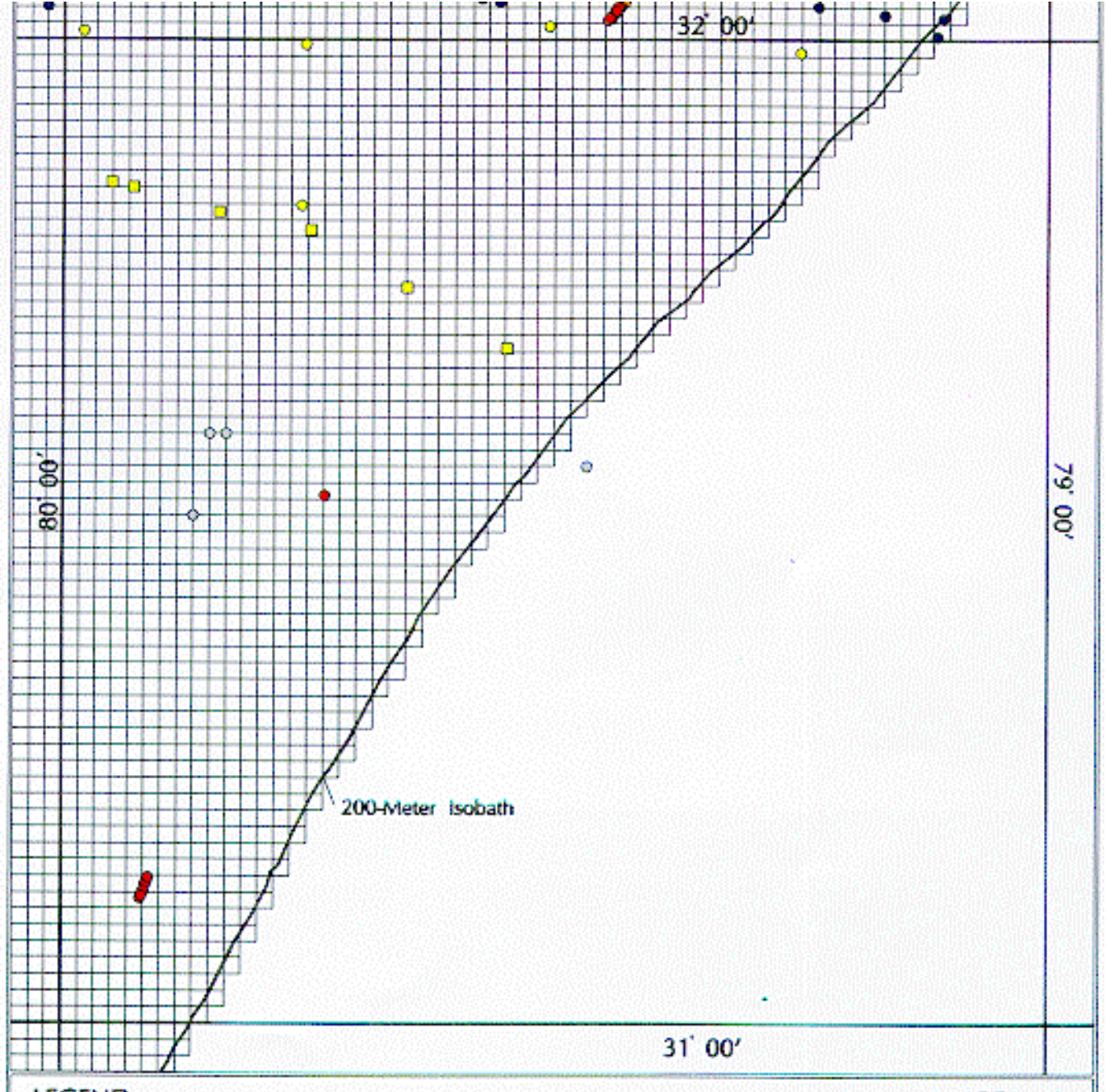
AREA 7

- Grabs/Cores (circles) and Vibracore (squares)
- Sub-Bottom Profiler
- Side-Scan Sonar and Closed-Circuit T.V.
- Side-Scan Sonar
- Trawl
- Closed-Circuit T.V.
- Dredge
- Traps
- SCUBA Diver

N

MMS-INTERMAR
Gear Type





LEGEND

- Grabs/Cores (circles) and Vibracore (squares)
- Sub-Bottom Profiler
- Side-Scan Sonar and Closed-Circuit T.V.
- Side-Scan Sonar
- Trawl
- Closed-Circuit T.V.
- Dredge
- Traps
- SCUBA Diver

N

MMS-INTERMAR
Gear Type

AREA 8