UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

A SUMMARY OF ENVIRONMENTAL GEOLOGIC STUDIES ON THE SOUTHEASTERN UNITED STATES ATLANTIC OUTER CONTINENTAL SHELF, 1979-1982

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Open-File Report 85-609

Prepared in cooperation with the
U.S. BUREAU OF LAND MANAGEMENT
(Now Minerals Management Service)
under Memoranda of Understanding
AA551-MU9-8, AA551-MU0-16
and Interagency Agreements
A851-IA1-15, AA851-IA2-26

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INTRODUCTION

In 1976 the U.S. Geological Survey (USGS) and the U.S. Bureau of Land Management (BLM) began a cooperative program to undertake geologic studies along the southeastern United States continental margin. These studies were funded by the Environmental Studies Program of the BLM and were aimed at providing information on the Outer Continental Shelf (OCS) environment that would enable the Department of Interior and the BLM (now Minerals Management Service) to make sound management decisions regarding the exploration for and development of petroleum and mineral resources. The investigations were funded under agreements made with the BLM as described in Memoranda of Understanding (MOU) or Interagency Agreements (IA) written on a fiscal year (FY) basis. Results of the first year and one-half of study, FY 1976 and 1977, were released as NTIS report PB300-820 and as USGS Open-File Reports 80-146 and 80-147. Results of the studies for FY-1978 were detailed in USGS Open-File Reports 81-582 and 81-583. This report summarizes the objectives, program, fieldwork, and results of the studies conducted in FY 1979 through 1982 (MOU's AA551-MU9-8, AA851-MUO-16, and IA's AA851-IA1-15 and AA851-IA2-26).

Most of the programs conducted during these years were multi-year efforts. Details of the procedures and result of separate studies were submitted to the BLM as separate reports and/or maps or were published in professional journals. Other results of this program have been presented in many unpublished talks, lectures at universities, symposia, and conferences, as well as submitted to the BLM for inclusion in the Environmental Impact Statements for the various Lease Sale areas. Many of the large regional geologic-map compilations resulting from the program are to be published by the Geological Society of America as part of the Decade of North American Geology Map Series. In addition, numerous conferences have been held with industry and Federal and State government personnel on various aspects of the studies throughout the history of the program.

A bibliography of published papers and abstracts resulting from the cooperative BLM-USGS Environmental Studies Program from its inception is included here as Appendix A. Copies of basic data gathered under this program, particularly the regional seismic-reflection and sidescan-sonar surveys, are available through the National Geophysical Data Center, Environmental Data and Information Service (NGDC/EDIS) in Boulder, Colorado and are listed in the bibliography included within this summary.

Because some results of the studies program were needed on a timely basis for decision making on OCS leasing and by industry for determining bottom conditions within lease areas, the basic data and preliminary results were released to the BLM as data were obtained. Other elements not critical to decision making have been or are in the process of being published in books or scientific journals.

RELATION TO OTHER CONTRACTORS

Open communication and exchange of data and results with the contractors of environmental studies under the BLM program has taken place largely through regional conferences and Administrative Council meetings, convened on a quarterly basis by BLM, and through exchange of progress reports. These

meetings have been hosted by Science Applications, Inc. (SAI), the prime contractor for physical oceanography. Project managers of the various study elements, including physical and biological oceanography, have presented their results to other researchers of the South Atlantic Regional Technical Working Group and to the South Atlantic Technical Working Group Committee, an ad hoc committee of prominent scientists from industry and State and Federal governments.

The exchange of data within programs has been particularly valuable in the overall analyses and interpretation. For instance, the physical-oceanography data have provided new information on present conditions and processes that can be extrapolated to decipher the past history of the margin. Because we are able to recognize that at present the Gulf Stream is being deflected by the Charlerston Bump, the prominent bathymetric ramp on the northern Blake Plateau, and understand the resultant upwelling and circulation patterns created on the shelf, we have new insight on the sediment distribution and dispersal processes of the past. This, in turn, has aided the analyses of geologic criteria important to the origin of phosphate and manganese deposits on the Blake Plateau. The overall program has benefited science, industry, and government.

GENERAL SUMMARY

The final four years of the BLM-USGS cooperative program of environmental investigations are jointly summarized together in this Executive Summary Report. All but one task, the development of a rapid and inexpensive method to determine the presence and concentration of barium in bottom sediments, were carried out over the four years.

The objectives of the studies reported herein by fiscal year were:

Fiscal Year 1979 (MOU AA551-MU9-8)

1. To regionally map and characterize the Florida-Hatteras Shelf in the Southeast Georgia Embayment for geological bottom features (reefs and hardgrounds) that are of ecological significance.

2. To map regionally the Continental Shelf, Blake Plateau, Slope, and upper Rise between Cape Fear and Cape Hatteras, North Carolina for geological features (faults, unstable bottom conditions, reefs and hardgrounds, shallow gas, mobile bed forms, etc.) having significance for pipeline or drilling rig/production platform siting and construction.
3. To map regionally the shallow stratigraphy and structure of the Continental Shelf, Blake Plateau, and Continental Slope between Cape Fear and Cape Hatteras, N.C.

4. To develop and test a rapid and inexpensive method of determining the presence and concentration of barium, a major component of drilling muds, in bottom sediments.

Fiscal Year 1980 (MOU AA851-MU0-16)

1. To map regionally and characterize the Florida-Hatteras Shelf

between the Southeast Georgia Embayment and Cape Hatteras, N.C. for geological bottom features (reefs and hardgrounds) that are of ecological significance.

2. To map regionally the Continental Shelf, Slope, and upper Rise between Cape Hatteras, N.C. and Virginia for geological features (faults, unstable bottom conditions, reefs and hardgrounds, shallow gas, mobile bed forms, etc.) of significance to pipeline or drilling rig/production platform construction.

3. To map regionally the shallow stratigraphy and structure of the Continental Shelf, Slope, and upper Rise between Cape Hatteras, N.C. and Virginia.

4. To develop and produce a series of standardized maps (Atlas Series Map) on which to present data gained from the studies program and on which to synthesize similar studies from the literature.

5. To conduct a midrange sidescan-sonar investigation of the Continental Slope in and near the area of Oil and Gas Lease Sale 56 in order to gain information on canyons, slope stability, and other bottom conditions.

Fiscal Year 1981 (Interagency Agreement AA851-IA1-15)

1. To continue analyses of seismic data gathered in 1979 and 1980 for geologic and hazards information in the area of the North Carolina continental margin.

2. To continue the synthesis of geological and biological data gained from the studies program and from the literature onto a series of standardized 1:250,000 scale maps for the Brunswick and Jacksonville OCS quardrangles.

3. To archive all data obtained under the studies program with the National Geophysical Data Center of NOAA.

Fiscal Year 1982 (AA851-IA2-26)

1. To complete all of the above studies.

Table 1 lists the tabulated study elements and reports submitted in fulfillment of the Memoranda of Understanding and the Interagency Agreeements for FY79-82. These products and supplemental reports are separately listed by Fiscal Year in Appendix A.

FIELD SURVEYS

Thirteen cruises using five different vessels, were conducted between 1979 and 1982 in which almost 12,000 km of airgun and 3.5-kHz seismic-reflection records, 4,944 km of sidescan-sonar records, and 361 km of underwater towed television records were collected for this program. These crusies are tabulated in table 2.

Figure 1 shows the location of tracklines for the four USGS cruises that collected airgun and 3.5-kHz high-resolution seismic data: R.V. GILLISS, 1979, leg 6; R.V. GYRE, 1980, leg 9-2; R.V. GYRE, 1981, leg 14; and R.V. NEECHO, 1982, leg 1. Figure 2 shows the location of tracklines of seismic-reflection sidescan-sonar, and underwater camera TV data collected by the University of Georgia (R.V. BLUE FIN and KIT JONES) under the BLM program. Figures 3 and 4 shows the location of Sea MARC I midrange sidescan-sonar trackline collected by the U.S. Geological Survey in cooperation with the Lamont-Doherty Geological Observatory.

SUMMARY RESULTS OF INDIVIDUAL INVESTIGATIONS

Popenoe, P., Coward, E.L., Cashman, K.V., 1982, A regional assessment of potential environmental hazards to and limitations on petroleum development of the southeastern United States Atlantic Continental Shelf, Slope and Rise offshore North Carolina: U.S. Geological Survey Open File Report 82-136, 67p., map 1:1,000,000.

More than 11,000 km of high-resolution seismic-reflection data, 325 km of midrange sidescan-sonar data, and 500 km of long-range sidescan-sonar data (GLORIA II) were examined and used to construct an environmental geology map of the Continental Shelf, Slope, and Rise along the U.S. Atlantic margin between lat, 32°N. and 37°N. Hardgrounds and two faults described in published literature are also shown on the map (fig. 5).

A 380-km long growth fault with associated splays and antithetic faults was mapped near the edge of the northern Blake Plateau. The fault parallels the western edge of the Carolina Trough and lies just inshore of 26 salt diapirs which underlie the lower Slope and upper Rise. Throw on this fault increases from about 1 m at 10 km depth, to 450 m at 5 km depth indicating that there was a long history of movement contemporaneous with deposition. The fault is believed to be a compensation fault for salt movement in the Carolina Trough, and therefore probably not seismic but still must be considered active. Associated with the fault are subsurface collapse features that are interpreted to be caused by karst solution and cavernous porosity in Eocene and early Oligocene limestones at depth.

The Helena Banks fault and the White Oak lineament appear to be tectonic in origin; however a lack of historical seismicity associated with these faults indicates that they are probably not active at the present time.

No instability features were noted on the Florida-Hatteras slope connecting the Shelf to the Blake Plateau, but several major slump scars were mapped on the Continental Slope east of Cape Hatteras. The southernmost slump scar is 50 km across and centered on the lower slope at lat 33°N., long 76°W, where it encircles three large salt diapirs. The scar is rimmed by a scarp 60 to 80 m high that sharply truncates bedding. A series of rotational slumps faults extend to the top of the slope. Sidescan-sonar images show slide tracks that extend downslope from the scarp face to rubble and scree lobes; downslope-widening avalanche tracks above the scarp face are also recorded.

The second major area of slope instability lies near lat 36°20'N., long 74°40'W, where a slump more than 20 km wide has removed all Pleistocene sediments from the lower slope. This area shows two steep scarps, each about 225 m high, where bedding has been truncated and removed.

Hardgrounds are widely scattered on the Florida-Hatteras shelf, but are most abundant in Onslow Bay. Although paleo-stream channels are common nearshore, they do not appear to be common on the central and outer shelf. Evidence for scour by strong currents is ubiquitous on the northern Blake Plateau, but deep-water reefs are sparse. Mobile bottom sediments are confined mainly to the shoals off Cape Romain, Cape Fear, Cape Lookout, and Cape Hatteras; elsewhere, the sand cover is thin.

A horizon of frozen sediment (clathrate) under which shallow free gas is trapped, is inferred to be present beneath the outer Blake Plateau, the Slope, and the upper Rise. Although the hazards of drilling into or through clathrates have not been tested, the uncontrolled release of gas from beneath this frozen layer may prove to be a primary hazard to exploration in deeper water.

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Popenoe, Peter, 1984, Cenozoic depositional and structural history of the North Carolina margin from seismic stratigraphic analyses, in Poag, C.W., ed., Stratigraphy and depositional history of the U.S. Atlantic margin: Stroudsburg, PA, Van Nostrand Reinhold, p. 125-183, 43 figs., 4 plates.

The Cenozoic depositional and structural history of the North Carolina margin was reconstructed from seismic stratigraphic analyses of high-resolution seismic-reflection profiles obtained under the USGS-BLM program. The Cenozoic strata were divided into eleven major depositional packages, each reflecting a large eustatic sea-level cycle. Isopach and structure contour maps were constructed for each of the major epochs or sub-epochs, as well as a subcrop geologic map of the North Carolina Shelf and northern Blake Plateau.

The data point up the interaction of subsidence of the continental edge, eustatic sea-level variations, and the resultant shifting of both the subaerial erosion zone, the offshore currents, and depocenters. The shifting and transposition of depocenters and erosion zones that have traditionally been interpreted as due to tectonic forces are here shown to be due to oceanographic and subaerial processes acting on a gradually subsiding continental edge. Major tectonic features such as the Norfolk and Cape Fear Arches are shown to owe their geometry to the subsidence pattern of the continental edge, which was initiated during rifting of Africa and North America in the Jurassic, and to the building of Cape Hatteras out into the Carolina Trough by oceanic currents in the Eocene. This contrasts with previous opinions that the Cape Fear Arch was produced by uplift in the Late Cretaceous, Eocene, or Miocene.

The effects of sea-level variations on the sedimentation patterns off North Carolina are amplified because of the presence of the Charleston Bump, a bathymetric ramp on the northern Blake Plateau, and its effect on Gulf Stream flow. During low eustatic sea level, the ramp has deflected the Gulf Stream offshore south of North Carolina. During low stands subaerial erosion occured across the North Carolina shelf and shelf type deposition shifted seaward across the northern Blake Plateau. During higher sea level the Gulf Stream overrode the northern Blake Plateau, and erodes tracks that are preserved beneath the plateau and Florida-Hatteras shelf. During highest eustatic sea level, the Gulf Stream flowed through the Suwannee Straits and the Gulf

Trough, creating depressions that are preserved beneath the Coastal Plain of northern Florida and southern Georgia. A reconstruction of the eustatic history of North Carolina during the Cenozoic, as deduced from shifts in Gulf Stream position and sedimentation-erosion patterns, is in good agreement with the Vail and Hardenbol (1979) sea-level curve.

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Henry, V.J., 1983, Final Report, Ocean bottom survey of the U.S. South Atlantic OCS region: Unpublished report submitted to the Minerals Management Service, June, 1983, 99p., 5 appendices.

The area between Jacksonville, FL and Cape Hatteras, N.C. from the 3-mi inner-shelf boundary seaward to the 50-m isobath, was surveyed on a 10-20-km grid (fig. 2) with high-resolution and 3.5-kHz seismic reflection profiles, sidescan sonar, and underwater towed television to: 1) map regionally biologically sensitive features such as live bottoms and reefs, 2) locate potential geological hazards and constraints such as hardgrounds, sinkholes, buried channels, mobile bed forms, 3) to relate the above features to shallow geologic structure and stratigraphy, 4) to map smaller bed forms, biota, texture, and other indicators of bottom conditions, 5) to evaluate remote-sensing system capability in terms of accomplishing project objectives, and 6) to prepare geologic atlases for the shelf areas included in the Jacksonville (NH17-5) and Brunswick (NH17-2) 2-degree topobathymetric sheets. The results were presented as both an illustrated text on the nature and distribution of shallow geologic hazards and constraints, and as a series of trackline and data summary maps. Four supplementary reports were also included as appendices to the Final Report: 1) the Neogene seismic stratigraphy and depositional history of the Tybee Trough area, Georgia/South Carolina, (2) Neogene seismic stratigraphy and depositional history of the lower Georgia coast and Continental Shelf, (3) hardgrounds of Long Bay, Southeastern United States, and (4) summary of results of reefs and hardgrounds workshop held by the Minerals Management Service Sept. 23-24, 1981.

The data show that generally coarser and thinner sand cover is present on the shelf off North Carolina and South Carolina than off Georgia, probably reflecting higher wave and current energy on the Carolina Shelf. Here, the sand veneer appears to migrate in patches and overlies more indurated, slightly coarser or higher shell content, older material.

Sand ridges or smaller scale bed forms such as sand waves, scoured areas, ripples, and megaripples were mapped and described. The presence of algal growth along the crests of many of the ripples, however, suggests inactivity, indicating that shear stress on bottom sediment is insufficient to effect bed-form migration except during storm events or when Gulf Stream circulation cells move across the area.

Large-scale sand waves are common, especially on the inner shelf within the 25-m bathymetric contour. Farther offshore, sand waves are less common, but scour is more common. Although scour is generally thought to be caused by storm-generated currents and/or incursions of the Gulf Stream onto the shelf, tidal scour was noted in the Tybee Trough, a feature believed to be a partially filled meander of the ancestral Savannah River, located 45 km east of Savannah, GA.

Shallow channels and hard bottoms are widely scattered across the shelf and a linear, more continuous exposure of hard bottoms is located near the shelf break. Buried channels, karstic topography, live bottoms and hardgrounds of all types are more abundant off the Carolinas and Florida than off Georgia, probably because of the more indurated and calcareous rocks off Florida and the non-depositional-erosional charter of the bottom over the Cape Fear Arch. The shallow stratigraphy off Georgia reflects the higher rates of deposition of the Southeast Georgia Embayment.

The distribution of benthic environments was estimated and mapped, as were the abundance and diversity of epibenthic species and demersal and pelagic fish. These were observed through a closed-circuit television system mounted on a sled towed across the bottom.

The report contains five appendices including Cruise Report Summary, Data Acquisition Inventory, four supplementary reports, a data map series, and Summary Atlas Series Maps of Geohazards and Reefs and Hardgrounds for the Burnswick and Jacksonville 1;250,000 sheets.

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Manheim, F.T., and Bowker, P.C., 1980, Analysis of barium in sediments: U.S. Geological Survey Open-File Report 80-665, 19 p.

An analytical procedure was developed which used a d.c. (direct current) airgun plasma as an excitation source in spectrochemical analyses for barium in marine sediments. The technique permits high analytical sensitivity for barium while achieving reproducibility close to levels typical for flame (emission or absorption) analyses. Detection limits were lowered to approximately 1 part per million (ppm), compared with 45 ppm for X-ray fluoresence and 10 ppm for atomic absorption and neutron activation analyses. The technique was applied to a wide range of sedimentary rock samples; results showed some variations due to effects caused by refractory components, the amount of solids introduced, background emission levels, the portion of plasma selected for imaging on the photodetector, and spectral interferences, but were generally satisfactory agreement with precision methods of analysis. Samples containing 10 ppm to more than 3,000 ppm Ba were tested.

Table 1. Tabulated study elements and final reports

Study element	Fiscal Year	Principal Investigator	Cruise	Final Report
To map regionally and characterize the Florida-Hatteras shelf between the Southeast Georgia Embayment and Cape Hatteras, N.C. for geological bottom features that are of ecological significance.	1979, 1980	V. J. Henry	GILLISS 79-6 GYRE 80-9-2 BLUEFIN (all) KIT JONES-80	1. Ocean bottom survey of the U.S. South Atlantic region, by V. J. Henry. Supplemental reports A. Neogene seismic stratigraphy and depositional history of the lower Georgia Coast and Continental Shelf by F.D. Foley, Jr. B. Neogene seismic stratigraphy and depositional history of the tybee Trough area, Georgia/South Carolina by J.A. Kellan C. Hardgrounds of Long Bay, Southeastern United States Continental Shelf, by L. J. Doyle and G. R. Brooks. D. Summary of results of reefs and hard-bottom workshop, by V. J. Henry.
To map regionally the Continental Shelf, Blake Plateau, slope, and upper rise between Cape Fear and Cape Hatteras, N. C. for geological features of significance to pipeline or drilling rig/production platform construction.	1979, 1980, 1981	P. Popenoe, V. J. Henry	GILLISS 79-6 GYRE 80-9-1, 2 BLUEFIN (all) KIT JONES (all)	1. A regional assessment of potential environmental hazards to and limitations on petroleum development of the Southeastern United States Atlantic Continental Shelf, Slope, and Rise, offshore N. C., by P. Popenoe, E. L. Coward, and K. V. Cashman. 2.Ocean bottom survey of the U.S. South Atlantic region, by V. J. Henry Supplemental reports Geology report for proposed Oil and Gas Lease Sale 90; continental margin off the southeastern United States, W.P. Dillon, ed. Summary Geologic report for the South Atlantic Outer Continental Shelf (OCS) Planning area, by Peter Popenoe.

Table 1. Tabulated study elements and final reports (Cont.)

Study element	Fiscal Year	Principal Investigator	Cruise	Final Report
To map regionally the shallow stratigraphy and structure of the Continental Shelf, Blake Plateau, and slope between Cape Fear and Cape Hatteras, N. C.	1979	P. Popenoe	GILLISS 79-6 GYRE 81-14	1. Cenozoic depositional and structural history of the North Carolina margin from seismic stratigraphic analyses, by P. Popenoe
To map regionally the shallow stratigraphy and structure of the Continental Shelf, Blake Plateau, and slope between Cape Hatteras and Virginia.	1980	P. Popenoe	GYRE 80-9-2 GYRE 81-14 NEECHO 82-1	1. Cenozoic depositional and structural history of the North Carolina margin from seismic stratigraphic analyses, by P. Popenoe
To develop and test a rapid and inexpensive method of determining the presence and concentration of barium in bottom sediments	1979	F. T. Manheim		1. Analysis of barium in sediments, by F. T. Manheim and P.C. Bowker.
To conduct a mid-range sidescan-sonar investigation of the Continental Slope in and near the area of Oil and Gas Lease Sale 56 in order to gain information on canyons, slope stability, and other bottom conditions	1980	P. Popenoe	GYRE 80-9-1	1. Mid-range sidescan-sonar images covering parts of proposed tracts for OCS Lease Sale 56 and contiguous areas, Manteo, Cape Fear, and adjacent quadrangles off North Carolina, by P. Popenoe, K. V. Cashman, D. Chayes, and W. B. F. Ryan. 2. A regional assessment of potential environmental hazards to and limitations on petroleum development of the Southeastern United States Continental Shelf, Slope, and Rise, offshore North Carolina, by P. Popenoe, E. L. Coward, and K. V. Cashman. Supplemental reports Slumping and shallow faulting related to the presence of salt on the Continental Slope and Rise off North Carolina, by K.V. Cashman and P. Popenoe.
To develop and produce a series of standardized maps on which to present data gained from the studies program and on which to synthesize similar studies from the literature	1980, 1981, 1982	V. J. Henry	All USGS-BLM and U. of Ga. cruises to date	1. Ocean bottom survey of the U.S. South Atlantic OCS region, Appendix V, Atlas Series Maps. Geohazards Brunswick Sheet (NH 17-2) Jacksonville Sheet (NH 17-5) Reefs and Hardgrounds Brunswick Sheet (NH 17-2) Jacksonville Sheet (NH 17-5)
To archive all data obtained under the studies program with the National Geophysical Data Center of NOAA	1981, 1982			Open-File data releases are listed in the publications list in the back of the Executive Summary Report.

Table 2. Summary of cruises utilized by the BLM-USGS Cooperative program, 1979-1982

Vessel	Year/Leg	Dates	Chief Scientist	Days at sea	No. in party	Sidescan sonar (km)	3.5-kHz seismic (km)	Hi-resol. seismic (km)	Underwater towed TV (km)	Notes
GILLISS	79/6	8/4-28	Popenoe	24	14		3,290	3,290		N. C. Margin, Cape Fear to Cape Hatteras
GYRE	80/9-1	9/18-25	Popenoe	8	17	335	335			OCS Sale 56 and contiguous areas, mid-range sidescan sonar
GYRE	80/9-2	9/26-10/14	Popenoe	18	13		2,950	2,950		N. C. Margin, Cape Hatteras to Virginia
GYRE	81/14	9/26-10/2	Popenoe	7	11		860	860		Cape Henry, Va. to Cape Romain N. C. Cruise not supported by BLM but necessary to complete BLM work.
NEECHO	82/1	4/15-29	Popenoe	7	4			208		Albemarle-Pamlico Sound, N. C. Cruise not supported by BLM but contributed to BLM work.
BLUE FIN	79/4	5/4-8	Henry	4	7	990	990	990	44	Hilton Head to Jacksonville, Fl.
BLUE FIN	79/5	6/18-22	McCreery	5	7	570	570	570		St. Helena Island to Cape Romain, S. C.
BLUE FIN	79/6	10/22-26	Henry	5	7	950	950	910	80	St. Helena Island to Cape Romain, S. C.
BLUE FIN	80/7	5/5-9	Henry	5	6	614	633	580	170	Savannah to Brunswick, Ga.
BLUE FIN	80/8	7/21-30	Henry	5	7	355	363	296	0	Long Bay, S. C., N. C.
BLUE FIN	80/9	8/18	Henry	5	7	933	983	832	67	Cape Fear to Cape Hatteras, N. C.
KIT JONES	80/1	9/3-4	Kellam	2	3	197		197		Tybee Trough, Ga.-S. C.
BLUE FIN	82/A	2/19	Henry	1	6			126		Savannah, Ga. to Altamaha River
TOTAL						4,944	11,924	11,809	361	

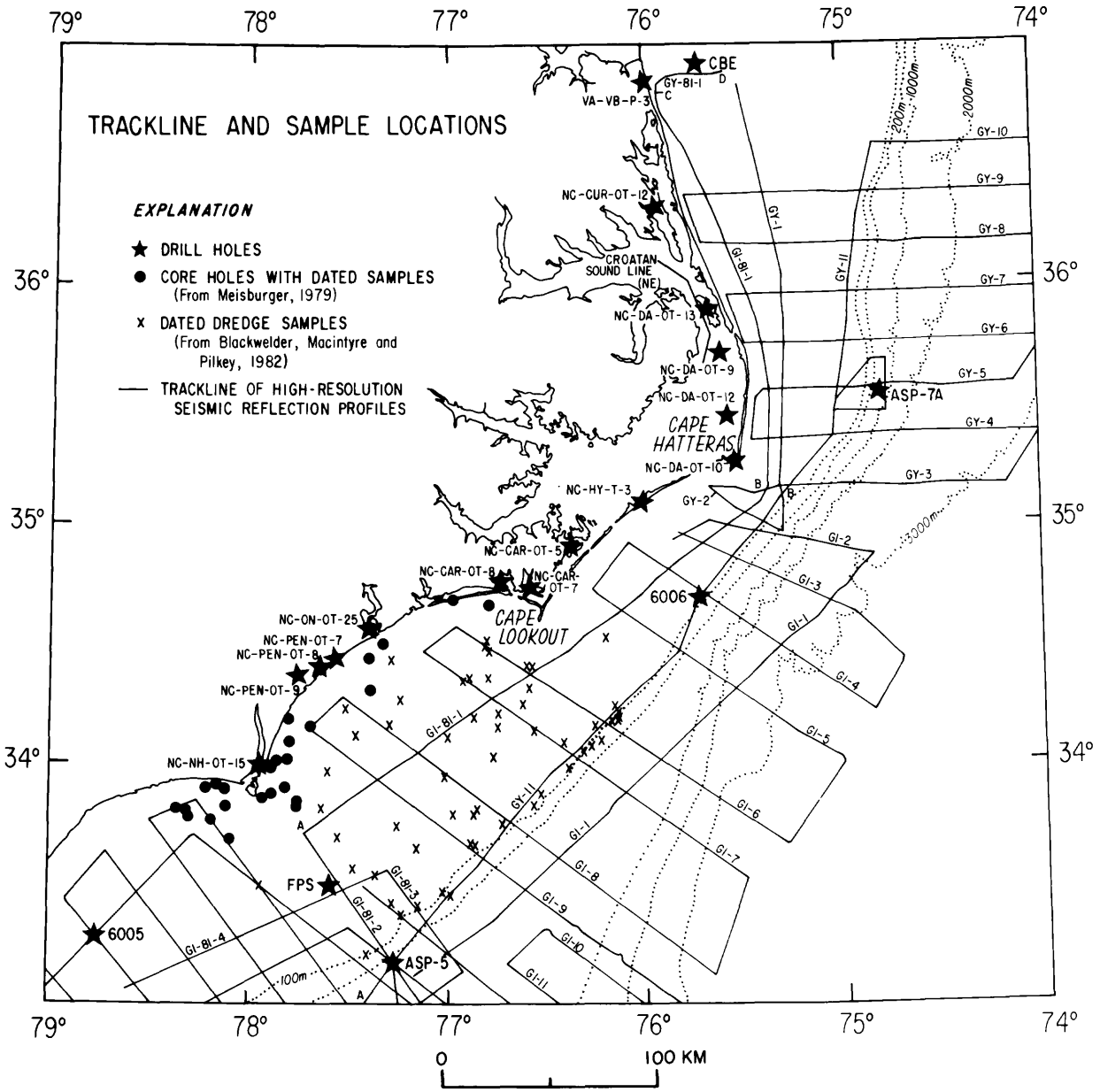

Figure 1: Location of tracklines of USGS operated cruises between 1979 and 1982 on which high-resolution seismic-refraction data was obtained and locations of existing geologic sample control. GI = R. V. GILLIS cruise 7903-6 (Popenoe, 1983); GY = R.V. GYRE cruise 80-G-9 (Popenoe and Meyer, 1983); GY = R.V. GYRE cruise 81-G-14 (Popenoe, 1983); Croaton Sound Line = R. V. NEECHO cruise NE-82-1 (Popenoe and Ward, 1983).

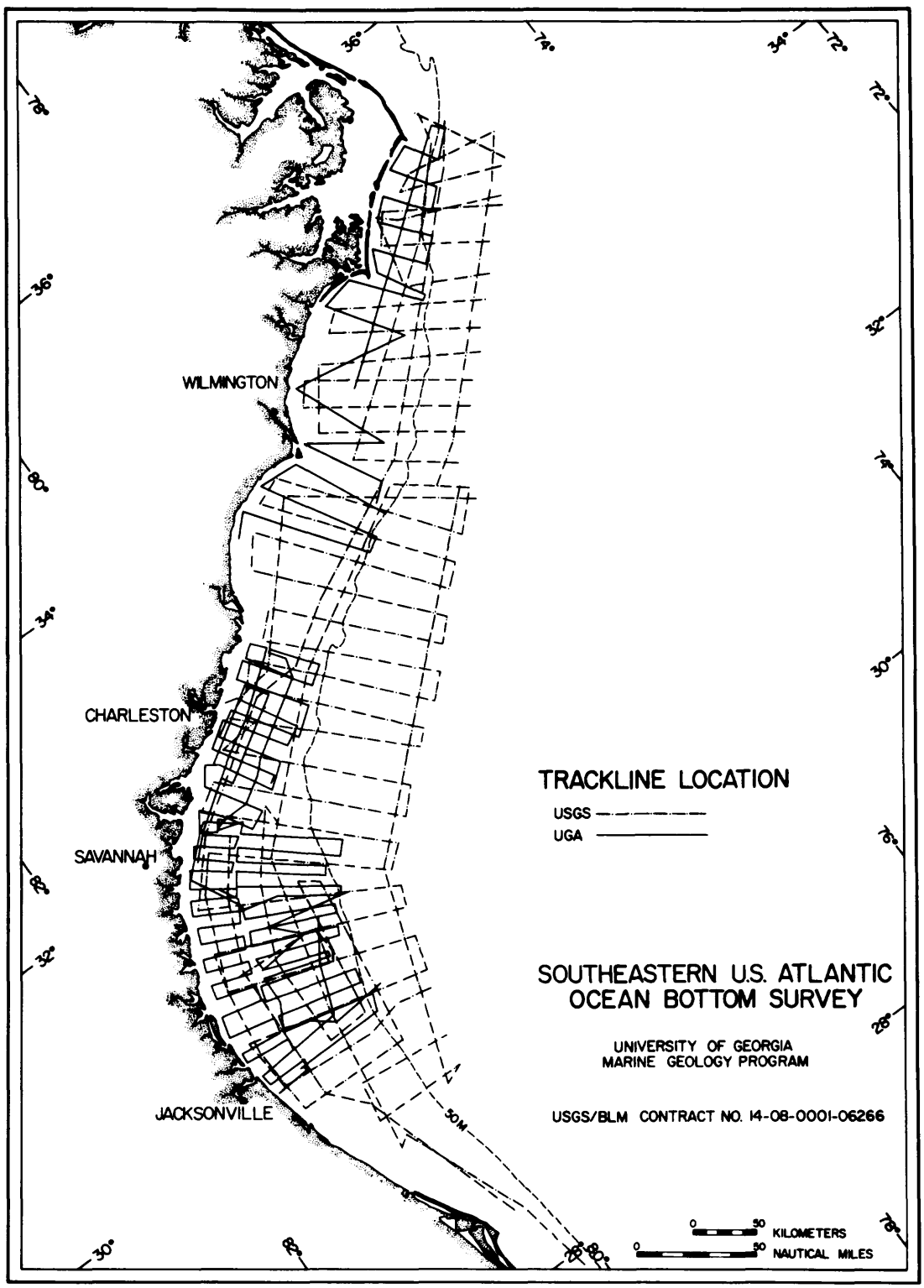

Figure 2: Location of tracklines obtained by the University of Georgia (UGA) to study the reefs and hardgrounds and shallow geologic structures of the continental shelf. Also shown are USGS tracklines used in the UGA study..

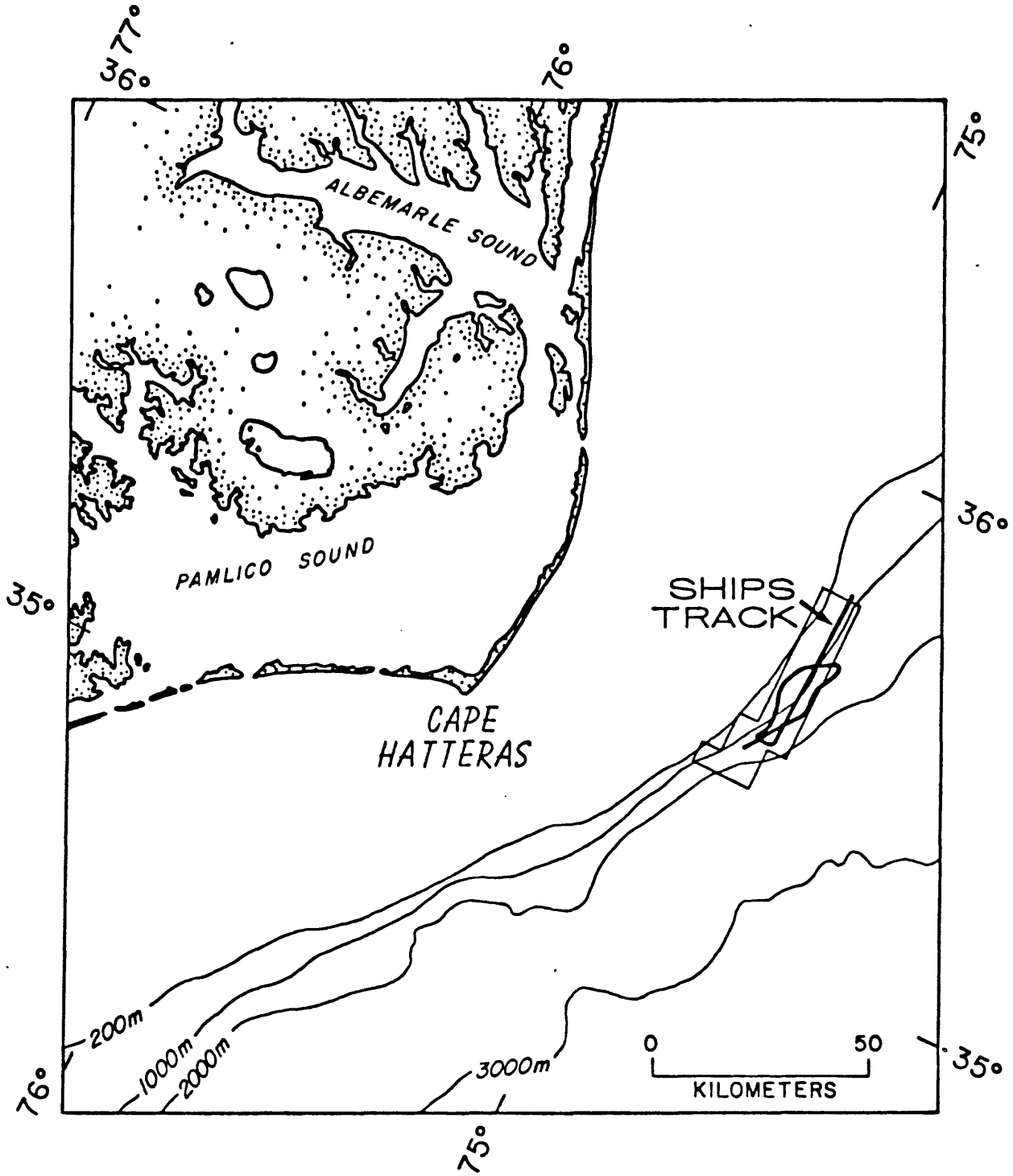

Figure 3: Location map showing ship's track line along which sidescan sonar data were acquired, and nominated lease blocks boundary in the Manteo quadrangle, Federal OCS Lease Sale 56 (from Popenoe, Cashman, Chayes, and Ryan, 1981).

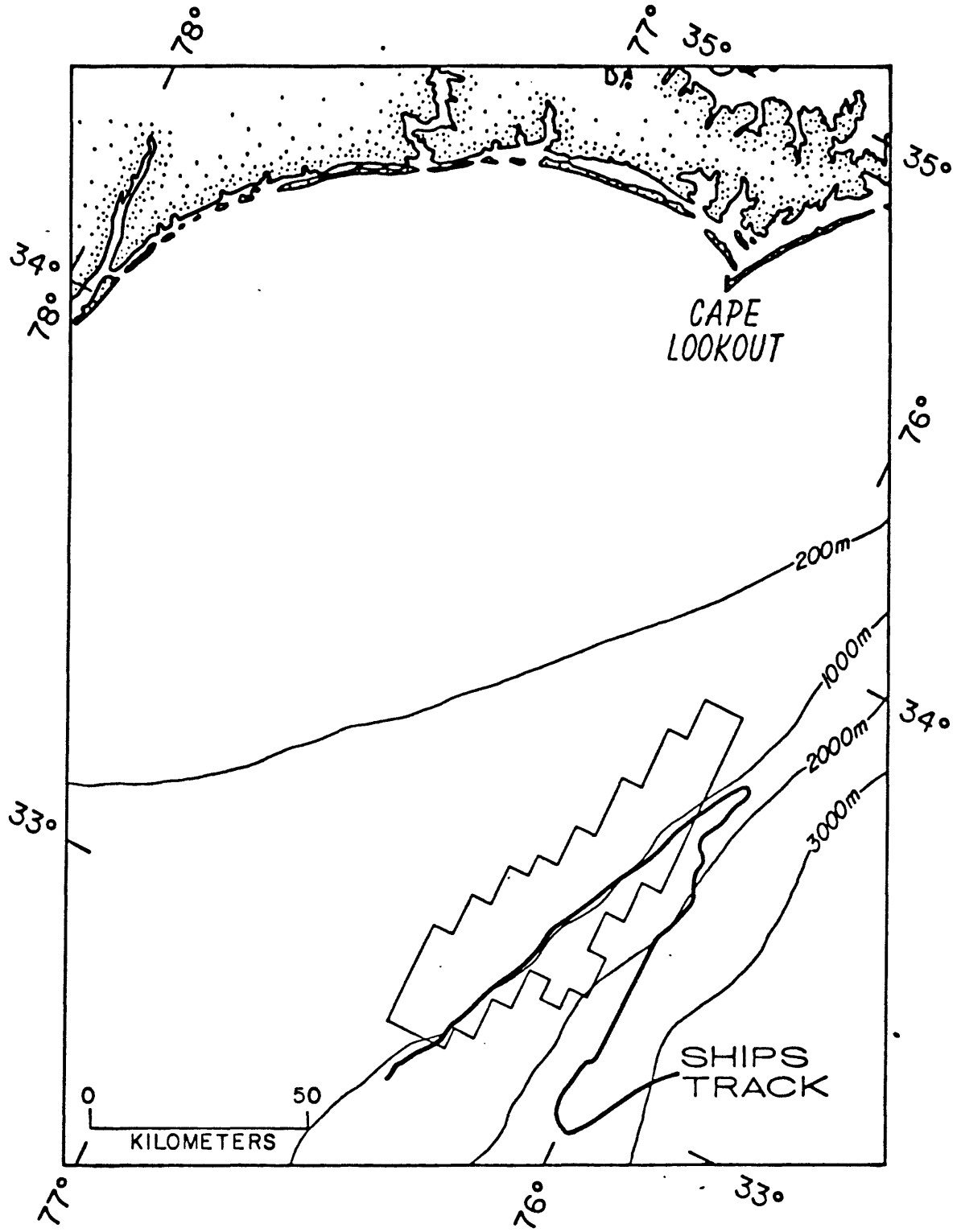

Figure 4: Location map showing ship's track line along which sidescan sonar data were acquired and nominated lease blocks boundary in the Cape Fear quadrangle, Federal OCS Lease Sale 56 (from Popenoe, Cashman, Chayes, and Ryan, 1981).

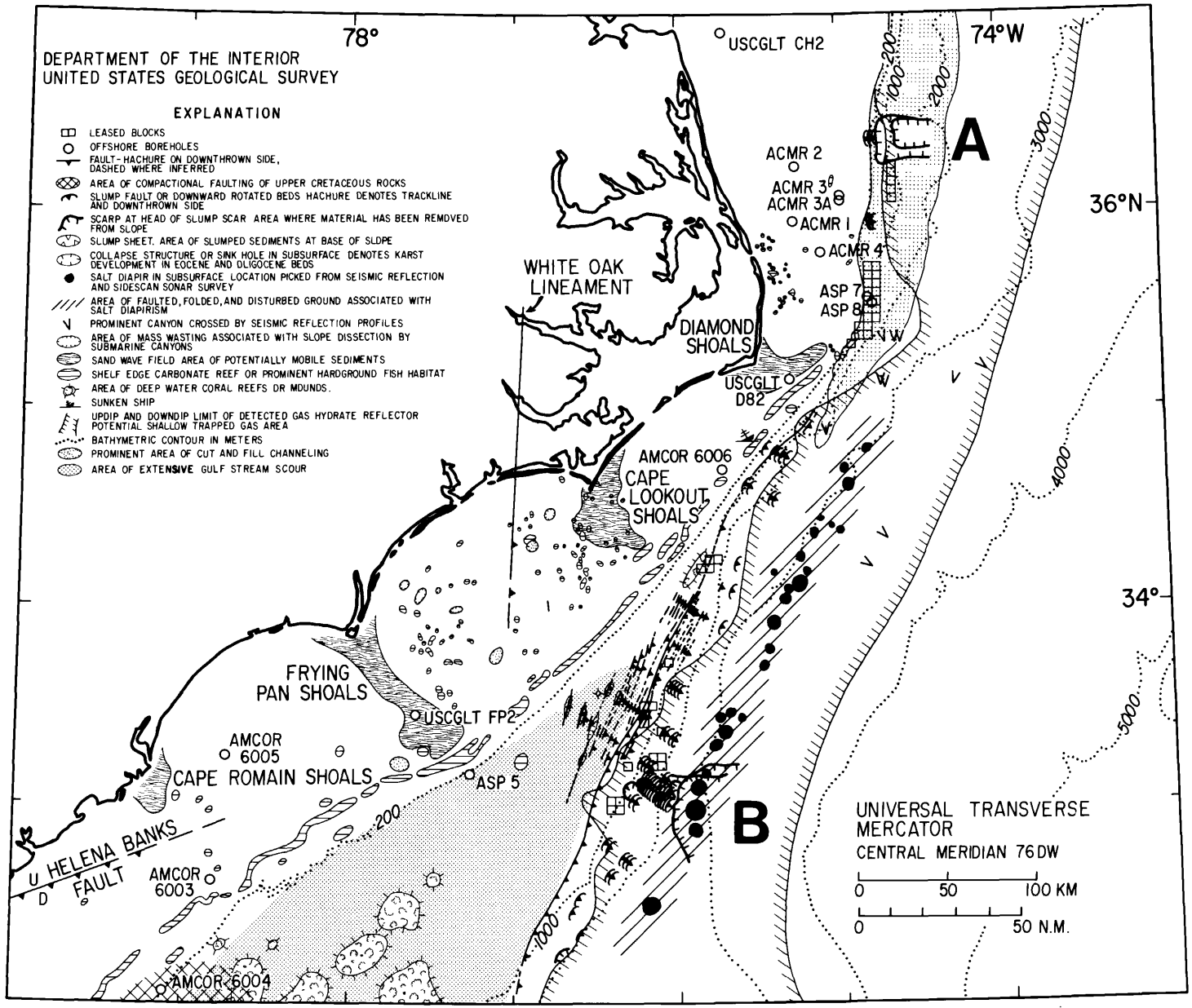

Figure 5: Geologic hazards map of the North Carolina continental margin (from Popenoe, Coward, and Cashman, 1982).

Appendix A

PUBLICATIONS

U.S. GEOLOGICAL SURVEY
ENVIRONMENTAL ASSESSMENT PROGRAM
IN COOPERATION WITH THE BUREAU OF LAND MANAGEMENT
AND THE MINERALS MANAGEMENT SERVICE

SOUTH ATLANTIC

Title:

Contract No.: AA550-MU6-56

Contract Year: 1976-1977

Final Report:

Popenoe, Peter, ed., 1980, Final report--Environmental studies, southeastern United States Atlantic Outer Continental Shelf, 1977--geology: U.S. Geological Survey Open-File Report 80-146, 651 p., 3 sheets, 6 microfiche, containing the following chapters:

Chapter 1. Introduction by Peter Popenoe.
Chapter 2. Seston of the Southeast Georgia Embayment by Larry J. Doyle, Peter R. Betzer, Martin Peacock, and Frederick Wall
Chapter 3. Turbidity in the Southeast Georgia Embayment by Michael H. Bothner
Chapter 4. Bottom currents and bottom sediment mobility in the offshore Southeast Georgia Embayment by Bradford Butman, David W. Folger, and Stephanie Pfirman
Chapter 5. Surficial sediments of the U.S. Atlantic Southeastern United States Continental Shelf by Orrin H. Pilkey, Fred Keer, and Stephanie Keer
Chapter 6. Vibracore studies: Georgia Embayment Shelf by Mark Ayers, Blake W. Blackwelder, James D. Howard, Fred Keer, Harley Knebel, and Orrin H. Pilkey
Chapter 7. Trace metal concentrations in sediment cores from the Continental Shelf off the Southeastern United States by Michael Bothner, Phil Aruscavage, Wayne Ferrebee, and Joan Lathrop
Chapter 8. Distribution and occurrence of reefs and hardgrounds in the Georgia Bight by Vernon J. Henry and Robert T. Giles
Chapter 9. Southeast Georgia Embayment high-resolution seismic-reflection survey by Douglas W. Edsall
Chapter 10. The geology of the Florida-Hatteras slope and inner Blake Plateau by Charles K. Paull and William P. Dillon
Chapter 11. South Atlantic Outer Continental Shelf hazards map by Mahlon Ball, Peter Popenoe, Michael Vazzana, Elizabeth Coward, William Dillon, Thomas Durden, Jack Hampson, and Charles Paull
Appendix I Cruise reports (microfiche)
Appendix 2A-G (to accompany chapter 2)
Appendix 3A (to accompany chapter 2

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Contract Year: 1977-1978

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Chapter 2. Components and pathways of seston flux of the Georgia Embayment by L. J. Doyle, P. R. Betzer, Zack Clayton, and M. A. Peacock
Chapter 3. ^{210}Pb in sediment cores from the Atlantic Continental Shelf: Estimates of rates of sediment mixing by Michael H. Bothner and Peter P. Johnson
Chapter 4. Sediments and sedimentary processes as interpreted from piston cores and grab samples from the Continental Slope of the southeastern United States by Larry J. Doyle, Frederick M. Wall and Paul Schroeder
Chapter 5. Piston core and surficial sediment investigations of the Florida-Hatteras Slope and inner Blake Plateau by Mark W. Ayers and Orrin H. Pilkey
Chapter 6. Ocean bottom survey of the Georgia Bight by Vernon J. Henry, Jr., Charles J. McCreery, Francis D. Foley, and David R. Kendall
Chapter 7. Seismic stratigraphy of the northern and central Blake Plateau by Paul R. Pinet, Peter Popenoe, Susan M. McCarthy, and Marshall L. Otter.
Chapter 8. An assessment of potnetial geologic hazards of thenorthern and central Blake Plateau by Paul R. Pinet, Peter Popenoe, Marshall L. Otter, and Susan M. McCarthy
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Appendix 2-5 (To accompany chapters 2-5, respectively, microfiche)

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Contract No.: AA851-IA1-15

Contract Year: 1980-1981

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Contract No.: AA851-IA2-26

Contract Year: 1981-1982

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Title:

Contract No.: AA851-IA2-26

Contract Year: 1981-1982

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