I.O.S.

MV FARNELLA

CRUISES 1/85 – 4/85

7 AUGUST – 3 DECEMBER 1985

GLORIA STUDIES OF THE EXCLUSIVE ECONOMIC ZONE OFF THE EASTERN UNITED STATES OF AMERICA, GULF OF MEXICO AND PUERTO RICO.

CRUISE REPORT NO. 185

1986

NATURAL ENVIRONMENT RESEARCH COUNCIL

INSTITUTE OF OCEANOGRAPHIC SCIENCES

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INSTITUTE OF OCEANOGRAPHIC SCIENCES

WORMLEY

MV FARNELLA

Cruises 1/85 - 4/85

7 August - 3 December 1985

GLORIA studies of the Exclusive Economic Zone off the eastern United States of America, Gulf of Mexico and Puerto Rico

Principal Scientists

N.H. Kenyon, D.G. Masson, L.M. Parson & R.G. Rothwell

CRUISE REPORT NO. 185

1986

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SCIENTIFIC PERSONNEL		Leg 1	Leg 2	Leg 3A	Leg 3B	Leg 4
Mr. Kim Benjamin	Engineer	X		X		
Mr. Dann Blackwood	Photographer				X	X
Mr. Robert Commeau	Geologist			X		
Dr. William Dillon	Geologist				X	
Dr. Terry Edgar	Co-chief				X	
Dr. Robert Halley	Geologist					X
Ms. Elsa Hernandez	Observer					X
Dr. Gary Hill	Geologist				X	
Dr. Bonnie McGregor	Co-chief	X	X			
Mr. Steve Mateus	Geologist			X		
Dr. Robert Mattick	Geologist	X				
Dr. Charlie Paull	Geologist			X		
Mr. Chris Polloni	Shipboard Computing					X
Dr. Raphael Rodriguez	Geologist					X
Ms. Kathy Scanlon	Co-chief				X	X
Dr. John Schlee	Geologist		X			
Dr. William Sweet	Geologist	X				
Mr. Juan Trias	Geologist					X
Mr. Dave Twichell	Co-chief			X	X	
Dr. Page Valentine	Geologist			X		
IOS						
Mr. Martin Beney	Shipboard computing					X
Mr. Derek Bishop	GLORIA engineer	X		X	X	
Mr. Robin Bonner	Air-gun technician			X	X	
Mr. Jon Campbell	GLORIA engineer			X	X	X
Mr. John Cherriman	GLORIA engineer			X	X	
Mr. Edward Cooper	Shipboard computing		X			
Mr. Eric Darlington	GLORIA engineer					X
Mr. Alan Gray	Air-gun technician		X			X
Mr. Andrew Harris	GLORIA engineer			X	X	
Mr. Malcolm Harris	GLORIA engineer					X
Mr. Quentin Huggett	Geologist	X				
Mr. Christopher Jackson	Shipboard computing	X				
Mr. Colin Jacobs	Geologist		X	X	X	

5.

		Leg 1	Leg 2	Leg 3A	Leg 3B	Leg 4
Ms. Doriel Jones	Shipboard computing			X	X	
Mr. Neil Kenyon	Co-chief		X			
Mr. Gareth Knight	Shipboard computing					X
Mr. Derek Lewis	Shipboard computing			X	X	
Dr. Douglas Masson	Co-chief					X
Dr. Lindsay Parson	Co-chief			X	X	
Mr. Guy Rothwell	Co-chief	X				
Mr. Michael Somers	GLORIA engineer	X	X			
Mr. Ross Walker	GLORIA engineer		X			X
Mr. Robert Wallace	Air-gun technician	X				
Dr. Stephen Williams	Geologist	X				

THE EEZ-SCAN PROGRAMME

1986 was the second year of a projected six-year co-operative research programme between the United States Geological Survey (USGS) and IOS to survey the exclusive economic zone (EEZ) of the United States and its island dependencies. The objective for 1986 included the completion of GLORIA sonar coverage for the EEZ lying within the Gulf of Mexico, part of which was surveyed in 1982 during the Farnella cruises 6/82 and 7/82, and seafloor north and south of Puerto Rico. Additional short surveys were to be carried out in the Cayman Trough and the Hispaniola Basin. As well as the GLORIA sidescan system, single channel seismic reflection profiles, recorded with either an 80 or 160 cubic inch airgun, 3.5kHz high resolution profiles, and 10kHz narrow beam echo-sounding profiles were recorded, along with continuous magnetic anomaly profiles.

Like the 1984 EEZ-SCAN programme, the 1985 survey was a resounding success. Despite problems of limited signal propagation by a strong thermocline, troublesome currents, long-line fishing gear intersecting tracklines, and a lively hurricane season, GLORIA sonograph mosaics were completed on board for all the areas, in total covering some 200,000 square nautical miles of seafloor.

Personnel on each of the four legs included UK and US scientists and technical support staff. As in previous years, there were no major problems with the use of the MV Farnella, and once again, the ship's crew were fully supportive of our scientific endeavours. Their collective experience in underway geophysical surveys such as this proved invaluable.

CRUISE NARRATIVE

LEG 1

Objectives - Scientific objectives included:

1. To complete a reconnaissance survey using overlapping sidescan data of the western part of the Gulf of Mexico lying within the US 200 nautical mile zone and in waters deeper than approximately 500m.
2. To complete sonar and seismic cover of the complex continental slope west of the Mississippi Fan, extensively deformed during recent salt tectonism.
3. To complete the sonar cover of the East Breaks Slide, a major submarine failure, first surveyed in part during the 6/82 Farnella cruise.

Narrative

Farnella sailed from Miami at 1000hrs (all times are local) August 7th, in pleasant weather. The 10kHz and 3.5kHz profilers were deployed at 1910hrs. GLORIA, the 80 cubic inch airgun and hydrophone streamer were deployed at 0815hrs 8th August. The magnetometer was deployed during 11th August, but was found to be faulty. Some time was spent getting the equipment operational, the GLORIA system going through a number of logging crashes which, coupled with other data losses throughout the leg, only resulted in the loss of about 24 hrs of data. The longest periods of down-time were 12 hrs during August 12th and 5 hours during August 16th. Contamination of the recording heads by dust appeared to have been the main problem and after cleaning and screening of the logger, the GLORIA system functioned well. Some 45,000 square nautical miles of sonograph coverage were obtained during the leg. A major problem was the poor GLORIA signal propagation in areas of strongly developed summer thermocline. Throughout the survey, the system was set to a 30 second pulse repetition rate, theoretically giving a 45 km maximum swath width, although in practice at times this only reached 8km (in water depths of around 1000 metres). This necessitated some reduction of trackline spacing and the inclusion of extra lines.

The seismic reflection profiling system performed well, although a number of problems, including failed hose couplings and clamps, caused trouble. These combined with some compressor trouble led to approximately 24 hours of data being lost. Plate-fin air-gun tails were replaced with tubular stabilisers which reduced some of the excessive wear problems. Experimental towing configurations, including towing the gun back to front were also attempted, with varying degrees of success. The longest periods of downtime occurred during two 7-hour stretches during 9th and 12th August.

Telephone links to the UK and the US were made through radio links to shore stations, as the Inmarsat did not function satisfactorily. The telex link was similarly non-operational. Navigation throughout was by transit satellite fixes and dead reckoning and initially hand plotted because of problems with the Calcomp plotter. Loran C was not useful until 9th August and the Global Positioning System (GPS) was only available for about four hours each day.

All the equipment was continuously deployed throughout the leg, except for 13 hours during 14th August (1139-2150hrs) when the gear had to be recovered due to an encounter with Hurricane Danny. All gear was finally recovered by 1100 hrs on September 1st, in preparation to dock in New Orleans, but a further delay due to the effects of Hurricane Elena meant that the ship could not dock until 2nd September.

Scientific results

Completion of Leg 1 resulted in high quality sonograph coverage of the entire US exclusive economic zone in the western Gulf of Mexico. As with previous legs, an onboard mosaic was constructed on a standard Mercator grid at a scale of 1:375000. Within two main geomorphic provinces - the Sigsbee Deep, forming the central part of the Gulf of Mexico basin; and the Texas-Louisiana slope considerable detail was observed. Fields of sediment waves and other bedforms were mapped in the Sigsbee Deep and variations in backscattering suggests changes in bottom, or sub-bottom sediment character. The Sigsbee Escarpment, marking the seaward edge of the salt front, is seen as a striking, somewhat lobate band of strong acoustic return, cut by a number of re-entrants which mark the sites of sediment pathways. Localised slope failure has resulted in discrete talus aprons along the base of the escarpment. The topography of the Texas-Louisiana slope is complicated by salt tectonism and diapir fields were identified and successfully mapped throughout the GLORIA survey. A prominent channel traced from the upper slope into the Sigsbee Deep is blocked on the mid-slope by the local effects of recent salt tectonism.

LEG 2

Scientific Objectives

The area to be covered in the second of the 1985 surveys extended from near the shelf break to the median line with Mexico, and the overlapping coverage was intended to include part of the West Florida Escarpment and Desoto Canyon, with a main objective to complete the sonar mosaic of the Mississippi Fan.

Narrative

Farnella sailed from New Orleans at 1000hrs (local) 5th September after a delayed arrival due to the closure of the Mississippi to navigation by hurricane Elena. Shortly after sailing, we were obliged to anchor for 7 hours whilst the automatic steering gear was repaired. The PES and the 3.5 kHz fish were deployed in fine weather at 1000hrs on 6th September, but because of a problem with the diesel compressor operating both the air-gun capstan and the GLORIA launching gantry, we were unable to lauch the main survey equipment to get on line until 1400hrs. The remainder of the cruise was carried out with minimal down-time, and on the whole, all scientific equipment worked well.

Leg 2 started several days behind schedule mainly because the very warm surface waters present at this time of the year had restricted the GLORIA range during Leg 1, and this proved to be a continuing problem during Leg 2. The line spacing on both legs was closer than had been originally planned. The pre-cruise range predictions for the GLORIA cruise to the Gulf in the winter of 1982 proved very accurate. The presence of the loop current for the last half of the cruise further delayed our progress in the southeast, and in the northeast near Desoto Canyon, fishing boats with long-lines set across our proposed tracks caused several tracks to be terminated early. By the end of the leg we were 8 days behind schedule.

The weather was favourable for the entire leg. Several hurricanes were tracked towards the Gulf including one that we seemed destined to meet up with, Hurricane Gloria. Fortunately, all turned off north before we encountered them.

By the time the ship docked in Tampa, Florida, at 1000hrs on 29th September, we had completed GLORIA coverage of approximately 45000 square miles of seafloor.

Two complete mosaics of the GLORIA data were made at a scale of 1:375000, with the quality of the prints being consistently high. The current shear present when the loop current was flowing across the line of our track, locally caused the GLORIA fish to tow oblique to the tracks. This introduced some distortion into the mosaics, especially at the eastern ends of the lines as we approached the west Florida Escarpment. Some of the distortion was removed initially by cutting the shipboard prints into short sections and mounting them oblique to the trackline. It is anticipated that some of this distortion will be removed by the post cruise digital processing. There appeared to be little in the way of yaw effect.

Scientific Results

Five days of GLORIA survey had been obtained in the Gulf of Mexico in 1982, half on Farnella 6/82, funded by NERC, and half on Farnella 7/82, funded by the Joint Oceanographic Institutions, Inc. On that occasion, the lone mid-fan channel on the Mississippi Fan had been discovered, as had flow patterns on the Mississippi Fan slide. The 1985 mosaic of the entire fan revealed the link between the mid-fan channel and the Mississippi Canyon, and also the termination of the channel on the lower fan. Mass sliding appears to be an important process in the distribution of sediments in the deep water of the central Gulf. Multiple slide events were mapped on the Mississippi Fan and slides were also mapped at the foot of the West Florida Escarpment, and the Desoto Canyon area. A number of previously unmapped buried channels, seen as high amplitude reflectors within the sediments of the Mississippi Fan, appear to originate from east of the Mississippi Canyon. A meandering leveed channel was traced from Desoto Canyon, and is spectacularly overwhelmed by submarine slides in both its upper and lower reaches. On the latest Mississippi fan lobe there are many traces of very low relief, straight channel-like features. These trend downslope at right angles to the main flow channel and are confined to its southern and western flank. The origin of these unusual features remains conjectural. Apparently cyclic sequences of seismic reflectors beneath the deep Gulf, imaged well on seismic data throughout the Gulf, are believed to indicate a history of repeated formation mainly during successive periods of low sealevel. The survey of the eastern end of the Sigsbee Escarpment was completed and various groups of salt diapirs were differentiated from their different surface effects.

LEG 3

Scientific Objectives

Leg 3 was split into two parts. The first being the longer of the two and wholly devoted to the completion of GLORIA cover of the Gulf of Mexico. The second, shorter, part would include short reconniassance surveys of the Cayman Trough and the Hispaniola Basin during an extended passage line between Key West and Puerto Rico.

Specific objectives included:

1. To complete the survey of the West Florida Escarpment, and to examine the processes both past and present contributing to the morphology of the shelf and slope.
2. To complete the GLORIA cover of the Walker-Massingill slide, a submarine failure of the mid - and lower Mississippi fan identified in earlier GLORIA work.

Narrative - Leg 3A

The ship departed Tampa at 1000hrs (local) 2nd October, having completed de-finning modifications to the remaining air-gun tails. The weather was calm and warm, enabling some repair work to the hydrophone streamer to be completed on passage to the start point. The 3.5 kHz fish and the 10 kHz echo-sounder were deployed 1830hrs. GLORIA and the seismic system were launched successfully in flat, calm conditions 0830hrs 3rd October. Loran C was clearly no longer reliable and damage to it during a lightning storm in port at Tampa was suspected. GPS was useful for approximately four hours each day throughout the cruise, with Satnav supported occasionally by the ship's own Omega transit navigation system. Wiring problems in the GLORIA logger, resulting in overwriting of passes, lost us some 11 hrs of data at the start of the cruise but this did not seriously affect our total coverage. Mismatch of contrast levels between leg 2 and leg 3 sonographs required a new crater tube in the Muirhead. Contrast recalibration of the new tube caused more delays to mosaic preparation.

More failures to the airgun tails lost us several hours of recording, but one of the most persistent problems encountered at the Northern limit of the survey was, again, the presence of long-line fishing trawls transverse to our projected tracks. On one occasion, non-communicative fellow seafarers cost us several hours of useful GLORIA record, and occasioned some unusual track configurations. Other ship traffic was minimal, although increased towards the Straits of Florida. All the gear was recovered by 1530hrs 21st October, in good condition, apart from some leakage from the hydrophone streamer. We docked in Key West at 0900hrs 22nd October.

Scientific results

1. The most startling result of this leg proved to be the discovery that the Walker-Massingill slide extended almost to the southernmost margin of the Gulf of Mexico. Ribbons of strong acoustic return, first recognised on an early transit line during Leg 1 appear to mark the distal limit of material derived from the slide. The slide is also easily recognisable as a composite failure, with several lobes or slide aprons readily recognisable in its north-eastern part.

2. Slope processes and failure systems were imaged well by the GLORIA system, and interpreted in conjunction with excellent 3.5kHz profiles. A smooth gradation from open, soft sediment slump folding on the Escarpment, through small scale sliding and slumping, to complete upper shelf failure and stripping of recent sediment can be recognised.

Narrative Leg 3B

Departed Key West 1500hrs 22nd October in glorious warm weather, heading for the Cayman Trough survey area. GLORIA and the rest of the survey equipment was deployed 0800hrs 24th October in perfect conditions. Along-track smearing of the starboard side GLORIA images at mid - to full range was more evident over the basement topography of the Cayman Trough. This was thought to be a problem with the resolvers. We experimented with a 40 second rate after the Cayman Trough grid had been completed. Loran C was no longer useful at night despite the replacement of the antenna, and reliance was placed fully on Satnav and dead-reckoning. Despite the computer's reluctance to accept fixes put in by hand, it proved possible to force updates using GPS positions provided they were at the same time as a rejected satellite fix. The 3.5kHz fish had to be replaced once following a build up of noise and the subsequent discovery of a faulty connection. Other irritating data losses included a circuit board failure in the magnetometer recorder, and time and data were lost whilst experimenting with a wave-shape kit fitted to the 160 cu in gun. This proved less successful than we had hoped and we resorted to the 80 in gun with no WSK. During 30th and 31st October we sustained five shark attacks to the synflex airline hose supplying the airgun, requiring repair by section inserts each time. The seismics were recovered soon after the end of the Hispaniola Basin survey at 2230hrs 31st October, and more speed was made with GLORIA and the 3.5

and 10kHz systems alone. GLORIA was recovered at 0000hrs 2nd November, and we docked at San Juan at 0800hrs 2nd November.

Scientific results

1. An overlapping coverage of the central section of the Cayman Trough was completed, and revealed much detail of this slowly-spreading extensional basin. Sections of well developed lineated oceanic basement alternate with areas of broad constructional volcanic ridges, suggesting variations in the accretionary processes operating at the spreading axis.
2. Growth anticlines recorded on seismic reflection profiles in the Hispaniola Basin, and associated with the complex plate junction bounding Puerto Rico, were imaged well using GLORIA. Mass-wasting of the crests and flanks into talus and debris aprons is clearly recognisable.

LEG 4

Narrative

Farnella sailed from San Juan at 1315hrs (local time) Monday 4th November to begin the survey of the EEZ north of Puerto Rico. It was decided that we would steam to the northern edge of the EEZ before beginning the survey as this would allow time for the preparation and repair of the geophysical equipment. In addition, this area being the southern edge of the Nares Abyssal Plain would be geologically and morphologically less complicated than the remainder of the EEZ, and would thus allow our largely inexperienced watchkeeping staff a gentle introduction to their work.

Deployment of the geophysical gear (GLORIA, single channel seismic reflection profiler, 3.5kHz high resolution profiler, 10kHz precision echo-sounder, magnetometer) began at 0800hrs Tuesday 5th November and was completed by 0930hrs. Weather was good with little wind and a gentle NE swell. It was decided to begin surveying on NW-SE orientated lines as these intersected the expected trends at a high angle and because this would put us beam on to the prevailing swell direction. The survey direction would not have to be changed if, as expected, the season of NE trade winds began during the survey period. The first survey line was begun at 1600hrs 5th November. Making use of the great water depth and the near ideal sound propagation conditions,

the GLORIA survey was begun using the maximum range 40 second pulse repetition rate. However, it was quickly realised that the greater resolution of the shorter 30 second rate would give better results and that sufficient time was available to survey the deep water area using this range and a 20 to 30 nautical mile track spacing. This allowed the entire area to be surveyed using a 30 second scan, removing potential survey and processing problems. GLORIA was switched to a 30 second rate at 1750hrs 5th November.

Routine surveying on NW-SE tracks continued until 1000hrs 8th November, when it was agreed that we should take advantage of the continuing good weather to run four E-W lines along the shallower part of the Puerto Rico continental slope. The only problem during the first few days was obtaining satisfactory prints from the Muirhead camera. A great deal of effort had to be applied before acceptable light intensities were obtained, and the first prints were not produced until the 7th November.

The E-W lines along the north Puerto Rico slope were occupied between 1000hrs 8th and 2000hrs 11th November with excellent results. The weather began to deteriorate during the last easterly line with 20 knot ENE winds and a large long-period swell; ship's speed was reduced to 6 knots during the latter part of the slope survey. At 2000hrs we broke off the slope survey and returned to NW-SE oriented lines. Farnella rolled particularly well in the large swell, and for the first time in this year's USGS/IOS survey, the scientific crew were occupied with securing the scientific equipment.

Survey of the Northern Puerto Rico EEZ was completed between 1600hrs 5th November and 1130hrs 15th November in moderate winds and seas. The geophysical gear was recovered between 1130hrs and 1315hrs 15th November and we sailed close to the port of Mayaguez in western Puerto Rico to change scientific personnel. The 3.5kHz fish which had been producing an increasingly noisy record was also changed while we were in sheltered water.

Crew change completed, we sailed south through the Mona Passage to begin the southern Puerto Rico EEZ survey. The geophysical gear was redeployed between 1645hrs and 1730hrs 15th November and all survey instruments were operational by 1800hrs. We immediately began surveying the southern Puerto Rico continental slope using slope-parallel (approximately E-W) tracks. During 17th November, warnings of Hurricane Kate, forming some 100 miles north of Puerto Rico, persuaded us to remain in the eastern part of our survey area,

where we ran two N-S survey lines along the western margin of Saba Bank. By 1400hrs 18th November, however, it was clear that Hurricane Kate was moving off to the NW, and we were able to resume our E-W continental slope survey.

During 18th November, the navigation system began to give trouble by refusing to accept any satellite fixes. This problem, and a further problem resulting from false headings being entered into to navigation system, plagued us in greater or lesser amounts until the end of the cruise, although tracks were eventually produced retrospectively for the entire cruise. The false headings were eventually traced to a fault on the gyro compass encoder and this problem was finally cured in the last few days of the cruise.

The southern Puerto Rico survey was completed on E-W lines between 1730hrs 15th November and 1600hrs 2nd December in moderate to good weather. Winds blew consistently from the ENE, but rarely exceeded 15-20 knots, while the slight ENE swell gave only slight ship motion. A number of equipment failures occurred during the latter part of the survey. These included the breakage of several air-gun tails, failure of both the AC and DC compressors, and a continuously noisy 3.5kHz record which was traced to worn bearings in the towing section of the fish. None of these problems, which resulted from general wear over the $3\frac{1}{2}$ month survey period, caused significant loss of data. Most impressively, no downtime was experienced in the GLORIA system.

Surveying was completed during 2nd December. The airgun and hydrophone streamer were recovered at 1300hrs 2nd December to allow time for airgun and compressor maintenance before docking. The remaining geophysical gear was recovered between 1700hrs and 1800hrs 2nd December, after which we began the passage to San Juan. Farnella docked in San Juan at 1100hrs (local) Tuesday 3rd December.

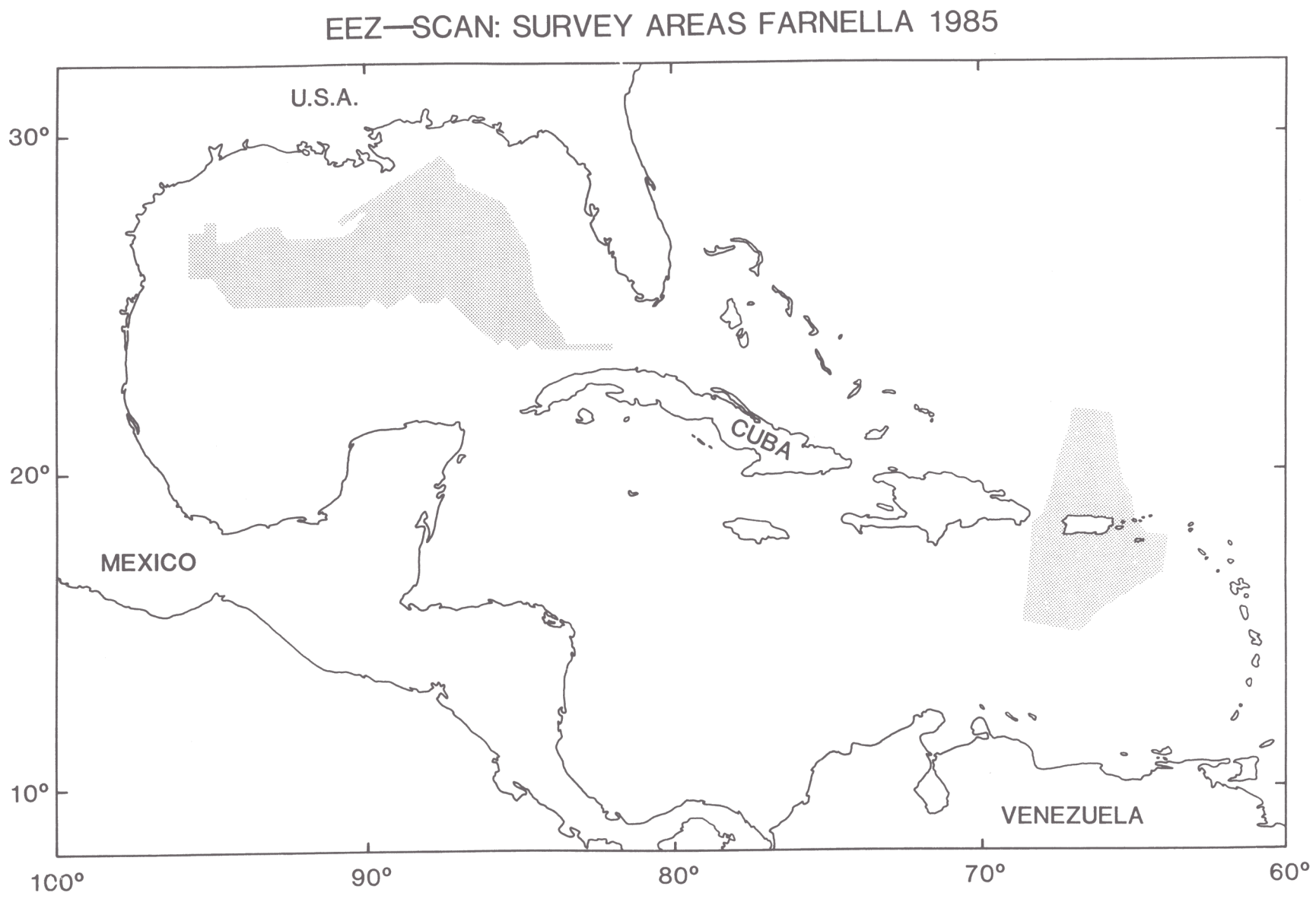

Figure 1: Survey areas covered during 1985 Farnella EEZ-SCAN legs 1-4.

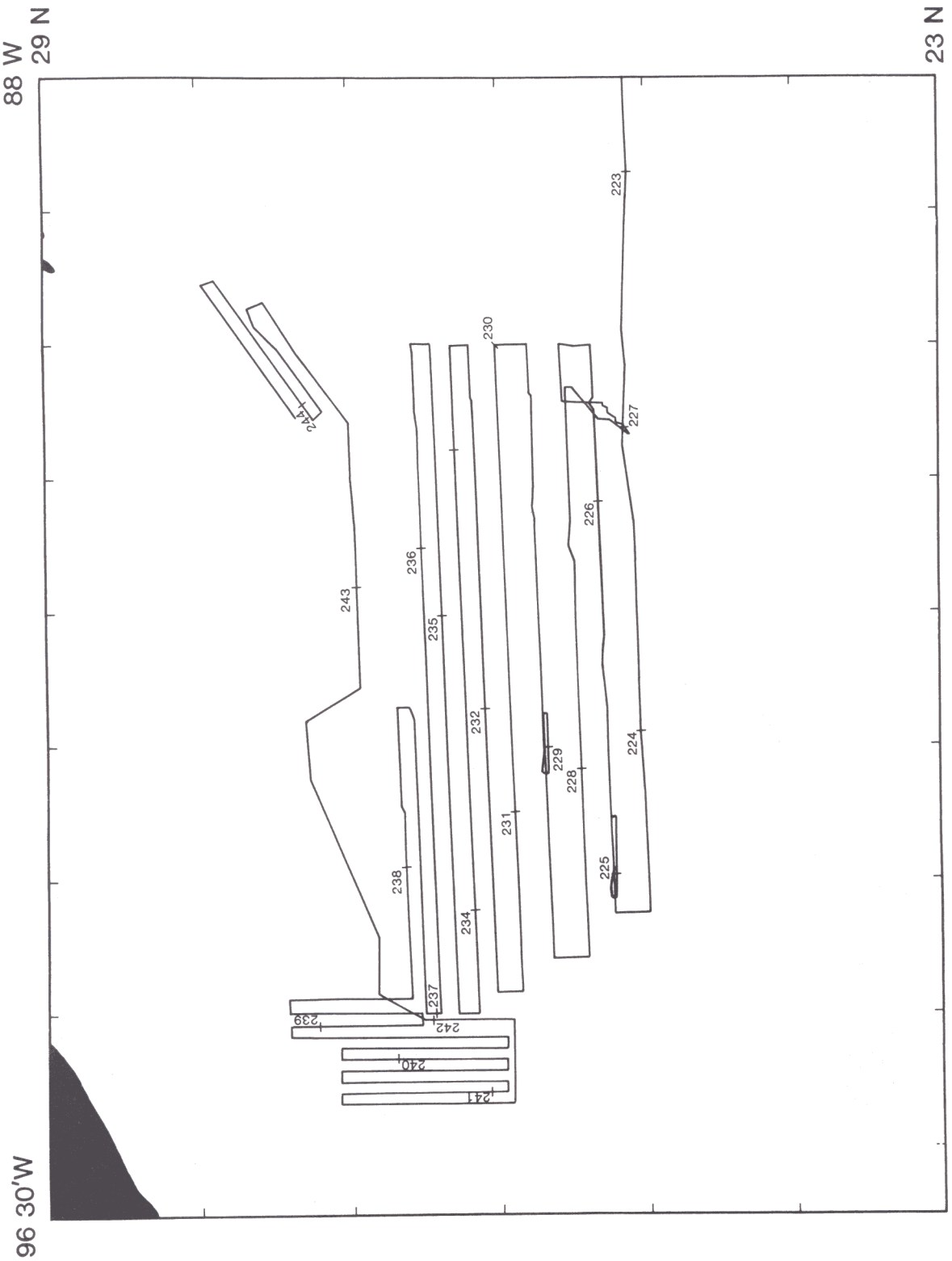

Figure 2: Track line and day numbering for Leg 1, northwestern Gulf and Sigsbee Escarpment.

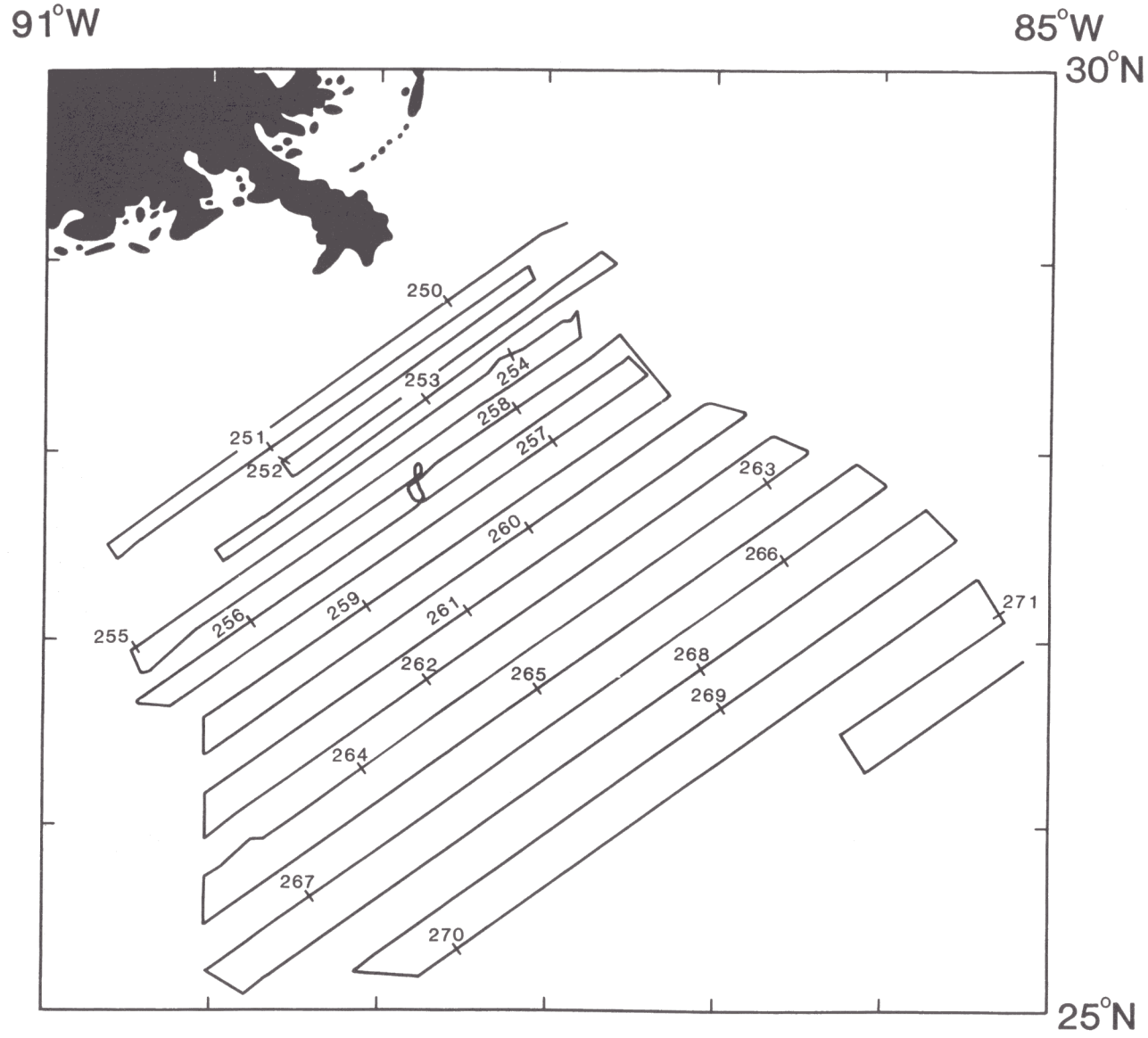

Figure 3: Track line and day numbering for Leg 2, central Mississippi fan and northeastern gulf.

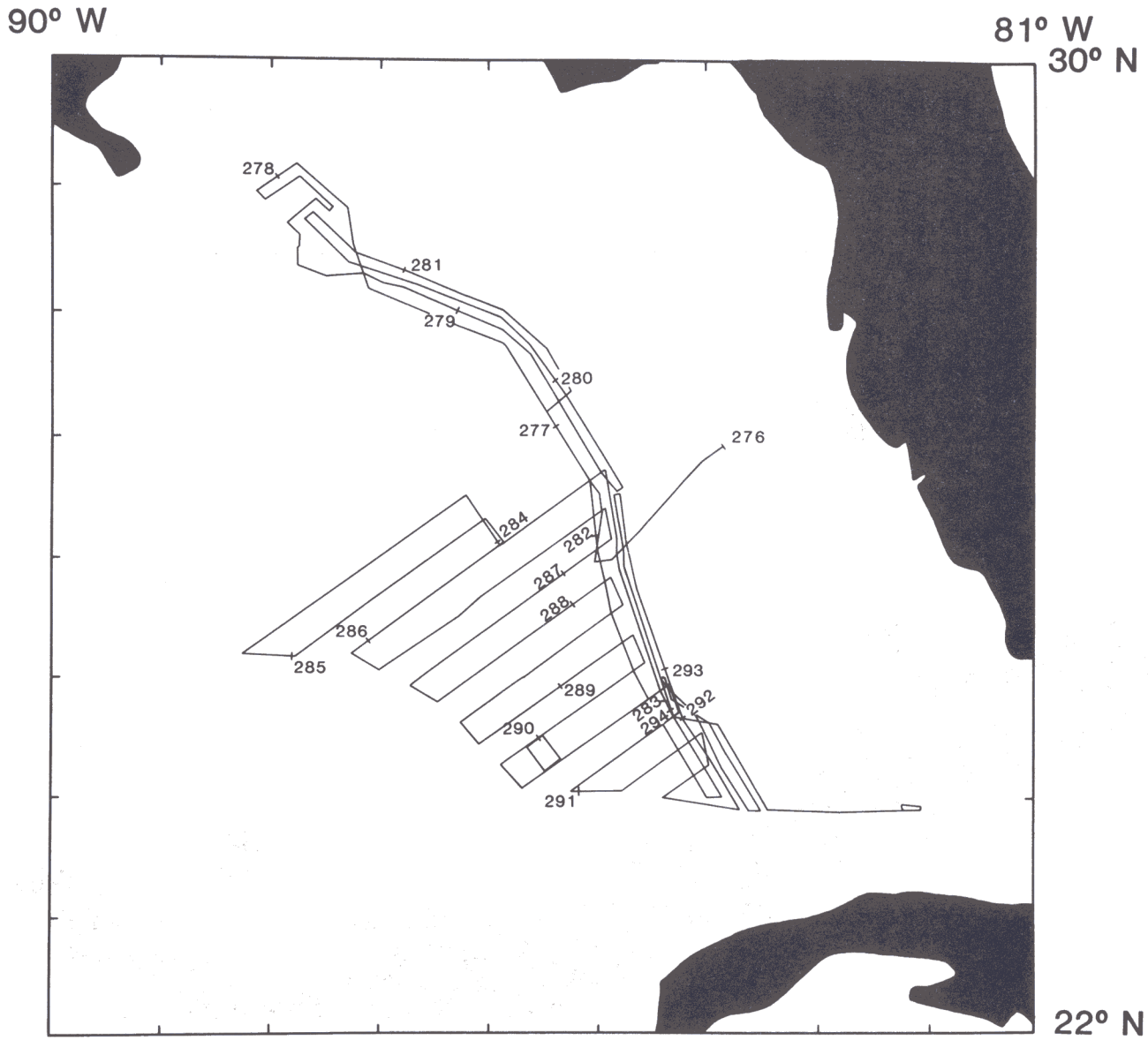

Figure 4: Track line and day numbering for Leg 3A, west Florida Escarpment, southeastern and central gulf.

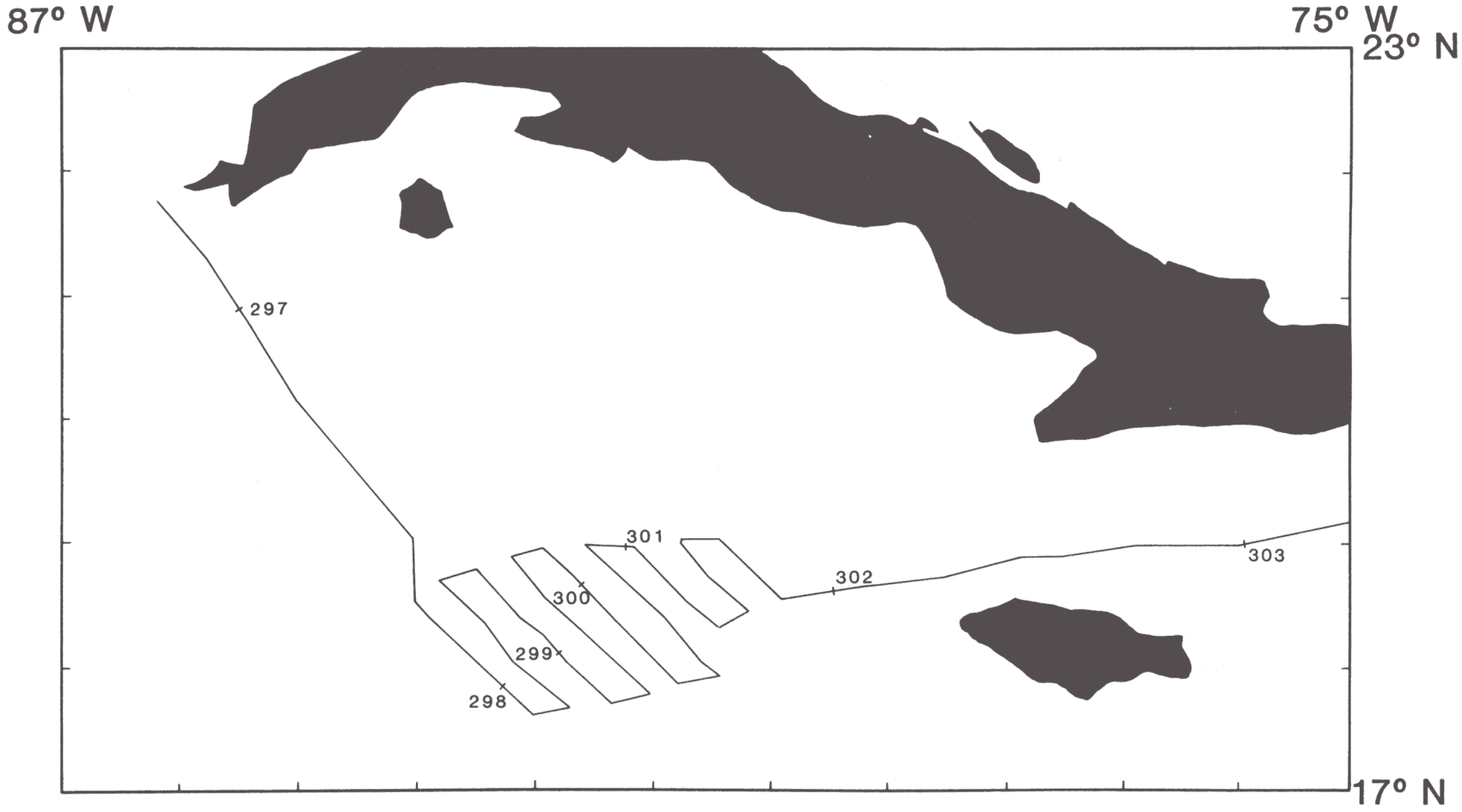

Figure 5: Track line and day numbering for Leg 3B extended transit, Cayman Trough.

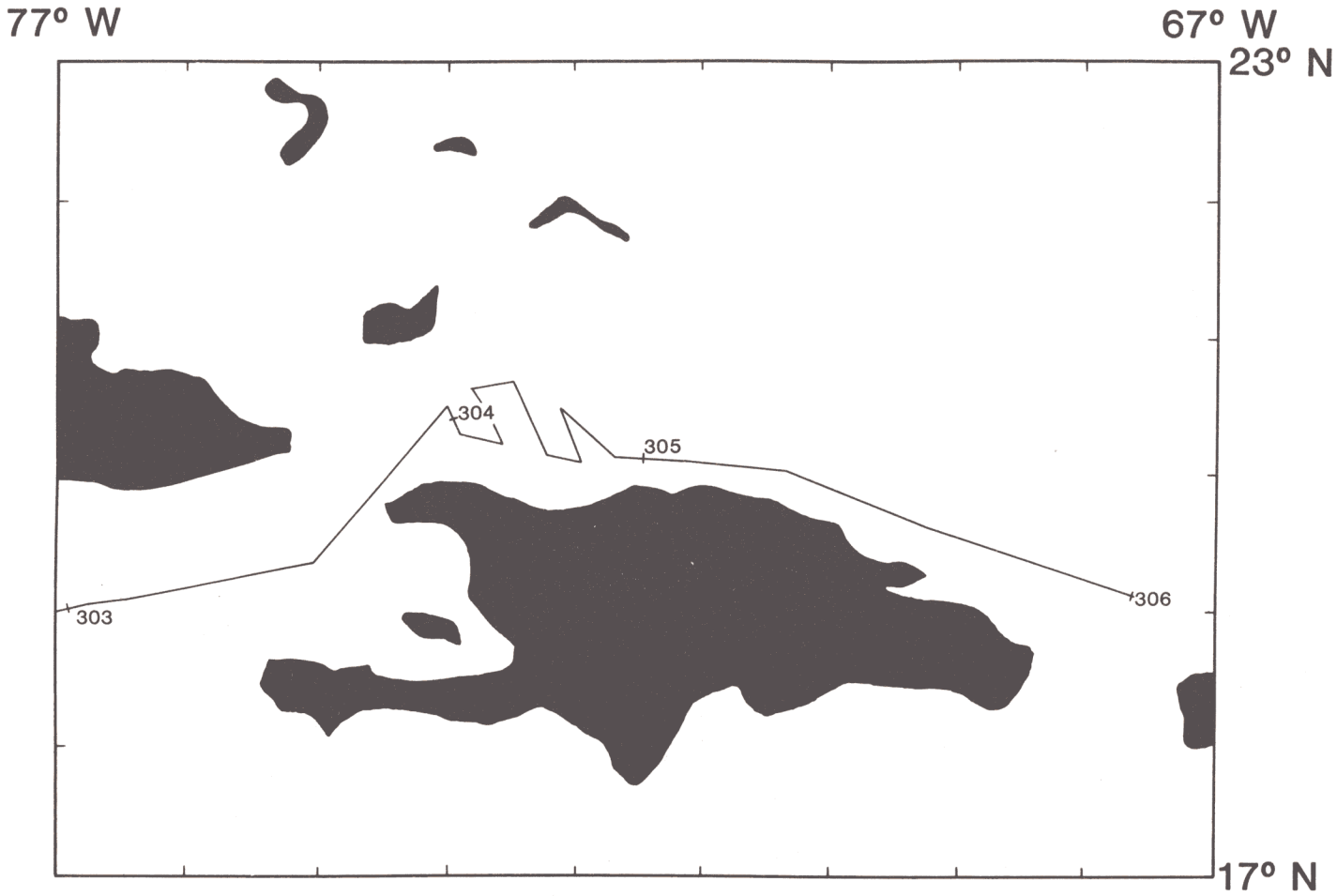

Figure 6: Track line and day numbering for Leg 3B extended transit, Hispaniola Basin.

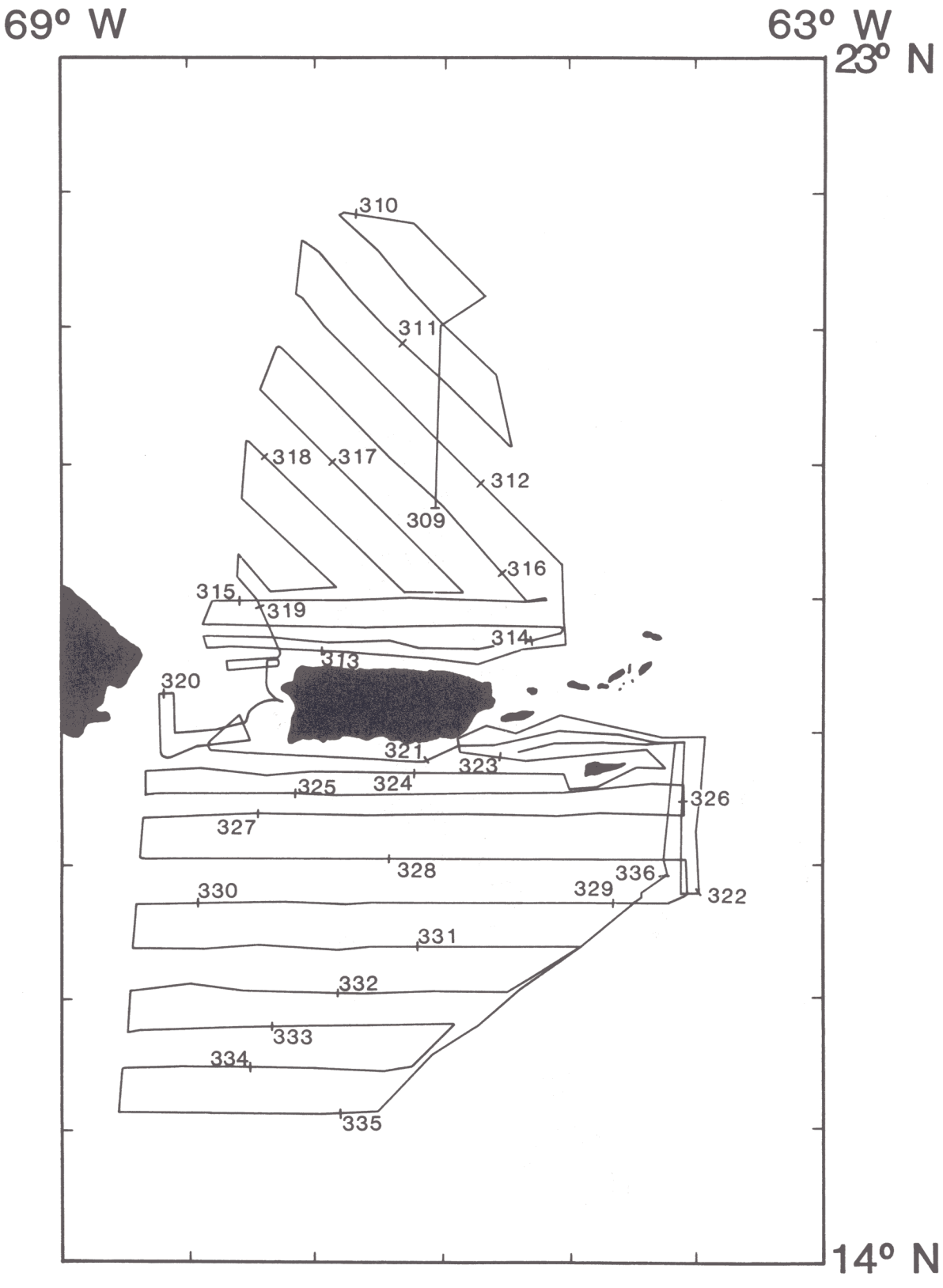

Figure 7: Track line and day numbering for Leg 4, north and south Puerto Rico.

20