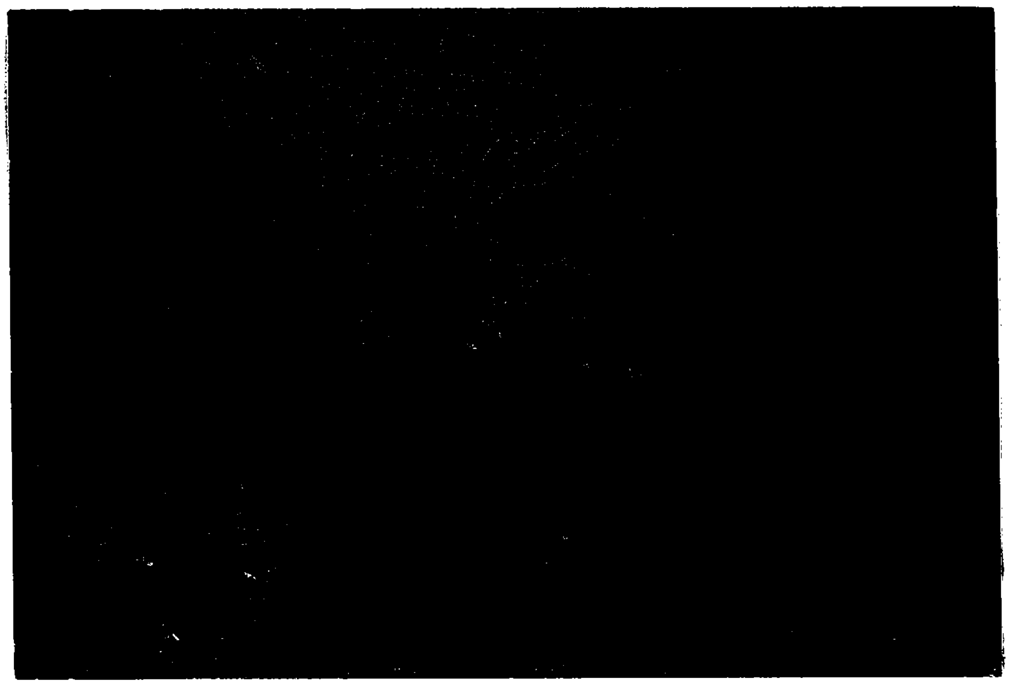
NMS-83-85

NA-83-AA-H-CZ055

04

DRAFT FINAL REPORT

RESULTS OF GRAY'S REEF NATIONAL MARINE SANCTUARY HYDROGRAPHIC AND GEOPHYSICAL SURVEY



Vernon J. Henry
Department of Geology
Georgia State University

Draft Final Report
Results of Gray's Reef National Marine Sanctuary Hydrographic and Geophysical Survey

Submitted To
Sanctuary Programs Division
Office of Ocean and Coastal Resources Management
National Oceanic and Atmospheric Administration
United States Department of Commerce

From
Vernon J. Henry
Department of Geology
Georgia State University
September, 1985

Draft Final Report on Results of Gray's Reef National Marine Sanctuary Hydrographic and Geophysical Survey

by

Vernon J. Henry

Department of Geology

Georgia State University

NTIS Bibliographic Data Sheet

Preface

The outstanding performance of the commanding officer and personnel of the NOAA Ship **WHITING** in carrying out project field operations is gratefully acknowledged. The onboard assistance of Lt. Virginia Shaffer (N/MOA) and Ms. Carroll Curtis (N/ORM2) was particularly helpful. The preparation of the original mosaic was carried out at the NOAA Atlantic Marine Center under the direction of Lt. Shaffer who also provided valuable post-plot data and logistical support.

The assistance of Mr. Nick Nicholson, Mr. Henry Ansley, and personnel of the Coastal Resources Division, Georgia Department of Natural Resources in providing ground-truth along dive transects was particularly helpful in resolving interpretation of the sonargrams. Dr. James L. Harding, Mrs. Carol Johnson and personnel of the University of Georgia Marine Extension Center interpreted the bathymetric data, supervised construction of the three-dimensional model of the bottom topography of the Sanctuary and provided valuable advice and logistical support.

Ms. Leslie Jones Rueth, graduate research assistant in the Department of Geology at Georgia State University, assisted in interpretation of the sonargrams and in drafting maps and figures used in the report and workshop presentation. Ms. Donna Davis also assisted in drafting maps and figures. Mrs. Debia McCulloch prepared the seabed texture map and sediment texture description as part of her Masters degree thesis at the Emory University Department of Geology. Mr. Gary Kozak of Klein Associates, Inc. supervised onboard sidescan sonar and subbottom data acquisition and provided technical assistance on post-survey data processing. The logistical support of Ms. Robin

Futch, Administrative Coordinator for the Department of Geology at Georgia State University is gratefully acknowledged. The report was typed by Frank Young of the Georgia State University Department of Geology.

Table of Contents

List of Illustrations

List of Tables

Abstract

INTRODUCTION

Statement of Work

Background

The South Atlantic Continental Shelf is flat and mostly sand-covered, except for infrequent outcroppings of limestone rock (Hollister, 1973; Henry and Giles, 1978; Henry, 1981). The outcroppings, known locally as live bottom reefs, are encrusted by hard and soft coral, sponges and seaweeds and are important fisheries habitat. Unlike tropical coral reef environments, however, very little is known about the ecology of these areas (Struhsaker, 1969; South Carolina Wildlife and Marine Resources Department et al., 1981).

The Gray's Reef National Marine Sanctuary (the Sanctuary) was designated in January 1981, pursuant to Title III of the Marine Protection, Research and Sanctuaries Act of 1972, to provide for protection and management of a 16.68 square nautical mile area of live bottom located approximately 17.5 nautical miles east of Sapelo Island, Georgia at the 20 meter isobath (Figure 1). Relative to surrounding areas, the Sanctuary contains contained extensive but patchy and discontinuous hardbottom with moderate to abundant epibenthic and fish communities (Henry and Van Sant, 1982). The Final Environmental Impact Statement (FEIS) on the Proposed Gray's Reef National Marine Sanctuary (OCZM, 1980) provides a general description of the Sanctuary environment. The Gray's Reef National Marine Sanctuary Managment Plan (OCRM, 1983) outlines site-specific sanctuary goals and objectives and describes priority programs, facilities and activities that are planned for the Sanctuary in response to evolving management issues.

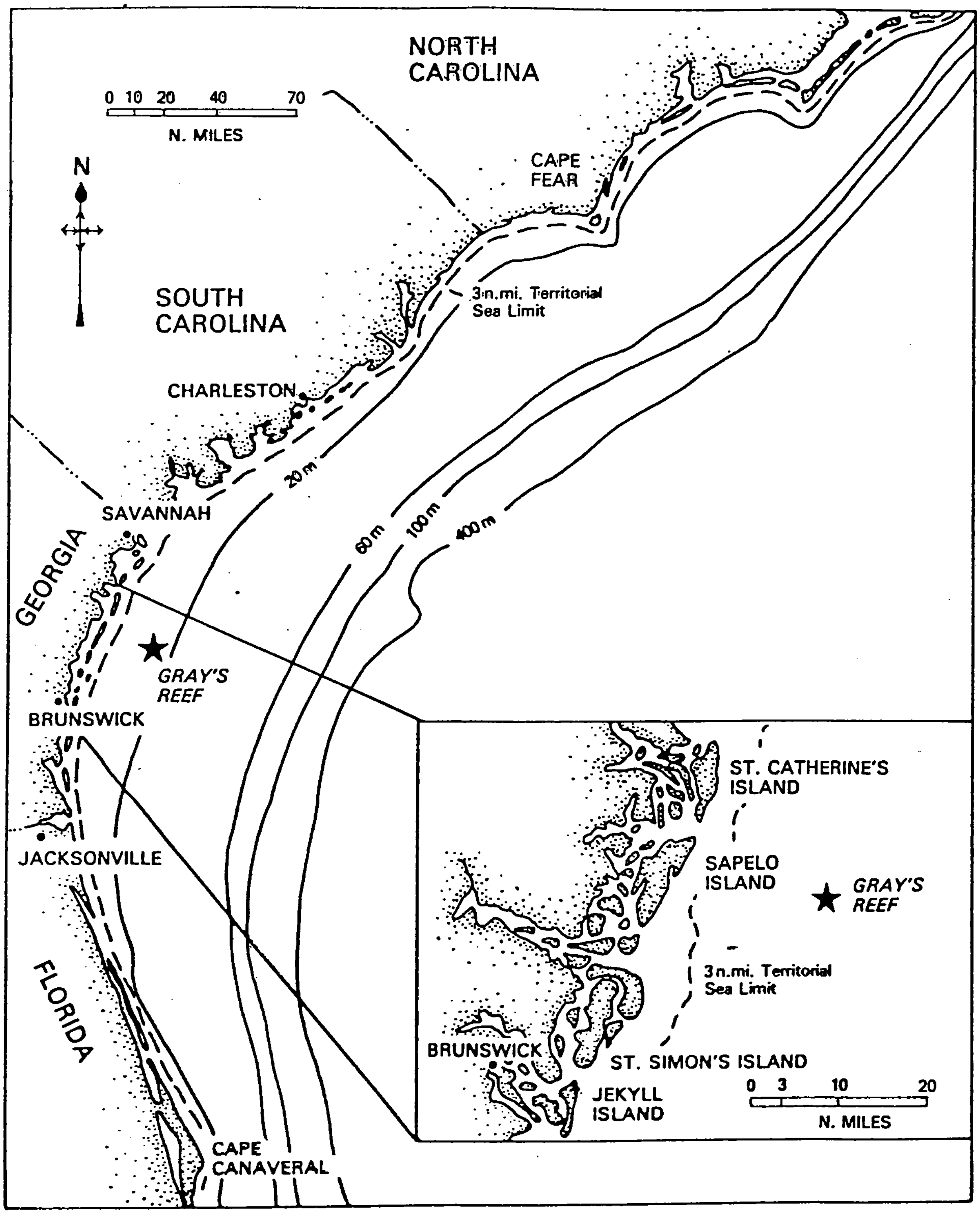


Figure 1. Gray's Reef National Marine Sanctuary Location Map

The Sanctuary is a popular site for recreational fishing, sport diving, research and educational activities.

The Management Plan discussed the need for a comprehensive hydrographic survey covering the entire Sanctuary to augment existing information on the nature of the seabed. Hunt (1974) describes the habitat as a series of rock ledges separated by wide expanses of shallow-buried hardlayer and sand bottom. Ledges range in topographic relief from a few centimeters to just over 2 meters. Hunt (1974) suggested that live bottom probably extended beyond his 12 square nautical mile study area.

Following sanctuary designation, a reconnaissance hydrographic survey was conducted to facilitate planning of a detailed, total coverage survey (Figures 2 and 3; Henry and Van Sant, 1982). Preliminary bathymetric, topographic, and shallow subbottom information was obtained for an 80 square nautical mile area centered around the Sanctuary. The results of the proposed reconnaissance survey indicated that 95 percent of live bottom encountered in the survey area was located within the Sanctuary, thus defining the limits of the detailed survey to the 16.68 square nautical mile Sanctuary area.

Objective

The purpose of the project was to conduct a comprehensive, total coverage hydrographic and geophysical survey of the Sanctuary to obtain accurate information on the location, distribution, structure, and areal extent of physically defined benthic habitats within the sanctuary boundaries. The primary objective of the survey was to produce a sonargram mosaic and seabed texture and bathymetric maps that covered

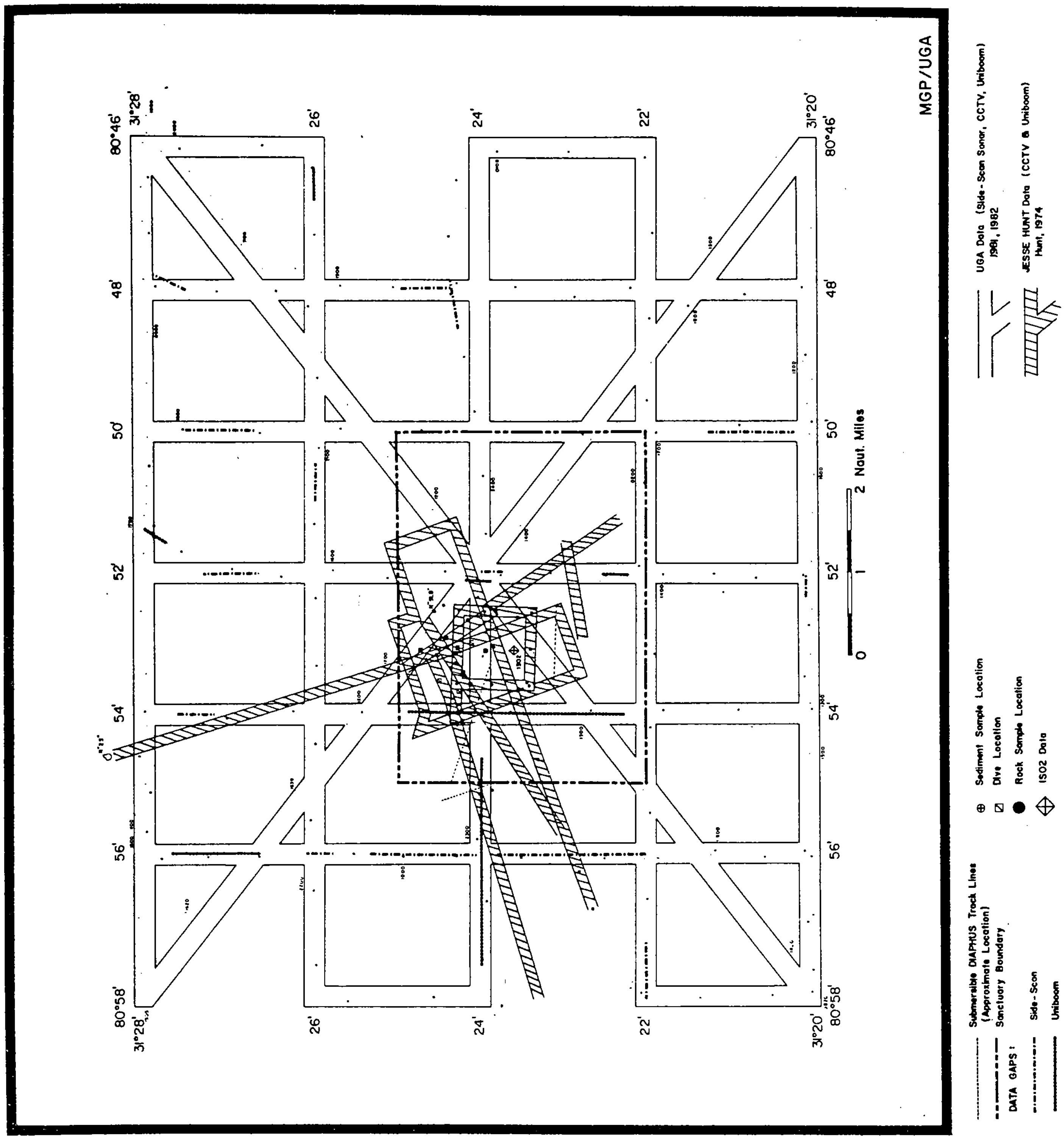


Figure 2. Data Sources - 1982 Gray's Reef Mapping Survey
(from Henry and Van Sant, 1982)

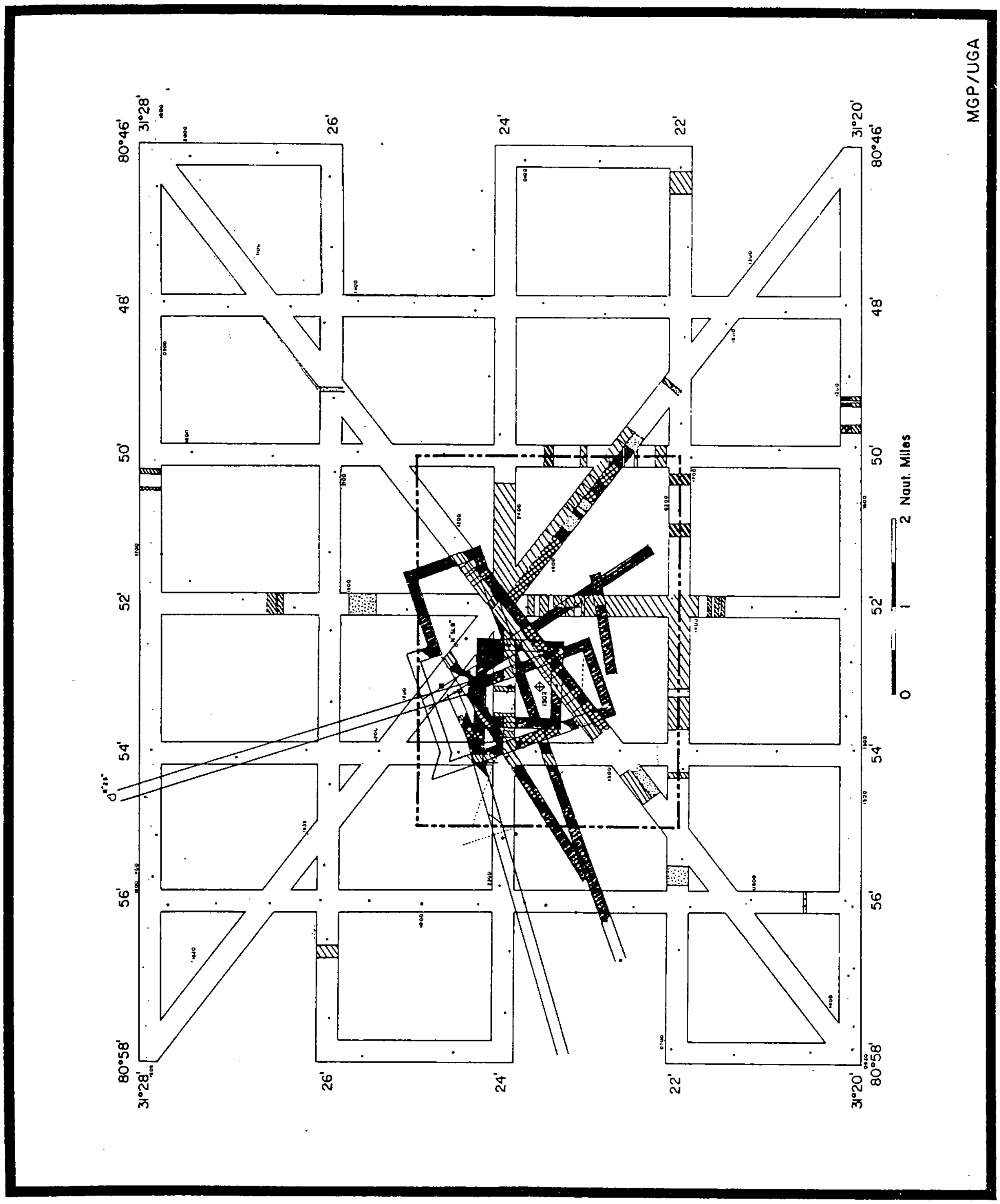


Figure 3. Location, Morphology and Density of Hardbottom/
Livebottom - 1982 Gray's Reef Mapping Survey
(from Henry and Van Sant, 1982)

the entire sanctuary.

Work Accomplished

The final products that resulted from the survey include a high-resolution, two dimensional side scan sonar mosaic of the Sanctuary seafloor, transparent overlays of seabed texture and substrate morphology and a three-dimensional bathymetric model of the Sanctuary, each at a scale of 1:10,000. The area surveyed encompassed the entire Sanctuary. Coordinates that mark the corners of the Sanctuary are: 31°21'45"N, 80°55'17"W; 31°25'15"N, 80°55'17"W; 31°25'15"N, 80°49'42"W; and 31°21'45"N, 80°49'42"W.

The resulting data base will serve as a benchmark for assessing changes in Sanctuary conditions over time and for planning a future biological resource mapping and monitoring study. Survey data will also provide materials of interest to the general public; maps will be used by recreational fishermen and SCUBA divers to locate productive and attractive fishery habitats and by scientists and educators to locate appropriate sites for resource studies.

Methods

Field Operations

A comprehensive hydrographic and geophysical survey was carried out during the period August 3-7, 1983 onboard the NOAA ship **WHITING.** The methods procedures, and instrumentation used during the survey and for post-survey data processing are discussed below.

Geodesy and Horizontal Control

Control for navigation and positioning was in accordance with IHO Standards for Hydrographic Surveys and Class Criteria for Deep Sea Soundings SP 44 (Second Edition) meeting accuracy requirements for a 1:20,000-scale survey, although the data were plotted at 1:10,000 scale for clarity. Horizontal control datum was North American Datum of 1927.

Observed Loran-C readings and radio direction finder bearings were recorded with time at the four corners of the Sanctuary and at the Sanctuary buoy (31°24.5'N,80°52.6'W). Each of these readings was compared with the project's shipboard navigation system.

Sidescan Sonar and Subbottom Profiling Survey

Sonargrams and subbottom data were aquired continuously and contemporaneously using a Klein K-Maps IV system. The instrumentation included two (2) 100 kH_z side scan sonar transducers mounted in a tow-fish; a 3.5 kH_z subottom profiling transducer mounted as a shroud on the tow-fish; and a three-channel, wet paper analog recorder. All of the raw data were recorded on magnetic tape.

A total of 34 east-west, parallel sonar/subbottom lines were run using a range scale of 150 meters. The lines were spaced to provide

for 50% overlap. Following a break in the survey at the end of Line 16 for positioning calibrations, Line 16 was rerun as Line 17; therefore, Lines 16 and 17 are duplicates. Five (5) north-south crosslines were run to supplement the east-west sonar coverage. During the sonar/subbottom survey, ship speed did not exceed six (6) knots and seas were never greater than five (5) feet.

Bathymetry

Soundings were acquired using a high frequency echo sounder with a hull-mounted transducer. The echo sounder was operated and digital track annotated concurrently with all side scan sonar operations. Sounding datum was mean low water. Soundings were conducted to meet a 1:20,000 horizontal positional accuracy requirement and plotted to 1:10,000 scale for clarity. Soundings were recorded in feet and corrected for predicted tides.

Bottom Sediment Texture

Sixty-three bottom samples were taken using a Shipek grab. Sample volumes ranged from little or no sample in some of the hardbottom areas to more than a quart in sandy bottom. After recovery, the samples were inspected by sight and touch, grossly described by on onboard personnel on standard log sheets and placed in storage bags for subsequent textural analysis.

Data Processing and Reduction

Side Scan Sonar and Subbottom Records

Sonar data were acquired, processed and plotted on a real-time basis using the Klein K-Maps IV automatic data acquisition and processing system. The raw data was stored on magnetic tape.

Sonargrams were annotated at the starts and stops of lines with time and fix marks, date, time, position numbers, vessel speed, initial recorder setting and all changes to recorder settings, and any other information needed for interpretation of records.

The post-survey data tapes, original sonargrams, and subbottom profiles and ship's track sheet were sent to Klein Associates for post-processing. The tapes were processed through the slant and speed range correction unit to reduce sonargram size and to adjust the reproduced sonargrams to the same ship speed. The water volume and outer one-third of the strips was cut off to reduce distortion and to produce 100% bottom coverage. The channel records on the sonargram were separated in an effort to produce a uniform appearance. Individual channel strips were labelled and sent to AMC for final assembly.

Personnel from the **WHITING** mounted the strips on foam core board (40"x60") using Fusion 400 adhesive as recommended by Klein. This material was cut into strips to match the sonargrams, then the strips were ironed onto the board. With heat reapplied, the strips could be removed and remounted - a valuable asset for this type of project. The board sections were connected and reinforced by gluing plywood pieces behind each joint. Three boards were joined to accommodate the sonargram panels producing a completed mosaic measuring 10' x 15'. To assemble the three sections, 10-foot 1"x4" boards were tacked to the panels to hold the mosaic upright for temporary periods of time.

A 4' x 5' photographic reduction of the mosaic was produced. Later several of the strips had to be removed and remounted due to a labelling error during processing. The paper-backed board allowed easy removal

of these strip sections. All were reapplied in correct order to the same board using 3M 8080 Spray Adhesive. The mosaic disassembled and was shipped to Georgia State University along with all records, an overlay of ship soundings and bottom sample positions.

Because the remounting of the strips on the original 10' x 15' mosaic voided the 4'x5' reduced photograph, a new photographic negative was required. The original mosaic was reassembled at the University of Georgia Marine Extension Center of Skidaway Island, Savannah, Georgia and a new photographic negative was made. From this negative prints were made at a scale of 1:10,000 and used to produce overlay transparencies of bottom morphology and sediment texture. These prints and overlays are provided as deliverables under separate cover. Reductions of these products are used as figures in this report. The bottom morphology overlay was constructed by detailed examination of each original sonargram, the reduced print of the mosaic and ground-truth data from direct bottom observation data provided by personnel of the Georgia Department of Natural Resources, Coastal Resource Division (Brunswick).

During assembly of the sonargram mosaic it became obvious that the starboard channel printout was considerably lighter than the port channel printout. This condition caused the completed mosaic to have a markedly striped appearance that was exacerbated during the photoreduction process. After much discussion with technicians from Klein Associates, Inc. it was concluded that the problem was caused by a defective transducer on the starboard side of the tow-fish. While this condition was not obvious at the time the original sonargram was being printed, it probably would have been detected if adjacent

lines had been compared during the course of the survey. As it was, the sonargrams were examined individually, and only over relatively short sections. Although it remains uncertain that the problems could have been corrected at the time, the incident does point out that, during the survey frequent and broad-coverage inspection of sonargrams is necessary to insure proper system performance. The subbottom profiling system also produced disappointing results as little or no bottom penetration was obtained on any of the lines. It appears that the Klein profiling system is simply underpowered for bottom conditions in the area surveyed. It is pointed out, however, that the O.R.E. 3.5 kH_z and the EG&G UNIBOOM systems have performed quite well in the same area.

Bathymetry

Sounding data was acquired, processed and plotted on a real-time basis using an automatic data aquisition and processing system. The data was annotated at the starts and stops of lines as well as with date, time and fix marks.

The soundings were smooth plotted with depth curve lines by Dr. James L. Harding of the University of Georgia Marine Extension Center (Savannah) and the results used to construct a three-dimensional bathymetric 1:10,000 scale model of the Sanctuary. The bathymetric map and model reside at the Sanctuary Interpretation Unit at the Center.

Bottom Sediment Texture

The textural characteristics (grain size and coarse-fraction constituents) of bottom sediment were examined using the standard techniques described by Folk (1980). A computer program at the Emory University Department of Geology was utilized by Ms. Debia McCulloch

to determine the statistical parameters of the bottom sediment. Sample colors were determined by comparison with Munsell Soil Color Charts (1975 Edition, Kollmorgen Corp., Baltimore, Md.).

Results

Side Scan Sonar and Subbottom Profiling Survey

The sonargram mosaic produced from the survey data is presented in Figure 4. Groundtruth surveys, consisting of 15 "bounce" dives and three (3) towed-diver transects, were carried out by personnel from the Coastal Resources Division of the Georgia Department of Natural Resources and were very valuable in interpreting the sonargram data in areas of indistinct or problematic signatures. The locations of the dive sites and towed-diver transects are shown on Figure 5. Mean grain size (texture) of bottom sediment in the sanctuary is shown on Figure 6. Observations were made of the occurrence and density of epibenthic biota, seabed texture and topographic features. Figures 7-10 illustrate the nature of the livebottom and seabed at dive sites selected to exemplify differing reef morphology and biotic abundance. Detailed descriptions of observations made at the dive location and along the transects are given in Appendix I.

The occurrence and distribution of rock outcrops and ledges forming the livebottom substrate are generally delineated as darker shading on the mosaic. The lighter areas, for the most part, indicate barren bottom composed of sand, shell fragments and reef debris. In some of the sandy areas, notably the northwest and southwest corners of the Sanctuary, sand waves and megaripples appear as dark, sharp to mottled signatures. The cloud-like features in the northeast corner of the Sanctuary are apparently signatures of water column turbidity occurring at the time of the survey (see Figure 5). Divers inspected that area during towed-diver transects (Leg 4 East and the East-West

Figure 4. Sonargram Mosaic of Gray's Reef National Marine Sanctuary with Overlay of Reef Morphology. East-West survey lines are numbered alternately on the right and left hand margins of the mosaic. The north-south crosslines, A-E, are indicated along the bottom margin.

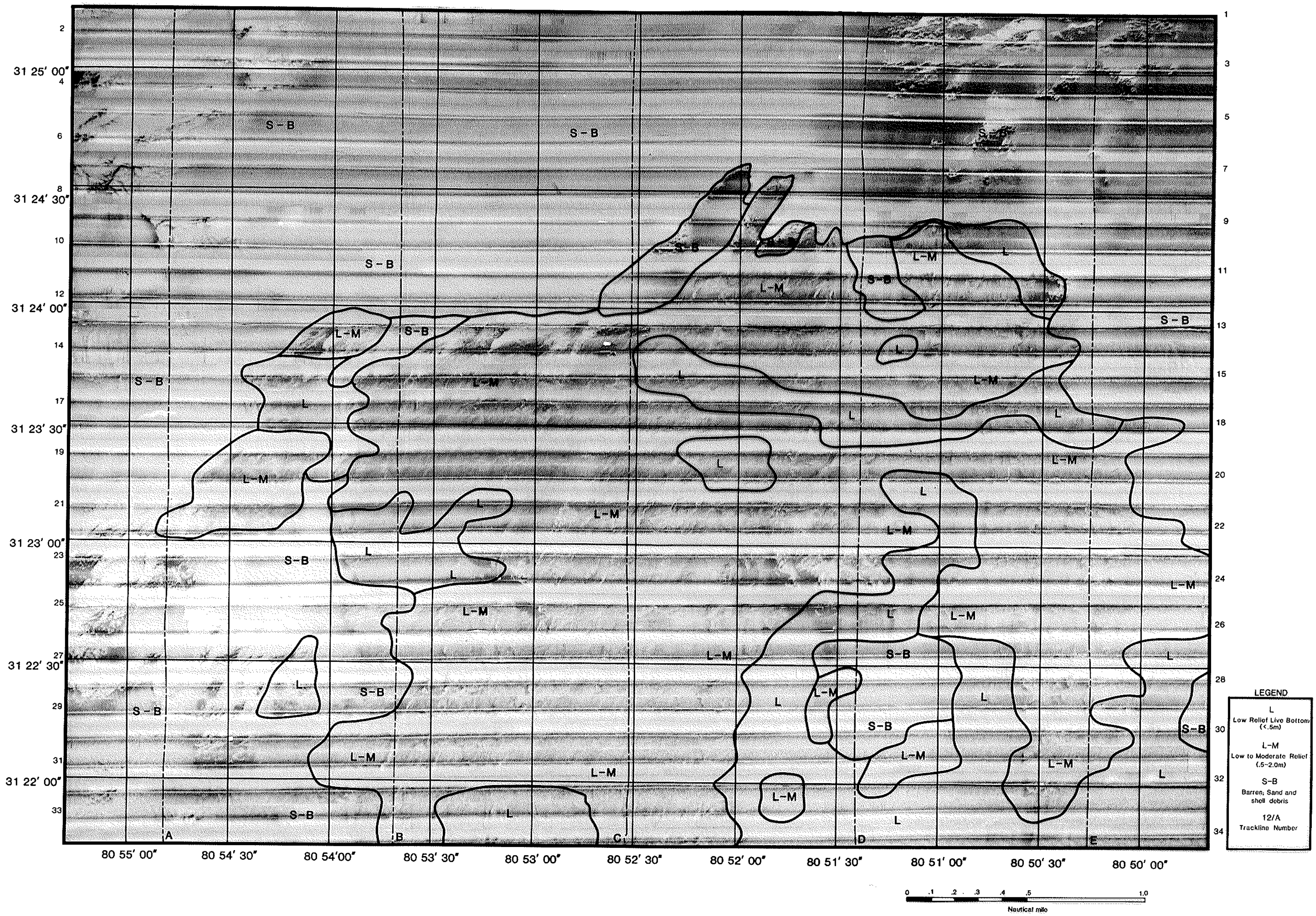

31 25' 00"
31 24' 30"
31 24' 00"
31 23' 30"
31 23' 00"
31 22' 30"
31 22' 00"
80 55' 00"
80 54' 30"
80 54'00"
80 53' 30"
80 53' 00"
80 52' 30"
80 52' 00"
80 51' 30"
80 51' 00"
80 50' 30"
80 50' 00"
S-B
L-M
L
A
B
C
D
E
0 .1 .2 .3 .4 .5 1.0
Nautical mile
LEGEND
L
Low Relief Live Bottom (<.5m)
L-M
Low to Moderate Relief (.5-2.0m)
S-B
Barren; Sand and shell debris
12/A
Trackline Number

Figure 5. Distribution and Morphology of Live Bottom Determined from Bounce-Dives and Towed-Diver Transects.

Legend:

Bounce-Dive Stations (1-15)
White Circles - coarse sand and shell
Gray Circles - sand
Dark Circles - low to high density livebottom

Towed-Diver Transects (West, East and West-East)
White Tape - coarse sand and shell
Gray Tape - sand
Striped Tape - low density live bottom
Dark Tape - moderate to high density live bottom

NOTE: density refers to qualitative estimate of epibenthic biota present.

GRAY'S REEF NATIONAL MARINE SANCTUARY

DISTRIBUTION AND MORPHOLOGY OF LIVE BOTTOM

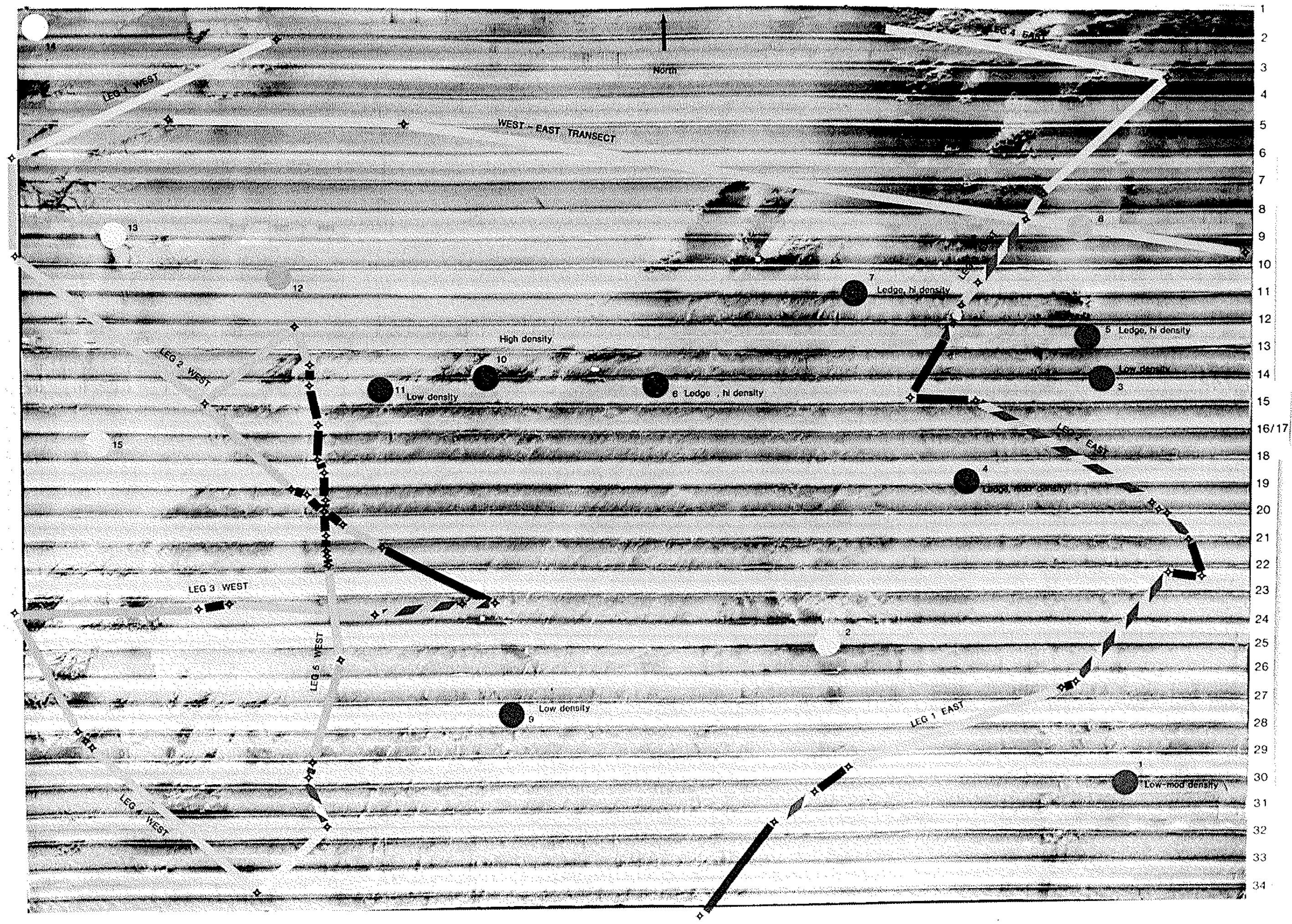
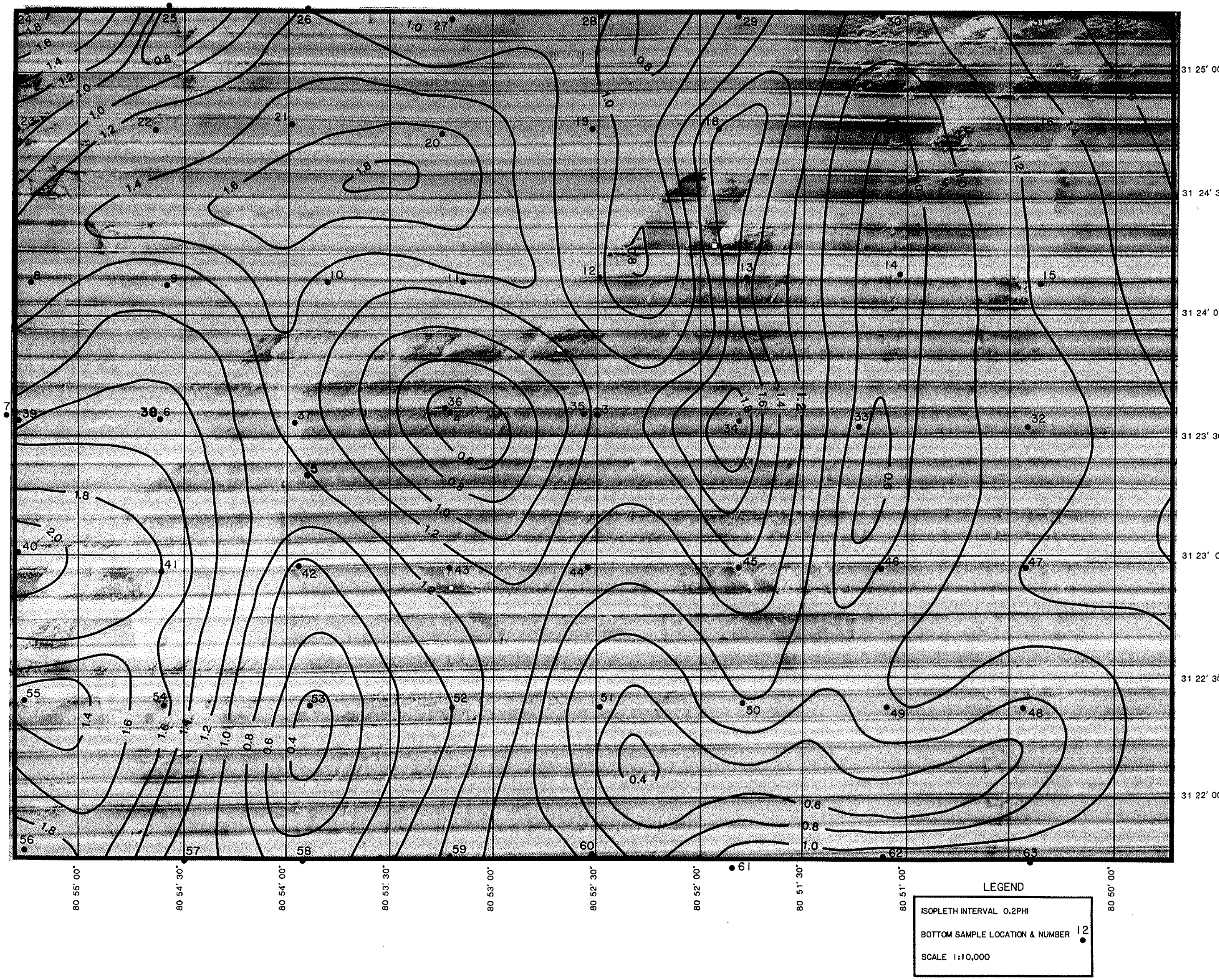


Figure 6. Mean Grain Size of Bottom Sediment, Gray's Reef National Marine Sanctuary.

Coarser sediment is denoted by smaller Phi (Ø) values, which range from 0.34 Ø mean grain size (coarse sand) to 2.09 Ø mean grain size (fine sand). Generally, the coarsest material occurs in the livebottom areas. However, scattered patches of whole shells and large shell fragments are present in the barren, sandy areas.



31 25' 00"
31 24' 30"
31 24' 00"
31 23' 30"
31 23' 00"
31 22' 30"
31 22' 00"
80 55' 00"
80 54' 30"
80 54' 00"
80 53' 30"
80 53' 00"
80 52' 30"
80 52' 00"
80 51' 30"
80 51' 00"
80 50' 00"
LEGEND
ISOPLETH INTERVAL 0.2PHI
BOTTOM SAMPLE LOCATION & NUMBER 12
SCALE 1:10,000

Figure 7. High Density Live Bottoms Developed on Outcropping Limestone Layer at Dive Site 5.

The rock ledges are approximately three (3) feet high and form the substrate for a diversity of epibenthic biota.

Figure 8. Moderate Density Livebottom Developed on Outcropping Limestone Layers at Dive Site 4.

The rock ledges are approximately one (1) foot high. Sponges and octocorals in the background are growing on hard substrate thinly covered with sand.

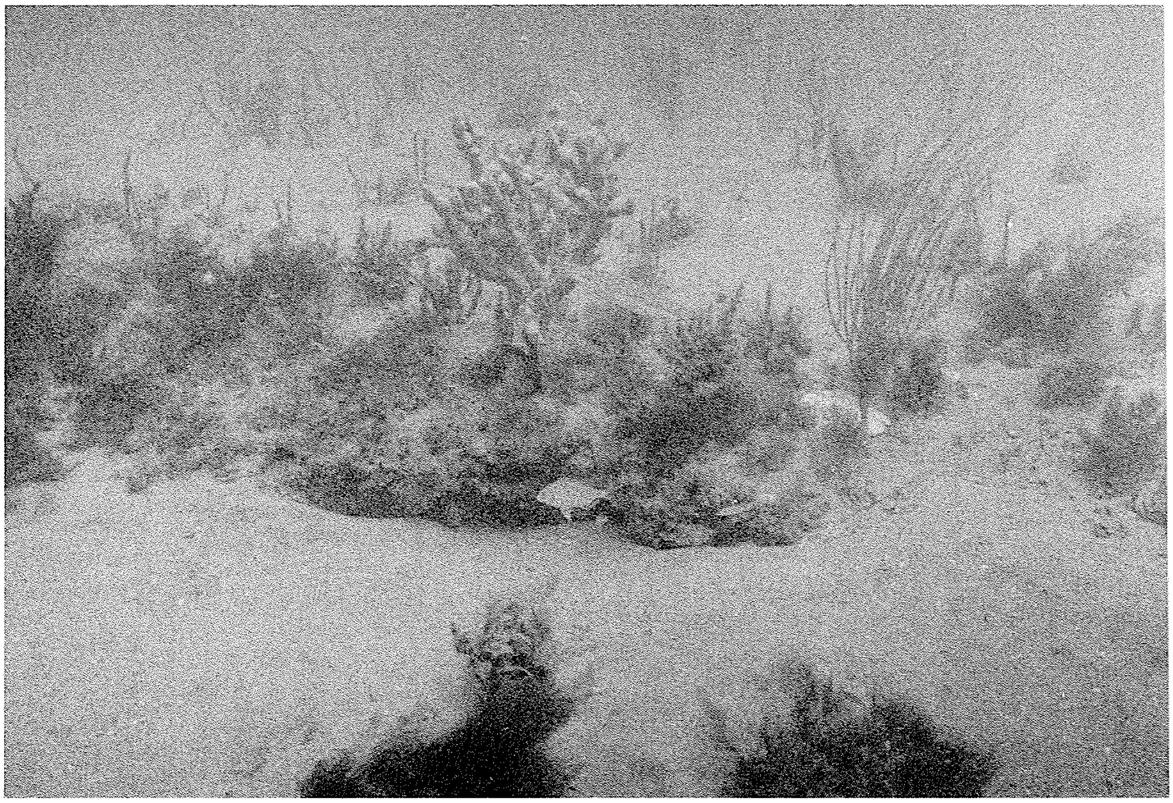
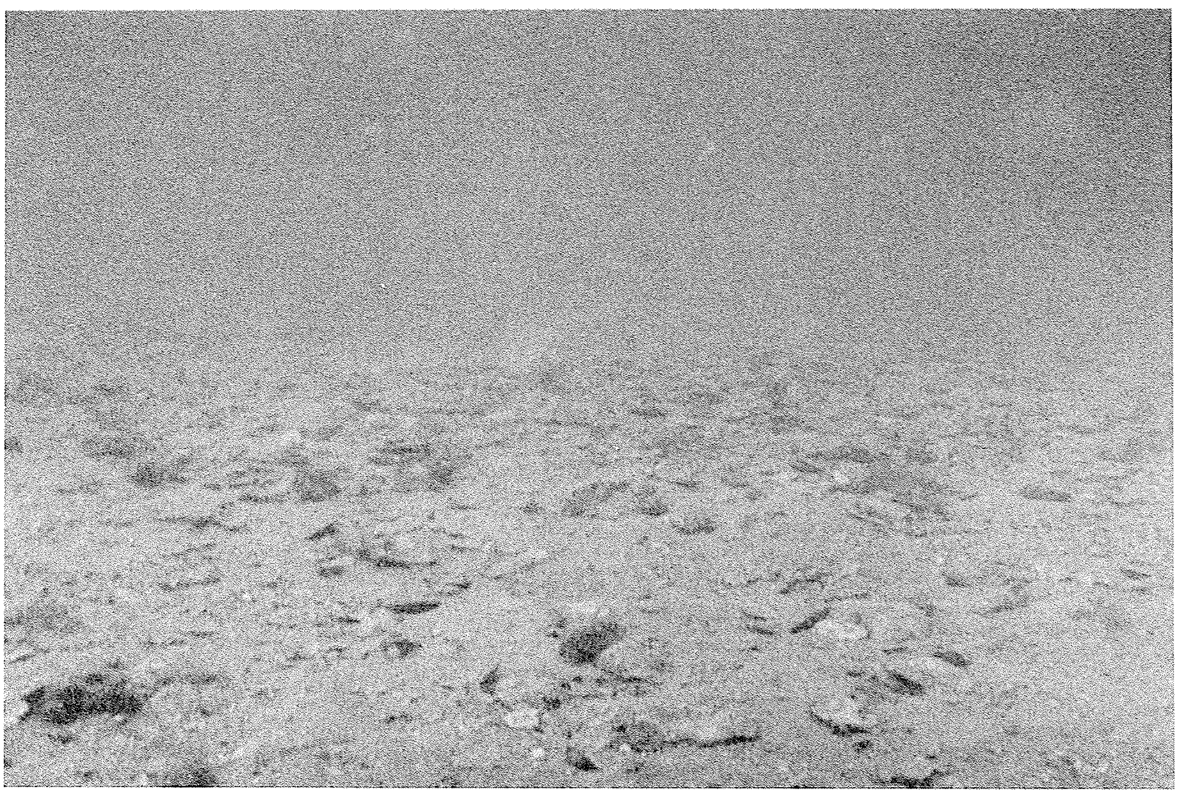


Figure 9. Low Density Livebottom Developed on Hard Substrate Beneath a Veneer of Sand at Dive Site 3.

Most livebottom of this type is located on the fringes of areas of higher relief. Overall, low density/low relief live bottom has the greatest areal distribution.

Figure 10. Barren Areas of Coarse Sand, Shells and Shell Fragments.

As shown in the lower photograph, dense accumulations of whole shells and coarse (gravel-size) shell debris are common.



transect) and a bounce dive (Station 8) and reported seeing only sandy bottom.

Water depth in the Sanctuary ranges from 48 feet in the southwest corner to 72 feet in the northeast corner. Overall, the sandy areas have the least relief although a distinct depression is present in the vicinity of Dive Station 13 in the northwest portion of the Sanctuary. This feature may relate to possible sink hole development in the limestone strata that shallowly underlies most if not all of the sandy areas. Water depth over the main livebottom area varies with local relief of up to six (6) feet. The northeast corner of the Sanctuary in which the greatest depths occur also showed significant variation, possibly due to the presence of sand waves.

Bottom Sediment Texture

The mean diameter of the bottom sediment ranged from coarse sand (0.34 Ø) to fine sand (2.09 Ø) with most samples in the medium sand sizes. In areas away from the livebottoms the coarser material was composed of pelecypod and gastropod shell fragments. In live bottom areas, the coarse fraction was composed of fragments of coral, bryozoa, algae, barnacles and worm tubes. Quartz, feldspar and phosphate grains were the most common constituents of the inorganic coarse fraction. The use of coarse fraction constituents of bottom sediment as an indication of proximity to live bottom areas is presently being studied.

It is pointed out that while the mean diameter of grain size in a given sample may fall in the sand size category, constitutents may range from gravel and larger size, particularly if whole shells or rock fragments are present. Tables 1 and 2 present information on grain size classification and descriptive classification of bottom

Table 1 - Grain Size Classification (Mean Diameter)

Wentworth Classification	Phi (Ø) Value	Size in Millimeters
Pebble	-6 to -2	64 - 4
Gravel	-2 to -1	4 - 2
Sand		
very coarse	-1 to 0	2 - 1
coarse	0 to 1	1 - 0.5
medium	1 to 2	0.5 - 0.25
fine	2 to 3	0.25 - 0.125
very fine	3 to 4	0.125 - 0.062
Silt	4 to 8	0.062 - 0.0039
Clay	8 to 12	0.0039 - 0.0024

Table 2

Bottom Sediment Categories

SAND	Sand in this context relates to the fine sand, medium sand, coarse sand and broken shell. Sand areas will normally fall into three sub-categories. a. Smooth areas. b. Rippled areas. c. Waved areas.
GRAVEL	Gravel refers to materials coarser than "Coarse Sand" and broken shell, and embraces the gravel,, stones, pebbles, shingle and shell notations of navigational charts.
ROCK	The term "rocky" is used when it is known positively that the bottom is bedrock or consists of material larger than gravel. "Rock" is used when solid rock or a rock ledge is visible to the hydrographer.

sediment, respectively, as used in this report. Table 3 summarizes, the textural characteristics of sediment samples obtained during the survey. Figure 6 shows the location of bottom sediment samples taken during the survey and the distribution of mean grain size of the sediment. Predictably, the coarsest sediment generally occurs in areas of rock outcrops. Coarse fraction constituents are usually reliable in differentiating livebottom from barren sandy areas.

Table 3 - Summary of Textural Characteristics of Sediment Samples

Grain Size (Phi Ø mean diameter - see Table 1)	
coarse sand	17 samples
medium sand	38 samples
fine sand	2 samples
Range of Mean Diameter	
0.34Ø (0.66mm)	2.09Ø (0.20mm)
Sorting (measures the uniformity of grain size)	
good	0 samples
moderate	38 samples
poor	9 samples
Skewness (measures asymmetry of grain size distribution)	
strongly coarse	4 samples
coarse	37 samples
near symmetrical	13 samples
fine	2 samples
strongly fine	1 sample
Kurtosis (measures the ratio between average and extremes in grain size)	
platykurtic (coarse)	2 samples
mesokurtic	32 samples
leptokurtic (finer)	20 samples
very leptokurtic	3 samples

Discussion

While the quality of the sonargram mosaic is less than expected and desired, this product, together with the bathymetric and seabed texture maps, will certainly serve as the most useful basis for resource planning and management that is presently available to the Program. For the first time Sanctuary management personnel have a full coverage seafloor map that immediately shows where livebottom occurs or is absent. First-order features such as the larger ridges that regionally trend NE/SW are readily seen and can be accurately located for study. The overlay of Figure 4 provides a map depicting morphology in terms of relative local relief as defined by Henry and Giles (1979) and shown on the overlay legend. While the nature of most of the problematic sonar signature has been determined, a great deal more site-specific study is needed to identify second- and third-order features related to both livebottom and sandy areas.

A new procedure and software program has been developed by the U.S. Geological Survey to very successfully enhance sonargram mosaics prepared from the **GLORIA** survey carried out off the California coast. This effort involved digitizing and computer printing of sonargrams of comparable quality to the sonargrams obtained during the **WHITING** survey and has great promise as a means of markedly improving the quality of the present mosaic.

Conclusions and Recommendations

As discussed in the Sanctuary Management Plan the needed comprehensive hydrographic survey covering the entire Sanctuary was carried out during the period 3-7 August 1983 aboard the NOAA Ship **WHITING.** Products include a full-coverage sonargram mosaic of the Sanctuary, showing the occurrence and distribution of hardbottom/livebottom and reef morphology; a seabed texture map; and a bathymetric map, a three-dimensional model of seafloor topography was constructed from the bathymetric data and is on display at the Sanctuary Interpretive Unit at the University of Georgia Marine Extension Center near Savannah, Georgia. Each of the products is at a scale of 1:10,000.

This data base should be of prime importance in assessing changes in Sanctuary conditions over time and for planning a future biological resource mapping and monitoring study. Survey data can also provide materials of interest to the general public. Derivative maps of the mosaic should be useful to recreational fishermen and SCUBA divers to locate productive and attractive fishery habitats and by scientists and educators to locate appropriate sites for resource studies.

Recommendations for further studies include:

1. improve quality of existing mosaic by digitizing and computer enhancement of data on magnetic tape.
2. finer tuning of the morphological boundaries and mapping of second- and third-order features using towed-diver and bounce-dive techniques in selected areas. North/south and east/west transects bisecting the Sanctuary should provide useful ground-truth data. More still-photos and probe

information is needed.

3. studies using time-lapse still photos and/or CCTV, and other techniques to document seasonal and short-term movement of sand on and off livebottom areas as well as the thickness of the sand cover throughout the Sanctuary.
4. determine in more detail the geological nature of the substrate that supports the livebottom - age, origin, mineralogy, etc.

LITERATURE CITED

Folk, R.C. 1980. Petrology of sedimentary rocks. Hemphill Publishing Co. Austin, Texas. 182 pp.

Henry, V.J. Jr. and R.T. Giles. 1979. Distribution and occurrence of reefs and hardgrounds in the Georgia Bight. A draft final report to U.S. Geological survey. Office of Marine Geology, Woods Hole, Mass. 55 pp.

Henry, V.J., Jr. and Van Sant. 1982. Results of reconnaissance mapping of the Grays Reef National Marine Sanctuary. A report prepared for the Georgia Department of Natural Resources, Coastal Resources Division, Brunswick, Georgia, under Cooperative Agreement (NA 81 AAA CZ098, Amendment 1, with the Sanctuary Programs Division of the National Oceanic and Atmospheric Administration.

Hollister, D.C. 1973. Atlantic continental shelf and slope of the U.S.--texture of surface sediments from New Jersey to southern Florida. U.S. Geol. Survey Prof. Paper. 529-M, 23 pp.

Hunt, J.L., Jr. 1974. The geology and origin of Gray's Reef, Georgia Continental Shelf. M.S. Thesis Univ. of Georgia. Athens, Georgia, 83 pp.

Office of Coastal Zone Management. 1980. Final environmental impact statement on the proposed Gray's Reef National Marine Sanctuary. Washington, D.C. 175 pp. and app.

Office of Ocean and Coastal Resource Management (Office of Coastal Zone Management). 1983. Gray's Reef National Marine Sanctuary Management Plan. Washington, D.C.

Struhsaker, P. 1969. Demersal fish resources: composition, distribution and commercial potential of the continental shelf stocks off southeast United States. Fishery Industrial Research (4(7): 261-287.

APPENDICES

APPENDIX I

Location and Description of Observations Made Along Towed-Diver Transects and at Bounce-Dive Sites

APPENDIX I

Location and Description of Observations Made Along Towed-Diver Transects and at Bounce-Dive Sites

Towed-Diver Transects (see Figure 5)

East Transect

Leg 1 - Start -	31:21.70 N	45447.6
	80:52.20 W	61530.7
End -	31:23:05 N	45441.3
	80:49:90 W	61503.6

Vessel heading - generally NE

Description

Transect starts in moderate cover live bottom (30 - 50%) cover), separated by areas of sand - "patchy" bottom;

No. 1 (31:22:.07 N/80:51.85 W) (45447.6/61525.8) bottom from moderate density live bottom to low density;

No. 2 (31:22.20 N/80:51.67 W) (45447.2/61523.5) - from low density (10 - 15% cover) into more intense bottom and hilly rolls, no ledges or exposed rock;

No. 3 (31:22.31 N/80:51.52 W) (45447.0/61521.6) - moved into sand area;

No. 4 (31:22.61 N/80:50.53 W) (45442.7/61511.4) - low density (10 - 15% cover) scattered live bottom;

No. 5 (31:22.63 N/80:50.47 W) (45442.3/61510.8) - small ledge (10 - 30 cm relief) Note: this is an exact location, all other readings are approximately 150' behind the marked location;

No 6 (31:23.05 N/80:49.90 W) (45441.3/61503.6) - end diver transect.

Leg 2 - Start -	31:23.05 N	45441.3
	80:49.90 W	61503.6
End -	31:23.75 N	45453.5
	80:51.25 W	61511.8

Vessel heading - generally NW

No. 7 (31:23.20 N/80.49.96 W) (45442.6/61503.3) - moderate density (30 - 50% cover), live bottom; small ledge near mark;

No. 8 (31:23.31 N/80:50.09 W) (45443.9/61503.9) - low to moderate density live bottom with ledge near mark;

No. 9 (31:23.32 N/80:50.10 W) (45444.0/61504.0) - barren sand beyond ledge;

No. 10 (31:23.35 N/80:50.14 W) (45444.4/61504.1) moved over low density (10 - 30% cover) live area, fairly widely scattered;

No. 11 (31:23.75 N/80:50.95 W) (45451.6/61509.2) - moved into more intense bottom of moderate density (30 - 50% cover);

No. 12 (31.23.75 N/80.51.25 W) (45453.4/61511.9) end diver transect; no change in bottom.

Leg 3 - Start -	31:23.75 N 80:51.25 W	45453.4 61511.9
End	31:25.05 N 80:50.10 W	45453.7 61495.0

Vessel heading generally NE

Description Bottom at start is moderate cover (30 - 50%) live.

No. 13 (31:24.05 N/80.51.05 W) (45453.8/61508.5) - moving into low density live bottom (10 - 30% cover);

No. 14 (31:24.12 N/80:51.01 W) 45454.0/61507.8) - moved into sand area;

No. 15 (31.24.21 N/80:50.95 W) (45454.2/61506.8) - moved into low density (10 - 30% cover) live area;

No. 16 (31:24.46 N/80:50.75 W) (45454.3/61503.8) - moved into sand;

No. 17 (31:24.55 N/80:50.66 W) (45454.3/61502.6) - end mark for dive team - still over sand.

Leg 4 - Start -	31:25.05 N 80:50.10 W	45453.7 61595.0
End -	31:25.20 N 80:51.40 W	45462.4 61505.8

Vessel heading generally NNW

Description Divers started at the end point on the previous transect and turned the corner; uniform sand habitat for the duration of the transect.

West Transect

Leg 1 - Start -	31:25.15 N 80.54.15 W	45478.7 61530.3

End - 31:24.79 N 45483.6
80:55.35 W 61543.1

Vessel heading generally SW

Description - Bottom type is fairly uniform sand; any changes over shell material was too subtle to call for a distinct mark.

No. W1 (31:24.31 N/80:55.35 W) (45481.5/61545.2) - divers actually ended transect at this mark and not the above location.

Leg 2 - Start - 31:24:70 N 45483.6
80:55.35 W 61543.1

End - 31:22.95 N 45460.5
80:53.15 W 61532.7

Vessel heading generally SE

Description NOTE: The divers started the transect at 31:24.31 N/80:55.35 W (45481.5/61545.2) and not at the above location;

No. W2 (31:23.41 N/80:54.07 W) (45468.7/61538.4) - bottom type up to this point has been sand and some shell debris, moved into low density (10 - 30% cover) live area;

No. W3 (31:23.38 N/80:54.00 W) (45468.0/61538.0) - moved into area of moderate live (30 - 50% cover) bottom;

No. W4 (31:23.26 N/80:53.84 W) (45466.4/61537.2) - moved into sand area;

No. W5 (31:23.17 N/80:53.67 W) (45464.8/61536.1) - moved into moderate live bottom (30 - 50% cover) for the duration of transect.

Leg 3 - Start 31:22.95 N 45460.5
80.53.15 W 61532.7

End 31:22.90 N 45473.6
80:55.35 W 61552.3

Vessel heading generally W

Description - Bottom starts in low to moderate density cover;

No. W6 (31:22.95 N/80:53.29 W) (45461.2/61533.9) - position marks small exposed rock outcrops, maybe small ledges;

No. W7 (31:22.90 N/80:53.69 W) (45463.5/61537.7) - bottom changes from low density live bottom to sand;

No. W8 (31:22.94 N/80:54.37 W) (45467.8/61543.5) - bottom changes into patchy, low density (15 30% cover), scattered live bottom;

No. W9 (31:22.93 N/80:54.50 W) (45468.6/61544.7) - bottom changes from low density live to coarse, sand/shell areas; next mark indicates a dive team change

Leg 4 - Start -	31:22.90 N	45473.6
	80:55.35 W	61552.3
End	31:21.80 N	45460.7
	80:54.25 W	61548.2

Vessel heading generally SSE

Description Bottom is generally very coarse sand with varying amounts of shell debris;

No. W10 (31:22.43 N/80:55.07 W) (45469.3/61552.3) - moved from sand/shell area into a very low density (5 - 15% cover) live area, no rock, no sponges, but mostly scattered octocorals;

No. W11 (31:22.39 N/80:55.04 W) (45468.9/61552.2) moved back into coarse sand/shell area;

No. W12 (31:22.37 N/80:55.01 W) (45468.6/61552.1) - marks a change in dive teams into area of more shell materials, scattered sand and shell.

Leg 5 - Start -	31:21.80 N	45460.7
	80:54.25 W	61548.2
End	31:24.05 N	45472.1
	80:54.05 W	61534.9

Vessel heading generally N

Description - Bottom at start in coarse sand/shell area - then moving into more of a sand area as one moves N;

No. W13 (31:22.06 N/80.53.92 W) (45460.2/61544.0) - moved into low density (10 - 30% cover) scattered live bottom;

No. W14 (31:22.26 N/80:54.00 W) (45461.7/61543.7) - moved into high density (60 - 80% cover) live bottom; however, no exposed rock or ledges;

No. W15 (31:22.32 N/80:53.98 W) (45461.9/61543.2) - moved into sand/shell debris area;

No. W16 (31:22.72 N/80:53.86 W) (45463.5/61540.1) - moved into just sand area;

No. W17 (31:23.10 N/80:53.90 W) (45465.9/61538.5) - moved into low density (10 - 30% cover) scattered live bottom;

No. W18 (31:23.13 N/80:53.91 W) (45466.1/61538.4) - moved into sand area;

No. W19 (31:23.15 N/80:53.91 W) (45466.2/61538.3) - moved into low density (10 - 30% cover) live bottom area;

No. W20 (31:23.22 N/80:53.92 W) (45466.7/61538.1) - moved into area of intense growth (60 - 80%), but no ledges or exposed rock;

No. W21 (31:23.32 N/80:53.92 W) (45467.2/61537.6) - moved into sand area;

No. W22 (31:23.36 N/80:53.91 W) (45467.4/61537.3) - moved into area of moderate densit live bottom (30 - 50% cover);

No. W23 (31:23.47 N/80:53.91 W) (45468.0/61536.7) - this mark indicates a change in dive teams;

No. W24 (31:23.51 N/80:53.96 W) (45468.5/61536.9) - hit series of small, low relief, undercut ledges (10 - 15 cm relief) with associated, intense growth;

No. W25 (31:23.64 N/80:53.94 W) (45469.1/61536.1) - bottom thinned to low density (10 - 30% cover) patchy live growth;

No. W26 (31:23.80 N/80:53.99 W) (45470.3/61535.6) - bottom growth more intense, another series of exposed rock with small ledges;

No. W27 (31:23.88 N/80:53.99 W) (45470.7/61535.3) - moved into area of barren sand for the duration of the transect. NOTE: At the end of the transect, the vessel turned onto a SW heading and the divers observed only sand for the duration of their dives. Southwest transect ended at 31:23.73 N/80:54.48 W (46472.9/61540.4)

West to East Transect

Start	31:24.84 N 80:54.63	45480.0 61536.0
End	31:24.43 N 80:49.65 W	45447.6 61494.3
Vessel heading	generally E	
Description -	Sand bottom for the duration of the transect. Mark at 31:24.77 N/80:53.56 W (45473.1/61527.0) indicates a change in technique from drift diving to towing divers.	

Bounce Dive Sites

1. Location: 31:22.25 N 45438.9
80:50.25 W 61510.7

Description: Scattered live bottom of low to moderate density (20 - 50% cover). No exposed rock or ledges. Patchy, sandy area separating live areas.

2. Location: 31:22.80 N 45450.2
80:51.61 W 61519.9

Description: Coarse sand/shell debris area. No distinct segregation between sand and shell.

3. Location: 31:23.83 N 45448.6
80:50.38 W 61503.8

Description: Scattered live bottom area of low to moderate (20 - 50% cover) density. Bottom fairly patchy with coarse sand/shell areas separating the live areas. A few areas of exposed rock, but no ledges or ridges.

4. Location: 31:23.44 N 45450.0
80:50.98 W 61511.1

Description: Small isolated ledge area. Ledge of 10-20 cm relief with a small plateau area on top with associated live growth of moderate to low density. This plateau area rapidly thins into sand (50 - 60 m). Barren sand area below the ledge.

5. Location: 31:24.01 N 45450.0
80:50.44 W 61503.4

Description: Ledge area with a good amount of exposed rock and a large plateau area. Ledge relief runs 20-40 cm; extensive live growth associated with ledge. Below the ledge is very low density (3-15%) live growth. Ledge is undercut; however, no collapsed portions were observed.

6. Location: 31:23.81 N 45460.8
80:52.41 W 61521.7

Description: Large ledge (1-2 m relief) with extensive plateau above the ledge. Transects previously performed perpendicular to this ledge of 65 m duration indicate extensive live growth for the entire transect.

7. Location: 31:24.17 N 45457.4
80:51.51 W 61512.0

Description: A winter dive site. Ledge area with extensive plateau growth. Some rock rubble associated with the ledge; however, little growth observed below the ledge. Ledge relief varied from 40 to 90 cm.

8. Location: 31:24.43 N 45452.5
80:50.47 W 61501.4

Description: A winter dive site. Sand wave area with no live growth. Sand depth varied from 30-90 cm.

9. Location: 31:22.52 N 45457.7
80:53.09 W 61534.4

Description: A winter dive site. Patchy, scattered, low density live bottom (20 - 50% cover). Sand veneer varied from 0-10 cm in depth. Bottom growth appeared to become more intense west of the dive site. No exposed ledges or ridges

10. Location: 31:23.83 N 45465.1
80.53.10 W 61527.8

Description: Dive site was area of large table rocks, some ridges, but no ledges. No undercutting was observed. Bottom was high density live with a lot of exposed rock.

11. Location: 31:23.79 N 45468.3
80:53.68 W 61533.1

Description: Live bottom of low density (15 - 30% cover) growth, continuous, and not patchy. Sand veneer of 4-10 cm depth.

12. Location: 31:24.23 N 45473.7
80:54.14 W 61534.9

Description: A winter dive site. Thick sand station for the duration of all dives (50 m transects performed N,S, E, and W). Sand depths were greater than 120 cm in places.

13. Location: 31:24.41 N 45479.4
80:54.92 W 61540.8

Description: The area of the "hole" on the topo map and recorded as a distinct depression. Divers observed sand on the bottom of the depression and increasing amounts of shell debris as they swam out.

14. Location: 31:25.01 N 45484.9
80:55.28 W 61540.8

Description: Coarse sand and shell area. Divers did report one area distinctive in amount of shell rubble from surrounding area.

15. Location: 31:23.58 N 45475.1
80:54.97 W 61545.6

Description: Sand and shell rubble area. No distinct separation between sand and shell debris.

APPENDIX II

Location and Petrologic Description of Sediment Samples

APPENDIX II

Location and Petrologic Description of Sediment Samples

(see Figure 6)

Sample #1 31°21'48"N 80°55'15"W
sample too small to analyze

Sample #2 31°21'43"N 80°54'24"W
sample too small to analyze

Sample #3 31°23'35"N 80°52'28"W
Medium sand, moderately sorted, near-symmetrical, mesokurtic. Mean diameter 1.34Ø. Slightly shelly. Coarse fraction: pelecypod fragments quartz, feldspar, phosphate. Color: 5Y 6/2 light olive gray.

Sample #4 31°23'36"N 80°53'13"W
see sample #36

Sample #5 31°23'20"N 80°53'54"
Medium sand, poorly sorted, strongly coarse-skewed, platykurtic. Mean diameter: 1.51Ø. Very shelly. Coarse fraction: pelecypods, echinoderms, bryozoa, quartz feldspar, phosphate. Color: 5Y 6/3 pale olive.

Sample #6 31°23'34"N 80°54'36"W
Medium sand, moderately sorted, near-symmetrical, mesokurtic. Mean diameter: 1.69Ø. Slightly shelly. Coarse fraction: pelecypods, bryozoa, quartz, feldspar, very phosphate. Color: 5Y 5/2 olive gray.

Sample #7 31°23'35"N 80°55'21"W
Medium sand, poorly sorted, strongly coarse - skewed, leptokurtic. Mean diameter: 1.16Ø. Slightly shelly. Coarse fraction: pelecypods, bryozoa, echinoderm spines, quartz, feldspar, phosphate. Color: 5Y 6/2 Light olive gray.

Sample #8 31°24'08"N 80°55'14"W
sample too small to analyze

Sample #9 31°24'07"N 80°54'35"W
Medium sand, moderately sorted, coarse-skewed, leptokurtic. Mean diameter: 1.28Ø. Shelly. Coarse fraction: pelecypods, bryozoa, echinoderm spines, quartz, feldspar, phosphate. Color: 5Y 5/1 gray.

<u>Sample #10</u> 31°24'08"N 80°53'48"W
Medium sand, moderately sorted, near-symmetrical, leptokurtic. Mean diameter: 1.47Ø. Shelly. Coarse fraction: pelecypods, bryozoa, quartz, feldspar, phosphate. Color: 5Y 6/2 light olive gray.

<u>Sample #11</u> 31°24'08"N 80°53'09"W
Medium sand, moderately sorted, coarse-skewed, mesokurtic. Mean diameter: 1.43Ø. Shelly. Coarse fraction: pelecypods, gastropods, worm tubes, bryozoa, quartz, feldspar, phosphate. Color: 5Y 5/2 olive gray.

<u>Sample #12</u> 31°24'09"N 80°52'29"W
Medium sand, moderately sorted, coarse-skewed, mesokurtic. Mean diameter: 1.04Ø. Shelly. Coarse fraction: pelecypods, bryozoa, echinoderm spines, quartz, phosphate. Color: 5Y 6/1 gray.

<u>Sample #13</u> 31°24'09"N 80°51'46"W
Medium sand, poorly sorted, strongly coarse-skewed, leptokurtic. Mean diameter: 1.41Ø. Very shelly. Coarse fraction: coral, echinoderm fragments and spines, pelecypods, bryozoa, quartz, feldspar, phosphate, gastropod fragments, encrusting worm tubes. 5Y 5/2 olive gray.

<u>Sample #14</u> 31°24'10"N 80°51'02"W
Coarse sand, moderately sorted, near-symmetrical, mesokurtic. Mean diameter: 0.71Ø. Shelly. Coarse fraction: pelecypods, bryozoa, echinoderm spines, quartz, feldspar, phosphate. Color: 2.54 6/2 light brownish gray.

<u>Sample #15</u> 31°24'07"N 80°50'21"W
Medium sand, poorly sorted, coarse-skewed, leptokurtic. Mean diameter: 1.23Ø. Slightly shelly. Coarse fraction: echinoderm fragments, bryozoa quartz, feldspar, phosphate. Color: 2.5Y 6/2 light grayish brown.

<u>Sample #16</u> 31°24'46"N 80°50'23"W
Medium sand, poorly sorted, coarse-skewed, mesokurtic. Mean diameter: 1.25Ø. Shelly. Coarse fraction: pelecypods, bryozoa, quartz, feldspar, phosphate. Color: 5Y olive gray.

<u>Sample #17</u> 31°24'45"N 80°51'05"W
Coarse sand, poorly sorted, near-symmetrical, mesokurtic. Mean diameter: 0.78Ø. Shelly. Coarse fraction: pelecypods, bryozoa, encrusting worm tubes, quartz, feldspar, phosphate. Color 2.5Y 5/2 grayish brown.

<u>Sample #18</u> 31°24'46"N 80°51'55"W
Medium sand, moderately sorted, coarse-skewed, leptokurtic. Mean diameter: 1.61Ø. Shelly. Coarse fraction: pelecypods, gastropods, bryozoa, quartz, feldspar, phospate, Color: 5Y 5/1 gray.

Sample #19 31°24'46"N 80°52'31"W
Medium sand, moderately sorted coarse-skewed, mesokurtic. Mean diameter: 1.1∅. Slightly shelly. Coarse fraction: pelecypods, gastropods, bryozoa, echinoderm spines, egg cases, quartz, feldspar, phosphate. Color: 5Y 5/2 olive gray.

Sample #20 31°24'45"N 80°53'15"W
Medium sand, moderately sorted, coarse-skewed, mesokurtic. Mean diameter: 1.66∅. Shelly. Coarse fraction: pelecypods, bryozoa, echinoderm spines, quartz, feldspar, phosphate. Color: 5Y 6/1 gray.

Sample #21 31°24'47"N 80°53'58"W
Medium sand, poorly sorted, strongly fine-skewed, extremely leptokurtic. Mean diameter: 1.51∅. Shelly. Coarse fraction: bryozoa, pelecypods, quartz, feldspar, phosphate, encrusting worm tubes. Color: 5Y 6/2 light olive gray.

Sample #22 31°24'46"N 80°54'38"W
Medium sand, moderately sorted, coarse-skewed; leptokurtic. Mean diameter: 1.55∅. Very shelly. Coarse fraction: pelecypods; gastropods, echinoderm spines, barnacles, bryozoa, egg cases, quartz, feldspar, phosphate. Color: 5Y 6/2 light olive gray.

Sample #23 31°24'47"N 80°55'19"W
Coarse sand, poorly sorted, coarse-skewed, leptokurtic. Mean diameter: 097∅. Very shelly. Coarse fraction: pelecypods, gastropods bryozoa, worm tubes, echinoderm spines, barnacles, quartz, feldspar, phosphate. Color: 2.5Y 6/2 light brownish gray.

Sample #24 31°25'16"N 80°55'16"W
Fine sand, moderately sorted, coarse-skewed, mesokurtic. Mean diameter: 2.06∅. Slightly shelly. Coarse fraction: bryozoa, quartz, feldspar, phosphate. Large concentration of phosphate. Color: 10YR 5/1 gray.

Sample #25 31°25'17"N 80°54'34"W
Coarse sand, poorly sorted, coarse-skewed, mesokurtic. Mean diameter: 0.82∅. Shelly coarse fraction: pelecypods, bryozoa, echinoderm fragments, spines, gastropods, barnacles. Color: 5Y 6/2 light olive gray.

Sample #26 31°25'16"N 80°53'54"W
Medium sand, poorly sorted, coarse-skewed, mesokurtic. Mean diameter: 1.19∅. Shelly. Coarse fraction: pelecypods, encrusting, bryozoa worm tubes, quartz, feldspar, phosphate. Color: 5Y 5/1 gray.

Sample #27 31°25'13"N 80°53'13"W
Coarse sand, moderately sorted, coarse-skewed, mesokurtic. Mean diameter: 0.98∅. Slightly shelly. Coarse fraction: pelecypods, bryozoa, encrusting worm tubes, quartz, feldspar, phosphate. Color: 5Y 6/2 light olive gray.

Sample #28   31°25'14"N   80°52'29"W
Medium sand, moderately sorted, coarse-skewed, mesokurtic. Mean diameter: 1.02Ø. Shelly. Coarse fraction: pelecypods, bryozoa, worm tubes, quartz, feldspar, phosphate. Color: 2.5Y 5/2 grayish brown.

Sample #29   31°25'14"N   80°51'49"W
Medium sand, poorly sorted. Coarse-skewed, mesokurtic. Shelly. Coarse fraction: pelecypods, encrusting worm tubes, echinoderm spines, quartz, feldspar, phosphate. Color: 5Y 5/2 olive gray.

Sample #30   31°25'14"N   80°51'07"W
Medium sand, poorly sorted, near-symmetrical, mesokurtic. Mean diameter: 1.07Ø. Very shelly. Coarse fraction: pelecypods, bryozoa, echinoderm spines, gastropods, worm tubes, quartz, feldspar phosphate. Color: 5Y 5/1 gray.

Sample #31   31°25'14"N   80°50'25"W
Medium sand, poorly sorted, coarse-skewed, mesokurtic. Mean diameter: 1.55Ø. Very shelly. Coarse fraction: pelecypods, gastropods, echinoderm spines, bryozoa, quartz, feldspar, phosphate. Color: 5Y 6/1 gray.

Sample #32   31°23'32"N   80°50'25"W
Medium sand, moderately sorted, coarse-skewed, leptokurtic. Mean diameter: 1.14Ø. Shelly. Coarse fraction: pelecypods, bryozoa, worm tubes, quartz, feldspar, phosphate. Color: 5Y 6/2 olive gray.

Sample #33   31°23'32"N   80°51'14"W
Coarse sand, moderately sorted, near-symmetrical, mesokurtic. Mean diameter: 0.65Ø. Very shelly. Coarse fraction: pelecypods, gastropods, bryozoa, worm tubes, echinoderm spines, quartz, feldspar, phosphate. Color: 2.5Y 6/2 light brownish gray.

Sample #34   31°23'33"N   80°51'49"W
Medium sand, poorly sorted, strongly coarse-skewed, leptokurtic. Mean diameter: 1.89Ø. Shelly. Coarse fraction: gastropod and other mollusk fragments, quartz, feldspar, phosphate. Color: 2.5Y 6/2 light brownish gray.

Sample #35   31°23'35"N   80°52'34"W
Coarse sand, moderately sorted, near-symmetrical, mesokurtic. Mean diameter 0.95Ø. Shelly. Coarse fraction: pelecypods, echinoderm spines, gastropods, quartz, feldspar, phosphate. Color 5Y 5/2 olive gray.

Sample #36   31°23'36"N   80°53'14"W
Coarse sand, poorly sorted, fine-skewed, mesokurtic. Mean diameter: 0.47Ø. Very shelly. Coarse fraction: coral, pelecypods, rock fragment, bryozoa, worm tubes, gastropods, quartz, feldspar phosphate. Color: 2.5Y 6/2 H. brownish gray.

<u>Sample #37</u> 31°23'33"N 80°53'58"W
Medium sand, moderately sorted, near-symmetrical, leptokurtic. Mean diameter: 1.47Ø. Shelly. Coarse fraction: pelecypods, bryozoa, quartz, feldspar, phosphate. Color: 5Y 5/2 olive gray.

<u>Sample #38</u> 31°23'26"N 80°53'14"
see sample #6

<u>Sample #39</u> 31°23'34"N 80°55'18"W
Medium sand, moderately sorted, coarse-skewed, leptokurtic. Mean diameter 1.46Ø. Shelly. Coarse fraction: pelecypods, echinoderm fragments and spines, gastropods, bryozoa, quartz, feldspar, phosphate. Color: 5Y 5/1 gray.

<u>Sample #40</u> 31°23'01"N 80°55'18"W
Fine sand, moderately sorted, coarse-skewed, mesokurtic. Mean diameter: 2.09Ø. Shelly. Coarse fraction: pelecypods, echinoderm spines, bryozoa, quartz, feldspar, phosphate. Color: 5Y 6/2 light olive gray.

<u>Sample #41</u> 31°22'56"N 80°55'18"W
Medium sand, poorly sorted, coarse-skewed, leptokurtic. Mean diameter: 1.80Ø. Slightly shelly. Coarse fraction: pelecypods, bryozoa, worm tubes, quartz, feldspar, phosphate. Color: 5Y 6/1 gray.

<u>Sample #42</u> 31°22'57"N 80°53'56"W
Coarse sand, poorly sorted, coarse-skewed, mesokurtic. Mean diameter: 0.79Ø. Very shelly. Coarse fraction: coral, bryozoa, pelecypods, bone fragment, echinoderm spines, quartz, feldspar, phosphate. Color 5Y 6/2 olive gray.

<u>Sample #43</u> 31°22'57"N 80°53'56"W
Medium sand, poorly sorted, strongly coarse-skewed, very leptokurtic. Mean diameter: 1.45. Shelly. Coarse fraction: pelecypods, bryozoa, worm tubes, gastropods, quartz, feldspar, phosphate, rock fragment. Color: 5Y 6/2 light olive gray.

<u>Sample #44</u> 31°22'57"N 80°52'33"W
Medium sand, moderately sorted, coarse-skewed, leptokurtic. Mean diameter: 1.10Ø. Shelly. Coarse fraction: pelecypods, bryozoa, coral, quartz, feldspar, phosphate. Color: 2.5Y 6/2 light brownish gray.

<u>Sample #45</u> 31°22'57"N 80°51'49"W
Medium sand, poorly sorted, coarse-skewed, very leptokurtic. Mean diameter: 1.38Ø. Very shelly. Coarse fraction: pelecypods, bryozoa, gastropod fragments, worm tubes, echinoderm spines, quartz, feldspar, phosphate. Color: 2.5Y 6/2 light brownish gray.

Sample #46   31°22'57"N   80°51'07"W
Coarse sand, poorly sorted, coarse-skewed, mesokurtic. Mean diameter: 0.87Ø. Shelly. Coarse fraction: pelecypods, bryozoa, echinoderm spines, quartz feldspar, phosphate. Color: 2.5Y 6/2 light brownish gray.

Sample #47   31°22'57"N   80°50'25"W
Medium sand, moderately sorted, coarse-skewed, leptokurtic. Mean diameter: 1.22Ø. Shelly. Coarse fraction: pelecypods, bryozoa, quartz, feldspar, phosphate. Color: 2.5Y 7/2 light gray.

Sample #48   31°22'22"N   80°50'57"W
Coarse sand, poorly sorted, coarse-skewed, leptokurtic. Mean diameter: 0.84Ø. Coarse fraction: sponges, shell fragments. Color: 5Y 6/3 pale olive.

Sample #49   31°22'22"N   80°51'06"W
Coarse sand, moderately sorted, coarse-skewed, mesokurtic. Mean diameter: 1.06Ø. Shelly. Coarse fraction: pelecypod valves, bryozoa, echinoderm spines, barnacle, quartz, feldspar, phosphate. Color: 5Y 6/2 light olive gray.

Sample #50   31°22'23"N   80°51'48"W
Coarse sand, moderately sorted, coarse-skewed, mesokurtic. Mean diameter: 0.99Ø. Shelly. Coarse fraction: pelecypods, bryozoa, quartz, feldspar, phosphate. Color: 5Y 6/1 gray.

Sample #51   31°22'20"N   80°52'30"W
Coarse sand, moderately sorted, near-symmetrical, mesokurtic. Mean diameter: 0.66Ø. Shelly. Coarse fraction: coral, pelecypods, crustacean fragment, bryozoa, echinoderm spines, quartz, feldspar, phosphate. Color: 10YR 5/3 brown.

Sample #52   31°22'22"N   80°53'12"W
Medium sand, poorly sorted, coarse-skewed, leptokurtic. Mean diameter: 1.00Ø. Shelly. Coarse fraction: coral, pelecypod valves, quartz, feldspar phosphate. Color: 10YR 6/4 light yellowish brown.

Sample #53   31°22'23"N   80°53'54"W
Coarse sand, moderately sorted, fine-skewed, platykurtic. Mean diameter: 0.34Ø. Shelly. Coarse fraction: pelecypods, bryozoa, gastropods, echinoderm spines, worm tubes, quartz, feldspar, phosphate. Color: 5Y 6/2 light olive gray.

Sample #54   31°22'22"N   80°54'36"W
Medium sand, moderately sorted, near-symmetrical, mesokurtic. Mean diameter: 1.64Ø. Shelly. Coarse fraction: pelecypods, gastropods, bryozoa, echinoderm spines, quartz, feldspar, phosphate. Color: 5Y 6/1 gray.

Sample #55 31°22'24"N 80°55'17"W
Medium sand, moderately sorted, near-symmetrical, leptokurtic. Mean diameter: 1.46Ø. Shelly. Coarse fraction: pelecypods, bryozoa, echinoderm spines, quartz, feldspar, phosphate. Color 5Y 6/1 gray.

Sample #56 31°21'47"N 80°55'16"W
Medium sand, moderately sorted, coarse-skewed, mesokurtic. Mean diameter: 1.96Ø. Shelly. Coarse fraction: pelecypods, gastropods, bryozoa, echinoderm spines, quartz, feldspar, phosphate. Color: 5Y 6/2 light olive gray.

Sample #57 31°21'44"N 80°54'30"W
Medium sand, moderately sorted, coarse-skewed, leptokurtic. Mean diameter: 1.10Ø. Shelly. Coarse fraction: pelecypods, echinoderm spines, worm tubes, quartz, feldspar, phosphate. Color: 5Y 5/1 gray.

Sample #58 31°21'44"N 80°53'55"W
Coarse sand, moderately sorted, near-symmetrical, mesokurtic. Mean diameter: 0.69Ø. Shelly. Coarse fraction: pelecypods, bryozoa, echinoderm fragments and spines, worm tubes. Color: 10YR 5/3 brown.

Sample #59 31°21'45"N 80°53'12"W
Medium sand, moderately sorted, coarse-skewed, leptokurtic. Mean diameter: 1.25Ø. Very shelly. Coarse fraction: coral, pelecypods, gastropods, quartz, feldspar, phosphate. Color: 10YR 5/3 brown.

Sample #60 31°21'45"N 80°52'31"W
Coarse sand, moderately sorted, coarse-skewed, mesokurtic. Mean diameter: 0.98Ø. Shelly. Coarse fraction: coral, encrusting worm tubes, large mollusk fragments, pelecypods, worm tubes, quartz, feldspar, phosphate. Color: 2.5Y 6/2 light brownish gray.

Sample #61 31°21'42"N 80°51'50"W
Medium sand, moderately sorted, coarse-skewed, mesokurtic. Mean diameter: 1.13Ø. Shelly. Coarse fraction: pelecypods, bryozoa, quartz, feldspar, phosphate. Color: 5Y 6/1 gray.

Sample #62 31°21'41"N 80°51'50"W
Medium sand, moderately sorted, coarse-skewed, mesokurtic. Mean diameter: 1.07Ø. Shelly. Coarse fraction: pelecypods, bryozoa, echinoderm spines, gastropods, quartz, feldspar, phosphate. Color: 5Y 6/2 light olive gray.

Sample #63 31°21'44"N 80°50'24"W
Medium sand, moderately sorted, coarse-skewed, mesokurtic. Mean diameter: 1.17Ø. Slightly shelly. Coarse fraction: pelecypods, bryozoa, echinoderm spines, quartz, feldspar, phosphate. Color: 5Y 5/2 olive gray.