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SOUTH TEXAS TOPOGRAPHIC FEATURES STUDY

A Final Report

to the

U.S. DEPARTMENT OF THE INTERIOR

BUREAU OF LAND MANAGEMENT

OUTER CONTINENTAL SHELF OFFICE

NEW ORLEANS, LOUISIANA

Contract No. AA550-CT6-18

From The

TEXAS A&M RESEARCH FOUNDATION

and

TEXAS A&M DEPARTMENT OF OCEANOGRAPHY

September, 1978

RESEARCH CONDUCTED BY THE

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TEXAS A&M UNIVERSITY COLLEGE STATION, TEXAS

THROUGH THE

TEXAS A & M RESEARCH FOUNDATION

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CHAPTER I

INTRODUCTION

AND

OBJECTIVES

INTRODUCTION

AND

OBJECTIVES

Compiled By

Project Co-Directors

Thomas J. Bright
Richard Rezak

In 1976 studies were performed under the Bureau of Land Management (BLM) contract on the nine topographical features (banks) listed in Table I-1 and depicted in Figures I-1 through I-10. Detailed bathymetric charts were produced for Stetson Bank, the East Flower Garden Bank and 28 Fathom Bank, southwest peak (Figs. I-5, I-6 and 1-7).

Descriptive reconnaissance studies were completed in 1976 for Aransas Bank, Blackfish Ridge, Mysterious Bank and 28 Fathom Bank (Fig. 1). A descriptive account of biotic communities inhabiting Claypile Bank was prepared using existing data. The reconnaissance studies include: geology and biology of the banks and surrounding sediments; hydrography in the vicinity of the banks; chemical analyses of sediments and selected faunal components for trace metals and heavy molecular weight hydrocarbons; chemical analyses of the water column for nutrients, dissolved oxygen, and low molecular weight hydrocarbons; and temperature, salinity and transmissivity profiles of the water column.

Post-drilling environmental assessments were made at Stetson Bank, South Baker Bank, Southern Bank and the East Flower Garden Bank. A high salinity brine lake was discovered and documented at the East Flower Garden Bank during the post-drilling assessment.

Quantitative ecological studies were pursued into the relationships of epibenthic community distribution and abundance to the nepheloid layers at Southern Bank and Hospital Rock.

A number of scientific papers have been presented and published during 1976 and 1977 based on work done under B.L.M. funding (Bright

& Rezak, 1976; Rezak & Bright, 1976; Bright, 1976; Bright & Rezak, 1977; Bright, 1977; Ichiye, Bright & Rezak, 1977a; McGrail & Rezak, 1977).

Table I-1

TOPOGRAPHICAL FEATURES (BANKS) STUDIED DURING 1976

UNDER THE BLM CONTRACT

Topographical Feature	Nearest Coastal Pass	Range Nautical Miles	Bearing
1. Aransas Bank	Port Aransas	40 mi	114.5°
2. Blackfish Ridge	Port Aransas	68 mi	167°
3. Mysterious Bank	Port Aransas	74 mi	164.5°
4. Stetson Bank	Sabine Pass	109 mi	195°
5. East Flower Garden Bank	Sabine Pass	121 mi	173°
6. 28 Fathom Bank	Sabine Pass	123 mi	168°
7. Hospital Bank	Port Aransas	40 mi	121.5°
8. Southern Bank	Port Aransas	42 mi	131.5°
9. South Baker	Port Aransas	49 mi	104°

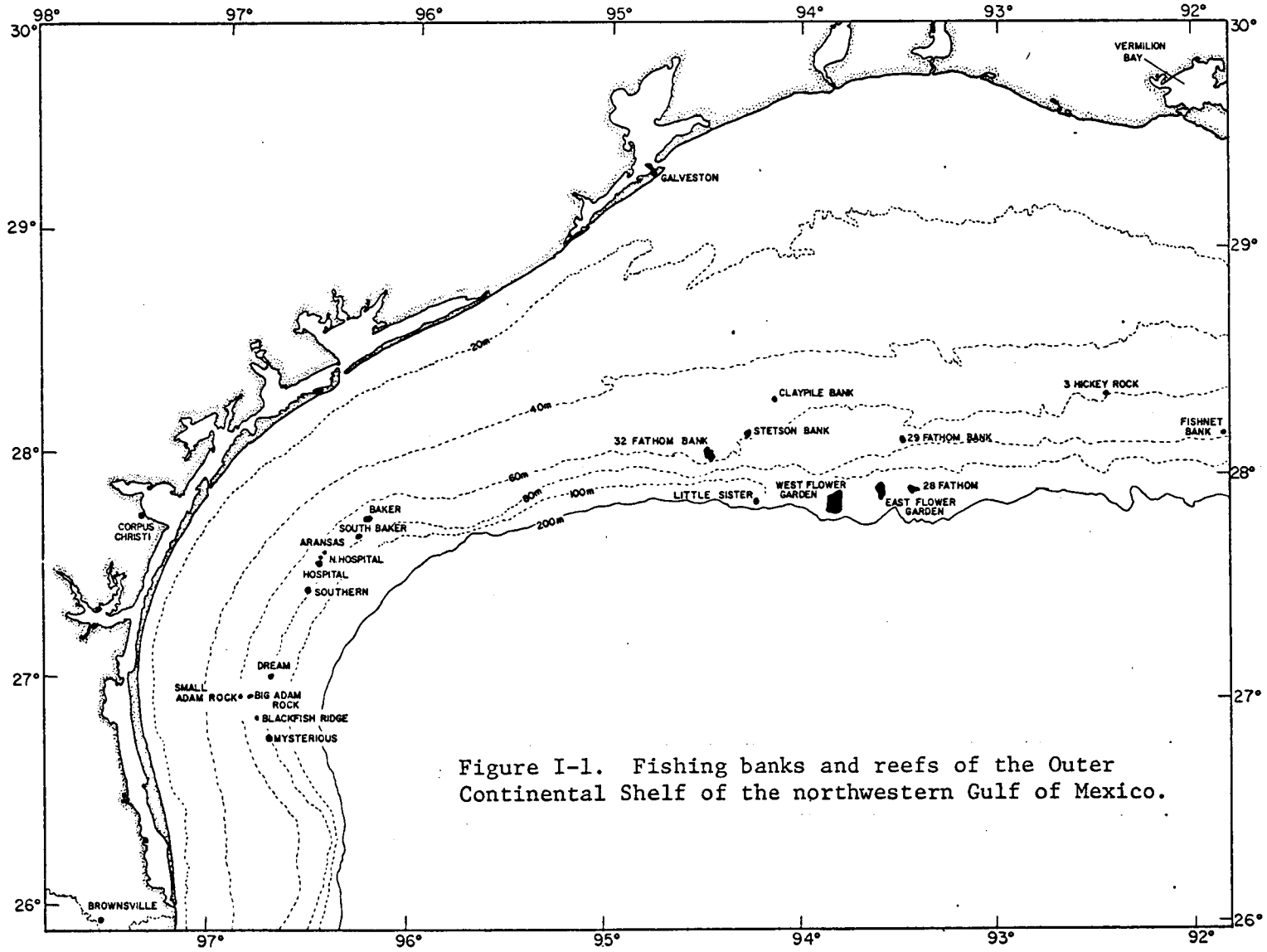


Figure I-1. Fishing banks and reefs of the Outer Continental Shelf of the northwestern Gulf of Mexico.

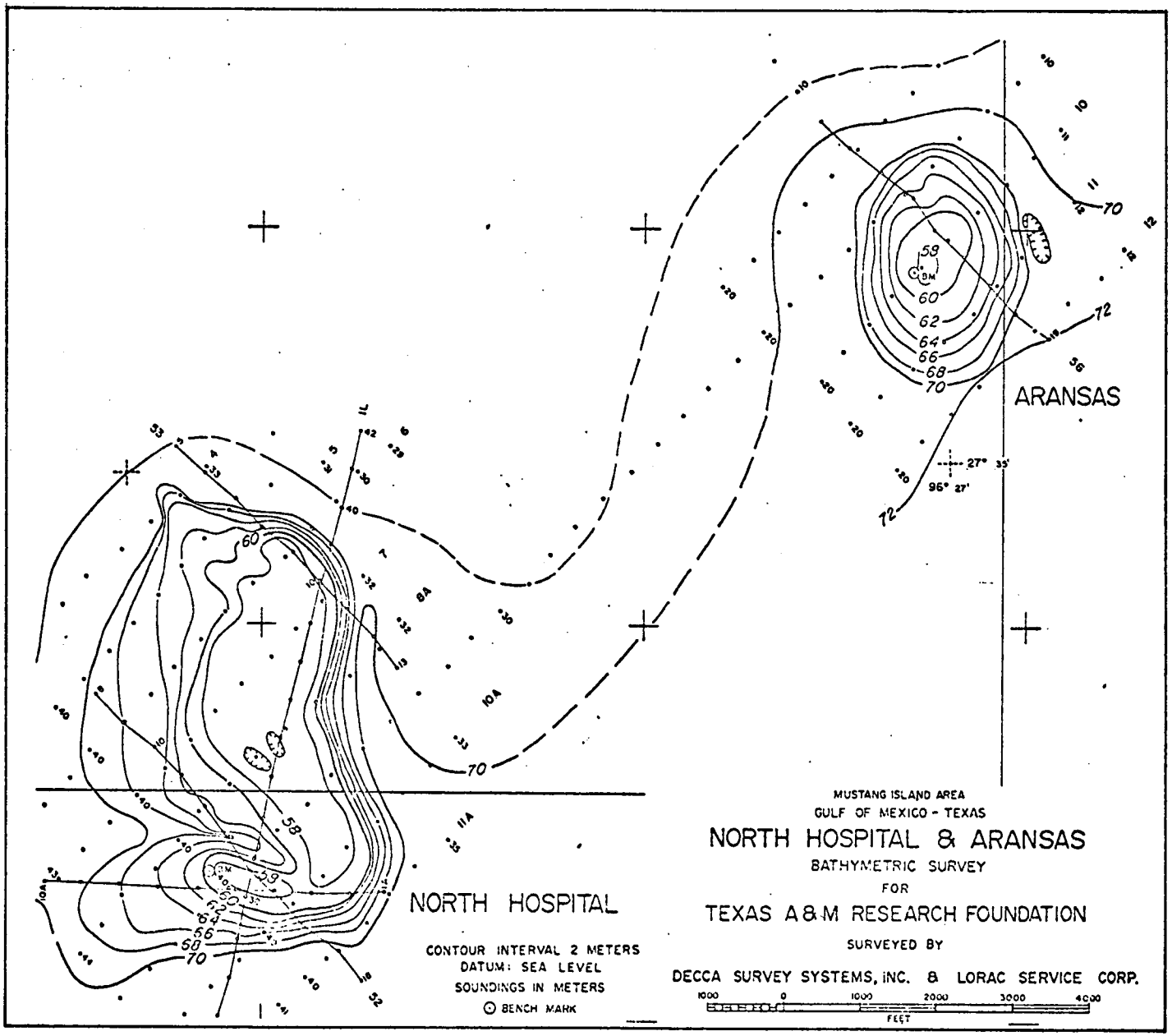


Figure I-2. Bathymetric map of Aransas and North Hospital Banks.

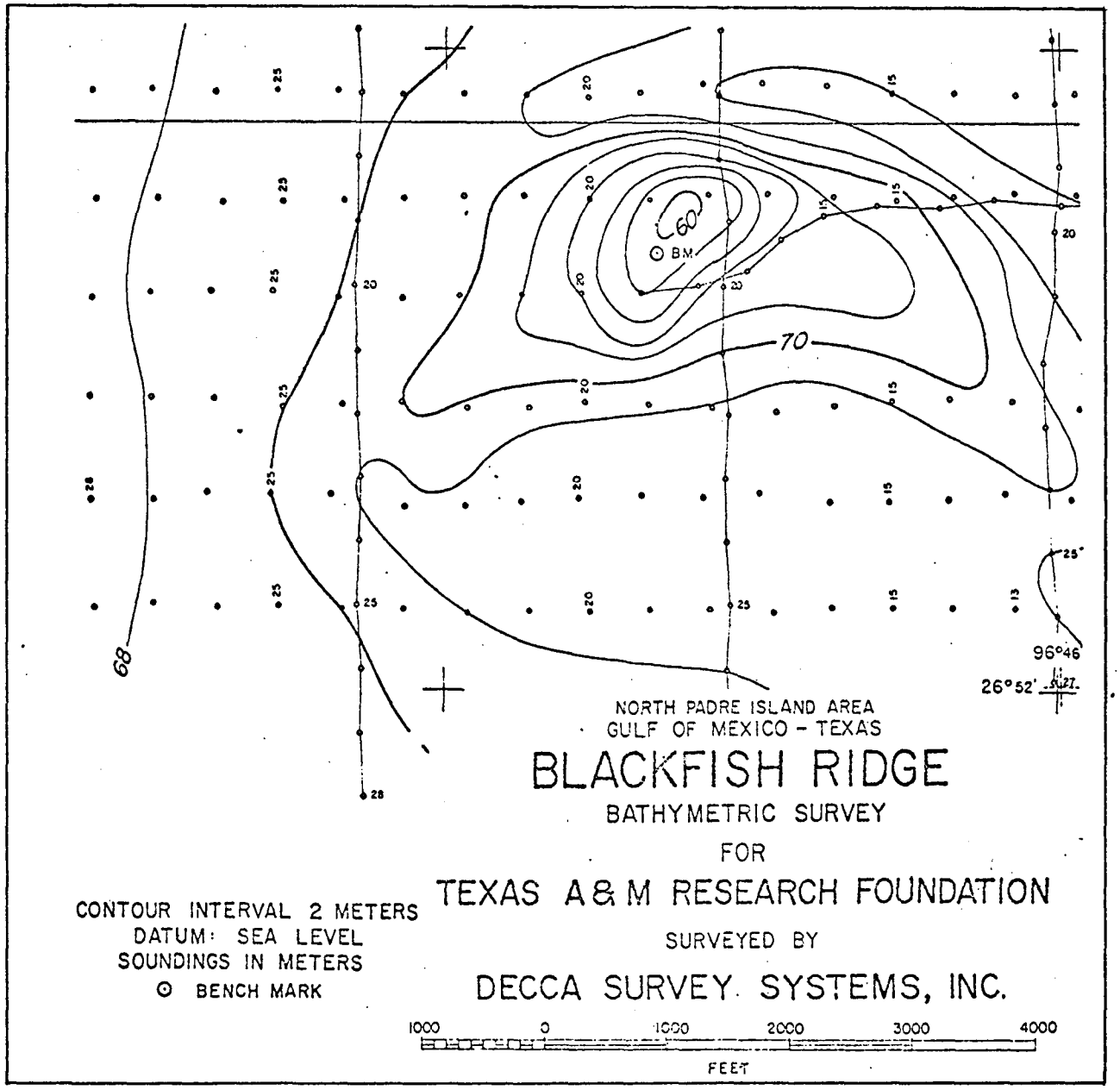


Figure I-3. Bathymetric map of Blackfish Ridge.

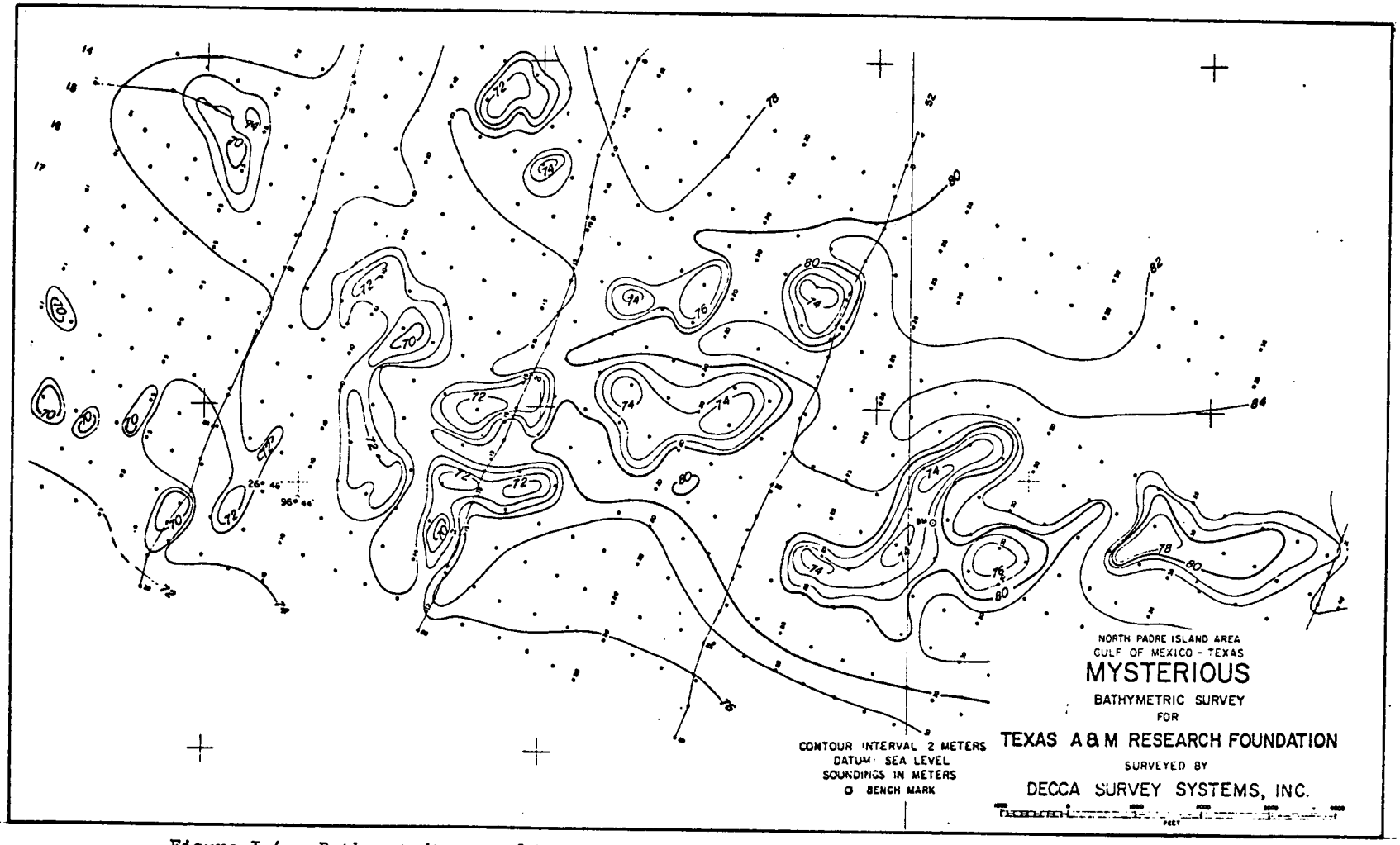


Figure I-4. Bathymetric map of Mysterious Bank.

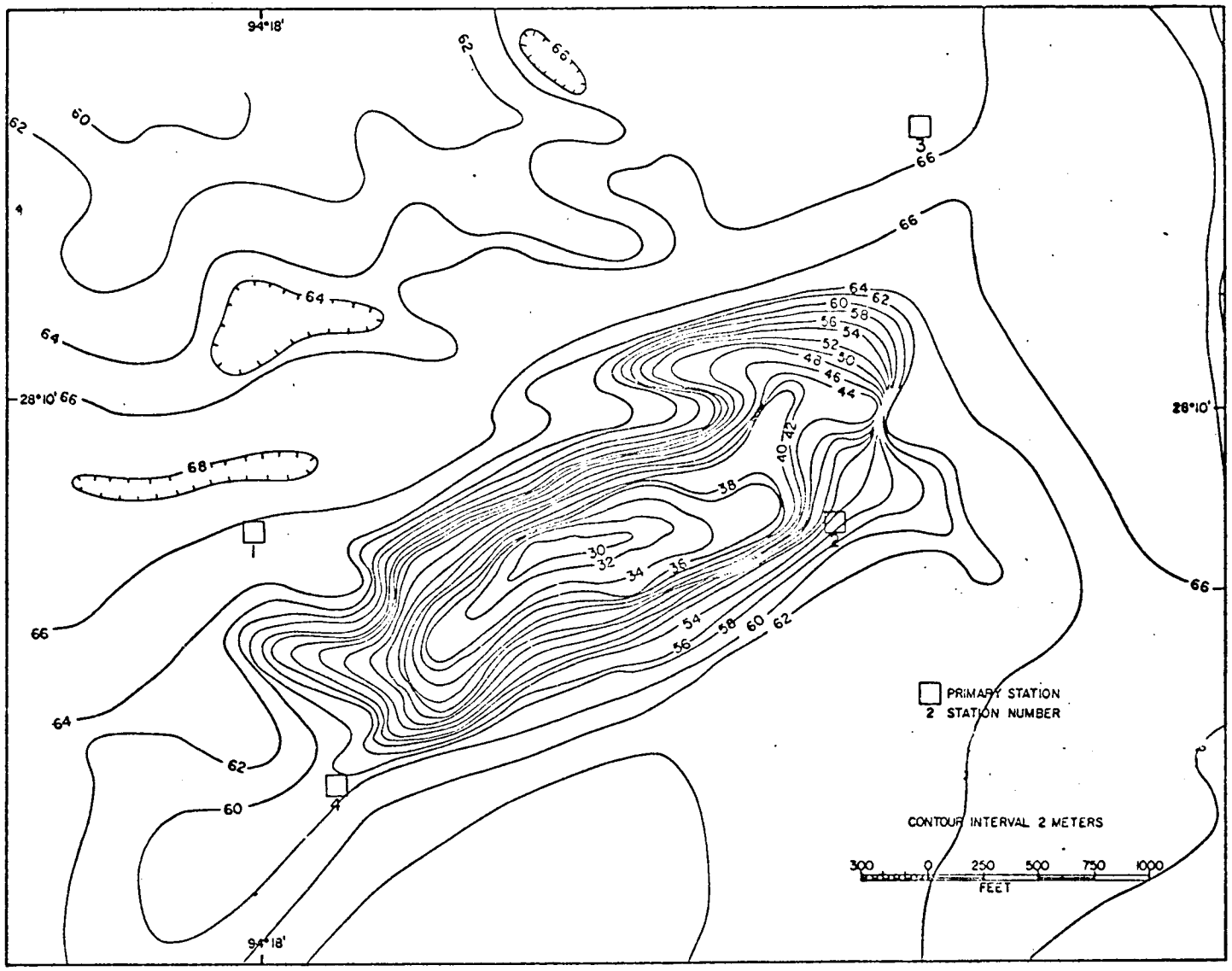


Figure I-5. Bathymetric map of Stetson Bank showing sampling station locations.

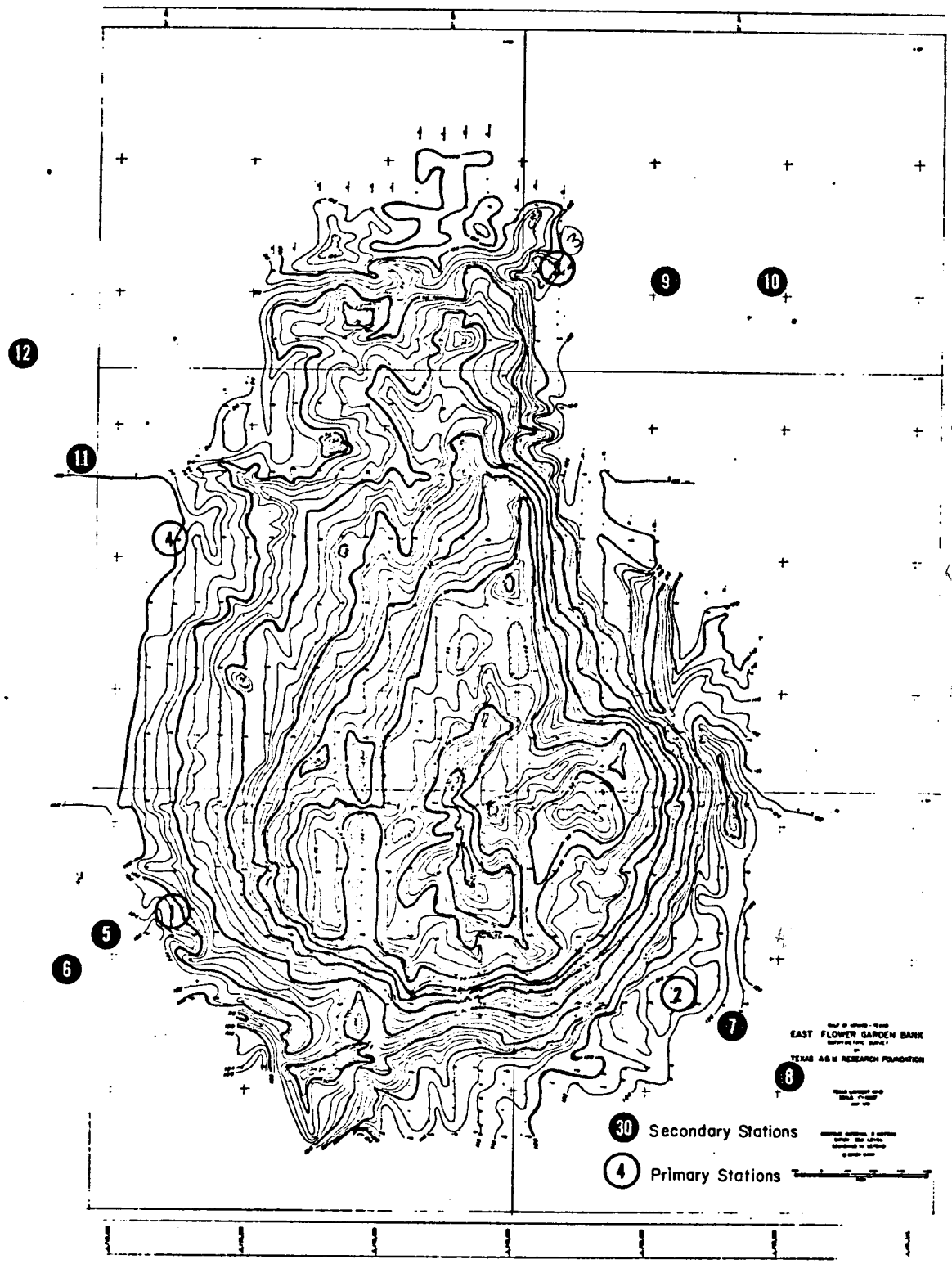


Figure I-6. Bathymetric map of East Flower Gardens Bank showing sampling station locations.

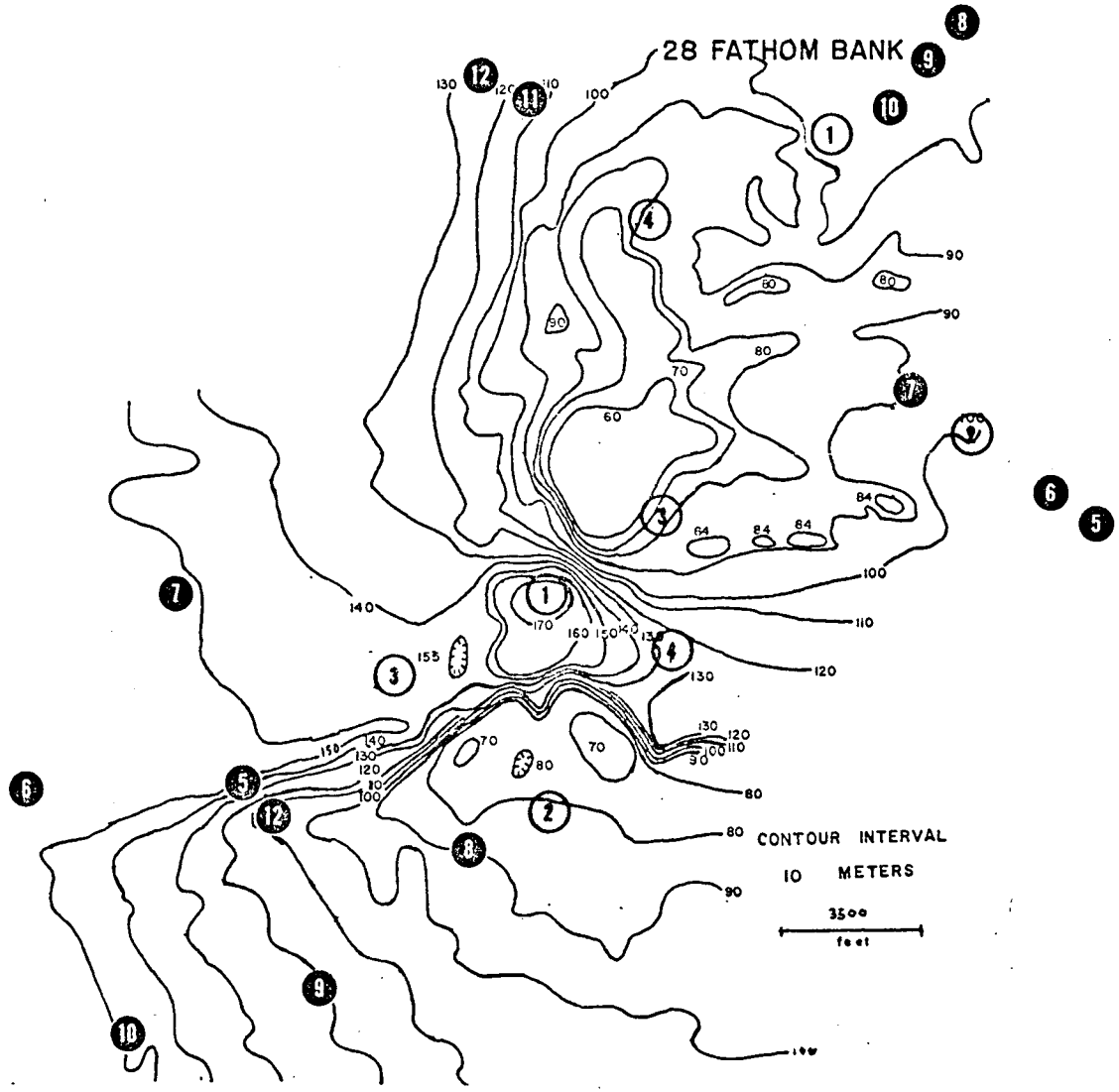


Figure I-7. Bathymetric map of 28 Fathom Bank showing sampling locations around the main bank and the southwest peak.

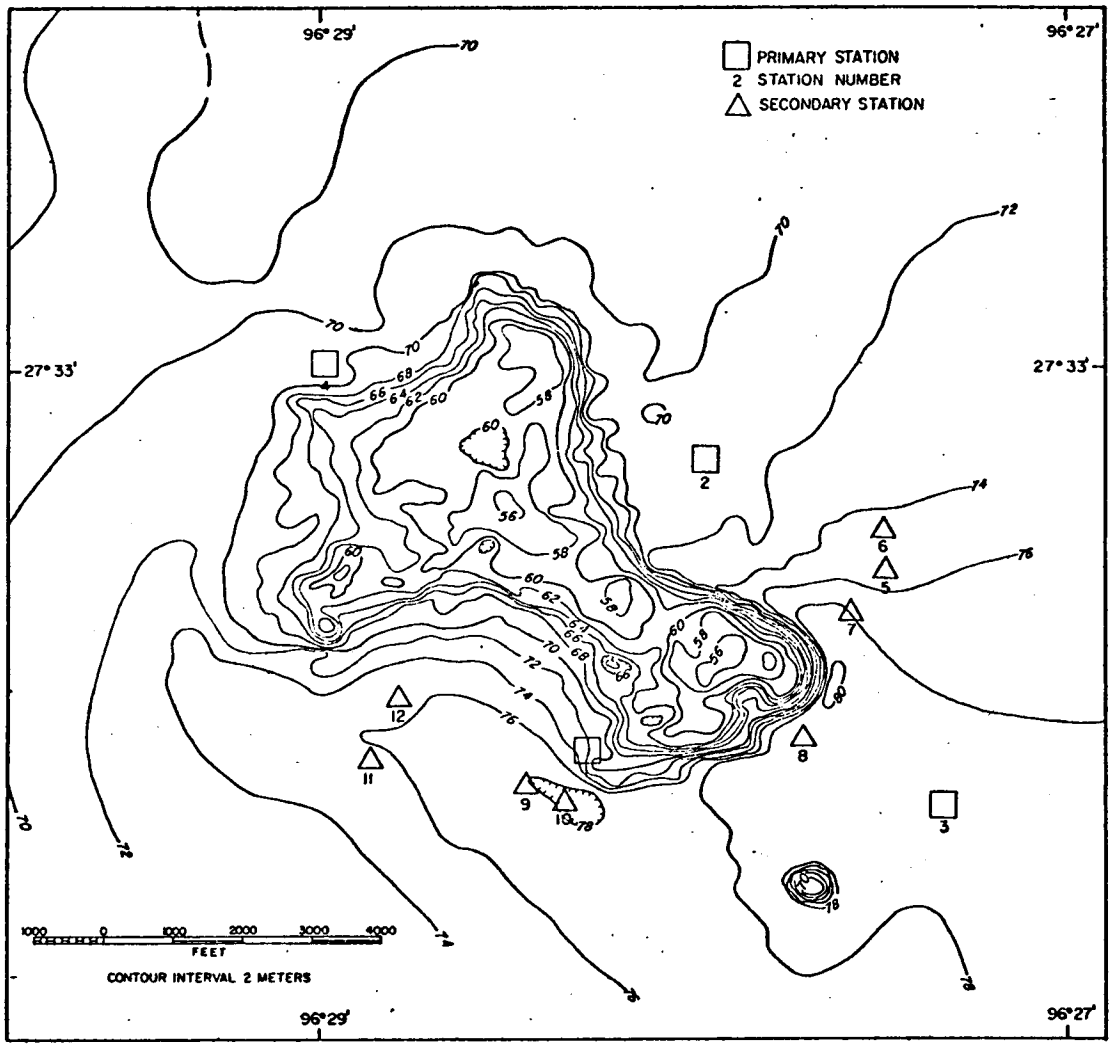


Figure I-8. Bathymetric map of Hospital Bank showing station locations.

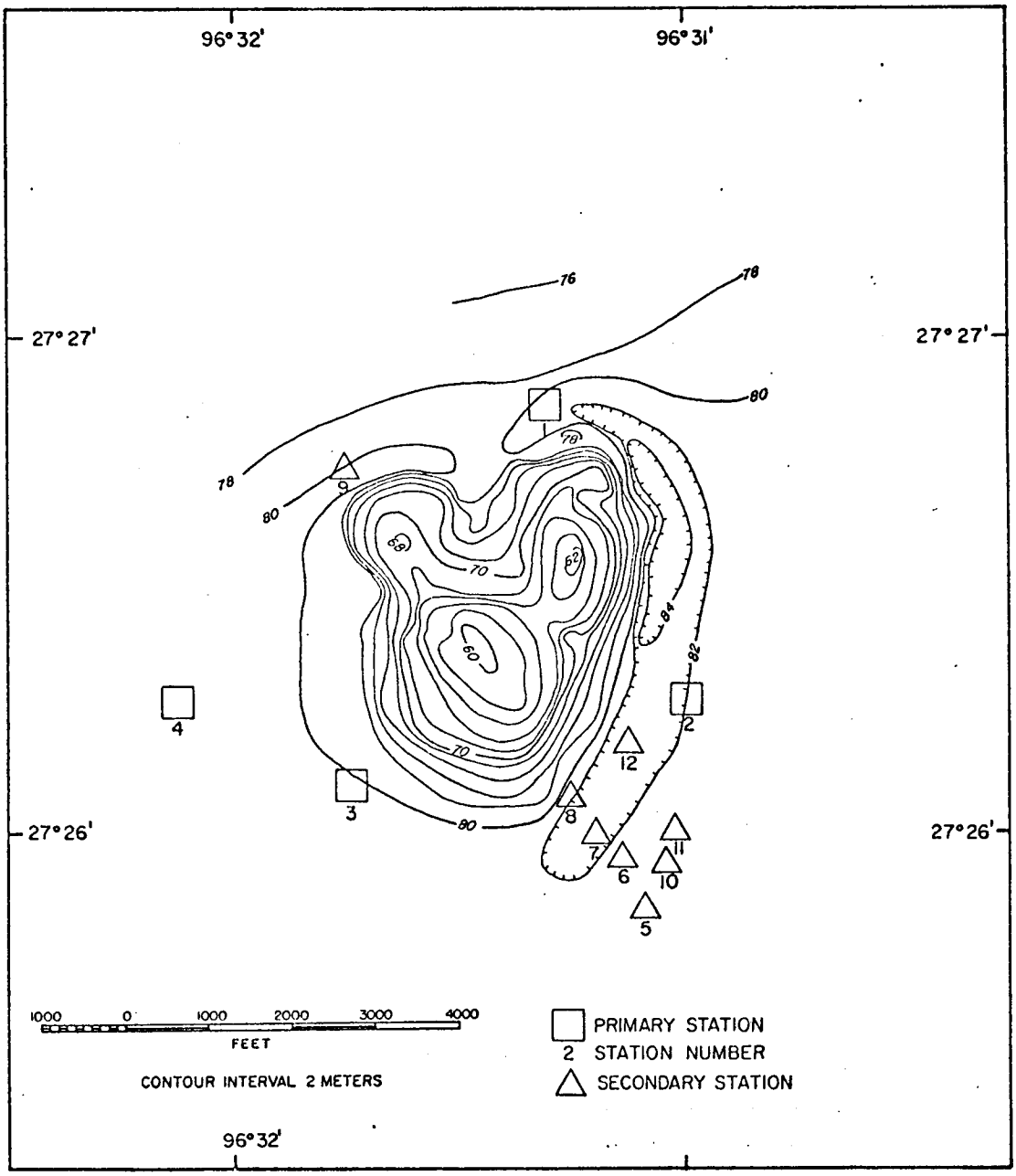


Figure I-9. Bathymetric map of Southern Bank showing sampling locations.

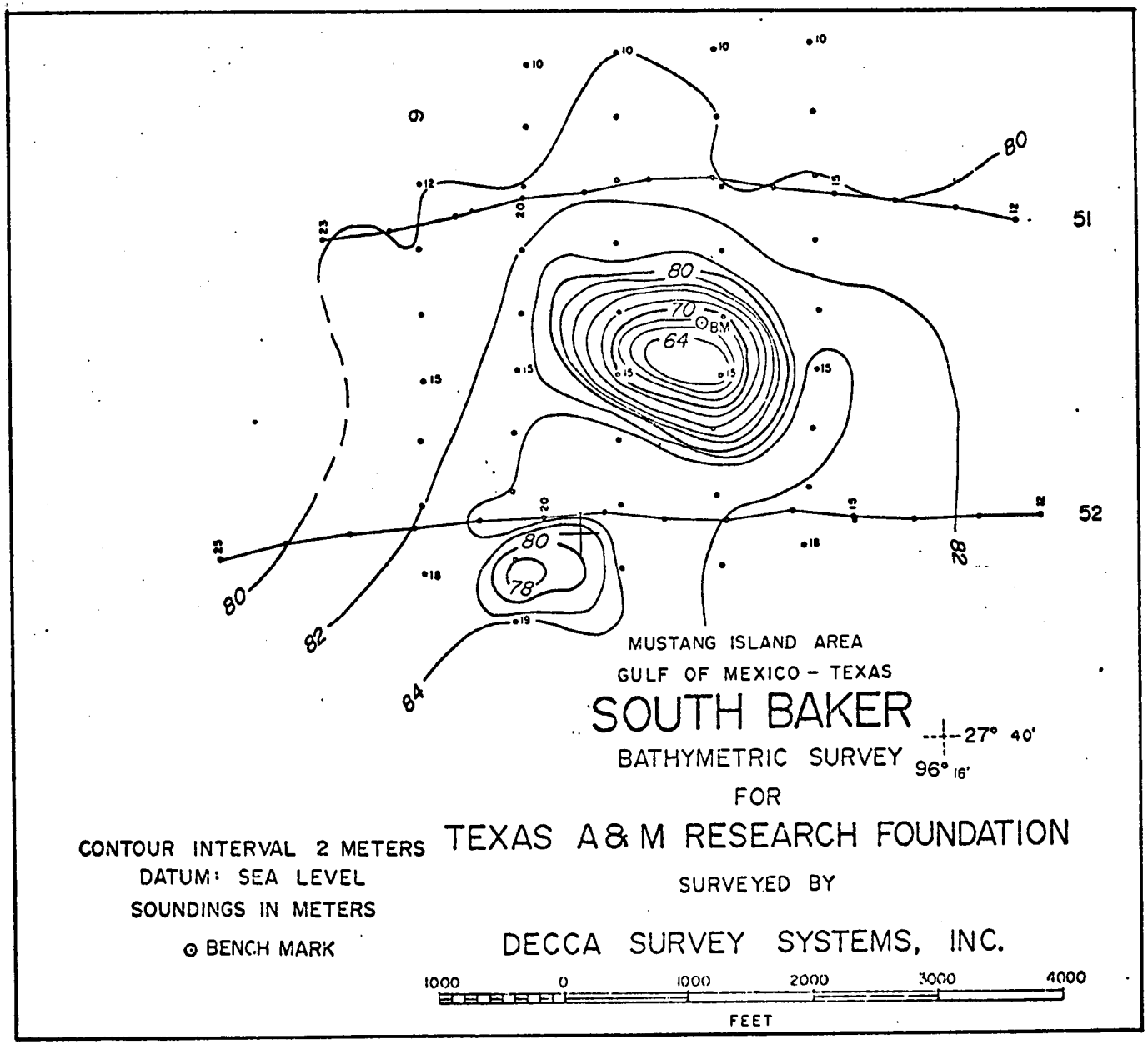


Figure I-10. Bathymetric map of South Baker Bank.

CHAPTER II

FIELD METHODS

FIELD METHODS

Compiled By

Project Co-Directors

Richard Rezak

Thomas J. Bright

INTRODUCTION

The field effort for this project was divided into three phases. As originally planned there were to be a mapping phase, a sampling phase, and a submersible phase. The mapping phase and a portion of the sampling phase were conducted on board the lease vessel M/V STATE HORN, chartered from Tracor Marine, Inc. at Port Everglades, Florida. Due to mechanical problems with the lease ship and our own shipboard equipment, a portion of the sampling phase was completed aboard the R/V GYRE during the submersible phase. The specifications of these two vessels can be found in Table II-1. Cruise dates are in Appendix II, Table II-1.

PHASE I - MAPPING CRUISE

Under sub-contract with Lorac Service Corporation of Tulsa, Oklahoma and Hydro Surveys, Inc. of Lafayette, Louisiana, bathymetric surveys were conducted at Stetson and the East Flower Garden Banks. Shipboard equipment utilized during Phase I included a 3.5 kHz subbottom profiling system with towed transudcer provided by the Department of Oceanography, Texas A&M University, an EG&G Side Scan Sonar System leased from Hydro Surveys, and a Lorac Navigation receiver with a brush recorder leased from Lorac Service Corporation.

Mobilization began on 6 July 1976 but due to various mechanical and electronic problems with the lease vessel and our own equipment, departure was delayed until 17 July 1976. Once the dockside problems were corrected, the remainder of the operations were conducted with very few problems. A Side Scan fish was lost at Stetson Bank necessitating a port call at Galveston in order to take on Side

Figure II-1. LORAC navigation electronics. Two Channel receiver at left; Brush Recorder behind Inter Com. Speaker.

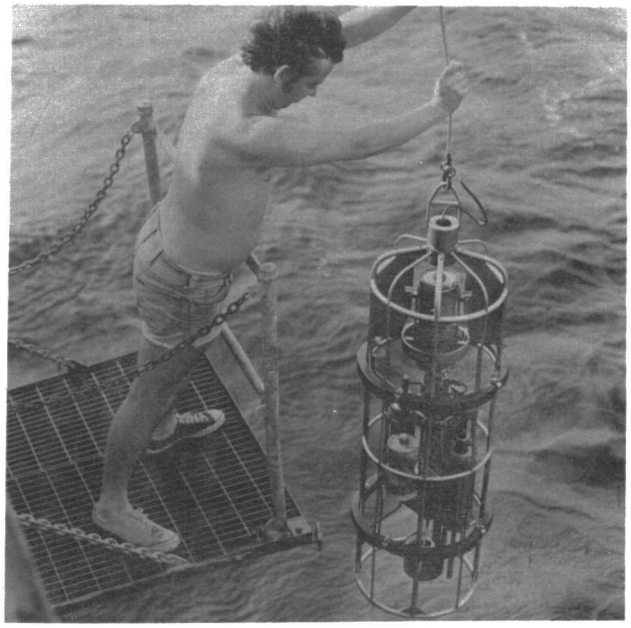


Figure II-2. Plessey 9006 STD instrument being lowered over the side.

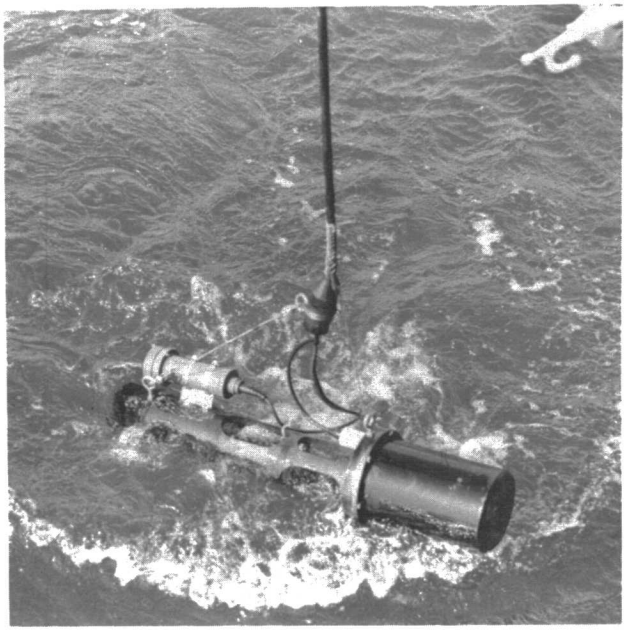


Figure II-3. Martek XMR transmissometer at the water surface.

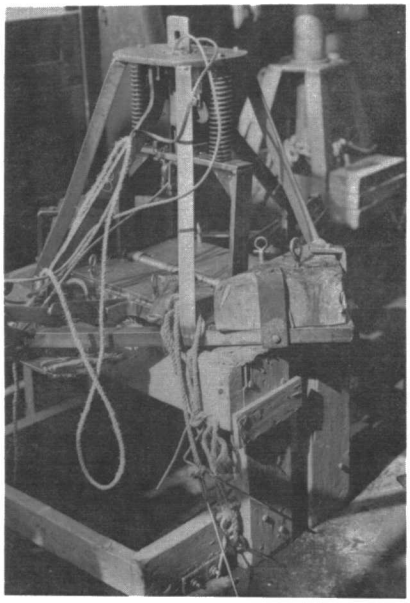


Figure II-4. Smith-McIntyre bottom sediment grab sampler.

Scan spare parts. The Chief Scientist during the Phase I cruise was Dr. Richard Rezak.

POSITIONING

The Lorac antenna was mounted amidship, 15.55 m from the ship's stern. Vessel positioning and navigation was accomplished using one of Lorac's service chains - LDE. The chain was operated in the hyperbolic mode. Lane counts were acquired at fixed production platforms, and were tracked on an analog recorder (Figure II-1). Closed lane count traverses were made between the lane count tie points (platforms) and the designated work areas. A preplot was prepared by Lorac for each area surveyed. Track spacing was 76 m at Stetson Bank and 152 m at the East Flower Garden Bank.

During surveying, fixes of the ship's position were recorded at 122 m intervals at Stetson Bank and 152 m intervals at the East Flower Garden Bank. Heading corrections were made when a deviation from the preplots was noted. The Lorac Office replotted the fix positions after the cruise and prior to our plotting of the bathymetric data. These fix locations are indicated on the charts as small circles.

BATHYMETRY

Bathymetry was accomplished through the use of an Edo-Western Batfish containing a 3.5 KHz transducer, connected to a Raytheon PTR 105B transceiver, with the returned signal then fed into a Raytheon UGR Recorder. The transducer unit was towed off the

starboard aft quarter at a depth of 18 meters. The UGR is a dry paper type recorder with variable sweep rates. For most of the operation, the recorder was operated at a 1/4 second sweep rate with the scale lines generated in meters. These records were then digitized for plotting, based on the sound velocity in seawater of 1510 meters per second.

Portions of the bathymetry were also obtained through the use of a mini-sparker system. The sensor for this system was an MSCS hydrophone array, consisting of 18 parallel hydrophones which were towed 76 meters from the stern. The signal from this array was fed into a Del Norte 502 Process Amplifier and then into an EPC Recorder. This recorder, also a dry paper type recorder, was normally operated on a 1/2 second sweep rate and a 1 second cycle rate. The output signal for the cycle rate was connected to a Del Norte Model 561 Acoustic Pulse Generator and operated at 100 joule output. The output of this unit was then fed into a MSCS Transmission/Output cable with a 12 pair multitip. The output tips were towed 61 m from the stern, generating a pulse in the 200-1000 Hz range each time the sparker fired.

Side Scan Sonar records were used to verify topographic features of the surveyed banks and to provide 100% coverage of the area surveyed.

SIDE SCAN SONAR

The side scan sonar fish was towed behind the vessel from the center stern. An electrically powered winch was mounted at the

stern to stream and recover the towed sonar fish. A nominal value of 5.9 feet (1.8 meters) per drum revolution was used to calculate the amount of side scan cable payed out during a survey line.

The unit used was an EG&G Mark B side scan sonar system, the recorder used was an EG&G Model 259-3 and the towed fish was an EG&G Model 272. The system operates at a frequency of 105± 10 kHz with a pulse duration of 0.1 milliseconds. The peak output is 118 db ref. 1 microbar at 1 meter. In the horizontal plane the beam width is 1° to left and right; in the vertical plane the beam width is 30° starting at 10° off the horizontal.

The recorder operates at 24-30 volts, 4-6 amperes, and makes two patterns out from the center, corresponding to the left (port) and right (starboard) windows of the fish. The range is 76, 152, or 305 meters to each side. The paper is a wet paper, 27.9 cm wide with 200, 150, or 100 lines per inch depending on the range used.

The sonar recorder utilized a stylus rotation corresponding to 1,500 meter/second seawater sonic velocity. A low gain setting was applied to enhance the topographic relief, and at the same time to minimize the cross-talk.

A range of 200 meters per channel was used during this phase, in order to achieve the greatest overlap of coverage while taking the involved geometry into consideration. The useable range was limited principally by the depth of the water; in some cases, the fish was towed directly in the vessel's wake, resulting in "wake noise" on the record. The fish towing stability characteristics deteriorate somewhat when towed close behind the vessel and near

the surface. Occasionally this had to be done when the water depth was shallow, to maintain a distance of about 40 meters off the bottom, to ensure sufficient coverage.

BENCHMARKS

Benchmarks were constructed from 55 gallon oil drums filled with concrete. Normally, they were emplaced following completion of a survey to insure a proper location. A 12 meter long polypropylene line was attached to the benchmarks to assist in relocation with the submersible. The benchmark locations for the banks surveyed during the 1976 study period are given in Table II-2. The table also includes the benchmark locations for banks surveyed during the 1975 study period that were sampled or observed with the submersible during the 1976 study period.

FINAL CHARTS

The Lorac Service Office constructed post plots of the actual track lines following completion of the surveys. These post-plot charts also displayed latitude and longitude, UTM grid coordinates, lease block numbers and benchmark locations. Bathymetric plotting and contouring were conducted in our laboratory.

The bathymetric chart of 28 Fathom Bank, southwest peak was compiled in our laboratory through the use of records and track lines furnished us by Sun Oil Company. As the southwest peak was contiguous to the area of 28 Fathom Bank both charts were combined into one.

Charts of 28 Fathom Bank, East Flower Garden Bank and Stetson

Bank are included as an appendix to this report.

PHASE II - SAMPLING CRUISES

Sampling was conducted aboard the M/V STATE HORN and the R/V GYRE. A portable van placed on board the lease vessel housed the wet lab during the sampling phase. Electronic instrumentation, including Lorac, was housed in the electronics lab of the STATE HORN.

Due to a mechanical failure of the transmissometry winch, the Transmissometry, STD, and Suspended Sediment Mineralogy portion of Phase II was postponed until the submersible cruise during August and September.

The sampling cruise aboard the M/V STATE HORN began on 28 July 1976 and ended on 6 August 1976 with Dr. Richard Rezak as Chief Scientist.

POSITIONING

Positioning during Phase II was accomplished by use of Lorac service chains LDE and LFG. Closed lane count segments were made as in Phase I. For Southern and Hospital Banks, station locations were selected prior to the cruise and pre-plotted by Lorac. For Stetson, East Flower Garden and 28 Fathom Bank, southwest peak, the station locations were selected after the surveys of Phase I were completed. The station locations for all banks sampled are given in Table II-3.

SAMPLING PROCEDURES, CRUISE 76SH2

The following description of the sequence of events is

necessarily an idealization. Variations in this procedure occurred as time, weather and events dictated. The sampling devices used are listed in Table II-4.

Upon arrival as the first priority banks, we first took water column samples for chemical analysis at all primary stations, then returned to those stations and took gravity cores and biological samples. We took gravity cores at all primary stations and the returned to the same stations and took biological samples.

This procedure was followed for two reasons. The first and most important reason being that both coring and grab sampling plus the washing of macroinfauna on deck, artificially create large amounts of turbidity in the water column. The small areal extent of the banks and the close proximity of the stations to each other would have greatly increased the chances for contamination of the water samples. The second reason is the time involved in re-rigging the sampling winch for taking different kinds of samples. The stations at each bank are sufficiently close to each other to permit a saving in time by taking the same kind of sample at each station and not changing samplers at each station.

Since no water column samples for chemical analysis were required at the second priority banks, we proceeded to take the biological samples first and then the gravity cores--following the procedure outlined above where all primary stations were first sampled using the Smith-McIntyre grab and all gravity cores at a bank were sampled last. A listing, in detail, of the samples taken from each grab follows.

a. Smith-McIntyre grabs designated A thru F were taken for macroinfauna. One subsample from each grab was placed in a sealed bag for geological textural and compositional analysis.

b. Smith-McIntyre grab G: one hydrocarbon and one textural and compositional sample taken.

c. Smith-McIntyre grab H: for trace metals and texture/composition samples; both placed in plastic bags, then sealed.

d. Smith-McIntyre I: took Casey foraminifera and geological texture/composition samples from the grab.

e. Smith-McIntyre J: for meiofauna and texture/composition samples.

SAMPLING PROCEDURES, CRUISES 76G8-II AND 76G8-III

The following description of the sequence of events is necessarily a general one. Variations in this procedure occurred as time, weather and events dictated.

During Legs II & III transmissometry and STD profiles were taken first at all stations so that water column sample depths could be determined. On Leg II water column samples were taken only at the primary stations on second priority banks, although transmissometry and STD profiles were taken at secondary stations. On Leg III water column samples were taken at both primary and secondary stations on first priority banks. The data acquired during sampling at Transect II of the STOCS study area, during Leg III,

followed the same procedure.

Smith-McIntyre grabs and gravity cores were also taken during Leg II at 28 Fathom, 28 Fathom southwest peak and East Flower Garden Banks. East Flower Garden and 28 Fathom, southwest peak Banks were revisited during Leg II only to take barium samples and grabs at Station 1, East Flower Gardens, that were not acquired on Cruise 76SH2. At 28 Fathom Bank all primary stations were visited and samples taken from each grab as follows:

a. Smith-McIntyre grabs number 1-6 were taken for macro-infauna. One subsample from each grab was placed in a sealed bag for geological textural and compositional analysis.

b. Smith-McIntyre grab number 9: took Casey formaminifera and textural composition samples from the grab.

c. Smith-McIntyre grab number 10: for meiofauna and geological texture/composition samples.

On Station 4 of this bank no samples were acquired although attempts were made at three locations. Each grab contained only large algal nodules. Only one (1) core was obtained on 28 Fathom Bank even though attempts were made at all stations. Bottom conditions (coarse algal nodule gravels) would not permit core penetration.

Fish for Chemical Analyses

Snappers of the species *Lutjanus campechanus* and *Rhomboplites aurorubens* were collected by hook-and-line at the banks. All specimens were labeled, double bagged in polyethylene bags, frozen, and delivered to be analyzed for trace metals and high molecular

weight hydrocarbons. The number of samples caught and analyzed at each bank are listed in Appendix II, Table II-2.

PHASE III - SUBMERSIBLE CRUISE

Biological and geological descriptions, post-drilling biological assessments and quantitative ecological observations were made on South Baker Bank, Aransas Bank, Hospital Rock, Southern Bank, Balckfish Ridge, Mysterious Bank, Claypile Bank, Stetson Bank, East Flower Garden Bank and 28 Fathom Bank. Surficial geology, epifauna and groundfishes were assessed visually using a submersible, scuba divers or underwater television. Observations were documented on videotape and 35 mm color photographs. Sampling of epifauna was accomplished primarily through the use of rock dredges, grab samplers and the submarine's manipulator arm. Specimens were either frozen or preserved in 10 percent buffered formalin or 95 percent ethyl alcohol. Epifauna and groundfish samples are listed in Table II-3 of Appendix II.

SUBMERSIBLE

The primary biological field survey tool for 1976 was the research submersible DR/V DIAPHUS (Table II-1). Several technical refinements were added to the submersible for the purposes of the 1976 BLM study. A hydraulically powered "underwater vacuum cleaner" (Figs. II-5, II-6, II-7) was used to suck up small organisms, sand and even small rocks which the manipulator claw could not grasp. The device is very effective and has enabled us to collect specimens which were not otherwise obtainable.

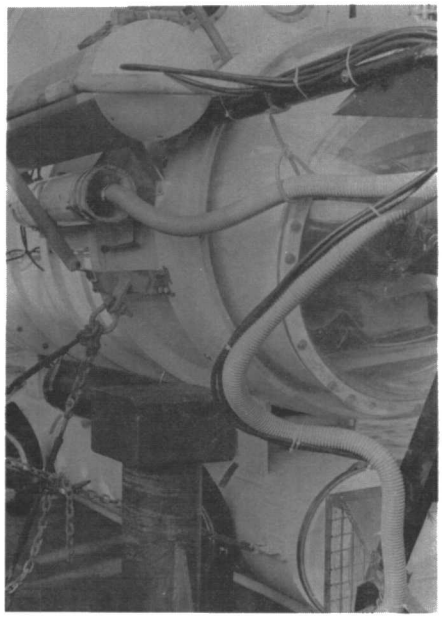


Figure II-5. "Underwater vacuum cleaner," upper left, with suction hose attached to manipulator arm.

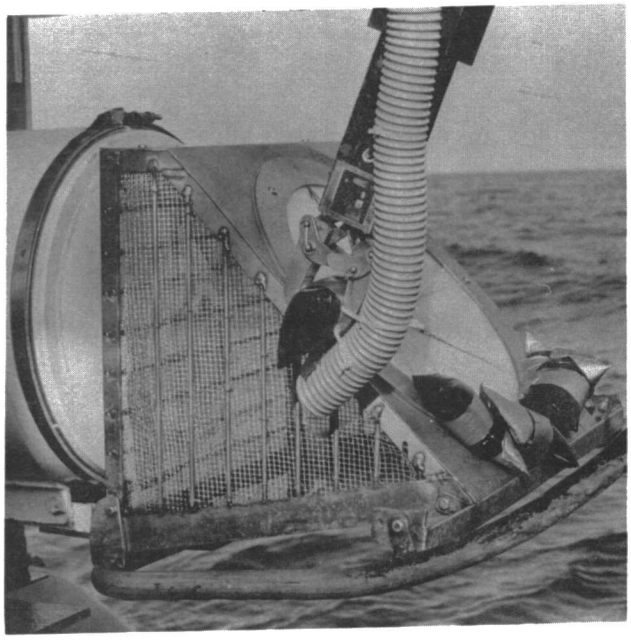


Figure II-6. Small plastic bags of rotenone attached to sample basket and held in manipulator arm claw.

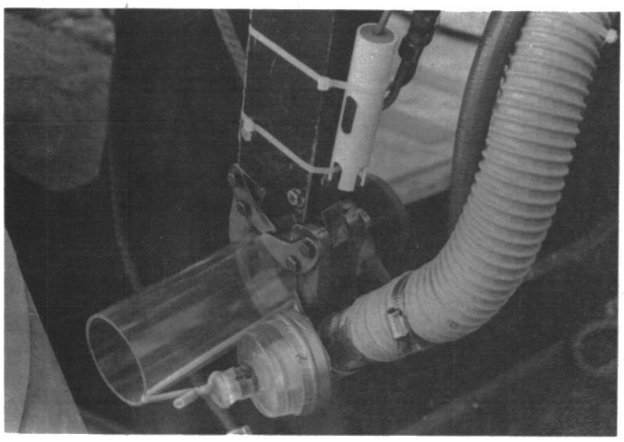


Figure II-7. Temperature probe, top center, garden hose, just left of the suction hose, and transparent sediment sampler.

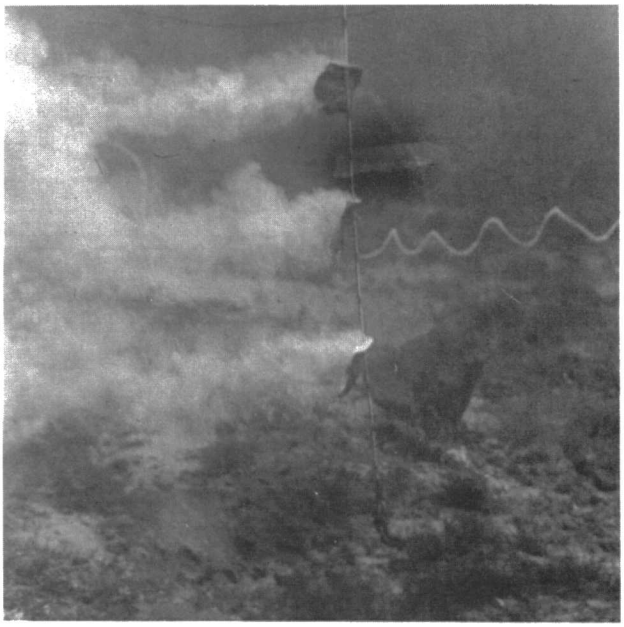


Figure II-8. Weighted array of dye markers for determinations of water movement.

An effort was made to poison a small area on Southern Bank in order to collect cryptic biota. Small plastic bags full of 5% rotenone solution were attached to the sample basket (Fig. II-6) and deployed by the manipulator claw on station. The rotenone effort was not effective, possibly due to a substantial current at the site on the day poisoning was tried.

At the East Flower Garden we attached a temperature probe and sediment sampler to the lower part of the submersible's manipulator arm (Fig. II-7). These devices were used successfully in collecting temperature data, sediment samples, and algae at the site of a brine seep on the eastern edge of the bank. A hose attached to the manipulator claw and running to the variable ballast tank vent-flood system of the submersible was used to collect water samples from the brine seep.

Bottom currents and water movements were studied from the submersible by deploying several series of weighted dye markers, using the submersible manipulator arm (Fig. II-8).

Submarine Transects

Submarine transects were selected at each bank on the basis of topography and geological sampling. After launch the submarine proceeded on the surface to the desired dive site and submerged. Upon reaching the bottom it followed a predetermined course using the gyrocompass. Tracking of the submarine from the anchored ship was accomplished by taking visual bearings and radar ranges on a

two foot diameter tether buoy attached to the submarine by a light polypropylene line. In sea conditions not favorable to radar, a 4.3 meter rubber ZODIAC boat was sent to the position of the tether buoy to provide a larger "target" for the radar. Course corrections were conveyed to the submarine from the ship through the underwater telephone (UQC). A maneuvering board plot of the submarine's position relative to the stationary ship was kept during each dive. Dives made using the DR/V DIAPHUS are summarized in Appendix II, Table II-4.

SCIENTIFIC DIVING

Self contained underwater breathing equipment (SCUBA) was used on the shallowest parts of the East Flower Garden Bank and Stetson Bank. During SCUBA dives, observations were documented photographically using a NIKONOS II underwater camera and SUBSEA strobe light. Divers selectively gathered certain biological specimens.

SCUBA dives are documented in Table II-5 of Appendix II.

Photographic Equipment

A Nikon Model FTN camera was used for color transparency photographs of the bottom from inside the submersible. We mounted in the submersible a Minolta XL 400 Super 8 motion picture camera in time-lapse mode, shooting one frame per second. This provided fast-action records of dives which later facilitated correlation of data. A Nikon F-2, 35 mm camera with a 250 frame magazine and intervalometer was mounted inside the submersible to provide 35 mm

still photographs each 30 seconds through the dives. Table II-6 of Appendix II lists the numbers of slides taken during the submersible dives.

Television Equipment

A Sony TV system was used in the submersible to document the transects. This system consisted of an AVC 3400 TV camera, an AV 3400 TV recorder, and an 18 cm monitor. The TV system was supplied converted power (110 volts A.C.) from the main batteries of the submersible. The TV camera was mounted on a bracket and aimed through the forward viewing port but was easily detached from the bracket for hand-held use. Mounting of the TV camera permitted TV coverage while the observer was taking 35 mm still pictures, collecting samples or describing visual observations. TV coverage along transects was quite adequate but not 100%.

An identical TV system was modified as an Underwater Television for use from the deck of the ship. The extent of TV coverage of the banks visited is indicated in Appendix II, Table II-7.

Table II-1

Vessels Used During the 1976 Study Period

VESSEL	LENGTH	BEAM	SPECIAL EQUIPMENT
M/V STATE HORN	33.5 m	7.01 m	"A" frame, Daybrook crane
R/V GYRE	53.05 m	10.97 m	2 "A" frames, hydraulic crane, STD winch, coring winch, hydro winch
DR/V DIAPHUS	6.05 m		

Additional Data:

Mass: 4568 kg

Depth Capacity: 366 meters

Payload: 409 kg

Life Support Capability: 180 man hours

Speed: up to 4.6 km/hr.

Power: 36-volt D.C. system

110-volt A.C. for lights and TV recorder and camera

Passengers: one pilot and one observer

Viewports: Seven 20 cm viewports in conning tower and one 91 cm hemispherical viewport in nose

Photography: One externally mounted strobe light which will couple with standard camera systems inside sub

Scientific Sampling: Hydraulic manipulator arm with four functions: forward-aft, left-right, in-out, claw-open/claw close. Sample basket.

Table II-2

BENCHMARK LOCATIONS

Banks Marked During 1976

BANK	LAT.	LONG.	LAMBERT COORDINATES X	Y
Stetson	28.16592	94.29697	3,514,717	150,447
East Flower Garden	27.90887	93.59996	3,743,824	67,218
28 Fathom Bank, Southwest Peak	27.89425	93.45773	3,789,961	64,570

Banks Marked During 1975

BANK	LAT.	LONG.	LAMBERT COORDINATES X	Y
Aransas	27.59000	96.45139	2,665,516	704,459
Blackfish	26.87611	96.77667	2,561,739	443,305
Mysterious	26.76500	96.70444	2,585,854	403,376
South Baker	27.67583	96.27222	2,721,006	736,610
Southern	27.43917	96.52444	2,640,738	649,275
28 Fathom	27.91444	93.44722	3,792,940	72,150

Table II-3

SAMPLING STATION LOCATIONS AT EACH BANK

STATION	LAMBERT COORDINATES X	Y	LAT	LONG	WATER DEPTH
East Flower Garden Bank					
1 (Aug 3,4,5)	3,731,826	67,477	27.90968	93.63707	100 m
1 (XMS)	3,731,118	66,869	27.90810	93.63934	
1 (Hydrocast)	3,730,785	67,673	27.91035	93.64026	
2 (Aug 3,4,5,30)	3,750,860	64,125	27.89806	93.57869	120 m
3 (Aug 3,4,5)	3,746,395	89,541	27.96884	93.58885	100 m
3 (Aug 30)	3,746,114	91,281	27.97327	93.58948	
4 (Aug 3,4,5)	3,732,112	81,100	27.94707	93.63425	97 m
4 (Aug 29,30)	3,732,037	80,923	27.94659	93.63451	
5 (Aug 30)	3,729,205	65,155	27.90363	93.64550	99 m
6 (Aug 30)	3,727,547	62,955	27.89780	93.65094	97 m
7 (Aug 29)	3,753,378	62,619	27.89360	93.57112	119 m
8 (Aug 29)	3,755,304	60,525	27.88760	93.56547	105 m
9 (Aug 30)	3,751,065	90,659	27.97093	93.57425	95 m
10 (Aug 30)	3,754,426	90,964	27.97133	93.56380	97 m
11 (Aug 30)	3,728,374	84,653	27.95730	93.64531	95 m
12 (Aug 30)	3,725,685	87,312	27.96495	93.65325	91 m
Hospital Rock					
1 (Jul 31-Aug 1 & Sept 15)	2,657,530	684,083	27.53422	96.47105	73 m
2 (Jul 31-Aug 1 & Sept 14)	2,658,441	688,366	27.54588	96.46805	72 m
3 (Jul 31-Aug 1 & Sept 13)	2,661,283	684,161	27.53421	96.45937	80 m
4 (Jul 31-Aug 1 & Sept 15)	2,653,224	689,891	27.55033	96.48395	72 m
5 (Jul 31-Aug 1 & Sept 13)	2,660,994	686,703	27.54128	96.46019	76 m
6 (Jul 31-Aug 1 & Sept 13)	2,661,020	687,263	27.54276	96.46002	76 m
7 (Jul 31-Aug 1 & Sept 13)	2,660,867	686,310	27.54018	96.46048	78 m
8 (Jul 31-Aug 1 & Sept 13)	2,660,071	683,880	27.53350	96.46312	80 m
9 (Jul 31-Aug 1 & Sept 14)	2,656,310	682,458	27.52975	96.47479	77 m
10 (Jul 31-Aug 1 & Sept 14)	2,656,506	683,231	27.53187	96.47415	78 m
11 (Jul 31-Aug 1 & Sept 14)	2,654,038	684,126	27.53445	96.48170	76 m
12 (Jul 31-Aug 1 & Sept 15)	2,654,655	684,839	27.53637	94.47978	76 m

Table II-3 cont.

SAMPLING STATION LOCATIONS AT EACH BANK

STATION	LAMBERT COORDINATES X	Y	LAT	LONG	WATER DEPTH
Hospital Bank (South Texas Outer Continental Shelf Monitoring Study)					
1	2,657,176	684,269	27.53469	96.47203	73 m
2	2,658,755	688,493	27.54624	96.45695	75 m
3	2,661,136	684,369	27.53479	96.45981	84 m
4	2,653,169	689,934	27.55045	96.48412	76 m
Southern Bank					
1 (Jul 29-Aug 31 & Sept 15)	2,641,326	652,100	27.44682	96.52254	77 m
2 (Jul 29-Aug 31 & Sept 15)	2,642,690	648,780	27.43769	96.51831	79 m
3 (Jul 29-Aug 31 & Sept 17)	2,639.118	647,685	27.43486	96.52951	79 m
4 (Jul 29-Aug 31 & Sept 17)	2,638,729	651,659	27.44581	96.53050	77 m
5 (Jul 29-Aug 31 & Sept 17)	2,642,889	646,100	27.43047	96.51796	80 m
6 (Jul 29-Aug 31 & Sept 17)	2,642,295	646,768	27.43219	96.51976	79 m
7 (Jul 29-Aug 31 & Sept 15)	2,641,861	647,303	27.43369	96.52107	80 m
8 (Jul 29-Aug 31 & Sept 17)	2,641,597	647,744	27.43491	96.52187	81 m
9 (Jul 29-Aug 31 & Sept 17)	2,639,009	651,512	27.44538	96.52966	78 m
10 (Jul 29-Aug 31 & Sept 15)	2,642,886	646,669	27.43191	96.51790	80 m
11 (Jul 29-Aug 31 & Sept 15)	2,642,965	646,986	27.43278	96.51770	81 m
12 (Jul 29-Aug 31 & Sept 15)	2,642,382	648,189	27.43610	96.51942	81 m
Southern Bank (South Texas Outer Continental Shelf Monitoring Study)					
1	2,641,587	652,153	27.44704	96.52168	75 m
2	2,643,053	648,623	27.43726	96.51733	85 m
3	2,639,083	647,723	27.43496	96.52962	79 m
4	2,637,214	648,511	27.43721	96.53534	79 m

Table II-3 cont.

SAMPLING STATION LOCATIONS AT EACH BANK

STATION	LAMBERT COORDINATES X	Y	LAT	LONG	WATER DEPTH
Stetson Bank					
1 (grab Aug 5)	3,513,707	151,420	28.16613	94.30130	55 m
1 (XMS Sept 4)	3,513,878	151,685	28.16684	94.30074	
1 (STD Sept 4)	3,513,903	151,331	28.16586	94.30070	
1 (hydrocast Sept 4)	3,513,505	150,581	28.16384	94.30203	
2 (grab & XMS)	3,516,495	151,469	28.16595	94.29265	51 m
2 (STD[2])	3,516,696	151,137	28.16502	94.29207	
2 (hydro[2])	3,516,463	152,028	28.16749	94.29268	
3 (grab & hydro)	3,516,852	153,233	28.17076	94.29132	55 m
3 XMS	3,516,592	153,335	28.17107	94.29211	
3 STD	3,516,808	153,111	28.17043	94.29147	
4 (STD & grab)	3,514,214	150,306	28.16301	94.29987	50 m
4 (hydro)	3,514,260	150,635	28.16391	94.29968	
4 (XMS)	3,513,954	150,544	28.16369	94.30064	
5 (Sept 2)	3,514,213	151,938	28.16749	94.29967	48 m
6 (STD)	3,514,954	152,348	28.16854	94.29732	53 m
6 (hydro & XMS)	3,515,273	151,518	28.16622	94.29643	
7 (STD & XMS)	3,517,317	152,521	28.16875	94.28997	53 m
8 (hydro & XMS)	3,514,718	152,337	28.16853	94.29805	
8 (STD)	3,515,132	151,840	28.16712	94.29683	
9 (hydro & XMS)	3,513,291	152,825	28.17003	94.30241	51 m
9 (STD)	3,513,343	152,512	28.16917	94.30229	
10 (hydro & XMS)	3,515,815	150,510	28.16339	94.29488	49 m
10 (STD)	3,515,484	150,423	28.16319	94.29591	
11 (hydro & XMS)	3,515,620	151,204	28.16532	94.29539	48 m
12 hydro & XMS	3,516,216	150,341	28.16288	92.29366	53 m
12 STD	3,516,922	150,291	28.16267	94.29147	
28 Fathom Bank					
1 (Aug 31-Sept 1)	3,799,155	78,840	27.93224	93.42720	100 m
2 (Aug 31)	3,801,940	71,808	27.91256	93.41963	53 m
3 (Sept 4)	3,794,908	70,232	27.90915	93.44161	78 m
4 (hydrocast, STD, XMS)	3,794,524	77,643	27.92956	93.44170	78 m
4 (grabs)	3,794,327	77,895	27.93028	93.44228	
5 (Sept 4)	3,804,674	69,065	27.90467	93.41158	98 m
6 (Sept 4)	3,803,719	70,284	27.90814	93.41436	97 m
7 (Sept 4)	3,800,548	72,883	27.91570	93.42378	83 m
8 (Sept 4)	3,804,146	82,489	27.94161	93.41123	113 m
9 (Sept 1)	3,802,265	80,641	27.93678	93.41732	93 m
10 (Sept 1)	3,801,019	79,662	27.93426	93.42132	104 m
11 (Sept 4)	3,792,273	81,043	27.93919	93.44817	108 m
12 (Sept 4)	3,790,675	81,565	27.94084	93.45303	117 m

Table II-3 cont.

SAMPLING STATION LOCATIONS AT EACH BANK

STATION	LAMBERT COORDINATES X	Y	LAT	LONG	WATER DEPTH
28 Fathom Bank, Southwest Peak					
1 (Sept 5-6)	3,791,225	67,793	27.90293	93.45335	166 m
2 (Sept 5)	3,791,572	62,759	27.88906	93.45302	77 m
3 (Sept 5)	3,787,522	65,851	27.89808	93.46509	137 m
4 (Sept 6)	3,794,667	66,393	27.89864	93.44292	132 m
5 (XMS)	3,783,425,	64,072	27.89373	93.47801	145 m
5 (STD)	3,784,189	63,580	27.89228	93.47572	
6 (Sept 5)	3,778,703	63,165	27.89185	93.49274	174 m
7 (Sept 5)	3,782,451	68,039	27.90475	93.48045	143 m
9 (XMS)	3,789,313	61,156	27.88495	93.45024	83 m
8 (STD)	3,789,562	62,147	27.88764	93.45932	
9 (Sept 5)	3,785,739	58,736	27.87877	93.47164	110 m
10 (Sept 5)	3,781,096	57,497	27.87567	93.48618	138 m
11 (Sept 5)	3,789,160	46,944	27.84593	93.46279	117 m
12 (Sept 5)	3,784,666	62,737	27.88990	93.47437	99 m
Ba Sample Site	3,787,589	59,299	27.88008	93.46584	
Transect II (South Texas Outer Continental Shelf Monitoring Study)					
1			27.667	96.983	22 m
2			27.500	96.750	49 m
3			27.300	96.383	131 m
4			27.567	96.833	35 m
5			27.400	96.600	78 m
6			27.400	96.483	98 m

Table II-4

SAMPLING DEVICES

Geological

Gravity Corer

Mass: 136 Kg

Length of Barrel: 3.05 m

Diameter of Barrel: 7.62 cm ID Stainless Steel

Flapper valve at top of barrel.

Smith-McIntyre Sampler (Figure II-4)

Mass: 90.72 Kg

Sample Size: .0125 m^3

Hydrography

Transmissometry

Martek XMR (1 meter light path) (Figure II-3)

Hewlett-Parkard X-Y Plotter

STD

Plessey 9006 (Figure II-2)

Water

30 liter Niskin bottles

Biological

Smith-McIntyre (as above): for Meiofauna, and microfauna

Sport fishing gear: for Macronekton

CHAPTER III

HYDROGRAPHY

AND

SUSPENDED SEDIMENTS

TRANSMISSIVITY AND DENSITY STRUCTURE IN THE WATER COLUMN AROUND SOUTHERN, STETSON, 28 FATHOM AND EAST FLOWER GARDENS BANKS

Principal Investigator

Richard Rezak

Author

David McGrail

INTRODUCTION

During 1976, 136 STD and transmissometer profiles were obtained at the locations shown in the field methods section (Chapter II) of this report. The purpose of the sampling program was to obtain observations of the turbid layer which partially, or wholly, envelopes the topographic features under study. Two types of information were being sought. The first type might be called descriptive and involved determining when and where the layer existed. This information could be obtained from the transmissometer profiles alone. The second type of information sought dealt with the question of how the layer was formed and maintained. In the latter case it was necessary to study the relationship between the distribution of the conservative properties of the water column (salinity and temperature) and the distribution of turbidity which is not a conservative property. The object of such a comparison was to develop an understanding of the physical processes which induce the suspension and transport of fine sediment around these banks which causes the turbidity.

RESULTS AND DISCUSSION

SOUTHERN BANK

Of the profiles obtained by STD and transmissometer during 1976 perhaps the most informative were those taken at Southern Bank in September. On the 22nd of that month the R/V GYRE was anchored over the trough on the eastern margin of Southern Bank (just SW of the location of Core 45 in Fig. IV-4) in 82 m of

water while serving as tender to DR/V Diaphus (Dives 76-27 and -28). Hourly profiles of salinity, temperature and transmissivity were taken at this station throughout a 12 hour period extending from 1034 to 2126.

At the time of the first profile there were 5 distinct regions in the water column with respect to salinity and temperature (Figure III-1). These regions will be referred to as: 1) surface mixed layer; 2) warm-saline layer; 3) major thermocline; 4) minor thermocline and 5) bottom boundary layer.

The "surface mixed" layer, rendered isothermal and isohaline by wind mixing, comprised the uppermost 20 m of the water column. Through this entire region the temperature was 24.34^{o}C and the salinity 35.92^{o}/oo. Beneath the well mixed surface waters lay a thin (3 m) layer of anomalously "warm, saline" water having a maximum temperature 0.5^{o}C greater than the superadjacent water. Since a part per mil change in salinity produces a 4 to 6 times greater change in the density of seawater than a one degree C change in temperature, the 0.16 ^{o}/oo increase in salinity within this layer maintained the stability of the stratification. The "major thermocline" extended from the base of the warm-saline layer to a depth of 37 m. Within this region the temperature gradient was -0.34^{o}C/m. At 37 m the temperature gradient abruptly decreased to -0.12^{o}C/m and continued at that rate to a depth of 62 m. The reduced thermal gradient suggested the designation of "minor thermocline" for this region. From 62 m to the bottom, designated "bottom boundary" layer, the structure of the water column was strongly affected by the adjustment of the flow to the no slip

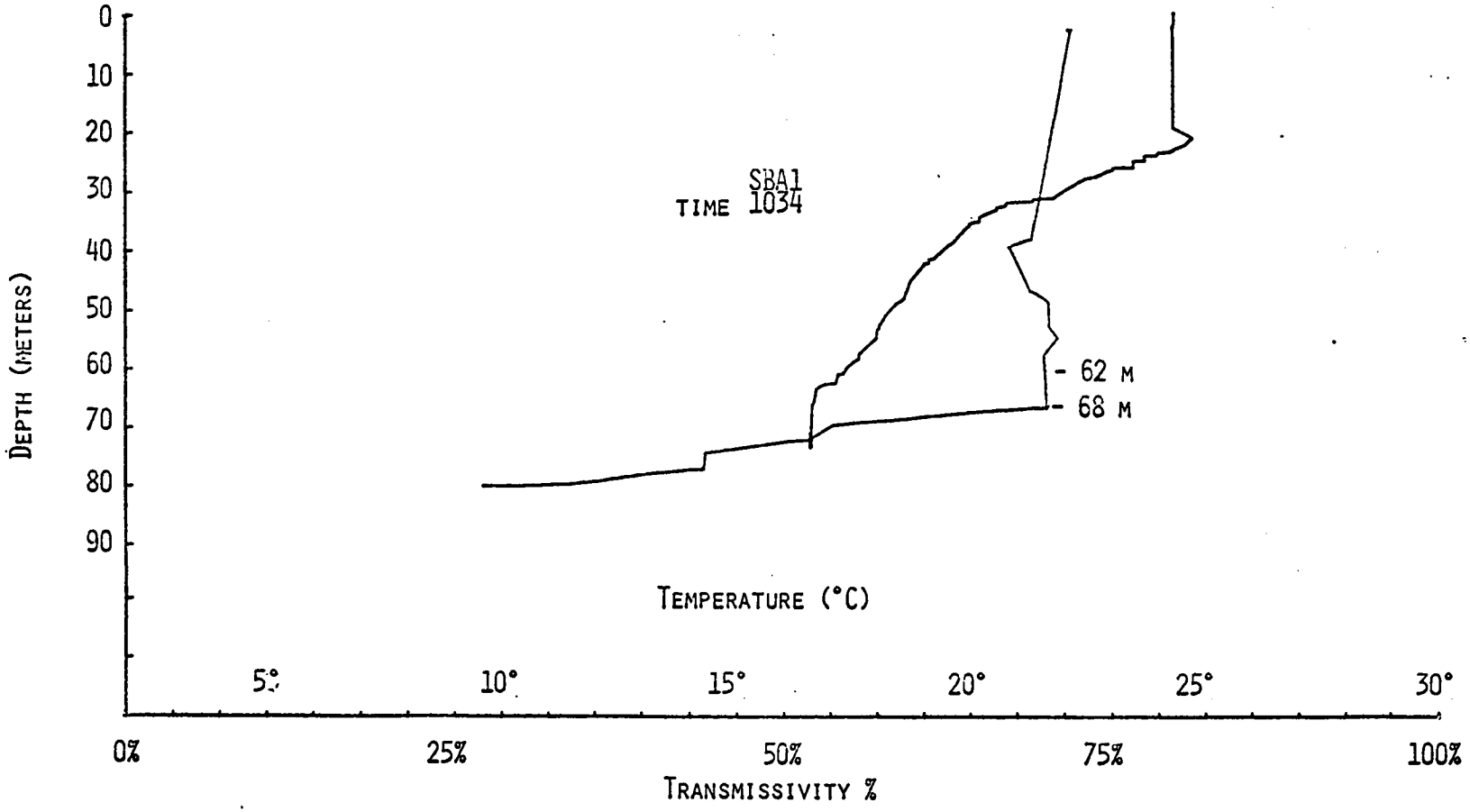


Figure III-1. Transmissivity and temperature plotted versus depth, Southern Bank, station "A", profile 1, 1034 hours.

condition at the bottom. This "no slip condition" is a term used by hydrodynamicists to describe the retardation of flow near a boundary by turbulence and viscosity. At the interface of the fluid and a solid boundary, this internal friction makes the fluid adhere to the bounding surface so that there is no relative motion between them and hence "no slip".

The top of the boundary layer was marked by a sharp increase in the temperature gradient to $-0.4^{\circ}C/m$ over an interval of only 1 m. Over the next 5 m, mixing had reduced the thermal gradient to $-0.03^{\circ}C/m$, an order of magnitude less than that in the major thermocline. Below 68 m mixing had eradicated all stratification, the water being essentially isothermal and isohaline.

The transmissivity profile taken concurrently with the first STD cast of the series showed a variation of only 5% from the surface to 68 m. At the surface, the transmissivity was about 72% or, stated differently, 28% of the light's intensity was attenuated over a 1 m path. At that rate 90% of a light's intensity would be attenuated over a 7 m path. Below 68 m, transmissivity decreased monotonically at such a rate that at 80 m depth, the bottom of the cast, it was only 26%. This indicates that the concentration of suspended sediment increased dramatically toward the bottom in the boundary layer. That, in turn, suggests that the source of the suspended material must have been the seafloor because if the sediment were merely being advected through from elsewhere, it would have been as uniformly mixed through the water of the boundary layer as heat and salinity.

A summary of some of the important changes which occurred in the distribution of temperature and transmissivity are given in Table III-1. At the beginning of the series the turbid, or nepheloid, layer was only 14 m thick with its upper surface coincident with the top of the isothermal region of the boundary layer. During the next 4 hours the nepheloid layer thickened by 3 m whereas both the upper surface of the isothermal layer and the location of the 50% transmissivity level rose by 5 m (profile 5, Figure III-2). This appears to represent a period of energetic mixing in the boundary layer. Between profiles 4 and 5 the upper portion of the boundary layer which exhibited some minor stratification from 67 m to 63 m became isothermal. This very strong mixing event peaked at the time of the tenth profile (Figure III-3). By that time the turbid layer had become 22 m thick and that portion which had a transmissivity of 50% or less had become 19 m thick. It would appear then that the event began with the erosion and suspension, near bottom, of fine sediment from the subadjacent seafloor. As turbulent mixing destroyed the stratification above the initial height of the boundary layer, sediment was also mixed higher into the water column.

After the tenth profile the boundary layer and turbid layer began to contract. The nature of the turbid layer also changed to one in which there was a strong gradient at the top followed by a rather well mixed layer (Figure III-4). This suggests that active resuspension was declining while advection of sediment through the area was growing in importance.

Table III-1

Summary of 12 Hour Time Series at
Southern Bank

(Station Depth 82 m)

Profile	SBA 1	SBA 2	SBA 3	SBA 4	SBA 5	SBA 6	SBA 7	SBA 8	SBA 9	SBA 10	SBA 11	SBA 12
Thickness of Surface Mixed Layer	20m	21m	23m	21m	22m	21m	22m	25m	20m	20m	21m	21m
Depth of 20°C Isotherm	35m	37m	38m	39m	39m	41m	39m	41m	43m	42m	41m	41m
Depth of Turbid Layers Upper Surface	68m	68m	67m	67m	65m	65m	64m	62m	64m	60m	65m	62m
Depth of 50% Transmissivity	73m	69m	68m	69m	68m	66m	68m	65m	66m	63m	67m	66m
Transmissivity at Top of Turbid Layer	70%	68%	67%	71%	71%	69%	69%	68%	66%	60%	66%	66%
Depth of Isothermal Layers Upper Surface	68m	68m	67m	67m	63m	66m	65m	65m	63m	63m	65m	65m

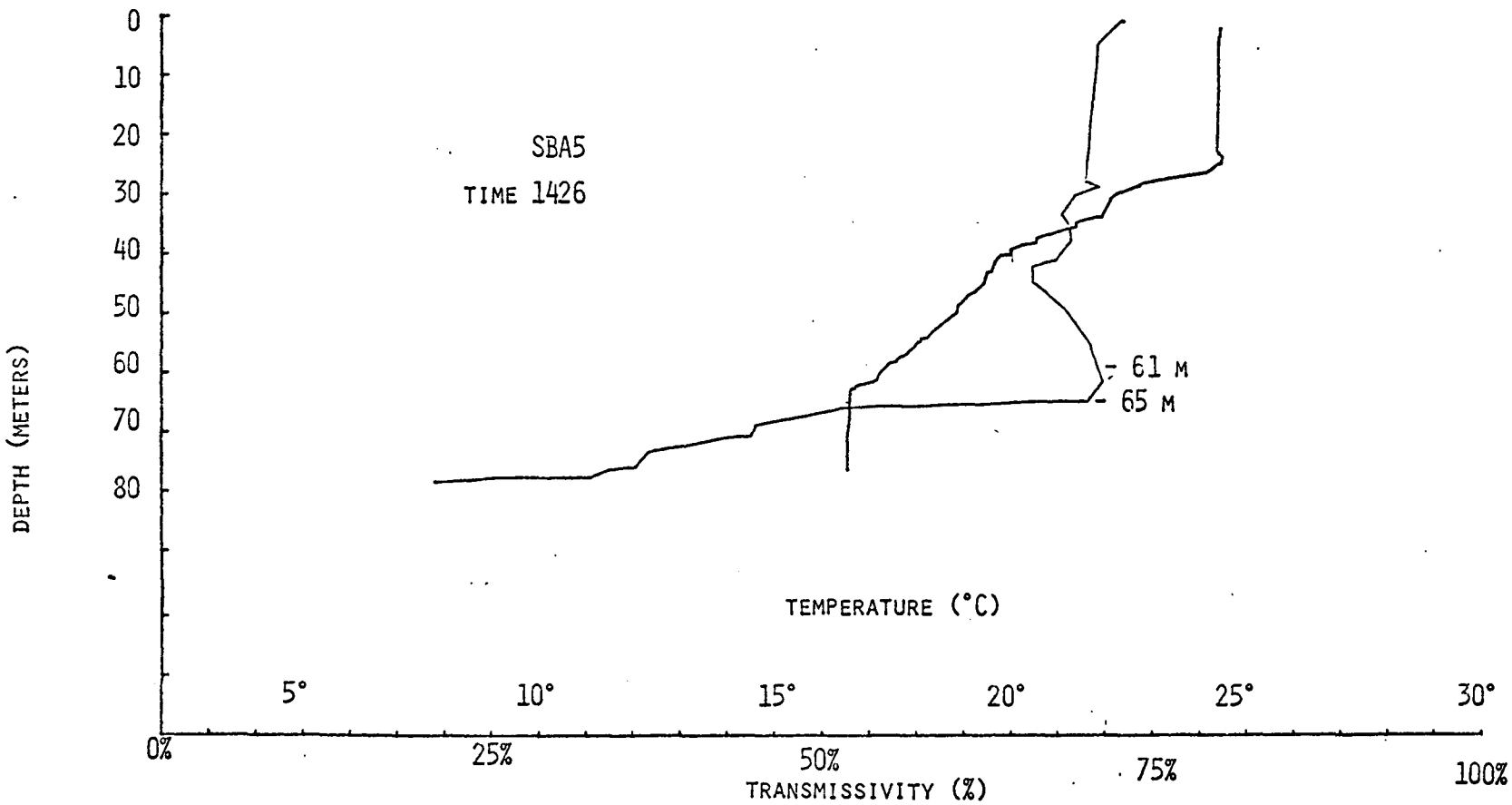


Figure III-2. Transmissivity and temperature plotted versus depth, Southern Bank, station "A", profile 5, 1426 hours.

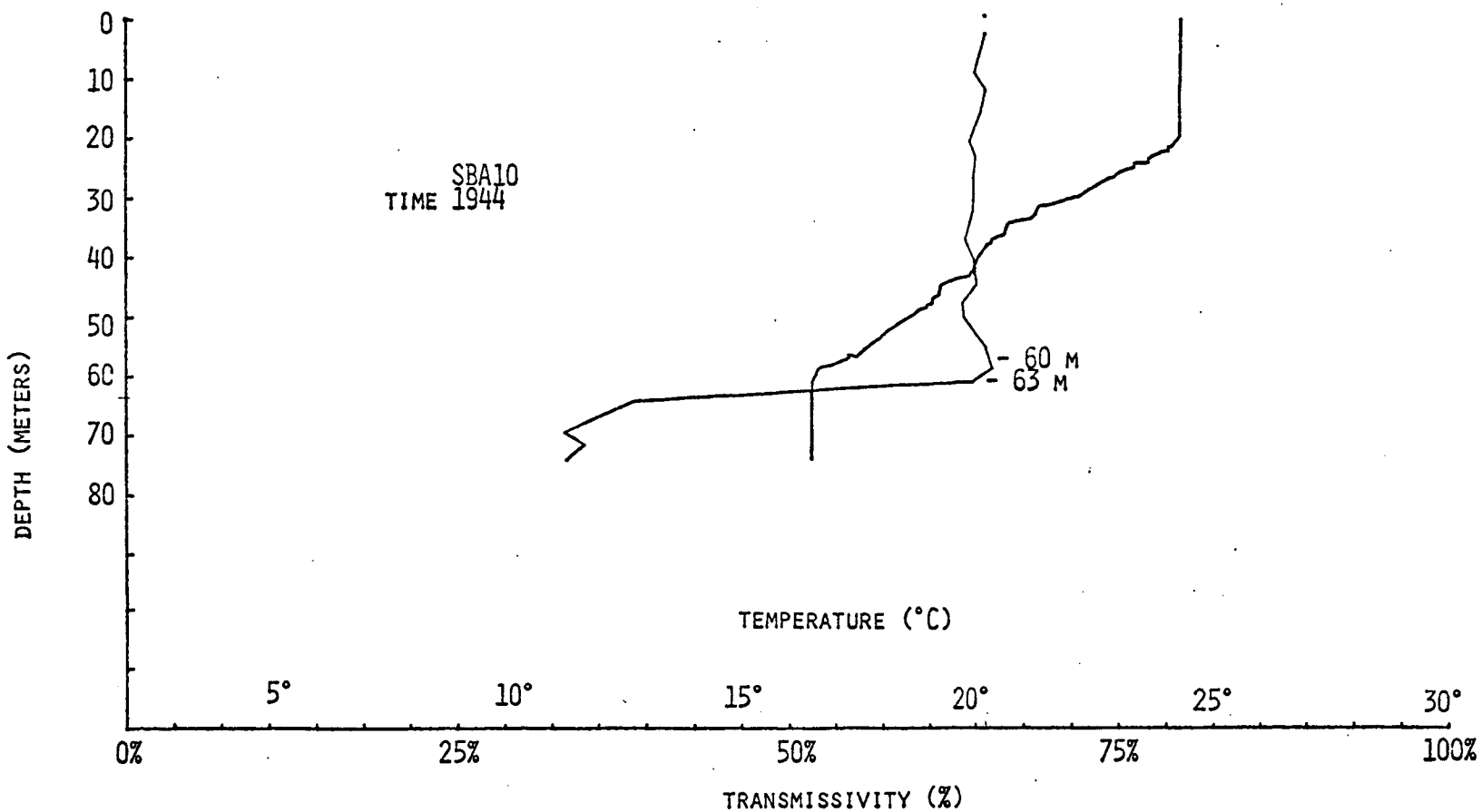


Figure III-3. Transmissivity and temperature plotted versus depth, Southern Bank, station "A", profile 10, 1944 hours.

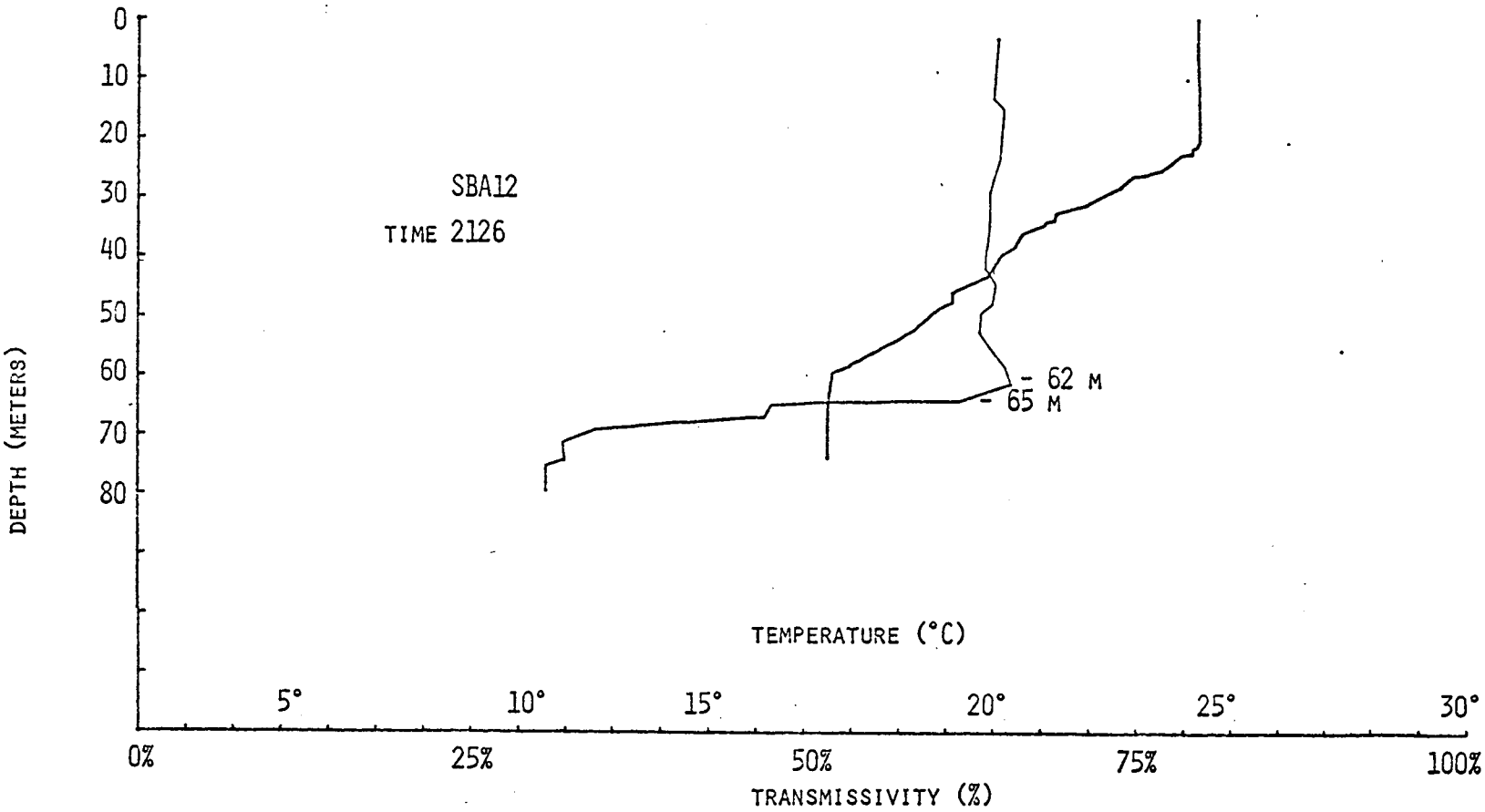


Figure III-4. Transmissivity and temperature plotted versus depth, Southern Bank, station "A", profile 12, 2126 hours.

Two other events of interest occurred during this period. The depth to the 20°C isotherm increased from 35 m to 43 m in the next hour. Such a migration of an isotherm, in conjunction with other observations using dye emission for flow visualization and precision depth recorder (PDR) returns from density interfaces strongly suggest that internal waves may supply considerable energy to the shelf edge dynamics. Also, the warm-saline layer observed in the first profile gradually lost its temperature contrast, thinned and finally disappeared.

As previously mentioned, these observations were made during the operation of the DR/V Diaphus. It was noted during these operations that the flow at the bottom was southward or offshore. It may well be, then, that the warm saline layer represented compensatory onshore flow at the base of the surface boundary layer. If it were, the dynamics and driving mechanism involved in this pehnomenon are without explanation. It does appear likely, however, that there is considerable vertical variation in the direction and magnitude of flow at this location.

When the information gained from the time series is combined with that obtained from the other profiles taken around Southern Bank the following picture emerges. Salinity contributes little to the density structure of the water column because of its uniformity (less than 1°/oo variation) during the late summer. The nepheloid layer is intimately bound to the processes which form the mixed benthic boundary layer. Suspended sediment in the layer may represent both locally derived material and that advected in

from some unknown distance. Though there is considerable temporal and spatial variation in the thickness of the nepheloid layer, its upper surface seems to range between 60 m and 70 m at Southern Bank.

Without direct observations of the flow at this, or the other banks of interest, it is not possible to determine the source of the fine sediment, the frequency or volume of its transport, or its ultimate destination.

STETSON BANK

Stetson Bank lies in much shallower water than Southern Bank (see Figs. L-5 and -9 for comparison). In fact the base of Stetson Bank is at approximately the same depth as the crest of Southern Bank. Not surprisingly, the stratification near bottom is more intense since this bank is farther up in the thermocline than Southern Bank.

In general there is no mixed layer at the bottom at this bank. The explanation for this may lie in the fact that the surface drift of the ship was to the SSE. This would require a compensating return flow which, if it were at the bottom, would bring cold water up the shelf and increase the intensity of the stratification. The lower bottom temperatures at stations on the south and west of the bank relative to those on the north and east side tend to support this hypothesis. The stratification there inhibits the formation of either an isothermal layer at the boundary or a thick nepheloid layer by turbulent mixing.

The nepheloid layer at this bank was both thin (maximum 7 m

thick) and less opaque than that at Southern Bank. Minimum near bottom transmissivities were on the order of 40%/m to 50%/m, excluding those stations where the transmissometer touched bottom. Those stations which were on the bank had no real nepheloid layer at all.

In summary then, it appears that the surface and bottom currents were in different directions, as at Southern Bank. At Stetson, however, the flow seems to have been onshore at the bottom and offshore at the surface. There was also very little suspended sediment in the water column and very little indication of turbulent mixing in the boundary layer.

28 FATHOM BANK (INCLUDING 28 FATHOM BANK, SOUTHWEST PEAK)

This bank complex is a shelf edge feature not unlike the nearby East Flower Garden Bank. The base of the bank is approximately 130 m to 150 m below sea level and the individual crests rise to within 52 m of the surface. Because of the depth of water and rapidity of currents it was not possible to get the transmissometer near bottom even with all of the cable extended. It was, therefore, not possible to get any transmissometer profiles of the deep nepheloid layer reported by Dr. Bright elsewhere in this report.

The temperature profiles indicate that the surface mixed layer at this location penetrated only about half as deep as at Southern Bank or about 10 m to 15 m. Below the mixed layer there was a strong thermocline ($-0.46^{\circ}C/m$) from there to about 70 m. From 70 m to the bottom there was variation from profile to profile. Some possessed a layer with a very minor stratification all the way to

the bottom and some had a stair step appearance with alternating isothermal and slightly stratified layers. The latter may be related to the alternating turbid and clear layers observed by Dr. Bright from the DR/V Diaphus. These layers appear to have lapped up on the deep flanks of this bank with the shallowest at about 80 m and the deepest at approximately 130 m.

With no time series data and no good transmissometer data from this bank it is not possible to tell whether the variations observed between profiles represent spatial or temporal changes in the structure of the water column. The presence of stratification all the way to the bottom in some profiles suggests onshore flow at the bottom which inhibits turbulent mixing.

EAST FLOWER GARDEN BANK

The East Flower Garden Bank is a shelf edge feature which extends from depths exceeding 120 m to only 16 m from the surface. The mixed layer at the surface was 15 m to 25 m thick at the time of the survey in late August. At many stations a mixed layer extended from the bottom upward about 8 m to 10 m. It would appear that at some of the stations where the mixed, or isothermal, layer was absent the STD was not lowered sufficiently close to the bottom to detect the boundary layer. In others it may be that an influx of cold water from offshore inhibited the formation of such a layer.

No real nepheloid layer was observed on the East Flower Garden Bank itself. Rather, at the seaward base of the bank,

below 120 m a thin (≈2 m) relatively weak (≈50%/m transmissivity) nepheloid layer was observed. Without current measurements the source of the fine sediment comprising the nepheloid layer there can not be determined.

As at the other banks, the salinity varied by less than 1% and contributed little to the density structure of the water column.

HYDROGRAPHY

AND

SUSPENDED MATERIAL

TRANSECT II

Principal Investigator

Richard Rezak

Contributors

Thomas Cool

Richard Parker

Robert Tompkins

INTRODUCTION

The generic terms "suspended matter" or "particulate matter" include many types of particles defined either by their source (i.e., suspended sediment and marine or terrestrial suspended organic matter) or their chemistry (particulate metals and certain elements). The term "total suspended matter" was introduced by Harris (1971) to refer to the sum total of all particulate suspended matter.

Quantity and distribution of total suspended matter in coastal environments are important in that they tend to indicate sedimentation patterns, define associated current and transport phenomena, and help to define bodies of water. Concentrations of suspended matter in the surface waters of the ocean are easily recognized and sampled (Scruton and Moore, 1953). From the color and transparency of ocean waters, Jerlov (1959) refined the theory of light scattering by particles. Gravimetric studies of marine particulate matter followed with the development of the membrane filter. Fox et al. (1952), Goldberg et al. (1952), and Armstrong (1958) refined the existing techniques and introduced new information. Investigations by western scientists have centered on the coastal regions off North America, as reported by Meade (1969), Eittriem et al. (1969), Manheim et al. (1969), Spencer and Sachs (1970), Beer and Borsline (1971), Drake (1971), Bornhold et al (1973), Emery et al. (1973), and Milliman et al. (1975) have all investigated suspended matter over the continental shelves in the Pacific Ocean and South Atlantic. Jacobs and Ewing (1969a) gave a synopsis of the concentration of

suspended matter in all of the world's oceans. A summary of numerous studies of suspended matter conducted by the Russians is given by Lisitzin (1972).

Profiles of total suspended matter in many oceans indicate the presence of a near-bottom turbid layer known as a nepheloid layer. This phenomenon was first reported by Ewing and Thorndike (1965) for the North Atlantic. Subsequent investigations showed it to occur in most ocean basins (Jacobs and Ewing, 1969a).

Little published information exists on the distribution and character of total suspended matter in the northwest Gulf of Mexico. What is in print focuses on the deep mid-Gulf waters and the Mississippi River regions. Jacobs and Ewing (1969b) reported on 15 samples obtained by centrifugation of samples taken in deep, mid-Gulf waters. Harris (1971) reported on samples from throughout the Gulf of Mexico, but these, too, are largely from deeper waters. Manheim et al. (1972) described concentrations of suspended matter in the northwest Gulf of Mexico from the Mississippi River to Galveston, Texas.

PROCEDURES

GRAVIMETRIC TECHNIQUES

Field sampling, as carried out on either the R/V Gyre or R/V Longhorn, consisted of taking 30 liter Niskin samples at predetermined depths. These depths were determined from observing inflection points on the transmissometer profiles in order to determine the depth to the nepheloid layer. Sea water was transferred from

the Niskin bottles to 2.5 or 5.0 liter cubitainers for storage in a refrigerator until such time as they could be transferred to the lab.

The gravimetric procedure followed in the analysis of the water samples is similar to that of Bassin (1975). Standard 47 mm diameter Nuclepore GE-40 membrane filters, having a nominal pore size of 0.40 μm, were pre-weighed on an Ainsworth Type 24 N precision weighing balance to an accuracy of 10^{-5} grams. Filters were passed over uranyl acetate crystals before being weighed in the presence of an α-emitting ionizing source (Polonium 210), which minimizes the effects of static electricity. Weighing occurred in blocks of 28, with three of the filters serving as control filters. The controls were weighed six times each, whereas the 'use' filters were weighed twice each. The controls were treated exactly as the use filters except that no sea water was filtered through. Filters were stored individually in plastic petri dishes over sodium hydroxide crystals within a desiccator.

To determine the amount of manufacturing residue present and its effect on filter gravimetry, an experiment was conducted with Nuclepore filters. Two liters of distilled, deionized water samples were filtered through each of five Nuclepore filters. The filtrate was considered particle free. The results are given in Table III-2. Nuclepore filters averaged a loss of 19 μg. Effects of such a loss due to manufacturing residue are minimal in this study, where concentrations were measured in mg/l or hundreds of μg/l.

Table III-2. Nuclepore Dissolution Experiment

Filter No.	Weight Loss (μg)	
1E	22	
2E	14	
3E	23	
4E	18	
5E	18	Mean loss: 19μg

Corrections due to changes in humidity, temperature, and balance were reflected by weight changes of control filters. These corrections were on the order of 4 to 7 μg. When applied to filter weights, in most cases correction values had very little effect on concentration levels.

The filtering system itself was as follows: the cubitainers, which contained the water samples, were placed on a holding rack and connected via Tygon tubing to Millipore in-line disc filter holders which had Nuclepore filters enclosed. A Gast vacuum pump provided the suction by which water was drawn through the Nuclepore filters into 4 liter collecting flasks. Water was drawn through the system until the filter became clogged or all but one liter of the water sample was filtered. These filters commonly became clogged so much that particles of an order of magnitude smaller than the nominal 0.40 μm pore size were retained (Sheldon and Sutcliffe, 1969). Volumes of filtered water samples were measured to the nearest 10 ml. Tygon vacuum tubing connected the filter holders to the collecting flasks and to the vacuum pump.

Immediately after filtration, the basal in-line filter holder, with saturated filter pad, was transferred to a 500 ml vacuum flask and rinsed three to five times with a total of 300 to 500 ml of

double-distilled, deionized water. The filters were allowed to drain nearly dry before the next rinsing session. Filtered effluent was tested with 0.1 N silver nitrate for indications of sea salts. After washing, the filters were stored in small plastic petri dishes over sodium hydroxide pellets in a desiccator. Five to seven days were allowed for drying and equilibration to the atmosphere of the weighing room before being reweighed. Concentration of total suspended matter in mg/l was found by determining the weight of material trapped on a filter and dividing this value by the volume of water filtered.

X-RAY DIFFRACTION TECHNIQUES

Prior to the suspended mineralogy analysis, the total suspended load was obtained. Techniques for preparing suspended solids for mineral analysis follow those of Manheim et al. (1972). To collect suspended solids, water samples were filtered through Selas Flotronic silver membranes (0.45 μm size, and 25 mm diameter). In order to intensify the clay peaks and to prevent differential settling of particles, a controlled unit of water sample (2 ml) was introduced at approximately five minute time intervals. The sample was then washed with deionized water to remove residual salts and treated with four aliquots of 20% glycerol at the time intervals given above. This glycerol treatment was to differentiate the 14Å mineral assemblage on the diffractogram.

The suspended mineral analysis was carried out by placing the silver filters on a special vacuum holder attachment to keep the

sample surface flat. Separate diffractograms were obtained for (1) glycerol treatment and drying at 25°C (2) heating treatment of 110°C for 12 hours, and (3) 550°C for 1 hour. Mineral identification was by the same criteria as given in the bottom sediment analysis section, with the same diffractometer and recorder conditions.

RESULTS

Transect II extends southeast across the shelf from Port Aransas, Texas (see Figure V-1). The nearest shore station, Station 1, is in about 20 m of water while the furthest offshore station is in about 125 m of water. A total of 61 samples, taken during 5 monthly cruises, from the six stations were analyzed for total suspended matter. The x-ray diffraction analysis, hampered because of the small sample size, got usable results from only fourteen of the samples. Therefore, the diagrams interpreting the suspended sediment distribution are highly conjectural.

MARCH

Surface waters during this month's sampling cruise consist of high concentrations of total suspended matter (TSM) at all stations except number 4. The nearshore stations are characterized by low salinity waters (Figure III-6) which are indicative of a nearby source of runoff. Concentrations of TSM in surface waters increase seaward from Station 4. Seaward of Station 5 concentrations of TSM in mid-depth waters increase noticeably, also. In fact, concentrations of TSM in mid-depth waters exceed those found in the

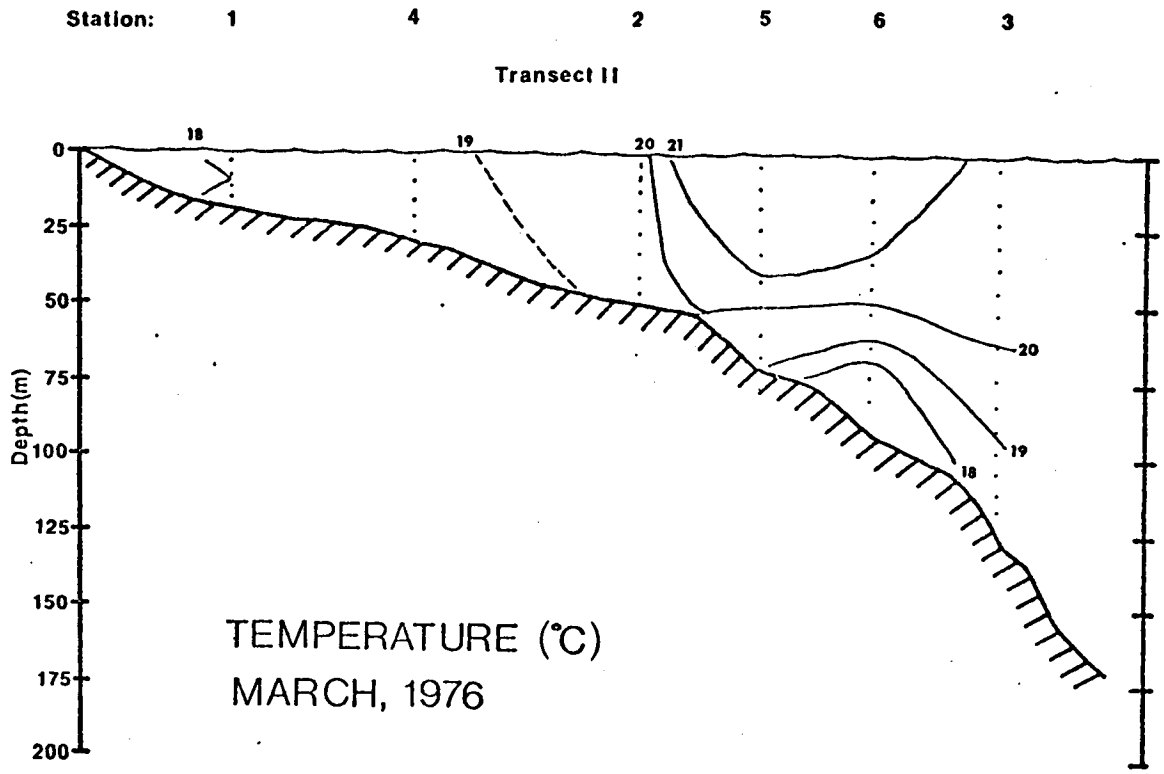


Figure III-5

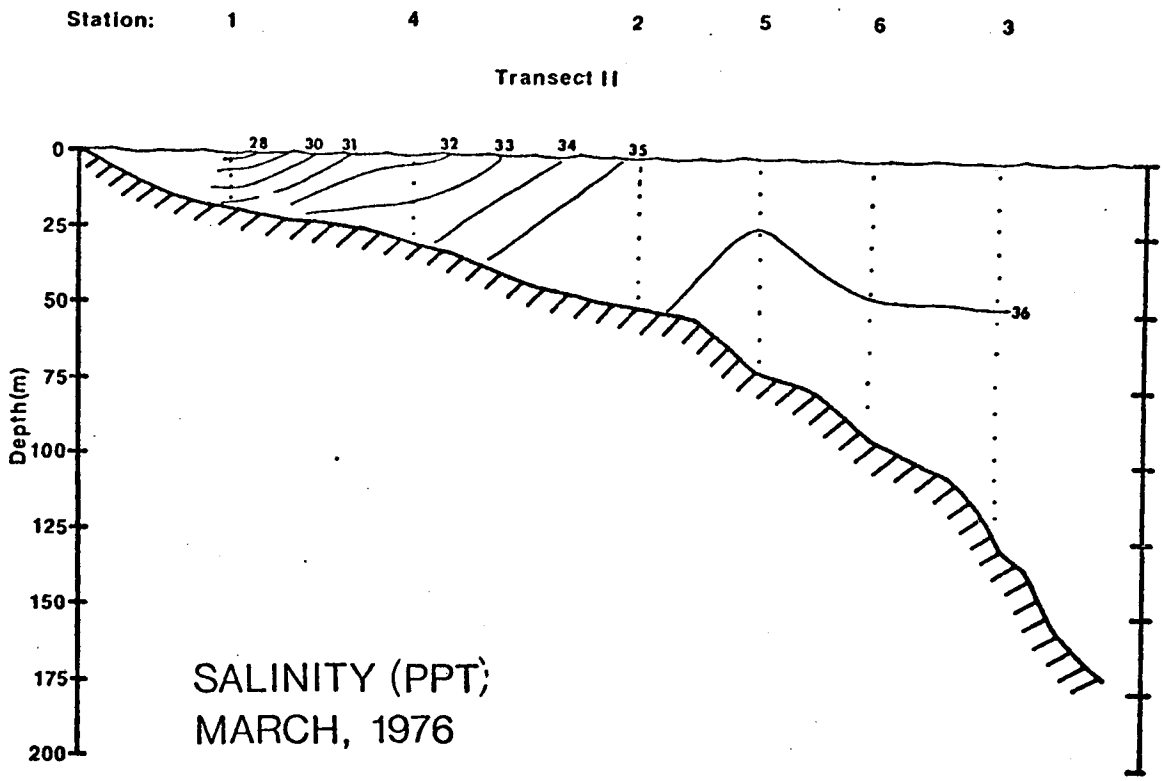


Figure III-6

nepheloid layer. Microscopic examination of the membrane filters from the mid-depth samples indicates a very high percentage of organic matter.

A nepheloid layer exists at all stations but generally is thickest at the shallowest stations. Highest concentrations of TSM within the nepheloid layer occur here also. The nepheloid layer thins slightly seaward but concentration levels increase progressively seaward (Figure III-7).

The X-ray data (Figure III-8) indicate a thin layer of material possibly derived from local runoff along the bottom with the overlying waters having smectite as the predominant mineral. The rivers draining into the western gulf carry a mineral assemblage that has kaolinite and illite as the predominant minerals; see the discussion on the relationship between river runoff and bottom sediments along transect II in Chapter IV. There is also a small area of smectite domination along the bottom, possibly material resuspended by currents or internal waves impinging on the bottom.

APRIL

Very high concentrations of TSM which occurred in surface waters at Station 1 were probably derived from ebb tidal outflow of fresher waters (Figures III-9 and III-11). A similar concentration of high TSM values in surface waters exists at Station 3. The high concentration of suspended matter at this offshore station is primarily organic matter; its origin is not apparent but it is felt to be derived from open-gulf waters.

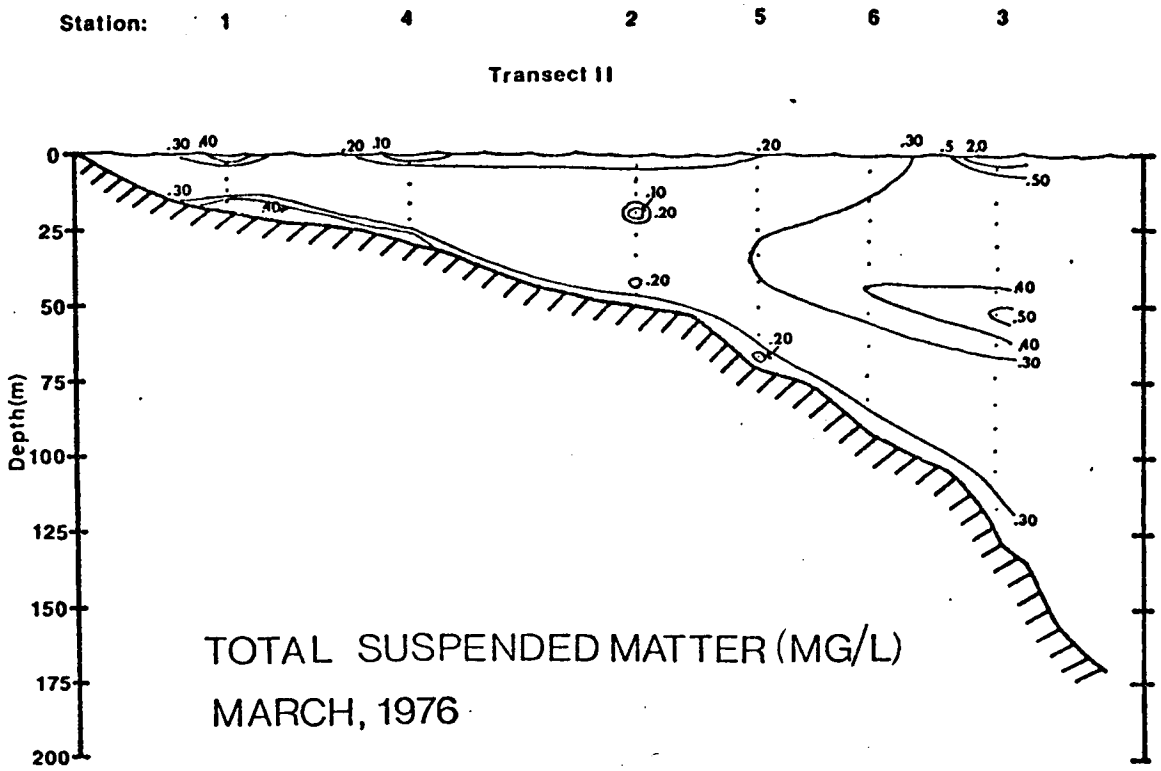


Figure III-7

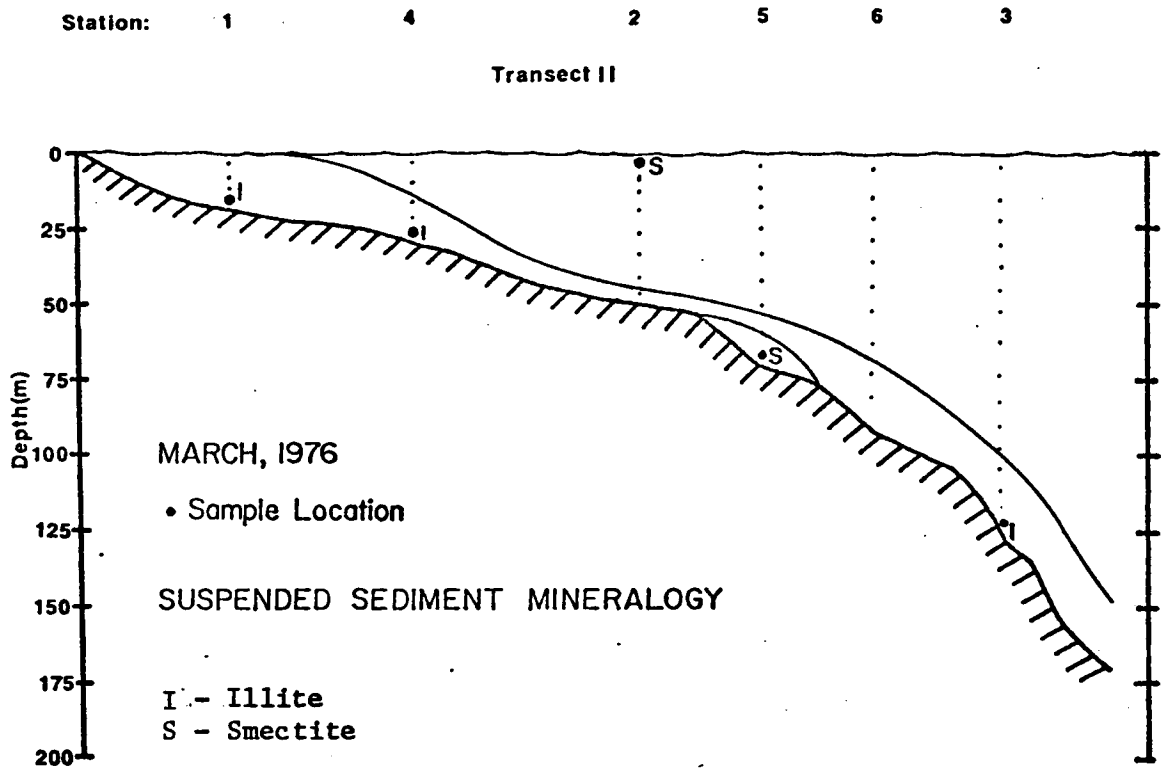


Figure III-8

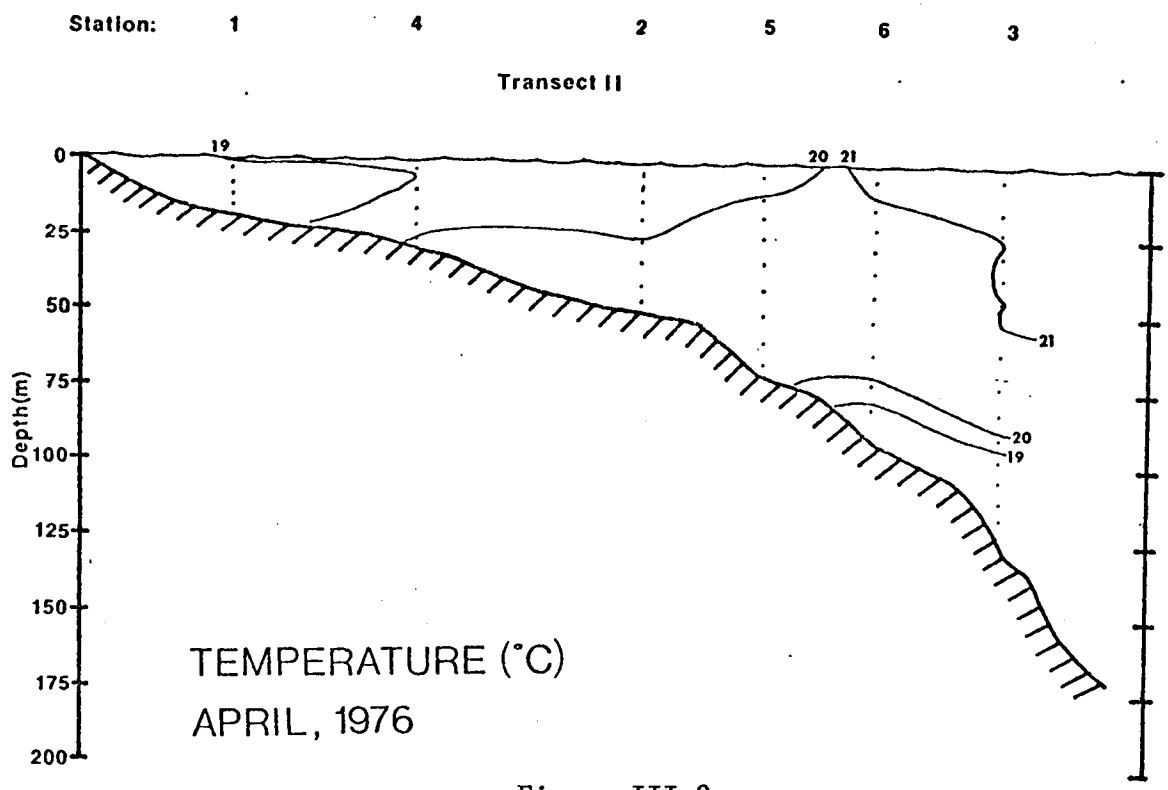


Figure III-9

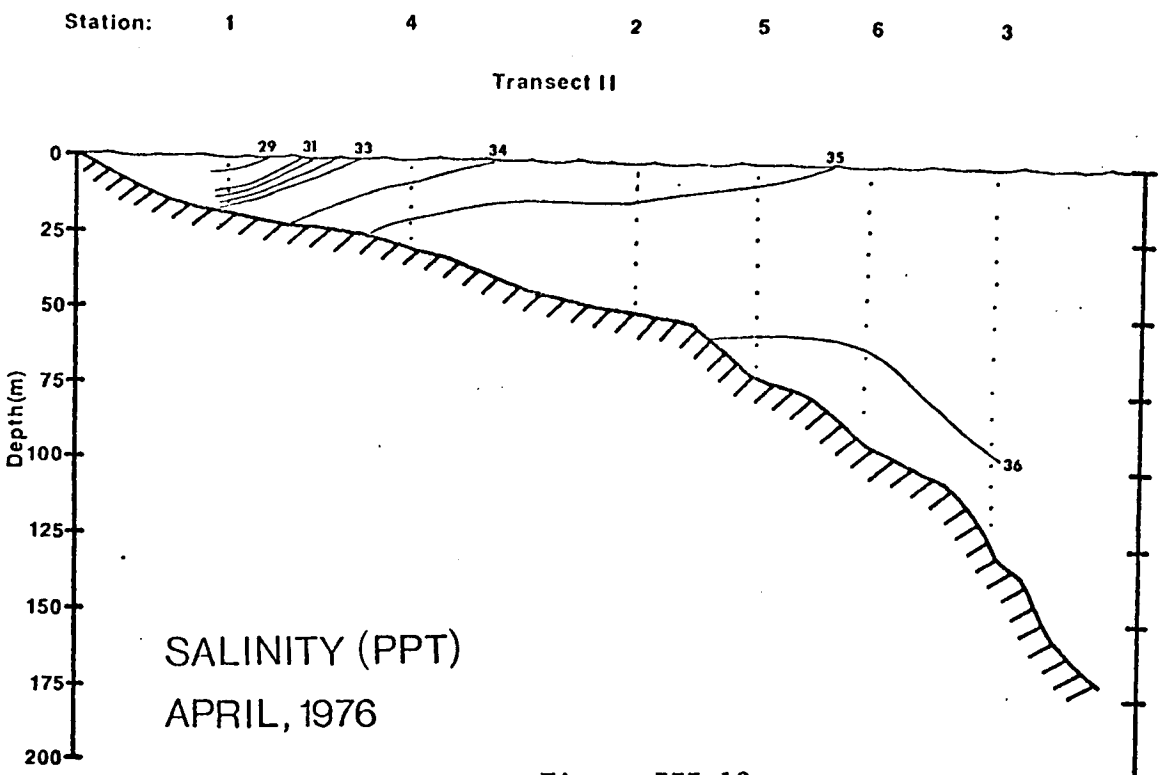


Figure III-10

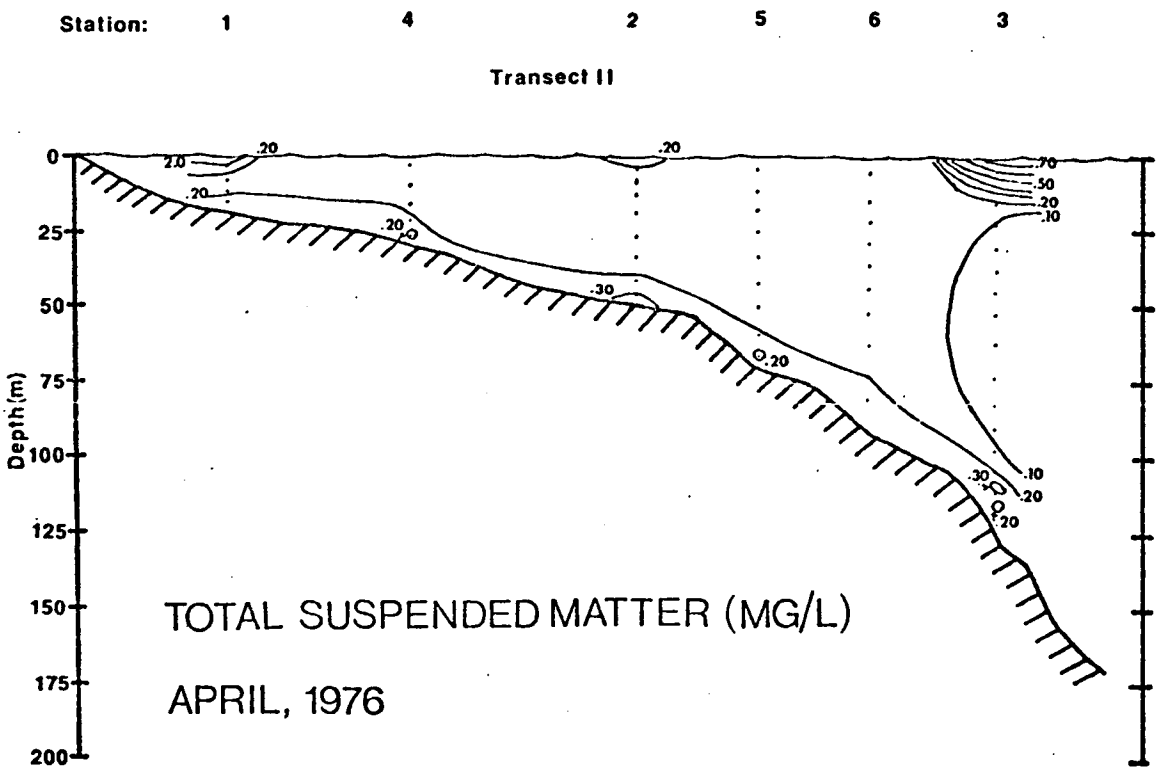


Figure III-11

A nepheloid layer exists at all stations along the transect. Several zones of low concentrations of TSM occur within the nepheloid layer commonly just seaward of a topographic high. A rather sharp temperature contrast occurs just above the nepheloid layer at Stations 6 and 3. The temperature cross section indicates that the upper 90 meters at these stations are very homogeneous. The temperature and salinity cross sections (Figures III-9 and III-10) together indicate a core of warmer, more saline waters located above the bottom over the middle shelf. This is associated with a thick nepheloid layer which in turn contains high values of suspended matter. X-ray data was obtained on only one sample from this month, so a diagram was not attempted.

JUNE

The nearshore concentration of more turbid surface waters does not correspond directly with the low salinity water cut off from the shore (Figure III-14). Concentrations of TSM at the three farthest offshore stations are of nearly the same magnitude from surface to mid-depth. A nepheloid layer is present along the whole transect with especially high concentrations of suspended matter at Station 4. The very high concentrations of suspended matter here, in relation to others on the transect, occur where the isopycnals and isohalines appear to impinge upon the bottom (Figures III-12 and III-13). The water directly overlying the nepheloid layer is high salinity, cold, and very clear indicating that it could possibly be derived from offshore waters.

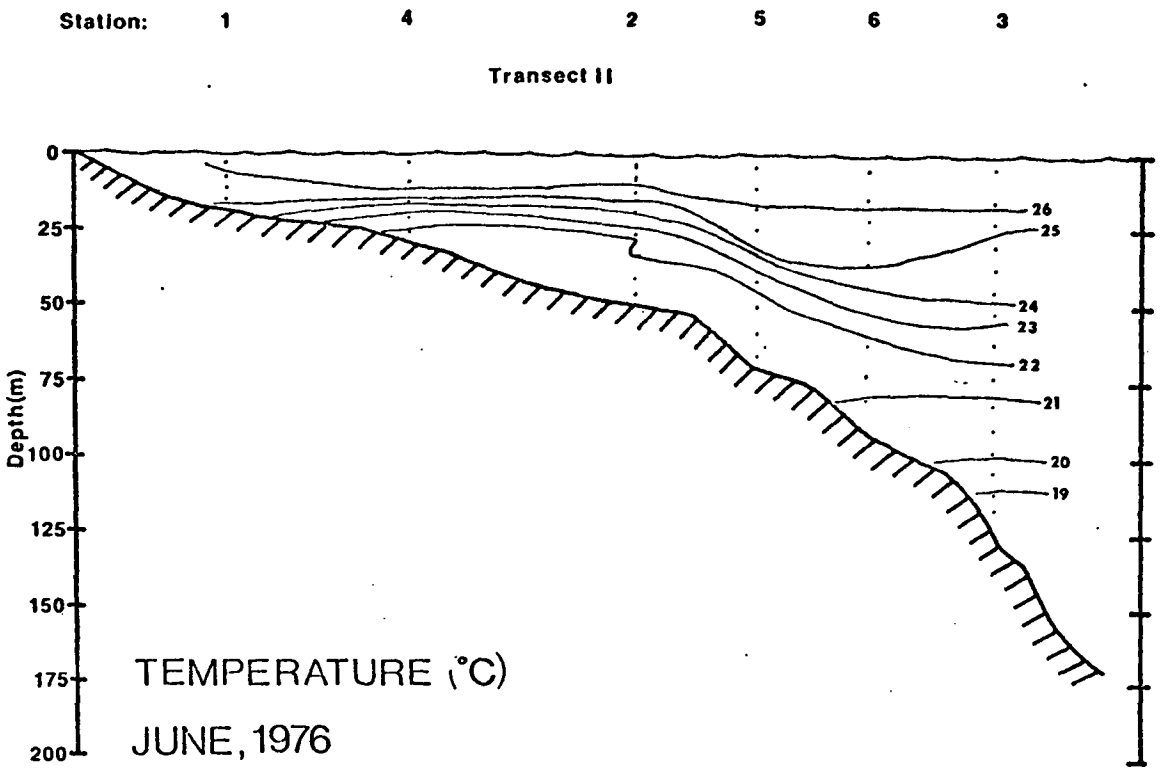


Figure III-12

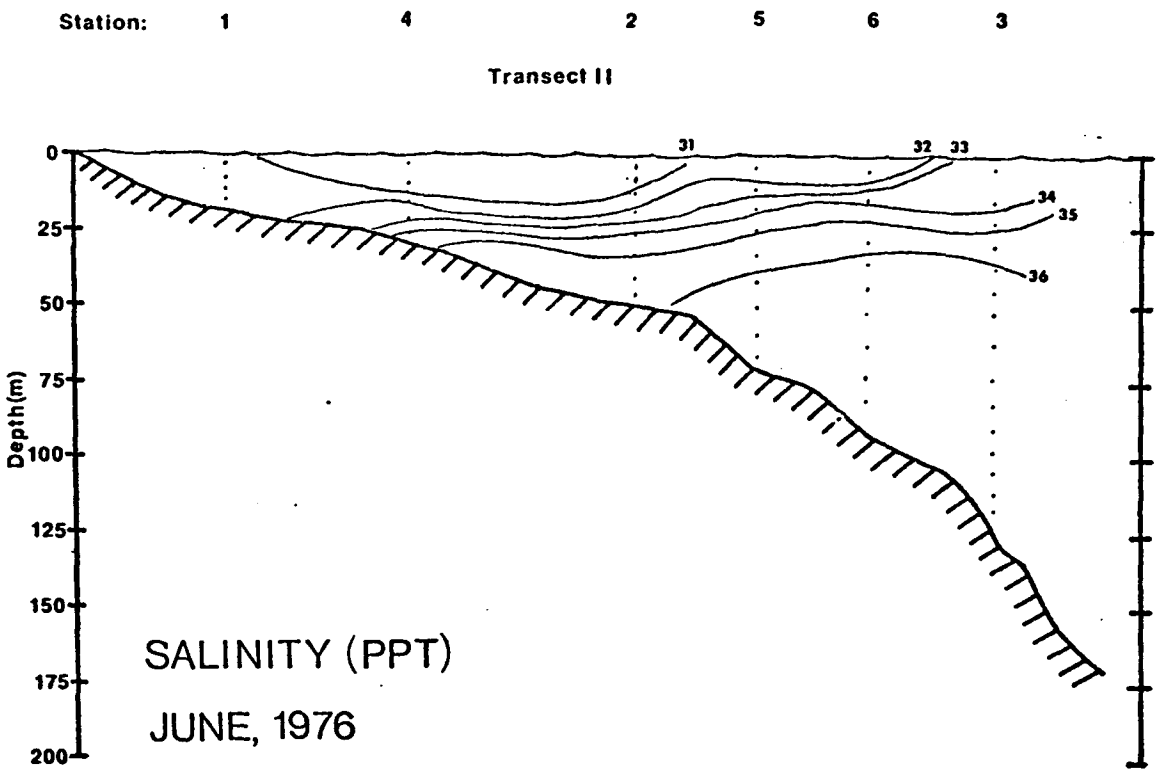


Figure III-13

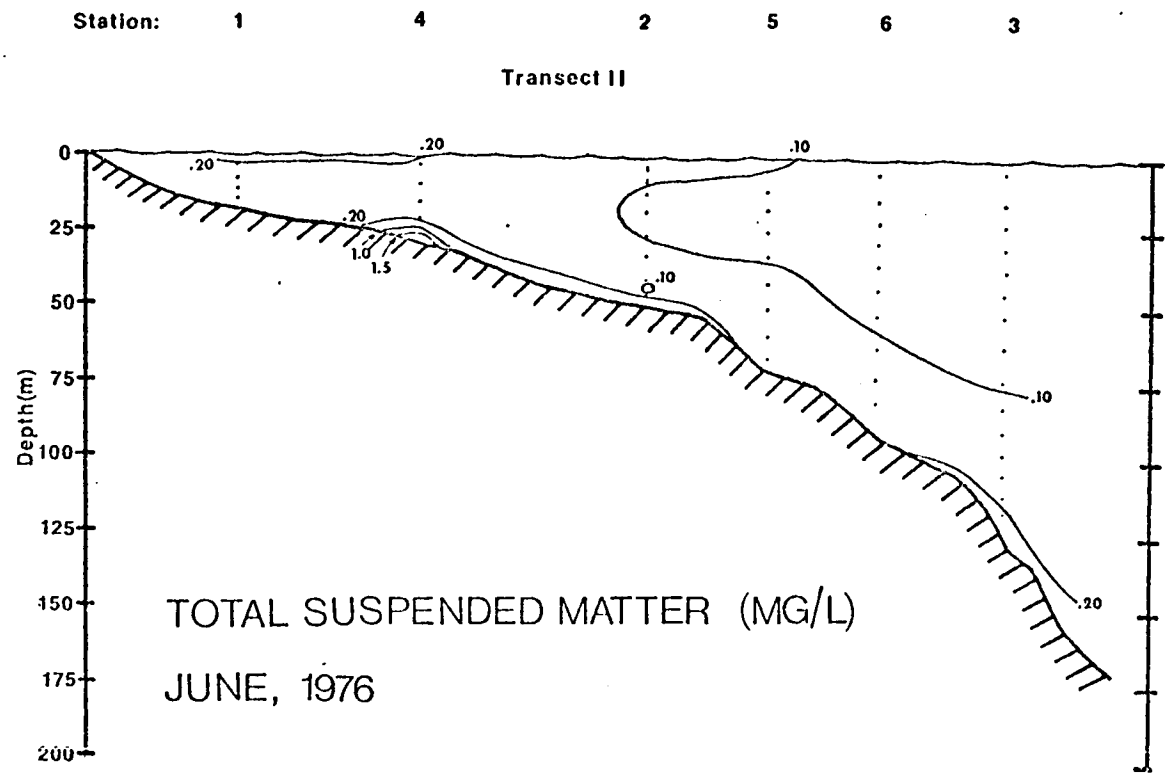


Figure III-14

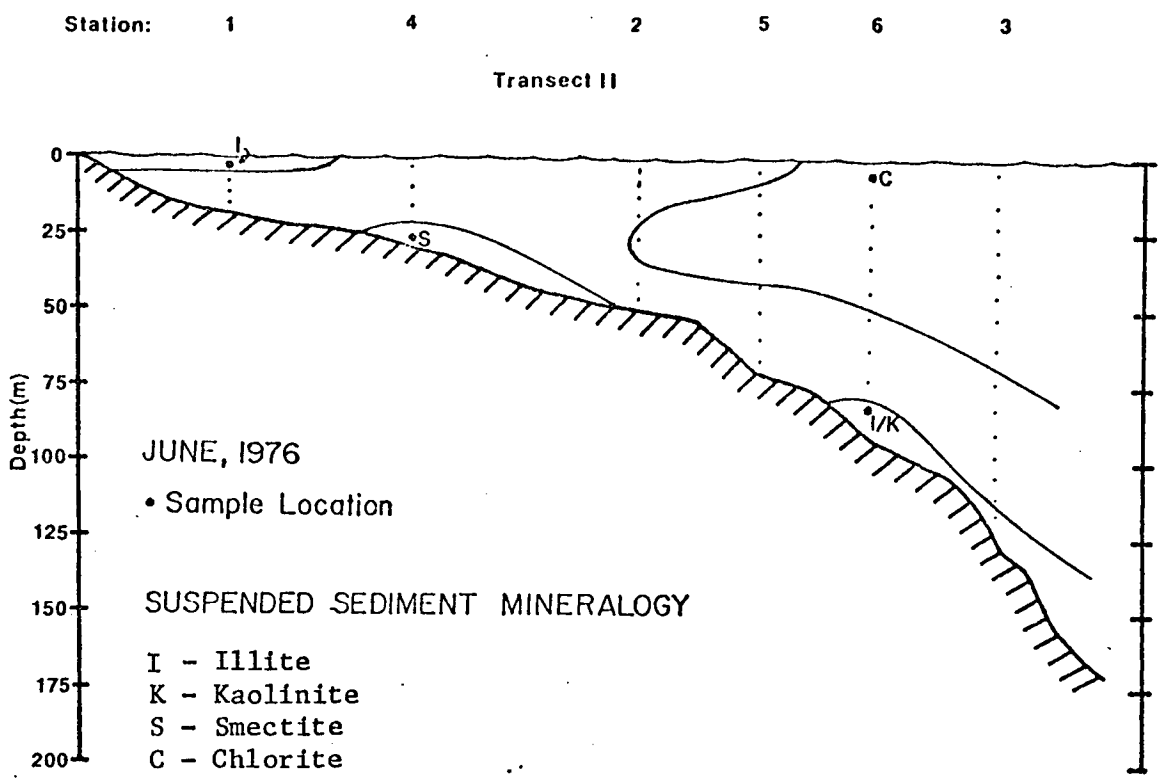


Figure III-15

The distribution of predominant minerals during June (Figure III-15) is intriguing in the appearance of chlorite in the surface waters of the seaward Station 6. This is an area of very low total suspended material, so the chlorite may be the only crystalline material present. The appearance of smectite in a small area of high TSM indicates that it was resuspended from the bottom sediments. Although the TSM diagram does not support it, there may be a thin layer of illite/kaolinite.

SEPTEMBER

The TSM profile along Transect II indicates a body of turbid water nearshore (Figure III-18). A nepheloid layer containing very high concentrations of suspended matter exists along the bottom at Station 1. This corresponds to where isotherms impinge on the bottom (Figure III-16). High concentrations of suspended matter occur at mid-depth at Stations 4 and 3. The nepheloid layer is continuous offshore from Station 4. The thickness of the nepheloid layer and the concentration of suspended matter within it increase at mid-shelf stations (numbers 2 and 5). This thickening of the nepheloid layer and the increase in concentration of the suspended matter occur at or just below where a strong thermocline occurs on the mid-shelf area.

The September mineral distribution (Figure 19) is interesting in that the predominant mineral is, in all samples, smectite. There must have been resuspension over a large area of the bottom.

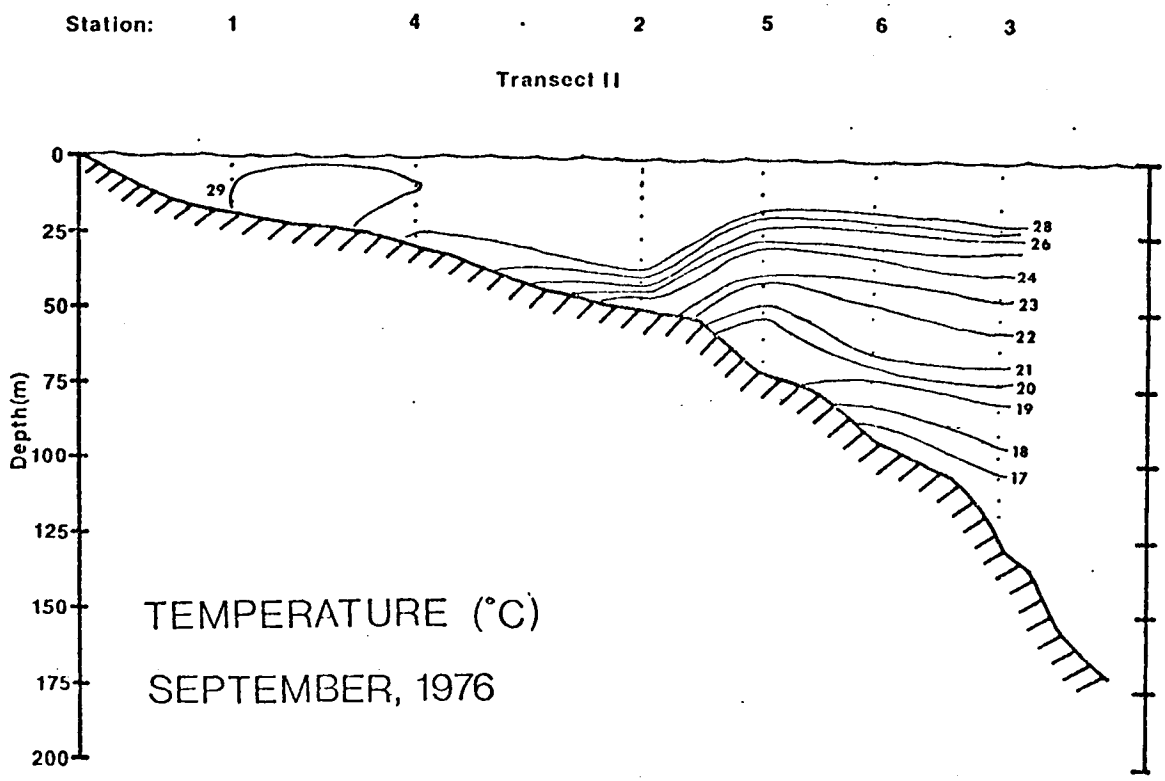


Figure III-16

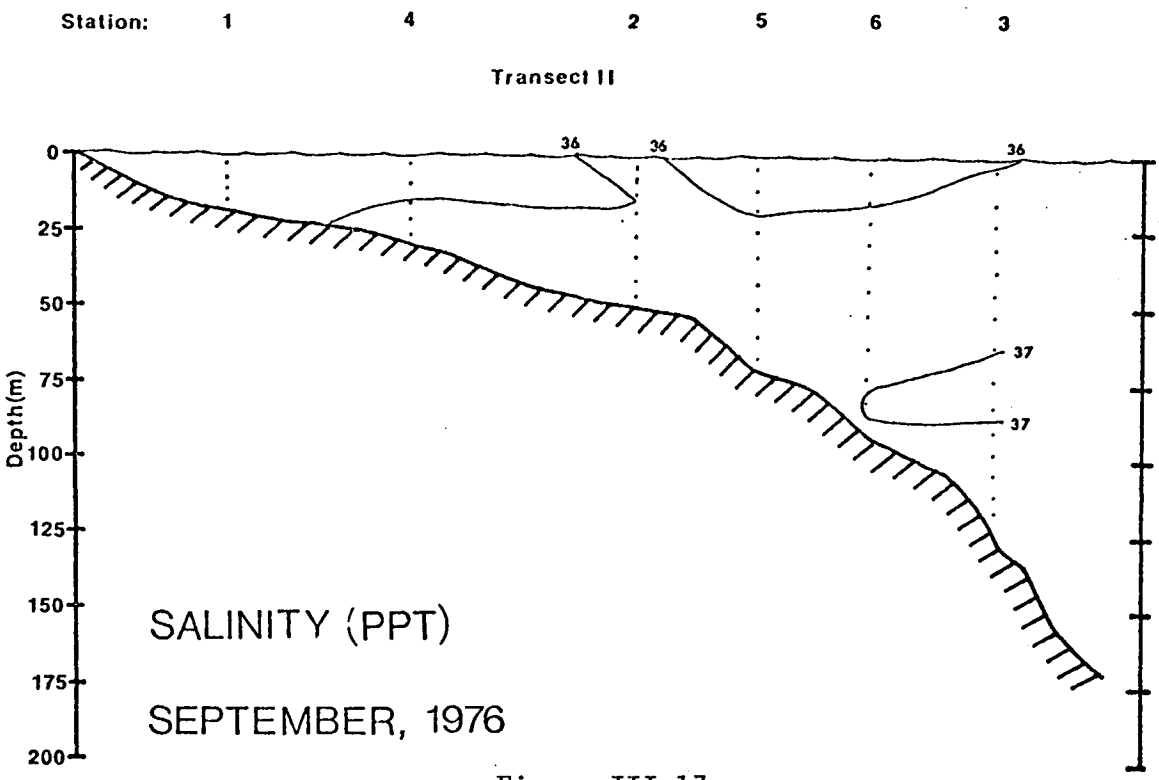


Figure III-17

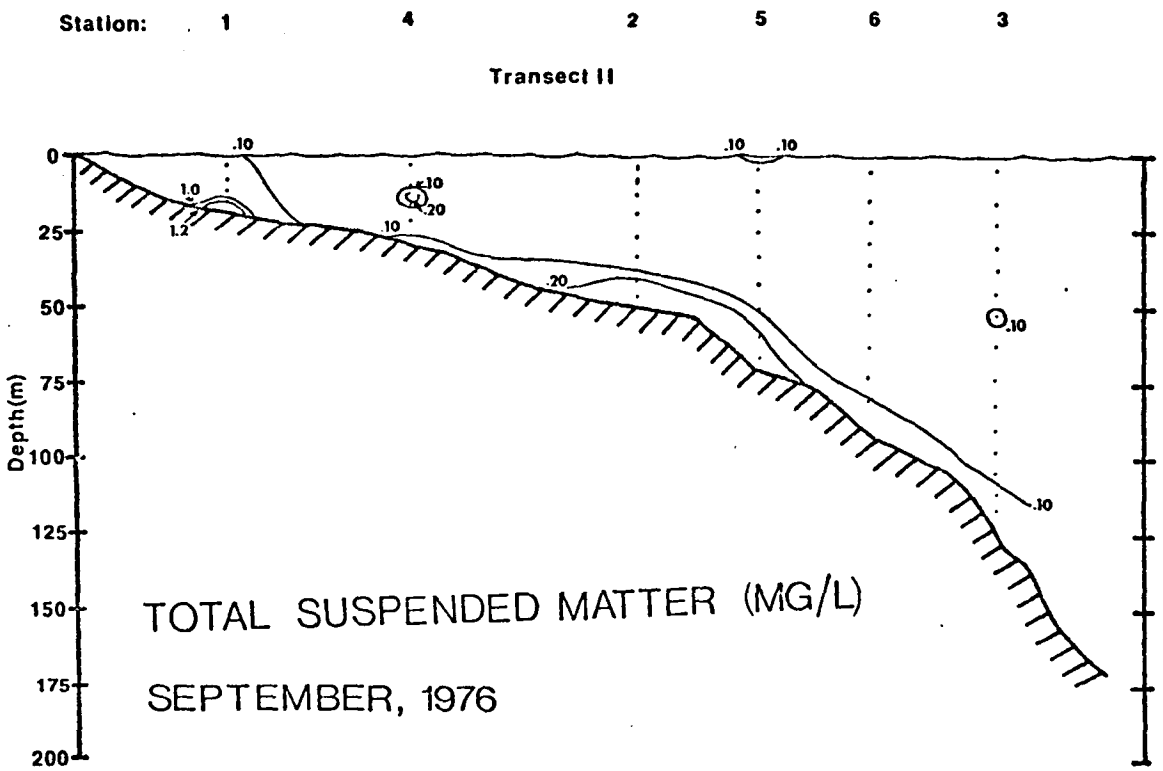


Figure III-18

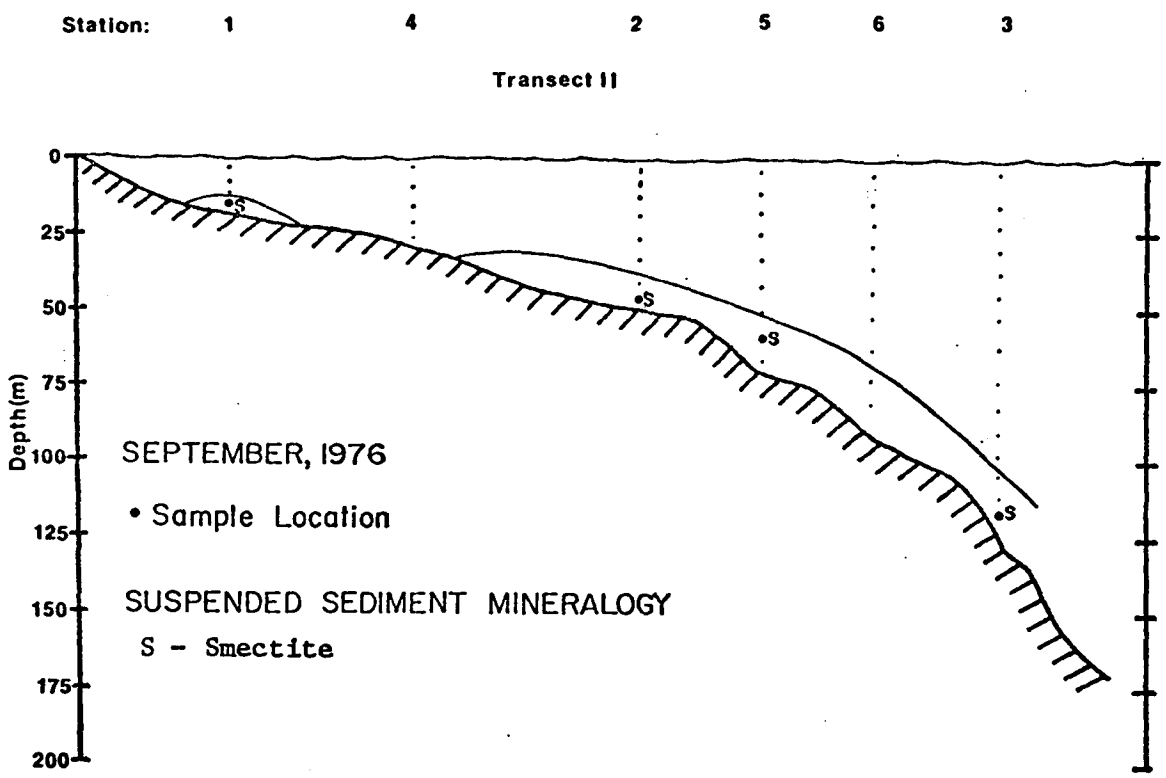


Figure III-19

NOVEMBER

A pocket of turbid surface waters corresponds with nearshore low temperature, low salinity waters (Figures III-20, III-21 and III-22). Waters between the surface and the nepheloid layer are generally quite clear. A prominent nepheloid layer exists from just landward of Station 4 increasing in thickness offshore. The top of the layer at Station 3 corresponds closely with the base of the thermocline at this station. Highest values of TSM occurred some 20 m off the bottom within the nepheloid layer at Station 3. The very cold, high salinity waters at this station are probably derived from the Gulf of Mexico rather than from along the shelf.

The mineral distribution during November (Figure III-23) is a complete reversal from the September distribution. The only sample where smectite is important is from Station 6, where the three major minerals are approximately equal. The near bottom waters contain illite in predominance, with a midwater zone of kaolinite at Station 3.

DISCUSSION

Occurrences to note are: (1) the presence of a nepheloid layer over transect II at all times of the year, though variable in thickness and in the concentration of the suspended matter within it, and (2) extremely variable concentrations of TSM in surface and mid-depth waters.

These variations may be seasonal effects. Highest concentrations of TSM in surface and mid-depth waters occurred during the spring. The farthest offshore stations exhibit these patterns in

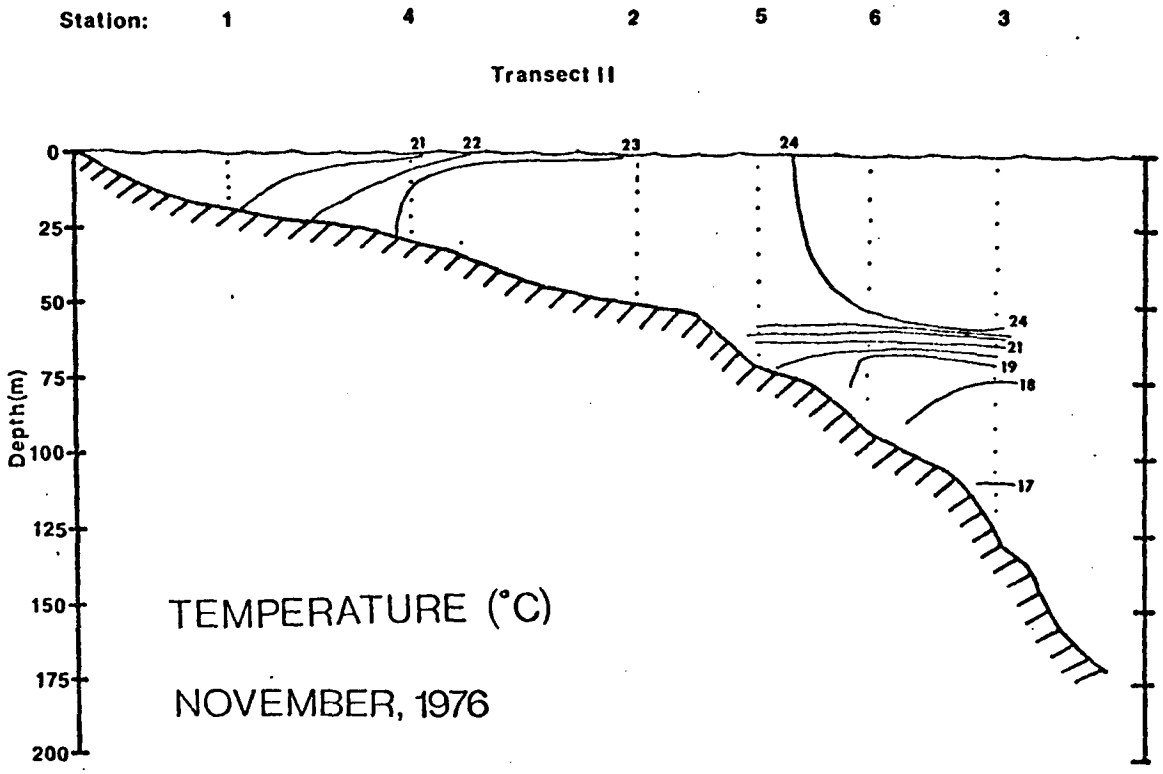


Figure III-20

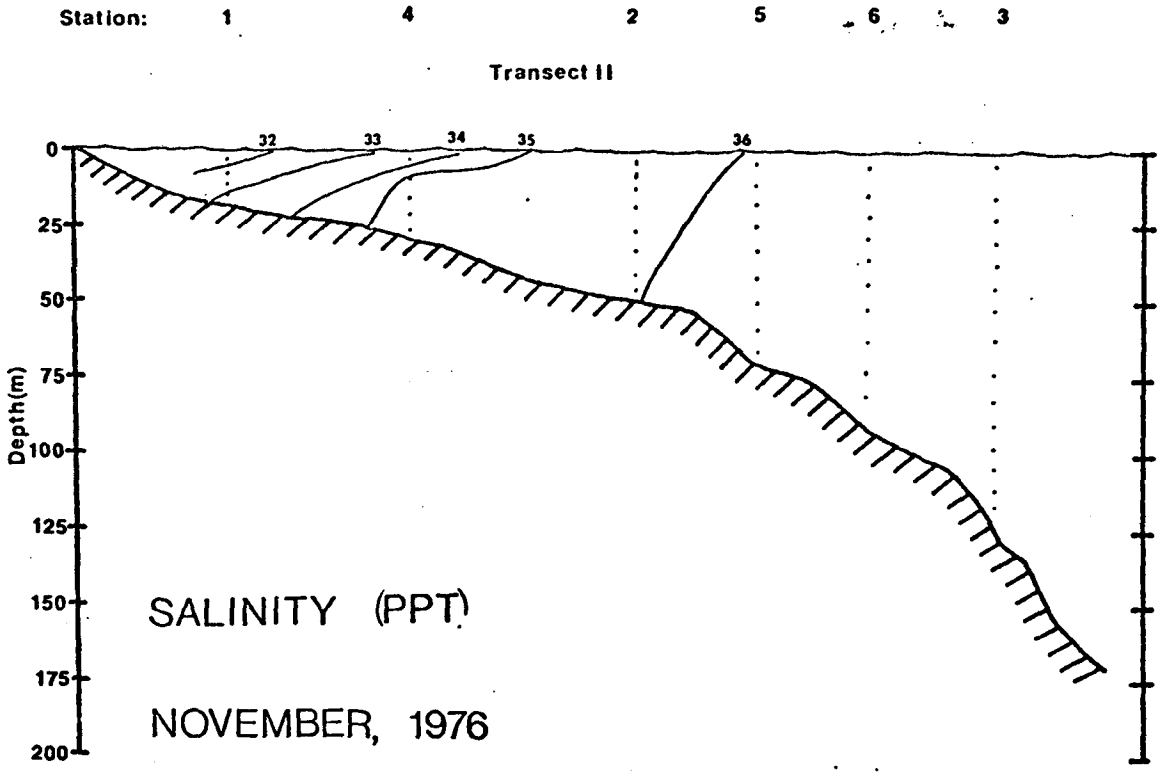


Figure III-21

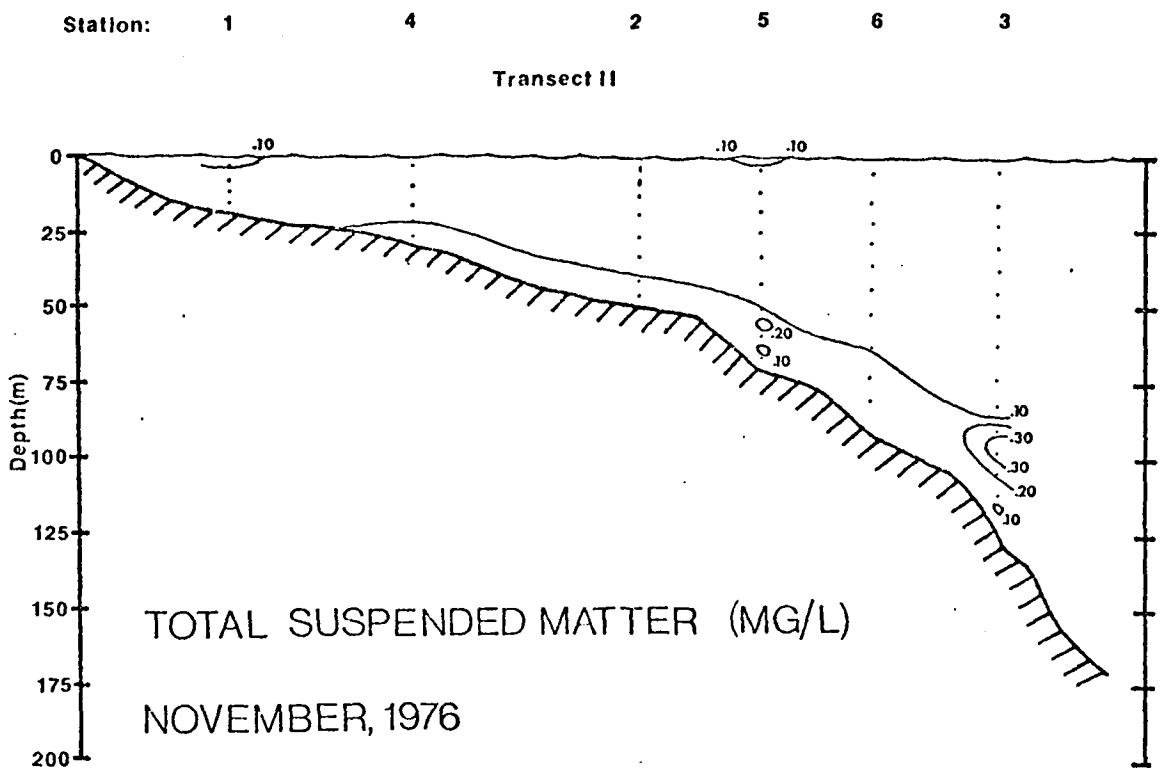


Figure III-22

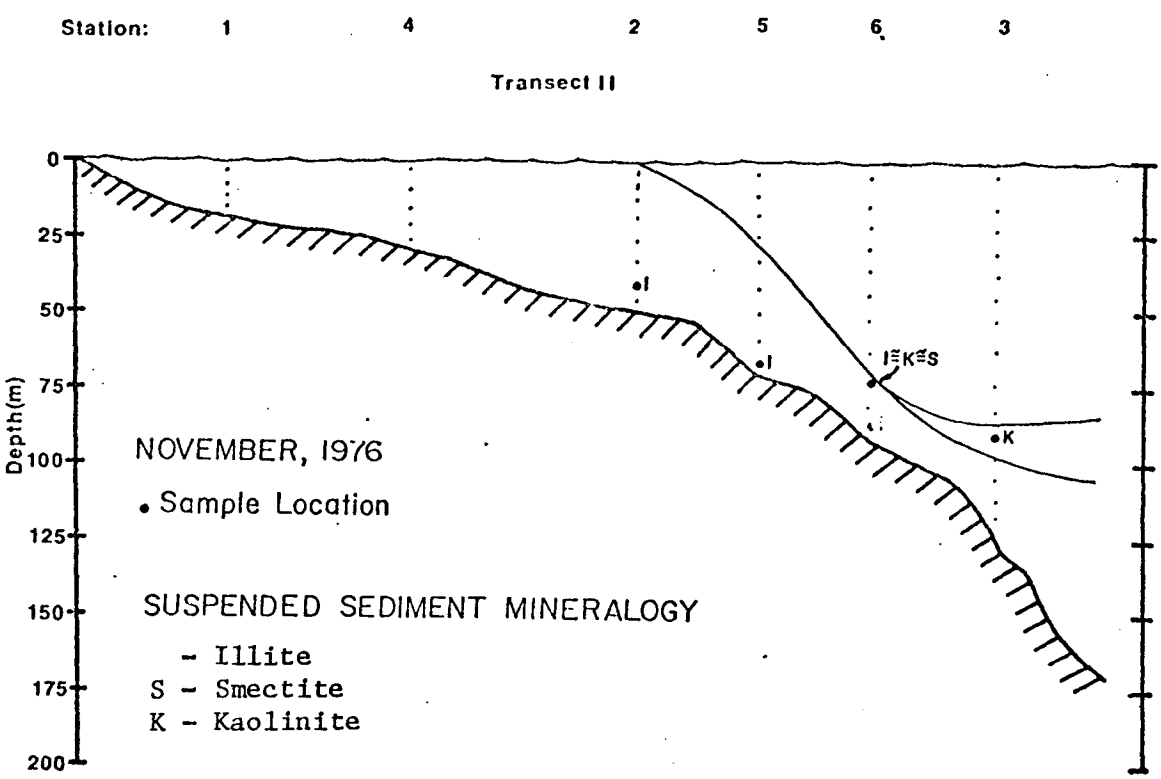


Figure III-23

conjunction with higher salinity, lower temperature waters which probably originate more from the open Gulf than the shelf. The nepheloid layer along the bottom during these months is fairly thick, especially nearshore, and of relatively high concentrations of TSM with respect to the mid-depth waters. Exceptions to this pattern occur at Stations 6 and 3 in March.

Summer and early fall cross sections show: (1) high concentrations of TSM in surface waters, but restricted to nearshore stations, (2) mid-depth and shallow waters in the more offshore stations to be characterized by clearer, less turbid waters than in previous months, and (3) a nepheloid layer occurring over the whole shelf. Zones of highest concentration within this layer appear to occur deeper on the shelf as seasons change from summer to fall. The nepheloid layer also seems to thicken with this seasonal change.

This pattern of events may be reflected by the seasonal change in the physical nature of the water column. There is a change from a barotropic nature in the late spring through early fall to a baroclinic nature from fall through late spring. Wind stress on the surface is probably the most important driving mechanism for barotropic conditions whereas baroclinic conditions (sloping isopycnals and isohalines) provide a driving force for currents. A thicker nepheloid layer with more material suspended within it may result from direct impingement by, or from shear caused by, currents generated under baroclinic conditions.

As stated at the beginning of this discussion, the X-ray

diffraction data is so sparse that any conclusions drawn using them is very tenuous. However, there are some indications of resuspension of bottom material and the seaward extent of the suspended load of the western gulf rivers.

VISUAL EXAMINATION OF SUSPENDED SEDIMENT WITH A SCANNING ELECTRON MICROSCOPE

Principal Investigator

Stefan Gartner

Contributors

Min-Pen Chen

INTRODUCTION

Terms such as suspended sediment and nepheloid layer describe the state of the sediments but convey nothing of their nature and composition. Grain size analyses and X-ray mineralogical determinations also are not entirely sufficient for visualization of what constitutes suspended sediment. In order to gain some further understanding of precisely what is contained in the suspended sediment, six samples were studied and photographed with the scanning electron microscope and one with the light microscope (see Table III-3). Five of the samples are from Hospital and Southern Banks, and represent different seasons, different depths (as well as different distances off the bottom), and different concentrations of suspended material. They, therefore, represent a good overview of the suspended sediment on the banks, even though they are not comparable. The sixth sample is from transect Station 9 near Aransas Pass in an area that has abundant suspended sediments.

SAMPLE PREPARATION

The suspended sediment from the two banks was filtered and air dried on the filters. Portions of the filter were mounted on metal stubs and coated with a thin film of gold-palladium alloy. These coated samples were examined and photographed with a scanning electron microscope.

Table III-3. The water depth, sampling depth and concentration of suspended sediment in samples studied with a scanning electron microscope.

CRUISE	DATE	LOCATION	WATER DEPTH TO BOTTOM(m)	SAMPLING DEPTH(m)	CONCENTRATION OF SUSPENDED MATERIAL(mg/l)
76L3	April, 1976	Southern Bank	84	80	0.34
76L3	April, 1976	Hospital Bank	75	64	0.21
76L5	June, 1976	Southern Bank	80	77	0.67
76G8	Sept., 1976	Southern Bank	75	70	0.14
76G8	Sept., 1976	Hospital Bank	77	74	0.35
	Nov., 1976	Transect Station 9		near bottom	

Plate III-1

Figures 1 - 4. Suspended sediment at 64 m (9 m off the bottom) on Hospital Bank, April, 1976. The concentration of suspended sediment in this sample was 0.21 mg/l. Much of the sediment is in the fine silt size range, and particles occur separated from one another.

Figures 5 - 8. Suspended sediment at 74 m (3 m off the bottom) on Hospital Bank, September, 1976. The concentration of suspended sediment in this sample was 0.35 mg/l. Much of the sediment is in the clay size range, and larger particles are actually aggregates of clays and clay size mineral grains. These aggregates are not solid, but contain large voids.

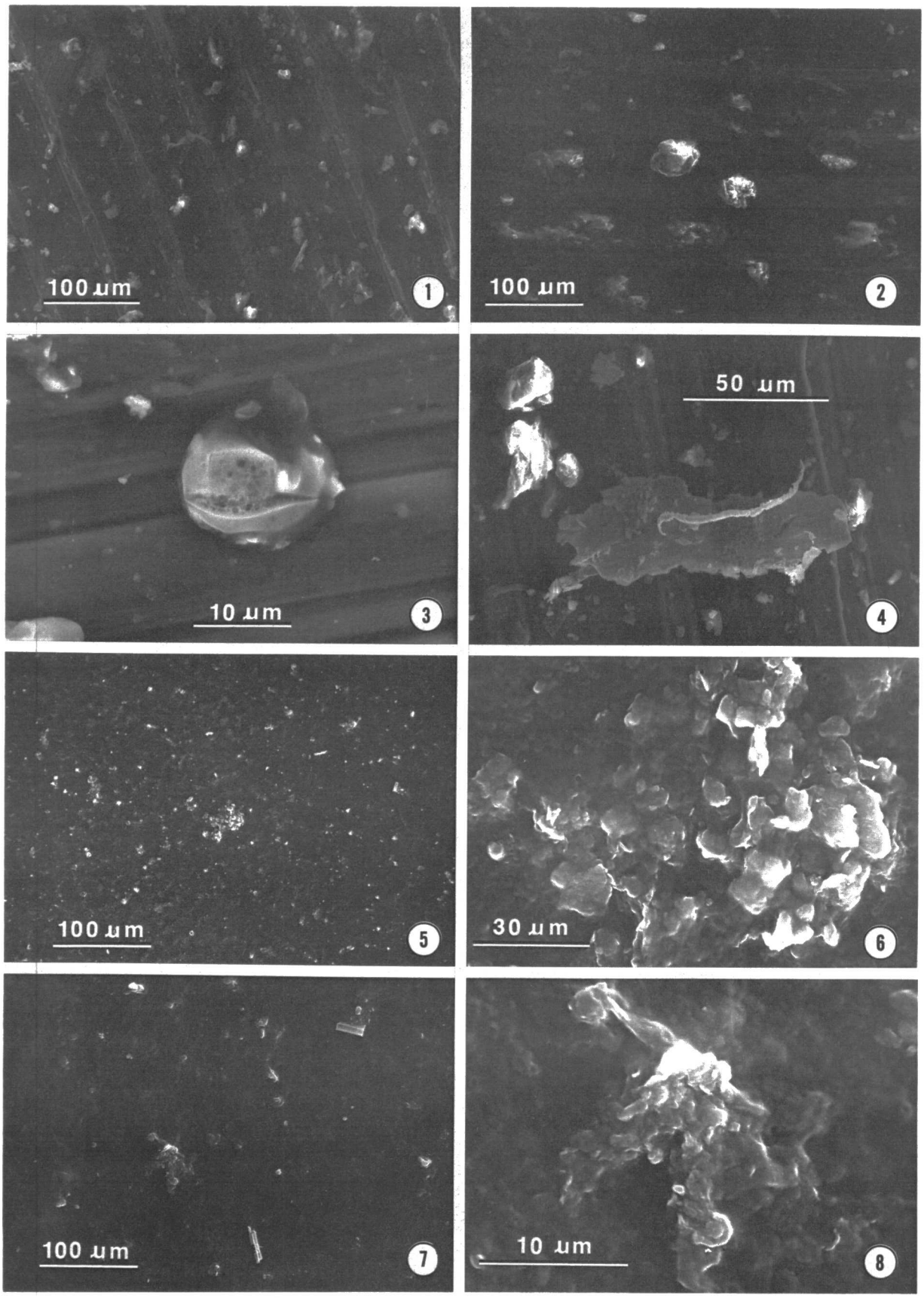

100 µm
1
100 µm
2
10 µm
3
50 µm
4
100 µm
5
30 µm
6
100 µm
7
10 µm
8

Plate III-2

Figures 9 - 12. Suspended sediment at 80 m (4 m off the bottom) on Southern Bank, April, 1976. The concentration of suspended sediment in this sample was 0.34 mg/l. Most of the sediment is in the clay size range and occurs as loosely aggregated clusters with much void space. Aside from the shell fragment (Figure 11) there seems to be little organogenic debris.

Figures 13 - 16. Suspended sediment at 70 m (5 m off the bottom) on Southern Bank, September 1976. The concentration of suspended sediment in this sample was 0.14 mg/l. Much of the sediment is in the form of relatively compact clusters, which also contain organogenic debris. These clusters may be partially degraded fecal pellets.

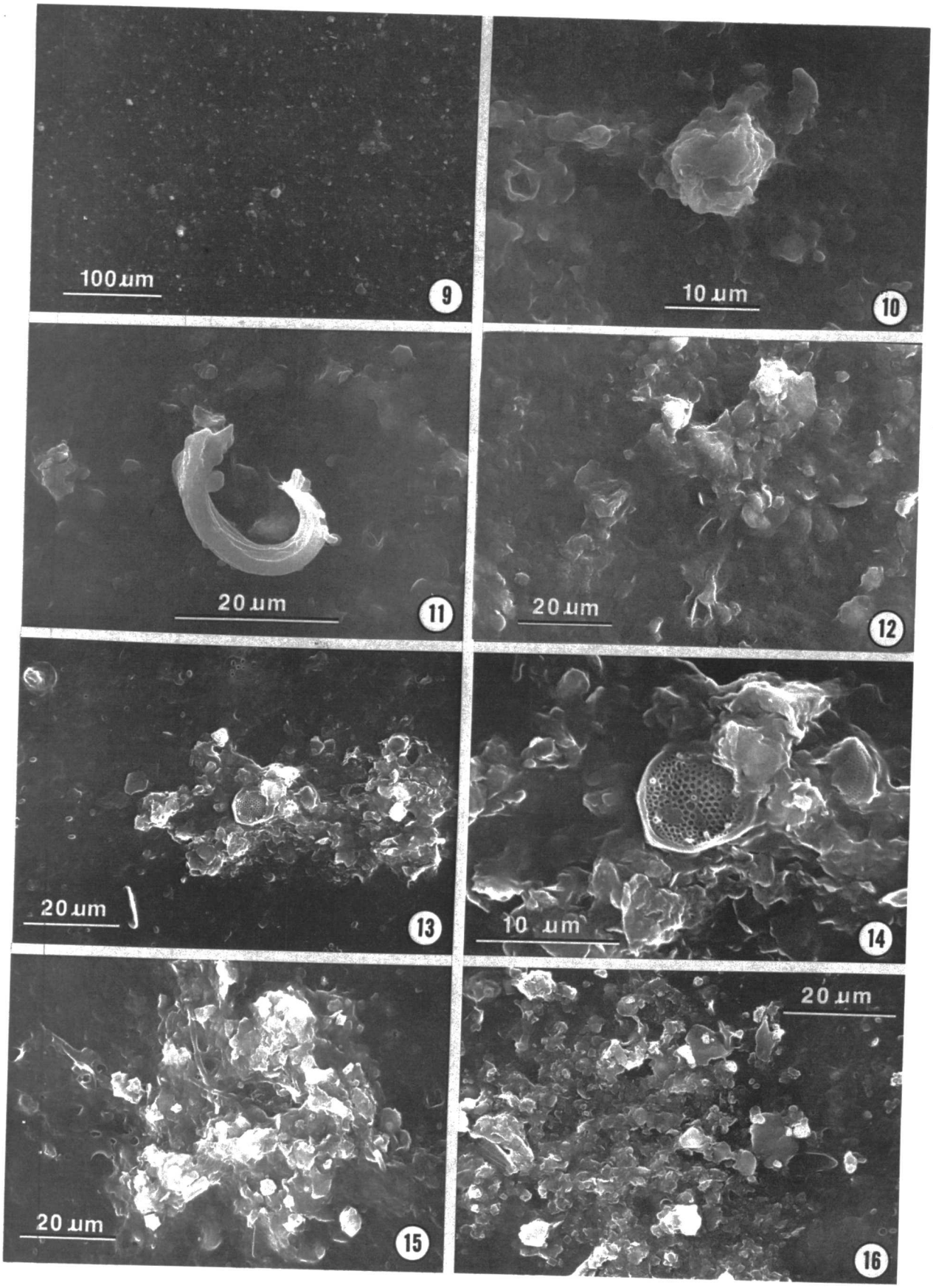

100 µm
9
10 µm
10
20 µm
11
20 µm
12
20 µm
13
10 µm
14
20 µm
15
20 µm
16

Plate III-3

Figures 17 - 22. Suspended sediment at 77 m (3 m off the bottom) on Southern Bank, June, 1976. The concentration of suspended sediment in this sample was 0.67 mg/l. The sediment consist of silt size grains and, some compact and a few loose aggregates, and much fibrous material to which may be bound relatively large clumps of sediment.

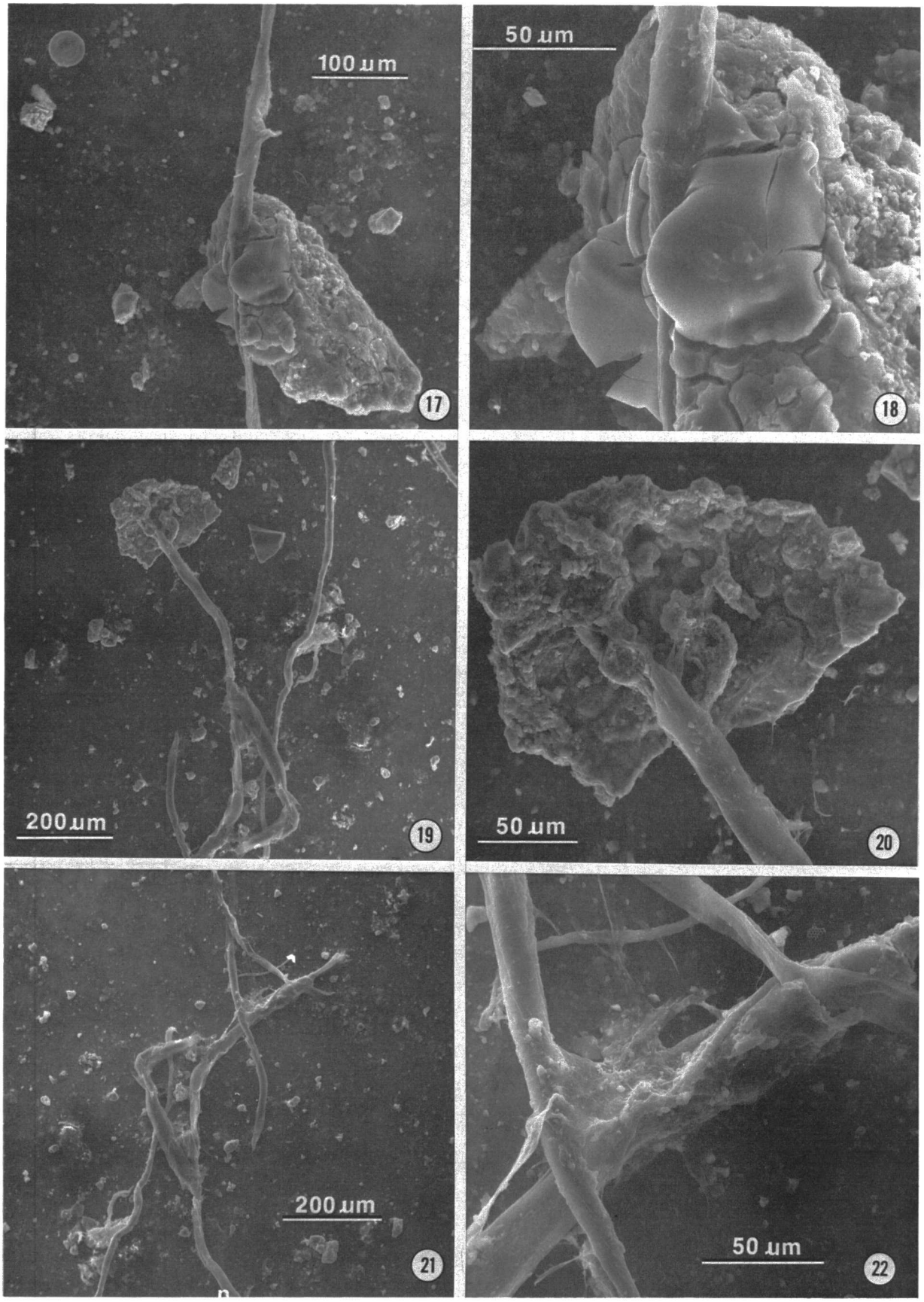
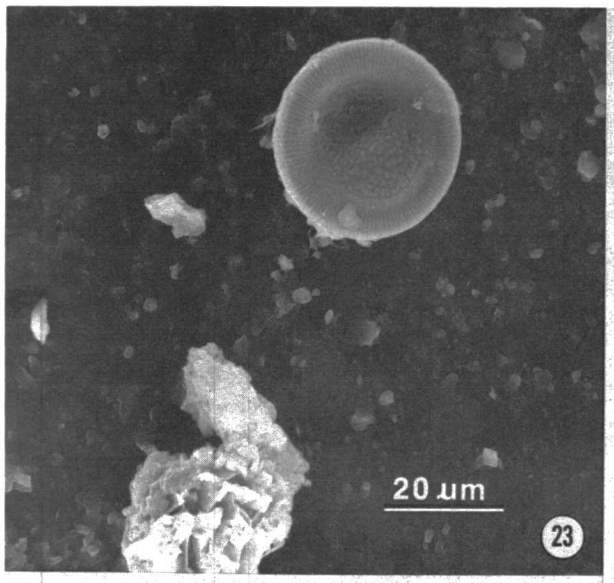

100 µm
17
50 µm
18
200 µm
19
50 µm
20
200 µm
21
50 µm
22

Plate III-4

Figures 23 - 28. Diatom fragments and compact clusters of clay size particles from the same samples as on Plate 3. Silt size grains are common in this sample.


20 µm
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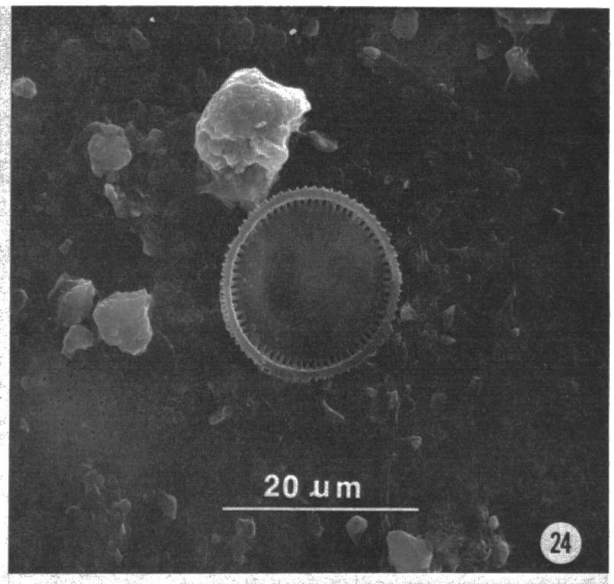
20 µm
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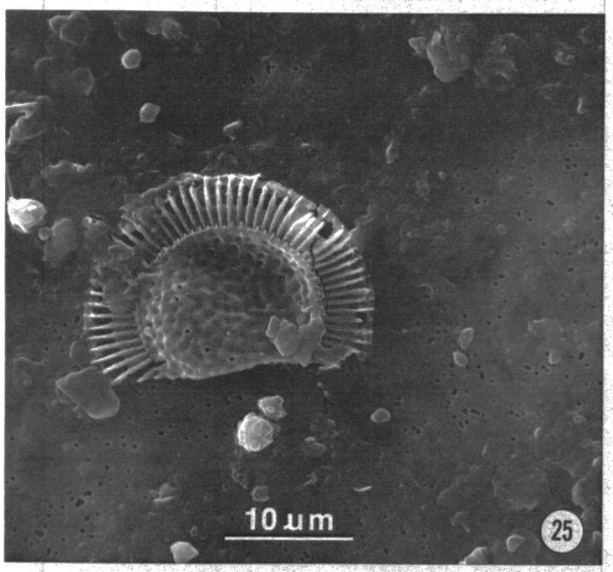
10 µm
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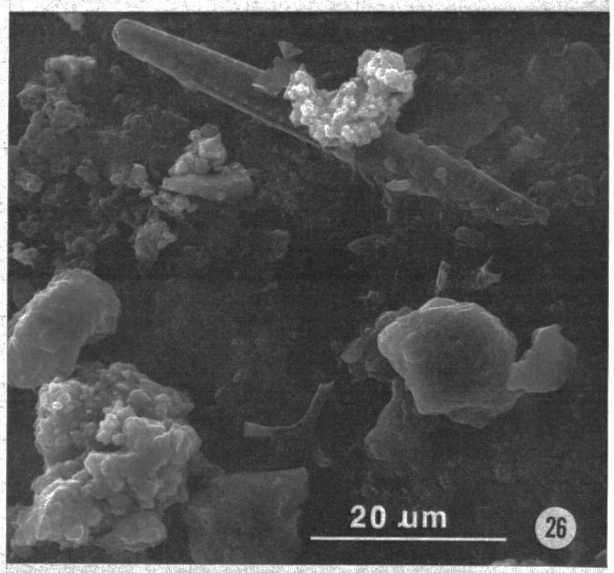
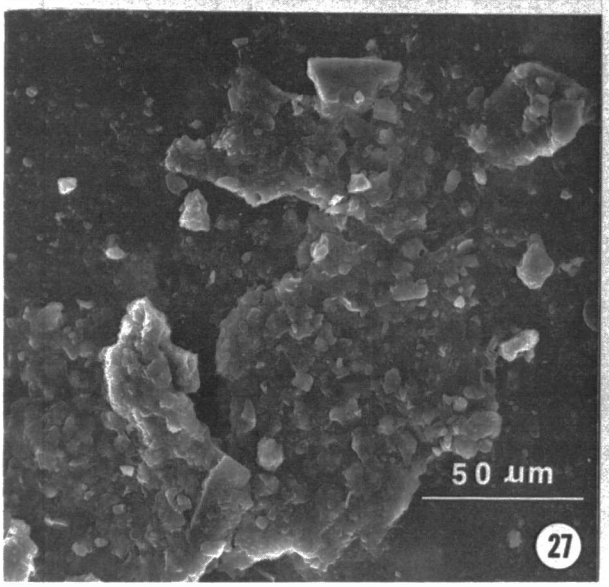

20 µm
26


50 µm
27

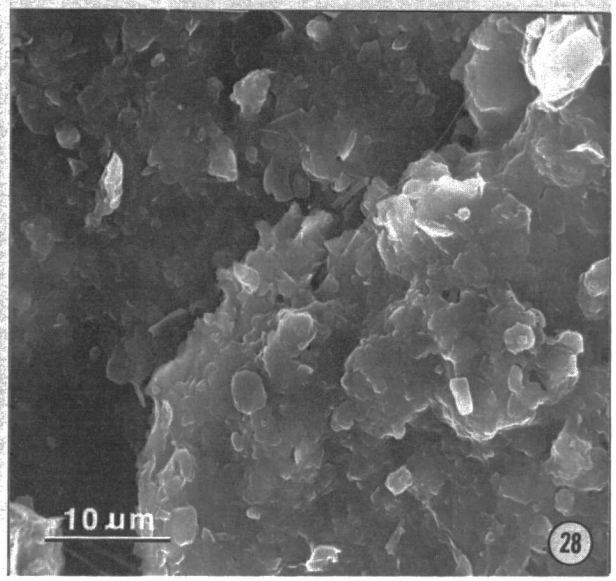
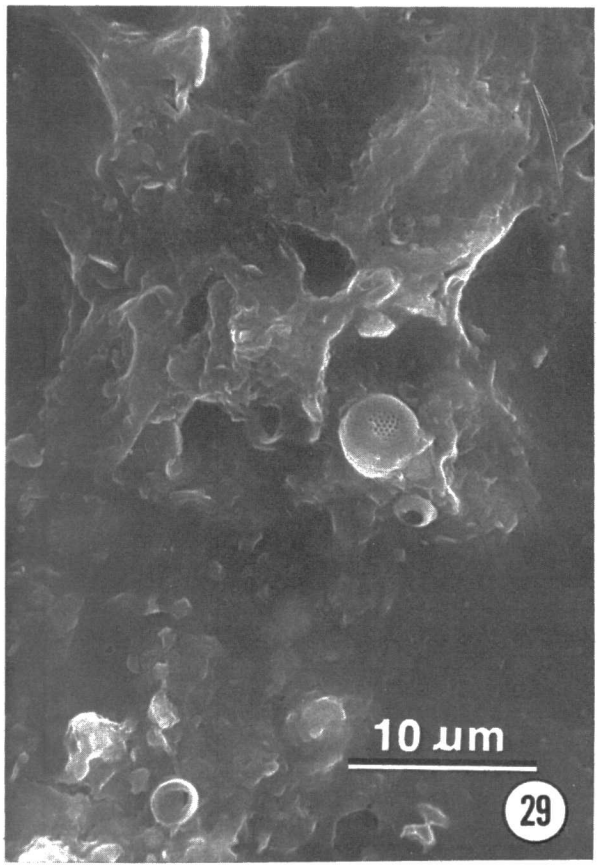

10 µm
28

Plate III-5

Figures 29 - 32. Aggregates of clay and silt size particles in the suspended sediment from 70 m (5 m off the bottom) on Southern Bank, September 1976. The concentration of suspended sediment in this sample was 0.14 mg/l. These aggregates are relatively compact, and probably represent partly degraded fecal pellets. They contain some organogenic debris but for the most part, they consist of inorganic mineral grains in the clay size range.


10 µm
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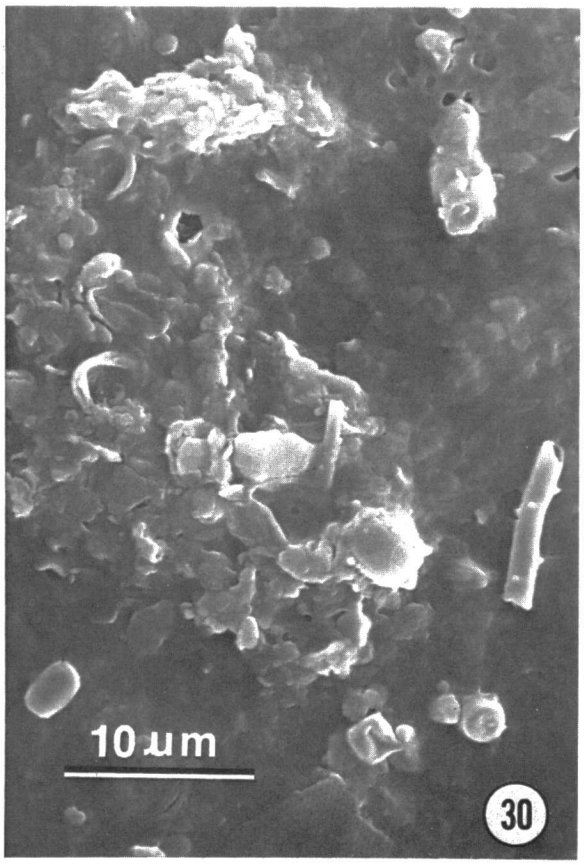
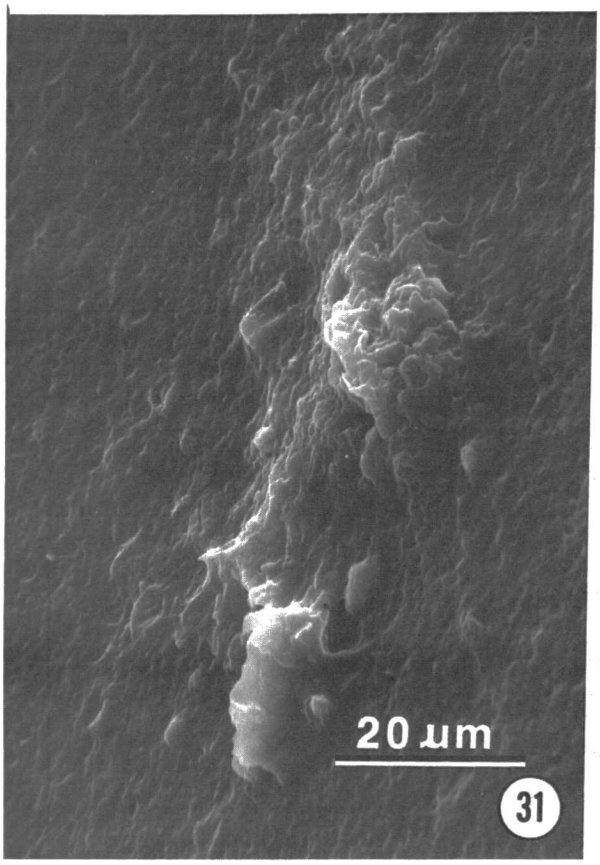

10 µm
30


20 µm
31

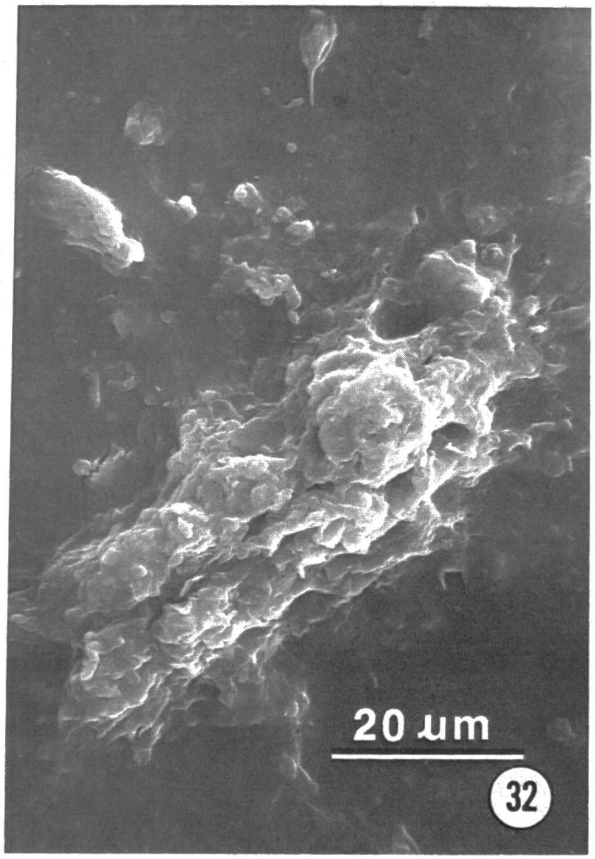
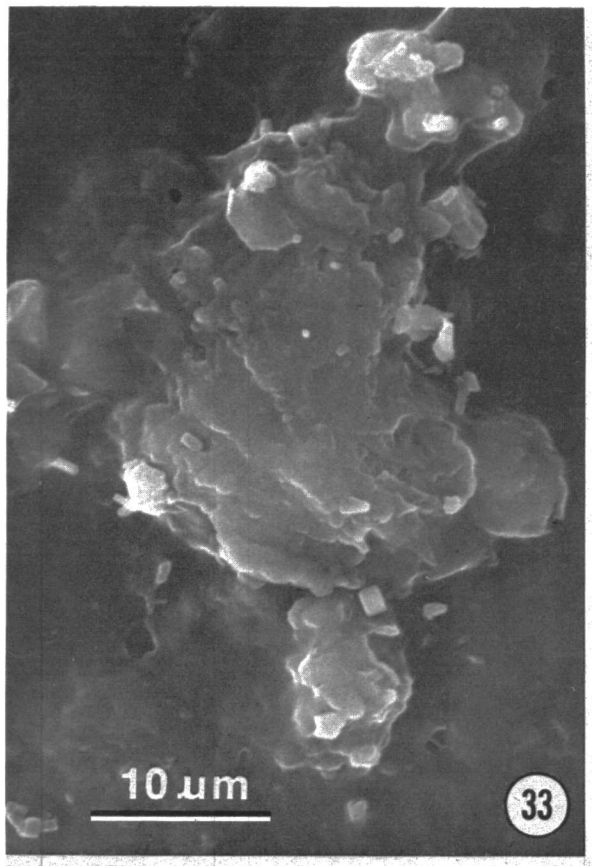
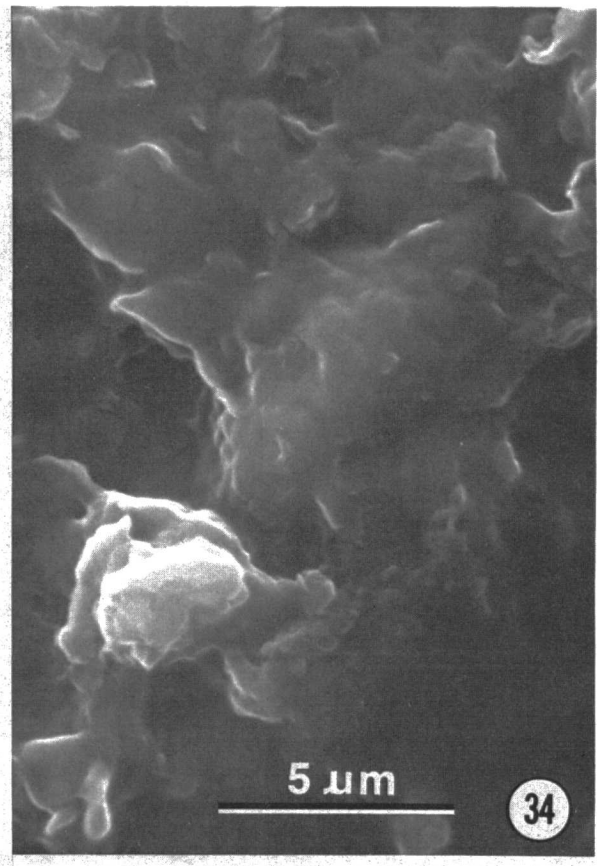
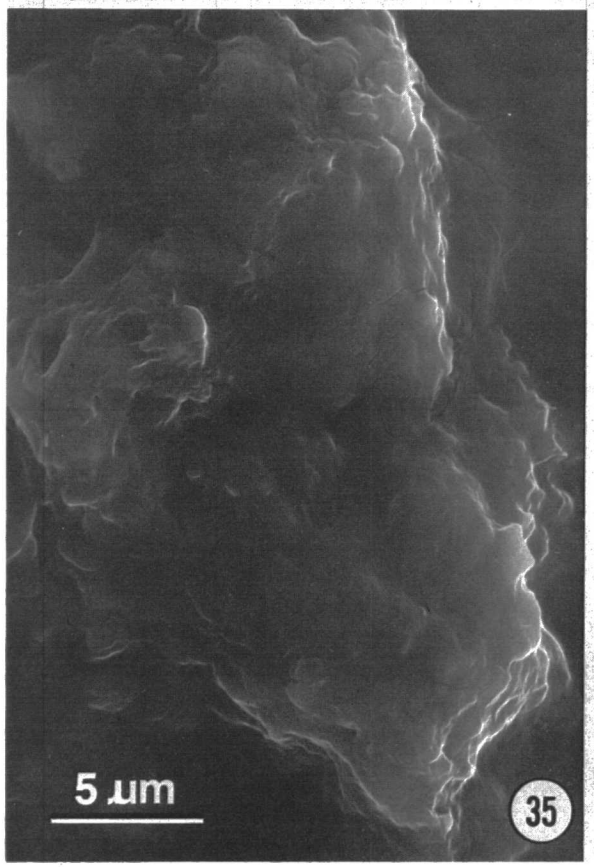

20 µm
32

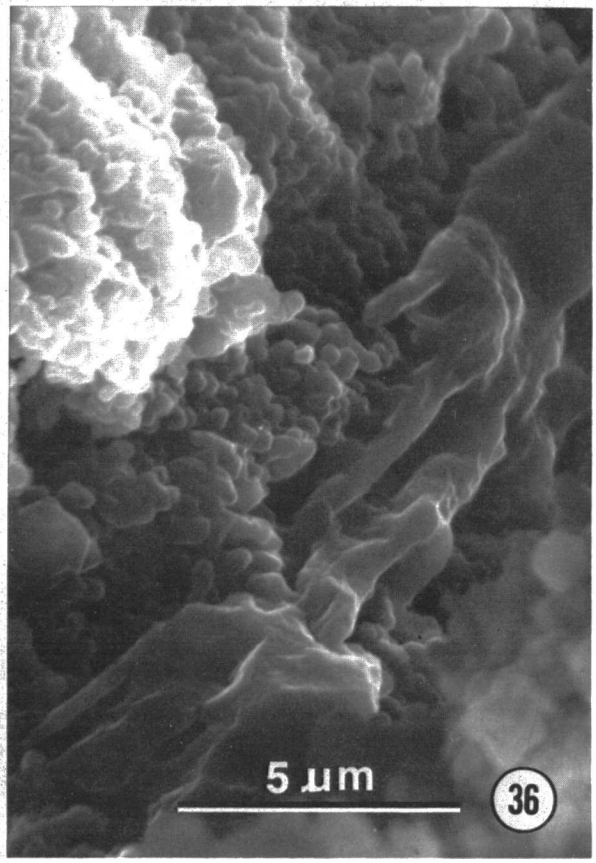
Plate III-6

Figures 33 - 36. Aggregates of chiefly smectite (montmorillonite) from four different stations. The samples in Figures 33, 34, and 35 were air dried. The air dried samples are collapsed and compacted, whereas the freeze dried sample preserves the loosely aggragated aspect of the material, and shows a remarkably uniform size for the particles.


10 µm
33


5 µm
34


5 µm
35


5 µm
36

NUTRIENTS, OXYGEN, AND LOW-MOLECULAR WEIGHT HYDROCARBONS IN THE WATER COLUMN AROUND SOUTHERN BANK AND HOSPITAL ROCK

Co-Principal Investigators

William Sackett

Jame Brooks

Contributor

Bernie Bernard

NUTRIENTS, OXYGEN, AND LOW-MOLECULAR WEIGHT HYDROCARBONS

Inorganic nutrients including nitrate, phosphate, and silicate, as well as dissolved gases including oxygen, methane, ethene, ethane, propene, and propane were measured at each of the four primary water column stations of Southern Bank (SB) and Hospital Rock (HR). Phasphate, nitrate, and silicate samples are taken in separate 6 oz. Whirl-Pak plastic bags and frozen. Samples are analyzed for the nutrients using a single-channel TECHNICON AUTOANALYZER, following the methods of Strickland and Parsons (1972), and as modified by Atlas et al. (1971).

Oxygen samples were analyzed using the Winkler method, as outlined by Strickland and Parsons (1972). Precision is somewhat dependent on the technician doing the analysis, but is generally better than ± 0.01 ml/L.

Low-molecular-weight (LMW) hydrocarbon samples were taken by standard hydrographic casts using a series of Niskin or Nansen bottles. After retrieval, the sea water samples are transferred by gravity flow into 1-liter ground-glass stoppered bottles. The bottles are stoppered in such a way as to avoid entrapment of gas bubbles. Samples are poisoned with sodium azide to prevent bacterial alteration.

The LMW hydrocarbon concentrations are determined by a modification of the Swinnerton and Linnenbom (1967) method. The 1-liter samples of sea water are purged by a hydrocarbon-free helium stream and the LMW hydrocarbons are adsorbed on a trap cooled to liquid nitrogen temperature. The trap is then isolated, heated, and coupled by a slider valve to the gas chromatographic stream for

analysis. The hydrocarbons are separated on a 1.8 m, 1.5 mm-I.D. Porapak Q column and detected with a FID. Sensitivity of the method is 0.1 nanoliters hydrocarbons per liter sea water, and precision is generally better than $\pm$ 5%.

Nutrient and dissolved oxygen concentrations are reported in Table III-4 and light hydrocarbon concentrations (in nannoliters per liter) are reported in Table III-5. Nutrient and oxygen concentrations are typical for the month of August on the South Texas shelf and compare favorable to those reported in the 1976 BLM South Texas Outer Continental Shelf, (Biology and Chemistry) Final Report. Nutrient concentrations generally increase in near-bottom waters of the bank stations, whereas dissolved oxygen begins to decrease below about 70 meters during August, due to stratification of the water column. Oxygen concentrations nearer the sea surface are generally in equilibrium with the partial pressure of atmospheric oxygen at the water temperature and salinity for this month.

Light hydrocarbon concentrations in the surface and half-photic zone samples also reflect equilibrium with the atmosphere, but near-bottom methane concentrations were all at least twice equilibrium values. These high concentrations indicate the presence of gas seepage from the bank sediments, and indeed, a sample of distinct, bubbling gas was later collected from Southern Bank with a submersible. The absence of dissolved ethane or propane anomalies coupled with the composition of the seep gas (99.98% methane; $\delta^{13}C \sim -60$ $^{o}/oo$) suggest that the seepage is of a microbial origin rather than related to reservoired petroleum. Near-bottom methane

anomalies at Hospital Rock imply the existence of seepage of a similar nature around that bank.

Table III-4

NUTRIENT AND DISSOLVED OXYGEN CONCENTRATIONS FOUND IN THE

STOCS TOPOGRAPHIC HIGHS STUDY DURING THE AUGUST CRUISE IN 1976

STATION	DEPTH	TEMP. (°C)	SALINITY (°/₀₀)	SILICATE (μM)	PHOSPHATE (μM)	NITRATE (μM)	OXYGEN (ml/L)
SB/1	0 m	-	-	0.7	0.23	0.1	4.61 4.68
	16 m (½PZ)	-	-	0.8	0.38	0.1	4.56 4.54
	75 m	-	-	3.2	0.58	1.8	4.03 4.03
SB/2	0 m	-	-	0.9	0.22	0.1	4.68 4.70
	15 m (½PZ)	-	-	0.8	0.08	<0.1	4.61 4.60
	77 m	-	-	4.2	0.76	3.8	3.89 3.90
SB/3	0 m	-	-	0.9	0.27	0.1	4.65 4.69
	15 m (½PZ)	-	-	1.2	0.33	0.1	4.63 4.70
	75 m	-	-	7.1	1.35	8.7	2.97 2.96
SB/4	0 m	-	-	1.2	0.07	0.2	4.92 4.91
	14 m (½PZ)	-	-	1.3	0.03	0.1	4.71 4.72
	75 m	-	-	3.7	1.23	4.8	2.99 2.76
HB/1	0 m	-	-	1.8	0.07	0.1	4.68 4.74
	15 m (½PZ)	-	-	1.8	0.07	<0.1	4.63 4.61
	65 m	-	-	1.4	0.32	0.9	4.49 4.50
HB/2	0 m	-	-	1.6	0.18	<0.1	4.73 4.76
	15 m (½PZ)	-	-	1.7	0.08	<0.1	4.62 4.62
	65 m	-	-	3.1	0.34	1.8	4.39 4.40
HB/3	0 m	-	-	1.5	0.25	0.1	4.30 4.65
	15 m (½PZ)	-	-	1.7	0.08	<0.1	4.65 4.78
	77 m	-	-	5.4	1.05	6.3	4.40 4.39
HB/4	0 m	-	-	1.4	0.32	0.1	4.70 4.64
	15 m (½PZ)	-	-	1.2	0.08	<0.1	4.66 4.66
	68 m	-	-	1.5	0.26	0.9	4.56 4.50

Table III-5

LOW-MOLECULAR-WEIGHT-HYDROCARBONS FOUND IN THE STOCS TOPOGRAPHIC HIGHS STUDY DURING THE AUGUST CRUISE IN 1976.

STATION	DEPTH	METHANE (nl/L)	ETHENE (nl/L)	ETHANE (nl/L)	PROPENE (nl/L)	PROPANE (nl/L)
SB/1	0 m	60	5.95	0.26	1.43	0.33
	16 m (½PZ)	-	-	-	-	-
	75 m	135	3.90	0.51	1.19	0.41
SB/2	0 m	50	4.55	0.19	1.25	0.27
	15 m (½PZ)	-	-	-	-	-
	77 m	141	3.05	0.56	0.55	0.46
SB/3	0 m	58	8.40	0.19	1.85	0.32
	15 m (½PZ)	-	-	-	-	-
	75 m	123	3.50	0.47	0.99	0.39
SB/4	0 m	69	6.82	0.37	0.93	0.42
	14 m (½PZ)	-	-	-	-	-
	75 m	141	2.31	0.47	0.87	0.58
HB/1	0 m	57	7.00	0.30	1.45	0.42
	15 m (½PZ)	-	-	-	-	-
	65 m	151	3.85	0.69	0.41	0.49
HB/2	0 m	62	7.85	0.19	1.21	0.36
	15 m (½PZ)	-	-	-	-	-
	65 m	192	4.85	0.67	0.53	0.56
HB/3	0 m	52	6.83	0.19	1.57	0.39
	15 m (½PZ)	-	-	-	-	-
	77 m	145	2.85	0.56	0.79	0.50
HB/4	0 m	59	7.74	0.19	1.57	0.26
	15 m (½PZ)	-	-	-	-	-
	68 m	148	5.15	0.69	0.63	0.48

CHAPTER IV

GEOLOGY

GEOLOGY AND SEDIMENTOLOGY

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INTRODUCTION

This chapter describes the bottom conditions at, and in close proximity to, the banks examined. Descriptions of the physiography of the banks are based on the bathymetric surveys and submersible observations. The sediments are characterized by: 1) clay mineralogy, 2) grain-size distribution, 3) total carbonate percentage, and 4) bulk mineralogy and particle identification of the coarse fraction. Cores taken from the sediment aprons surrounding the banks have been described and radiographed. The fossil coccolith content of the bottom sediments has been determined, to provide information on the net transport direction of sediments on the continental shelf.

PHYSIOGRAPHY

GENERAL

The discussion and descriptions that follow are based on the distinctions between the three types of northwest Gulf of Mexico banks as proposed in Bright, Rezak et al., 1976. Briefly, the banks of the Texas outer continental shelf may be divided into two main groups. Those banks north of 27°46'N. Lat. are associated with salt domes in the subsurface and their distribution is generally the same as the distribution of shallow salt domes. The banks south of 27°46'N. Lat. are not associated with any shallow subsurface structures and their distribution is most probably controlled by an ancient shoreline at about 60 meters depth.

The banks mapped for this study are all north of the 27°42'N.

latitude and are associated with shallow subsurface structures. Stetson Bank is structurally similar to the East Flower Garden, 28 Fathom and 28 Fathom, southwest peak Banks. All are due to salt tectonics. However, Stetson (a mid-shelf bank) is composed of Tertiary bedrock while the shelf edge banks (East Flower Garden, 28 Fathom, etc.) are coral reefs and banks that cover Tertiary bedrock.

The shelf edge banks show greater relief than the South Texas shelf banks mapped during the 1975 study, ranging from 104 m (East Flower Garden) to 120 m relief (28 Fathom Bank). The only North Texas Midshelf bank mapped, Stetson Bank has an intermediate relief of about 34 m.

These northern banks do not exhibit the partial moats found associated with some of the banks to the south, such as Southern Bank. The process by which the moats are formed is not yet known. Since most of them appear to be better developed on the eastern side of the banks, the most reasonable hypothesis is that the moats are due to differential sedimentation, or erosion, caused by asymmetric current flow around the banks.

Bathymetric maps of the banks mapped for the present study, along with overlays showing station locations and submersible transects have been drafted at a scale of 1:12000, except for Stetson Bank which is 1:3000.

DESCRIPTION OF BANKS

East Flower Garden

The East Flower Garden Bank has a tear drop shape with the long axis oriented along a north-south line. This bank has the largest areal dimensions of those mapped during this study. It is about 9.5 km N-S by 6.7 km E-W. It also extends nearest to the sea surface, coming within 16 meters. This vertical prominence is undoubtedly due to the actively growing coral and coralline algae colonies on the crest.

The bank has relatively steep east and southeast marginal slopes, between about 50 to 110 or 120 meters. The west and northern margins are more gently sloping in this depth range. A gently sloping terrace-like platform is found between the 40 m and 50 m isobath. It is from this platform that the relatively narrow, N-S oriented pinnacle rises to form the two peaks of the reef crest. The northern peak extends to within 24 meters and the southern peak to within 16 meters of the sea surface.

The different areas of the bank, as delineated by the depth zones, have different bottom characteristics and support different communities. The shallowest portion of the bank, above 40 m to 50 m is a hard bottom area due to the construction of the reef framework by corals and calcareous algae. There are pockets of carbonate sands, but they are restricted to isolated tunnels on the bank's surface. Between 40 and 50 meters, on the terrace, lies the algal sponge zone with a coarse sand covering.

The soft bottom zone begins at about 80 m to 90 m depth.

The sediments in this zone are very coarse reefal detritus which grade into finer sediments with increasing distance from the bank.

28 Fathom and 28 Fathom Bank, southwest peak

These two features are in close proximity to each other, with their peaks only 2.5 km apart. They might be considered part of the same bank but for a long, narrow trench-like depression that extends up the shelf from the west, passes north of 28 Fathom Bank, southwest peak and terminates, in a nearly circular depression 170 meters deep, almost directly between the two peaks.

28 Fathom Bank has a broad, sub-circular peak that comes within 52 meters of the surface. The bank extends to the north and east from the bank crest in ridge-like extensions with a spur also to the northeast. The bank is about 4.0 km wide (E-W) and 4.5 km in the direction N-S. There are numerous peaks of low relief along the sides of the ridges. A perspective view of this bank is in Bright, Rezak et al. (1976, p. 142). The crest of the bank is an algal nodule platform, as are the low peaks on other parts of the bank. Relief is greatest from the peak to the depression (120 m), but is only about 60-80 m to the surrounding shelf.

28 Fathom Bank, southwest peak is smaller than 28 Fathom Bank and lacks the broad, flat peak of that feature. The shallowest portions of 28 Fathom Bank, southwest peak are two peaks that come within 66 and 68 meters of the surface in the northern part of the bank. The rest of the bank slopes to the south until the surface of the shelf is reached. The peaks and the terrace immediately surrounding them are carpeted with algal nodules, but no coral growth

is evident. Relief from the shallowest peak to the depression is 104 meters, but local relief on the bank does not exceed 40 meters.

Stetson Bank

Stetson Bank is the only topographic feature mapped that is not a shelf edge bank and possesses the lowest relief. That the presence of the bank is structurally controlled is made obvious by the numerous upturned beds that form ridges and provide a substrate for a variety of organisms.

The bank is elongated in a NE-SW direction and is 6.0 km long by 1.8 km wide. The relief on this bank is only about 30 meters, from 25-55 m depth.

CLAY MINERALOGY OF BOTTOM SEDIMENTS

CLAY MINERAL ANALYSIS PROCEDURES

Samples prepared for clay mineral analysis were dispersed in deionized water overnight. The clay fractions (< 2 μm) were separated from bulk sample by treating with 1 ml. of 2.5 m NH_4OH to disperse the sample before centrifuging for 2 minutes at 1000 R.P.M. The remaining suspended sediment fraction (< 2 μm) from this process was decanted from each centrifuge bottle and continuously collected in a one gallon polyethylene bottle. Approximately ten to twelve centrifuge cycles were required to collect the entire 2 μm fraction.

Two oriented clay slides, one Mg-glycerol saturated and one K-saturated, were prepared on ceramic tiles for each sample (Carroll, 1970; Gibbs, 1971; Huang et al., 1975). To minimize any experimental variation, a 35 μm clay film was prepared for each sample by placing appropriate amounts of clay suspension onto the tiles. Acid treat-

ment to dissolve the carbonate minerals was not necessary, because the 25°C X-ray scan showed no visible masking of the clay mineral assemblage.

One set of X-ray diffractograms was obtained from each of the above two oriented clay slides. The Mg-glycerol saturated clays were subject to X-ray analysis after each consecutive step of drying in air at 25°C and then heating at 110°C for 12 hours. The K-saturated clays were subject to X-ray analysis after each consecutive step of drying in air at 25°C and then heating at 110°C for 12 hours, at 300°C for 4 hours, and at 550°C for 1 hour.

X-ray analysis was carried out on a Phillips Norelco diffractometer, operating at 35 Kv and 20 mA, a scanning speed of 1° 2θ per minute, and a chart speed of 30 inches per hour. A 1° beam slit, with a 0.003 inch receiving slit, was used for the entire 2θ (2° to 35° 2θ).

MINERAL IDENTIFICATION CRITERIA

Illite is used as a group name here to include all clay mineral constituents of "mica-type" structure in argillaceous sediments (Grim *et al.*, 1937). Basal reflections of illite are approximately 10, 5, and 3.3Å. Illite peaks in these samples, for the most part, show extremely well crystallized reflections, with relatively well developed [(002) Miller Index] resolution. Examples of peak spacing can be seen in Figures IV-1 and IV-2.

Kaolinite is difficult to differentiate from Chlorite by using X-ray diffraction techniques (Johns and Grim, 1958; and Griffin, 1962), because the d-spacings of Kaolinite (001) and Chlorite (002) are

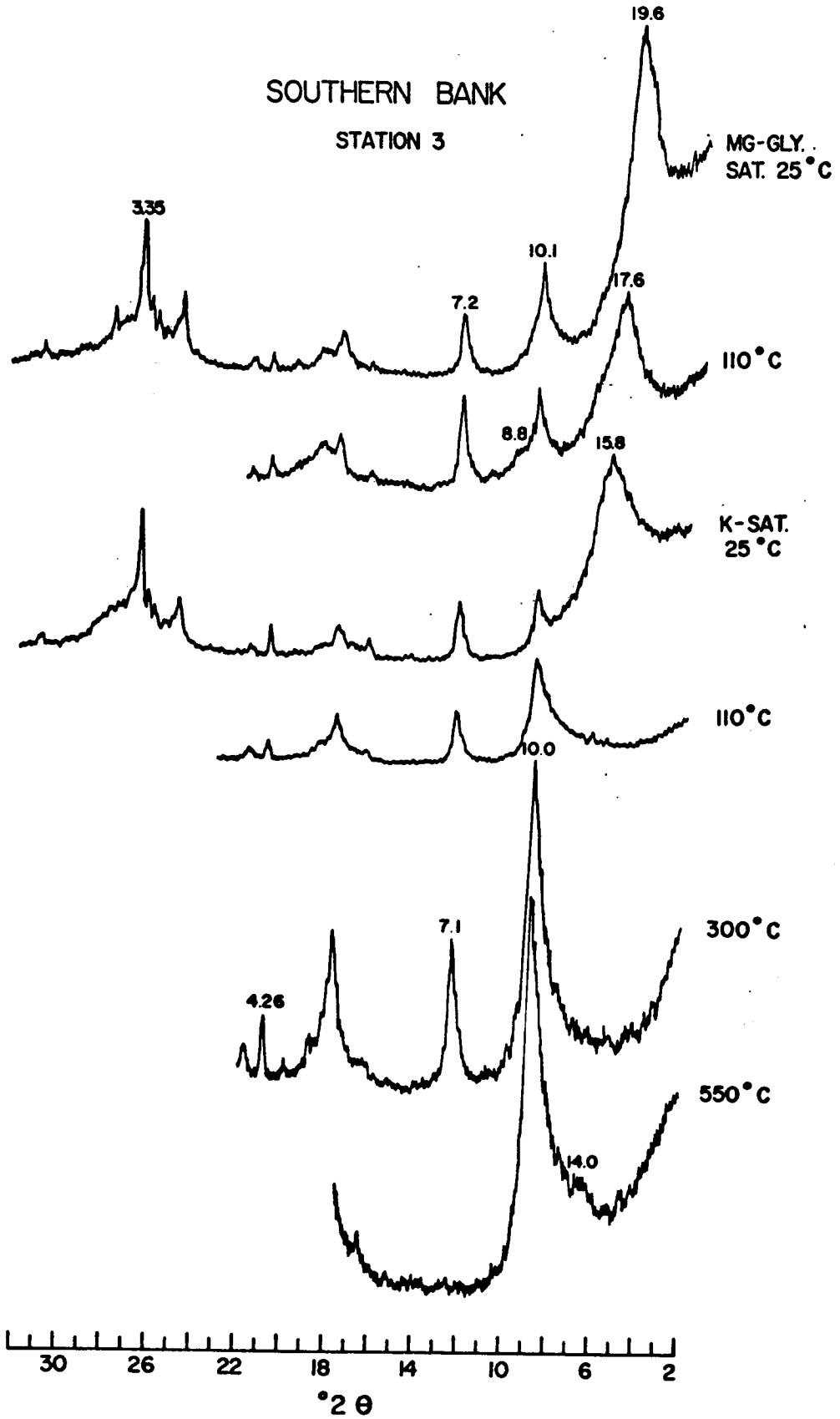

Figure IV-1. X-ray Diffractogram of the < 2 μm (clay) fraction of bottom sediments from Southern Bank

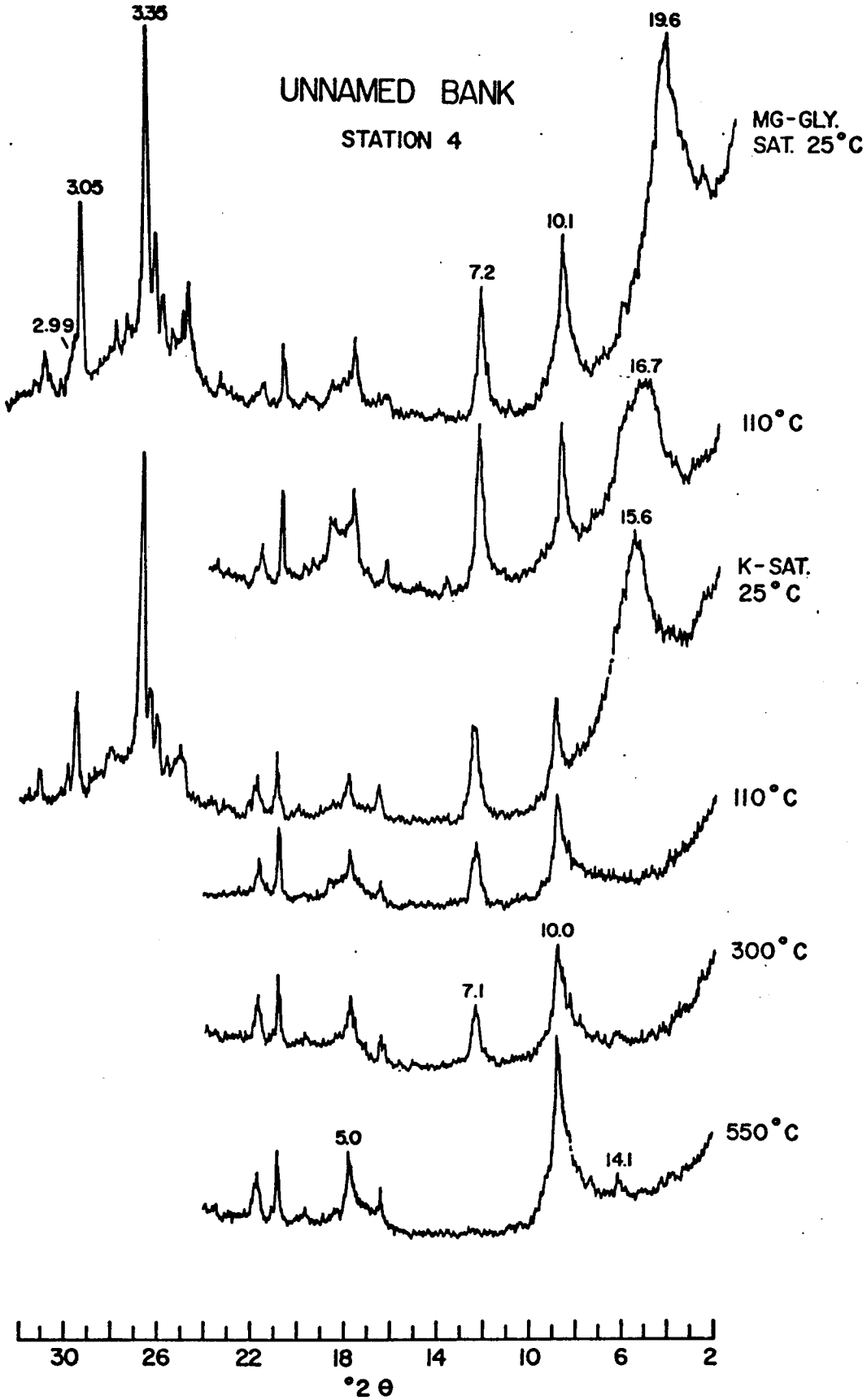

Figure IV-2. X-ray Diffractogram of the < 2 μm fraction of bottom sediments from 28 Fathom Bank, southwest peak.

both at 7.2Å, and Kaolinite (002) and Chlorite (004) coincide at 3.5Å. However, Kaolinite was identified by using both the (001) and (002), occurring at 7.15 - 7.20Å and 3.52 - 3.58Å, respectively, and which collapse to an amorphous state after heating at 550°C for 1 hour. Biscaye (1965) suggests that the 3.52 - 3.58Å reflection should be examined carefully to resolve this identification problem, but samples with the abundance of Kaolinite found in this study did not need such resolution.

Chlorite identification was resolved by the following criteria:
(1) Characteristic basal reflections at 14.1 - 14.5, 4.75, and 3.54Å for the (001), (003), and (004) respectively. Since the (002) coincides with the (001) of Kaolinite at 7.15 - 7.20Å, the (002) of Chlorite can only be used after the sample is heated at 550°C for 1 hour, when Kaolinite is in an amorphous state.
(2) The 14Å reflection will be intensified after being heated at 550°C (Brindley, 1961). Since Chlorite occurred in such small amounts, true identification of this mineral was accomplished after the 550°C treatment for the (001) and (002).

Smectite is a group of clay minerals characterized by a basal reflection which expands to 19.6Å (001) and 9.8Å (002) when saturated with magnesium and glycerol. The (001) reflection collapses to 10Å after being heated at 550°C. The large abundance of this mineral allows for simplified identification.

The non-clay minerals of the clay-sized fraction were identified in the following manner: Identification of quartz was primarily from the characteristic diffraction array between 2.99 - 3.05Å. There was a distinction made for these samples between high and low magnesium

calcite (2.99 - 3.01Å and 3.03 - 3.05Å respectively).

Numerous semi-quantitative estimation techniques have been proposed to determine abundances of clay minerals. These methods include the comparison of peak area, peak intensity, and chemical analyses (Johns et al, 1954; Jackson, 1956; Biscaye, 1964; Carroll, 1970; Griffin, 1971). No universal procedure has been adopted by clay mineralogists. The relative clay mineral percentages of this study were determined by measurement of the (001) peak area using a planimeter. The Mg-glycerol saturated samples were used to determine the relative percentages of smectite and chlorite, whereas the K-saturated samples were used to calculate the relative amounts of illite. These separate measurements at 25°C were to differentiate the illite (001), which was overlapped by the smectite (002) on the Mg-glycerol saturated sample. The relative abundance of Kaolinite was determined by the difference in the intensity of the 7.15 - 7.20Å reflection on the Mg-glycerol saturated diffraction patterns at 25°C and heated at 550°C for 1 hour. The non-clay minerals of this fraction were identified from both diffractograms, since they are not affected by the treatment.

CLAY MINERAL RESULTS

Table IV-1 lists the percent Smectite, Illite, Kaolinite, and Chlorite for the clay (< 2 μm) fraction of the bottom sediment. Smectite is the dominant clay mineral in all samples but one, ranging from 56% to a high of 78%. The one exception is Station 4 at Stetson Bank. At this station, illite is the dominant clay mineral followed by almost equal amounts of Smectite and Kaolinite.

In order to determine the relative concentrations of clay minerals being supplied to the OCS by streams, surface water samples were taken at the major passes along the Texas Coast north of Corpus Christi. The suspended sediment analyses are not quantitative, but relative peak heights give an indication of the relative abundance of the mineral species. Table IV-2 gives the results of these analyses. In all samples Kaolinite is equal to or greater than Illite, and Smectite is the least abundant clay mineral. This is a striking contrast to the concentrations of these minerals in the bottom sediment over most of the OCS. Station 1, Transect II lies 6 miles off Port Aransas, yet the concentrations there are Smectite 60%, Illite 24%, Kaolinite 16%. Resolution of this problem awaits more detailed sampling of the water column in the passes and offshore from the passes each month over the period of at least a year.

SEDIMENT SIZE

PROCEDURE FOR GRAIN SIZE ANALYSES

The procedures for grain size analysis have been modified extensively from those presented in Bright, Rezak *et al.*, 1976, because of the acquisition of Coulter Counter apparatus for silt and clay size analysis and the fabrication of Rapid Sediment Analyzer (RSA) for sand analysis.

The sample pre-analysis preparation procedures are as follows:

(1) Approximately 50-60 grams of sediment is placed into a 1 liter jar.

(2) Add 5 ml. of hydrogen peroxide every 15 minutes up to a total of 30 ml.

(3) Allow to react overnight.

(4) Fill jar with distilled water and again allow to sit overnight or until the water is clear.

(5) Pour off supernatant.

(6) Add 15 ml. of 40% sodium hexametaphosphate to sediment slurry.

(7) Wet seive through a 230 mesh sieve, collecting the fine material in a 1 liter column.

(8) Dry coarse fraction and sift through 230 mesh sieve again. Add the pan fraction to the fines. Weigh coarse fraction.

(9) Take a 20 ml. aliquot, dry and weigh. The weight of the sample equals the weight of solids in beaker minus .12 g (the sodium hexametaphosphate) x 50.

(10) The coarse fraction is placed into a labeled envelope and saved for the Rapid Sediment Analyzer (RSA).

(11) The fine fraction is now ready for analysis using the Coulter Counter.

The Coulter Counter procedures were taken from those used by the U.S.G.S. laboratory at Corpus Christi, Texas.

The RSA procedures are as follows:

(1) Sieve the coarse fraction using a 10 mesh (2 mm) sieve to separate the sand from the gravel.

(2) Weigh material retained on sieve.

(3) Split the sand fraction repeatedly, using a microsplitter to obtain an appropriate size work sample (1 - 3 grams when possible).

(4) Turn on the electronics and allow to warm up 20 minutes, then zero amplifier.

(5) Fill water column until flush with top edge of tube before calibration and each analysis. Record water temperature.

(6) Calibrate using Ottawa Sand (1 Ø size).

(7) Care must be used to minimize all shock waves in support and air due to walking, doors closing, etc.

(8) Spread sample evenly over the central portion of the moistened entry plate; avoid clumping grains.

(9) Turn on recorder pen and chart, using a chart speed of 10"/min.

(10) Gently close plate and start a stop watch to begin timing.

(11) Mark time of closing on chart and after 95 seconds change chart speed to 2"/min. or 1"/min. (depending on the sample).

(12) Continue monitoring chart for about 5 minutes until the curve reaches the baseline.

(13) Terminate analysis and label chart.

Interpretation of the RSA data consists of the following:[1]

(1) Mark the following three points on the pressure curve:

(a) Introduction time (T_o) - first major pressure deflection (usually downward),

(b) 0% inflection point,

(c) 100% termination point (minimal pressure).

(2) Draw baseline from termination point parallel with graph paper grid.

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[1] Modified from G. L. Shideler, 1976, personal communication.

(3) Using the size-fall time overlay, make the overlay's baseline coincident with the drawn baseline. Vertically align the "0" time line of overlay with the introduction time (To) mark on the graph paper. Tape down the graph paper and overlay.

(4) Place a Gerber scale perpendicular to the baseline at the 0% inflection point, and divide it into 100 increments. Using a straight-edge, read off the cumulative % for each half-phi size and record on data sheet (nearest 0.5%). Use the size value immediately preceding the 0% inflection point as the 0% size. If the 4.0ϕ size value occurs at less than 100%, consider it as the 100% size value. If the curve terminates prior to 4.0ϕ, consider the half-phi size value immediately prior to termination as the 100% size value.

GRAIN SIZE PARAMETERS

A program for use of the Amdahl 470 V6 was written by S. Helwick to combine the RSA and Coulter Counter Data, as well as the weight of gravel, and compute the gravel/sand/silt/clay percentages, median, mean, standard deviation, skewness and kurtosis. The statistical grain-size parameters were calculated using both the graphic method and method of moments. Calculations for the method of moments were taken from Carver, 1971. The results of the method of moments calculations are listed in Appendix II, Tables IV-1 to 6. Graphic statistical parameters were calculated as follows:

Median Diameter - That diameter corresponding to the 50 percent

mark on the cumulative curve. The measure determines that size in which half of the particles are coarser than the median and half are finer.

The Graphic Mean corresponds very closely to the mean as computed by the method of moments. It is computed by the formula

$$\text{Graphic Mean} = \frac{\phi 16 + \phi 50 + \phi 84}{3}.$$

The Inclusive Graphic Standard Deviation is a measure of sorting and is determined by the formula

$$\text{Standard Deviation} = \frac{\phi 84 - \phi 16}{4} + \frac{\phi 95 - \phi 5}{6.6}$$

This formula includes 90 percent of the distribution and is considered to be the best overall measure of sorting.

Folk, 1974 (p. 46) has suggested the following verbal classification scale for sorting:

Values less than .35Ø, very well sorted

.35 - 0.50Ø, well sorted

0.50 - 0.71Ø, moderately well sorted

0.71 - 1.0Ø, moderately sorted

1.0 - 2.0Ø, poorly sorted

2.0 - 4.0Ø, extremely poorly sorted.

Inclusive Graphic Skewness is a skewness measure that is geometrically independent of the sorting of the sample. It measures the degree of asymmetry as well as the "sign" of the curve. This determines whether a curve has an asymmetrical tail to the left or right. The following formula is used to determine the Inclusive Graphic Skewness SK_I:

$$SK_I = \frac{\phi 16 + \phi 84 - 2\phi 50}{2(\phi 84 - \phi 16)} + \frac{\phi 5 + 095 - 2\phi 50}{2(\phi 95 - \phi 5)}.$$

Graphic Kurtosis is used to determine the departure of the frequency from that of the normal probability curve. It is determined by the formula:

$$K_G = \frac{\phi 95 - \phi 5}{2.44(\phi 75 - \phi 25)}.$$

The value of this parameter is open to question as most sediments do not have a normal distribution curve but are bimodal or polymodal. Folk (1977, personal communication) feels that there is some value to the parameter and that it should be calculated for each analysis.

DISTRIBUTION OF GRAIN SIZE PARAMETERS

All of the results discussed in the following paragraphs are syntheses of data from 6 to 9 analyses at each station. The intermediate data for these analyses is presented in Appendix II, Tables IV-1 to IV-6. Due to wind and sea conditions, there was a certain amount of ship drift during sampling, so that the sample sites for each station may vary. However, for the majority of stations, the results display little variation. In most cases, the deviation of results of one sample out of six does not affect the general classifications assigned to the sediment, i.e., degree of sorting, skewness, kurtosis, and sediment classification. Another parameter used in the following discussions in the mode, which is the most frequently occurring particle diameter in a sample. It may be read directly from a size frequency curve or a histogram. Modes and sediment classification are given in Table IV-3.

East Flower Gardens Bank

The four primary sampling sites at this bank are in each of four quadrants (i.e., NE, SE, SW, NW; see Fig. I-6). There is significant variation of the textural parameters from station to station but only minor differences among samples from the same station (See Appendix II, Table IV-1). Sediment samples from Station 1 (SW) and 4 (NW) are bimodal with a primary mode of medium sand and a secondary mode of fine sand. All samples from Station 1 contained between 9 and 17% mud, resulting in the classification of this sediment as a muddy sand. Samples from Station 4 had generally less than 9% mud and are classified as sands. Samples from Stations 2 (SE) and 3 (NE) are generally finer than those at Stations 1 and 4. Station 2 has between 51 and 57% mud while Station 3 ranges from 27-53% mud. These two stations receive only a small portion of carbonate detritus from the bank (< 28% total carbonate). Samples from Stations 1 and 4 with > 70% total carbonate, thus are primarily sand. This suggests a net transport of sediment at the East Flower Gardens from east to west.

Stetson Bank

Stations 2 and 4 are approximately on the east and west ends of the bank, respectively, with Station 1 roughly north of Station 4 and Station 3 north of Station 2 (see Fig. I-5).

The sediments from the stations sampled at this bank range from gravelly sand to sandy mud. They reflect the presence of the products of erosion of the upturned beds that are characteristic of this bank. In the sand size fraction, quartz is a significant

but not predominant, constituent (< 20%); while foram tests, which constitute up to 45% of the sand around East Flower Gardens, are here less than 10%. There is some variation in the amount of shell material (31. - 47.5%) and a small amount of algal-coral fragments (2.5 - 6.5%). The miscellaneous classification, which includes lithoclasts (pieces of rock), however, is consistently high (26.5 - 46%). These lithoclasts must be derived from the siltstones and other rock outcrops on the bank.

28 Fathom Bank

Samples from this bank are generally very coarse and quite variable both within stations and between stations. This is due to the fact that all stations are located within the bank complex and not in a normal sedimentary apron that surrounds a bank such as is the case with the other banks sampled in this study. Within a bank complex, facies patterns change rapidly due to the extreme variability in slope steepness and amount of relief.

Only three stations were sampled at this bank because the hard substrate at the fourth station precluded sampling. Four attempts were made to change the station location in this area but none were successful. Two of the Smith-MacIntyre hauls recovered a few large algal nodules from this area so we can assume that the entire area around Station 4 is in the algal nodule facies.

All stations are high in total carbonate, with Station 1, 49.7%; Station 2, 86.9%; and Station 3, 100% (by the Schiebler method). The large percentage of coarse sediment in these samples is due to the influence of bank derived skeletal material. The

constituents of the coarser than silt fraction (> 4Ø) include a large amount of shell and foraminifers. Fewer foraminifers appear at Station 3.

28 Fathom Bank, southwest peak

Although this bank is a portion of 28 Fathom Bank and the sediment facies similar, we shall treat the samples acquired as a separate group.

The stations are arranged in the following pattern: Stations 1 and 2 lie on a north-south line that passes between the two peaks. Station 2 is nearer the crest than Station 1 and is shallower (82 meters). Station 1 is in the depression that separates this bank from 28 Fathom Bank, and is at 170 m depth. Stations 3 and 4 lie on an east-west line that passes between the crest and Station 1 (see Fig. I-7).

The sediments sampled here range from gravelly sand to sandy mud. The coarse sediment, as at 28 Fathom Bank, is due to the fact that Stations 1, 2, and 4 are located within the bank complex. Station 3 is anomalous in that very little bank detritus reaches it. It is cut off from both banks by a trough and depression that passes between the station and the banks. Samples from this station have up to 90% mud. Station 3 has a high percentage of quartz and miscellaneous material and the lowest amount of skeletal material of any of the seven stations. Station 4 is also unusual in the amount of quartz present (50.5% of the > 4Ø sediment). This may be an area of relict shoreline sediments.

Southern Bank

Because of the infaunal sampling done on Southern and Hospital Banks throughout 1976, there is a good deal more sediment data for these banks than for the others studied. Four stations were sampled five times during the monthly and seasonal cruises of the LONGHORN, and eight additional stations were sampled during cruise 76SH2 (see Fig. I-9).

Of the 12 stations sampled at Southern, nine are mud and the remainder are gravelly sand or sandy mud. This is typical of the South Texas OCS Topographic Features. All are dead reefs that are being buried by Recent muddy sediments. The eight secondary stations were chosen in an attempt to determine the origin of the moat on the east side of Southern Bank. Stations 2, 7, 8 and 12 are located in the moat and Stations 5, 6, 10 and 11 are seaward of the moat. Unfortunately, no distinctive difference in sediment characteristics was noted in the analyses from these stations. Stations 3 and 4 are characterized by muddy, gravelly sand and sandy mud respectively. Samples taken in 1975 and 1976 indicate that the bank is surrounded by silty and clayey sediment except for the southwest side where a lobe of bank debris extends to the southwest of the bank. This indicates a net transport direction of bank detritus towards the southwest.

Hospital Bank

As with Southern Bank, additional samples were acquired at the primary stations on this bank during the monthly and seasonal cruises conducted by UTMSI aboard the R/V LONGHORN. The secondary stations

were visited during the cruise 76SH2 (see Fig. I-8).

The sediments of this bank are predominantly muds with only Stations 1 and 12 being gravelly, muddy sand and sandy mud. Both of these stations are to the southwest of the bank indicating another case of northeast to southwest net transport of sediments and bank debris.

CARBONATE ANALYSES

TECHNIQUES

Total Carbonate

$CaCO_3$ percentage in the sediment was determined using the Scheibler method described by Bouma (1969). One-half gram of sample, along with 5 ml distilled water and 7 ml HCL (25%) in a small plastic beaker, is placed in a bottle and sealed. After mixing the acid and the sample by shaking them for 20 minutes, the volume of gas evolved is measured in a water-filled buret connected to the bottom by plastic tubing. Accuracy may be checked by duplicate sample analysis, allowing no greater than 10 percent $CaCO_3$ difference in the results.

Sand-sized Carbonate Mineral Analysis (X-ray Diffraction)

Samples for the greater than 63 μm fraction were separated from the silt and clay fraction during the clay preparation by sieving the silt through a 63 μm sieve after the clays were extracted. This sand-sized fraction was dried at 100°C, finely ground, packed randomly into aluminum holders, and analyzed by X-ray diffraction. The major minerals that made up the assemblage were identified by the following characteristic criteria: (1) Quartz: 4.26, 3.35Å; (2) Calcite: 2.99, 3.05Å (Distinction can be made for low or high magnesium calcite by the reflection position within this range.) (3) Aragonite: 3.40,

3.27, 2.70Å. Examples of these spacings are presented in Figure IV-3.

Particle Type Identification

The coarse fraction from each surface sediment sample was split until a sample of approximately 200 grains was obtained. These were then dispersed on a tray and examined using a Bausch and Lomb binocular light microscope. Two hundred grains were identified using nine compositional parameters based on relative abundance in the samples. These include: quartz, benthic foraminifera, planktonic foraminifera, echinoderms, molluscs, coral, algae, lithoclasts and miscellaneous. The miscellaneous category included not only heavy minerals and unidentified skeletal fragments, but also identifiable skeletal fragments not applicable to other categories, such as bryozoans, diatoms, and sponge spicules.

RESULTS

Total Carbonate Analysis

The percent of calcium carbonate in surface sediment samples varies from 3.0 to 100. Various samples were analyzed twice to determine accuracy and the percentages were found to be valid (Appendix II, Table IV-7). Total carbonate in the sediment aprons of the shelf edge banks (28 Fathom and East Flower Gardens Banks) is greater than at the mid-shelf banks (Southern, Hospital and Stetson Banks). This is due to the fact that the shelf edge banks are dormant in terms of carbonate production and are being buried by terrigenous sediments.

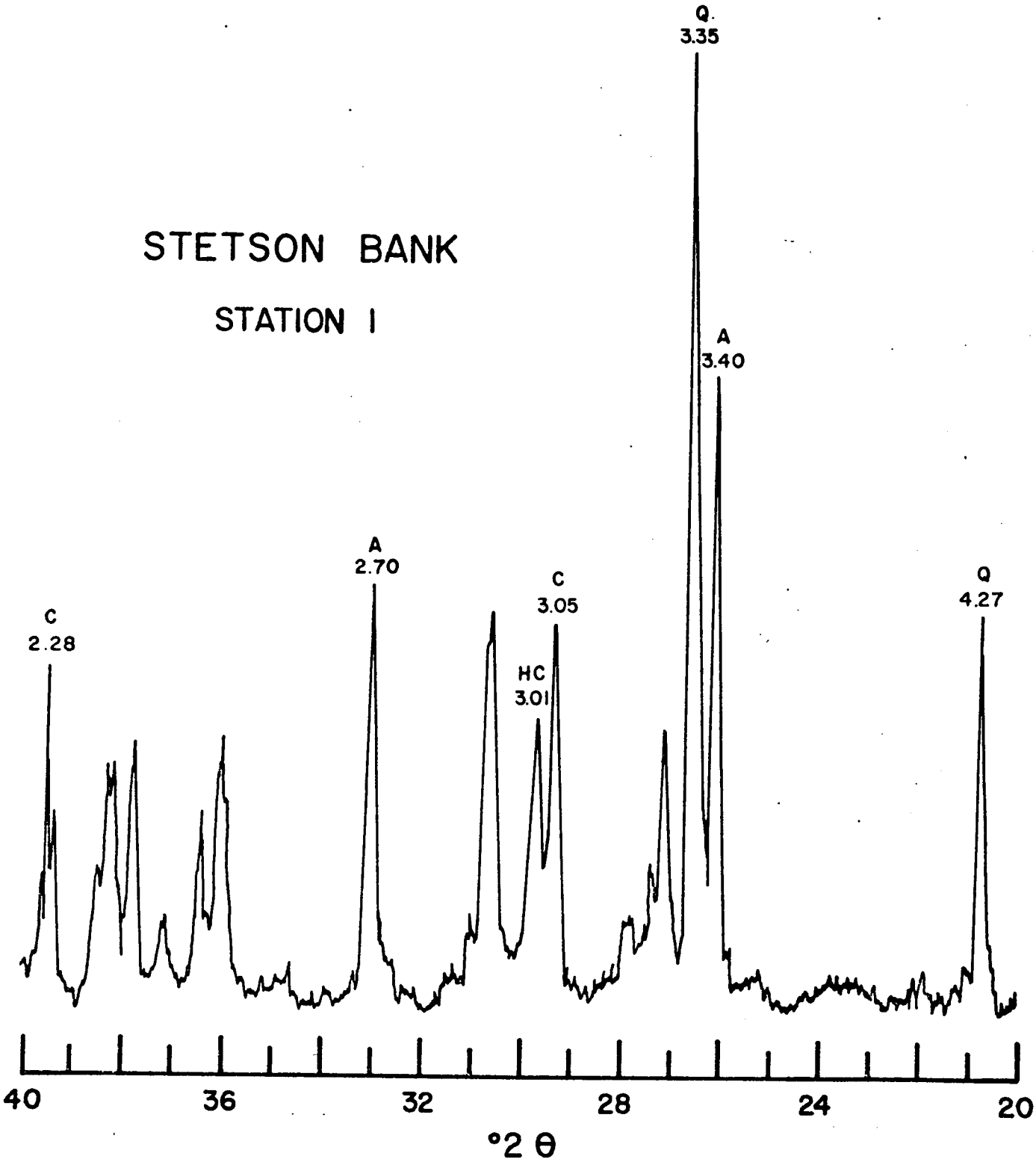


Figure IV-3. X-ray diffractogram of the > 62 μm (sand) fraction of bottom sediment from Stetson Bank. A = Aragonite, C = Calcite, HC = High MG Calcite, Q = Quartz.

Summary of Carbonate X-Ray Analysis

Stetson Bank appears to be the only anomalous bank with respect to coarse fraction mineralogy (Table IV-4). At Stetson, the dominant mineral in the coarse fraction is quartz. This difference is due to the fact that the major portion of Stetson Bank is bedrock consisting of quartz siltstones and claystones with less than 10% of the rock surfaces covered by the biota. The sediments adjacent to the remaining banks are typical of material eroded from either living or dead biologically created topographic highs.

Summary of Particle Type Identification

The counts for all samples are included in table form (Appendix II, Table IV-7). In addition, mica is a fairly common constituent of both Hospital Rock and Southern Bank and occurs in still smaller quantities in the sediment at the remaining banks. Iron oxide grains were noted frequently at Southern Bank and occasionally at Stetson Bank.

SEDIMENT CORES

From the 16 core stations, 14 gravity cores were recovered, varying from 28 to 200 cm in length. No cores were recovered from Stations 1 and 4 on Stetson Bank due to the siltstone substrate. The cores were split, visually described, color coded and radiographed. From the visual descriptions and radiographs, lithologies and sedimentary structures were delineated. This information is included in the data summary, Appendix II, Table IV-8. Eighty-six sediment samples were taken, representing each major lithology or

sedimentary structure, and analyzed for total $CaCO_3$ and grain size.

The cores show five major sediment types: silty clays, clayey silts, shelly muds, carbonate sands, and carbonate rubble. The distribution of these types with depth around the banks show several patterns.

Around Southern Bank (Fig. IV-4), the cores indicate that a zone of shelly muds extends 675 m off the west side of the bank and vertically to at least 132 cm. Figure IV-5, the location of which is shown on Figure IV-4, shows this shelly zone in core SOB 4 (104) to be covered by about 50 cm of clayey silt with some shell. Supplemental cores 42 and 48, taken during Cruise 75-G-7, further delineate this shelly zone, as does the 3.4 kHz reflection profile on which the cores are displayed. East of the bank over the marginal depression, core SOB 2 and several supplemental cores indicate the sediments are silty clays with occasional sand layers, several meters in depth. Figure IV-5 shows supplemental core 46 located at the rim of the marginal depression and several reflectors underlying it. These data indicate that the marginal depression is a relict feature that has been intermittently maintained in fine-grained sediment. Core SOB 1, north of the bank, shows the sediments to be clayey silts with occasional sand layers which is the dominant sediment type in this region of the shelf (Berryhill, et al., 1976).

Around Hospital (Fig. IV-6), the cores show the sediment to be shelly muds on the south and west side of the bank and clayey silts on the east. As on Southern, cores distant from the bank show the shelly muds covered by transgressive fine-grained sediments.

The two cores around Stetson contain clayey silt with some shell,

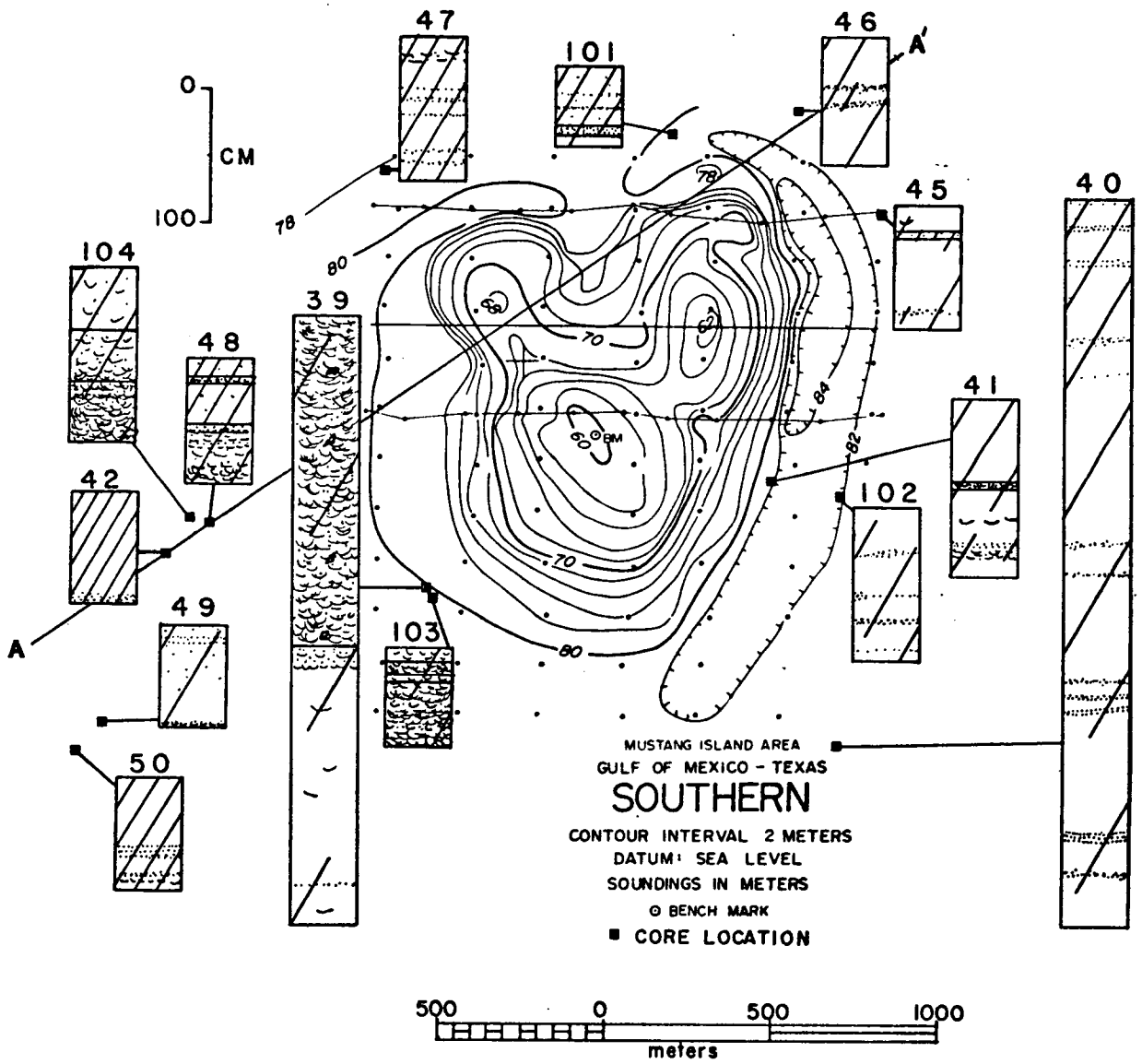


Figure IV-4. Map of Southern Bank showing core locations and location of cross section in Fig. IV-5.

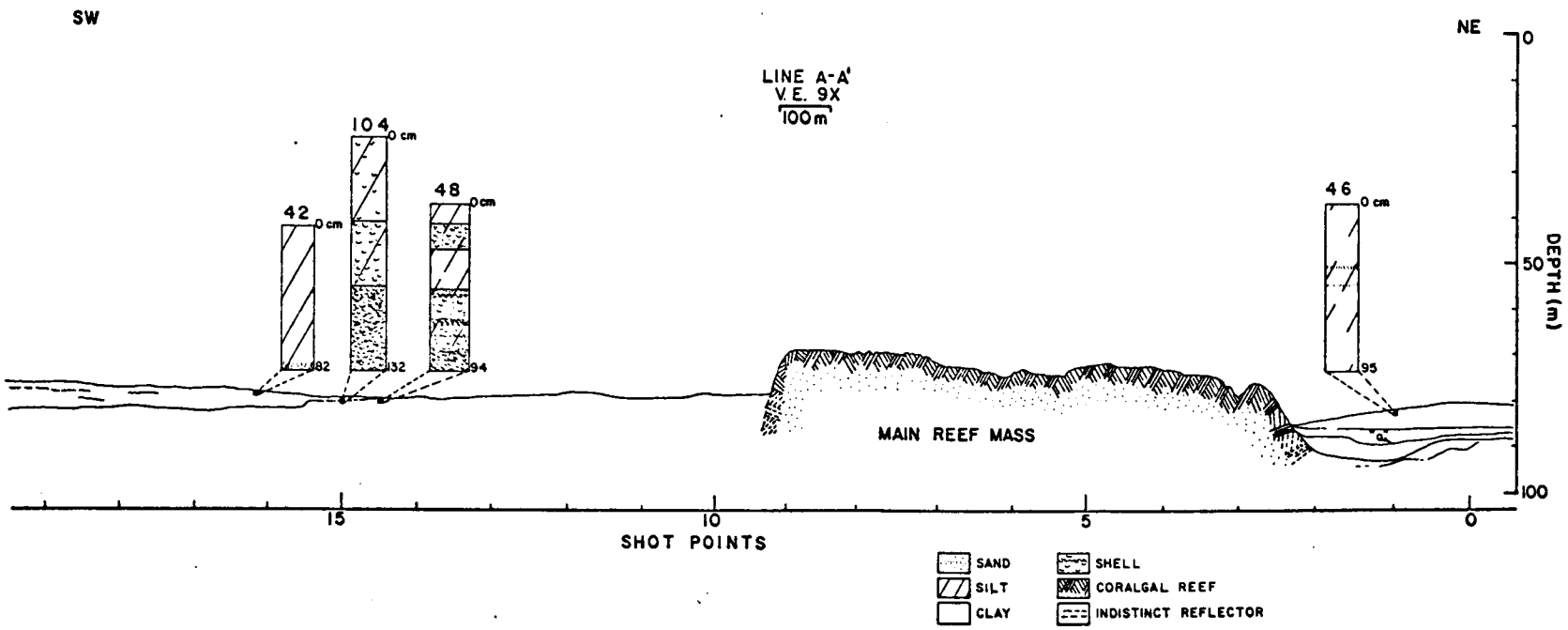


Figure VI-5. Cross section thru Southern Bank with locations of four cores showing sediment types around the bank.

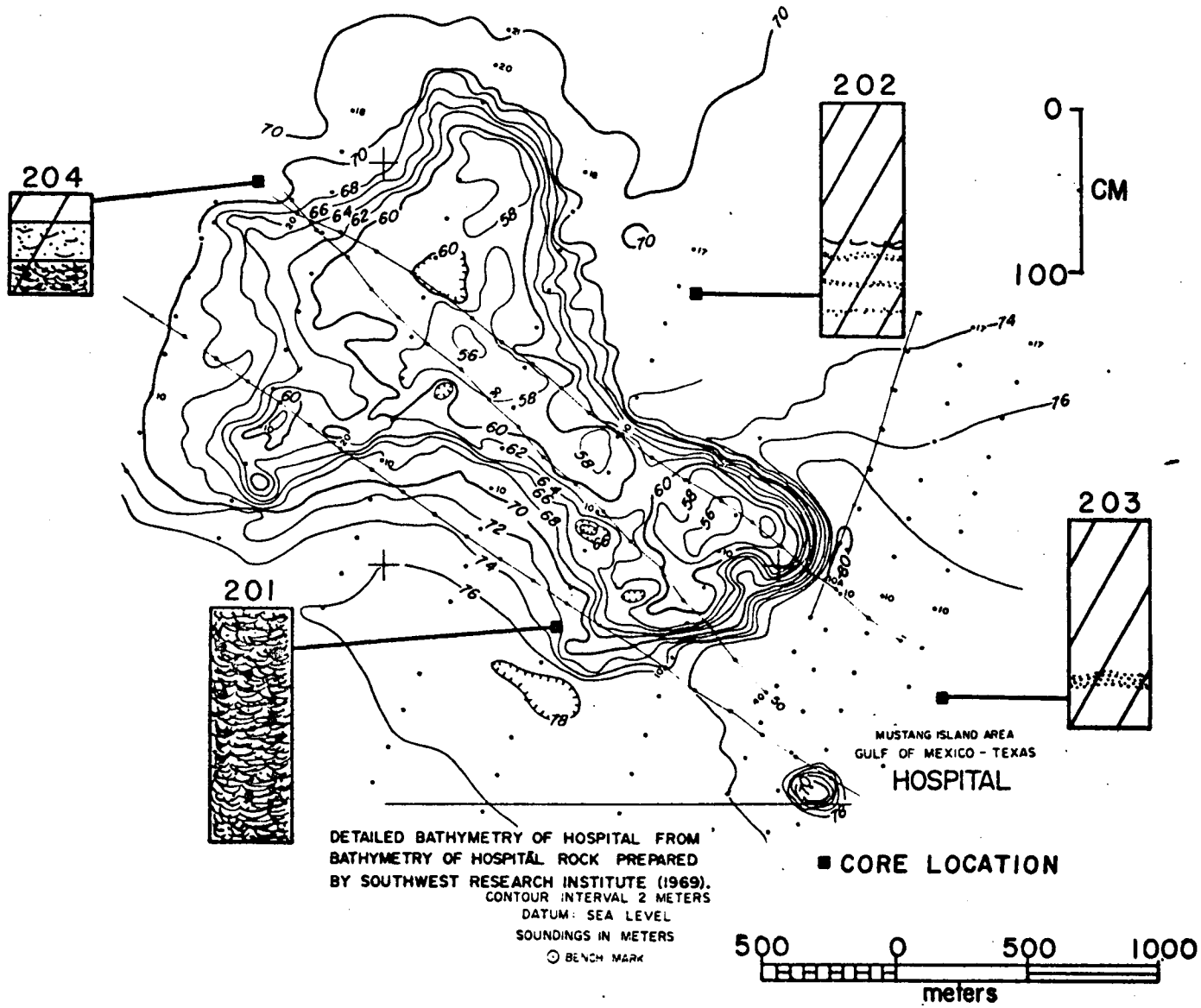


Figure IV-6. Core descriptions and locations around Hospital Rock.

shelly muds, and carbonate rubble. The major difference in these cores compared to those of the southern banks is the presence of siltstone fragments in the rubble. Both cores have a stiff clayey silt at their bases in sharp contact with the overlying rubble indicating an erosional surface, possibly during a lower stand of sea level, followed by deposition of the rubble.

The cores around East Flower Garden (Fig. IV-7) display a sediment distribution similar to that of the southern banks - shelly muds to the west, with those farther north off the bank being covered by fine-grained sediment, and clayey silts to the east. The one major difference is the presence of a carbonate sand in the upper 5 to 10 cm of the cores on the west and north side. These foraminiferal-coral-coral line algae sands are typical for actively growing coral reefs and have been reported around the bank between 85 and 106 m depth. The shelly muds below these sands were probably deposited when the bank was of smaller dimensions and in shallower water.

TRACE METALS IN BOTTOM SEDIMENTS

Thirteen samples of bottom sediment were collected and transmitted to the USGS in Corpus Christi for trace metal analysis. The analyses returned to us were of the 1975 samples and not those collected in 1976. The 1975 sample analyses are included in Appendix II, Table IV-9. No interpretations of the analyses are included in this report as none was supplied to us by the USGS.

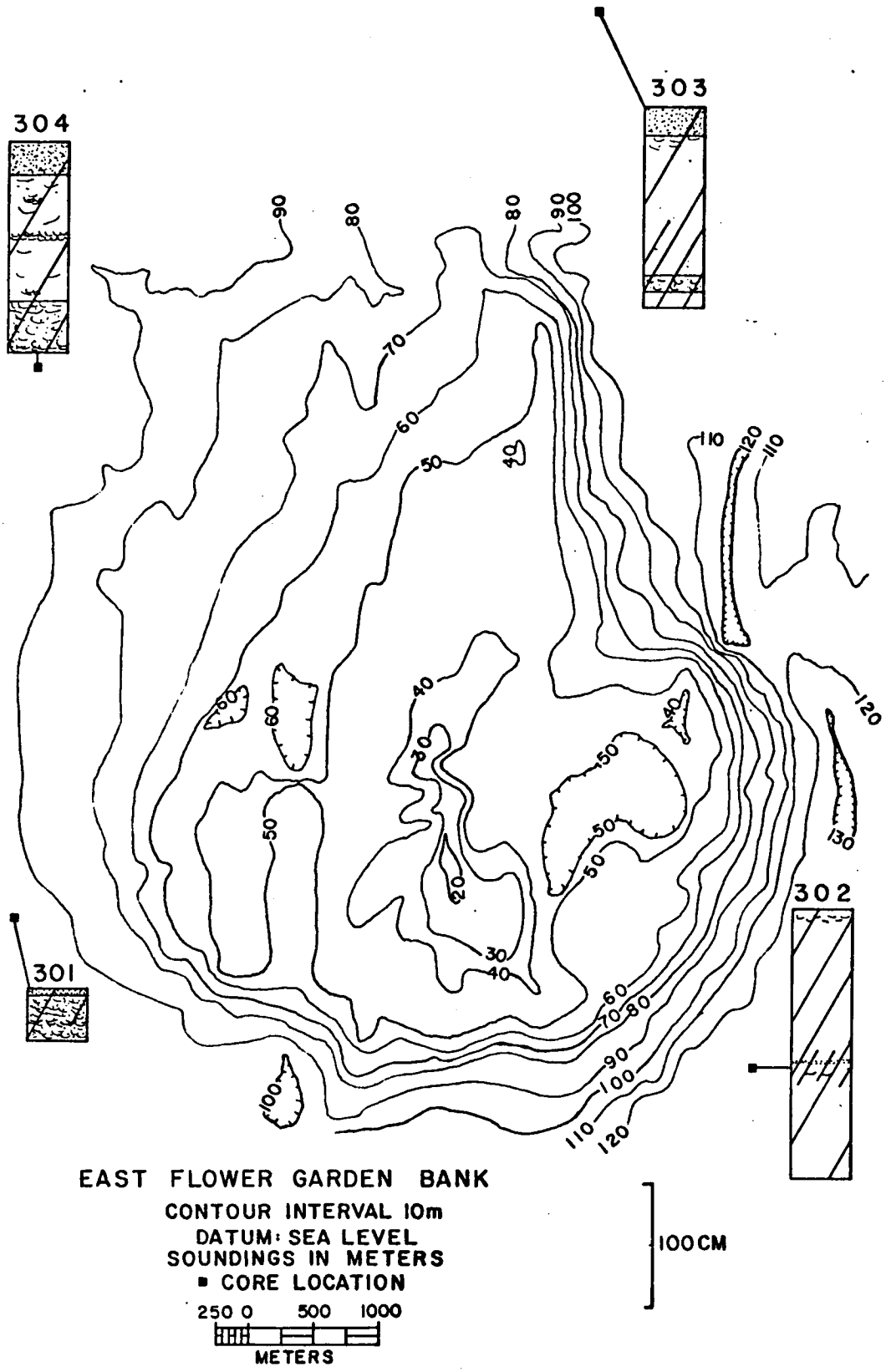


Figure IV-7. Core descriptions and locations around East Flower Gardens Bank.

DISPERSAL OF SUSPENDED SEDIMENT AS MEASURED BY THE DISTRIBUTION OF REDEPOSITED CRETACEOUS COCCOLITHS

Principal Investigator

Stefan Gartner

Contributors

Min-Pen Chen

Michael Curran

INTRODUCTION

During the previous reconnaissance studies of selected topographic features of the Texas continental shelf (Bright, Rezak, et al., 1976), it was noted that a "nepheloid" layer was observed around all of these topographic highs. Most of the banks, in fact, are immersed within this nepheloid layer, and only the uppermost part of the highest prominences protrude above the turbid water that is present near the bottom of the adjacent continental shelf. The presence of such a turbid layer presents numerous problems of which two are addressed by the present study. The first of these is to determine from visual study the source of the suspended sediment, its direction of movement, and, if possible, where it comes to rest. The second problem is visual characterization of the sediment in the nepheloid layer in order to ascertain uniformity or lack of uniformity of the suspended sediment at different locations and during different seasons of the year.

The sediment in the nepheloid layer consists of very fine particles, mostly in the clay size range (< 4 μm), but also included is some fine silt (4 μm to 8 μm). Within this size range there are very few naturally occurring particles that can be readily and consistently identified, and which, therefore, might serve as natural tracers. Among those most likely to be suitable are coccoliths, small calcareous plates produced by planktonic algae, which range in size from about 1 μm to about 10 μm, the fine silt and

coarse clay size ranges. Particles in this size range are generally carried in suspension and it seems reasonable, therefore, that coccoliths will be present as part of the suspended load in the nepheloid layer.

Coccoliths are produced by planktonic algae, the coccolithophores, within the photic zone. They are contributed to the sediment as a steady rain of particles, either as a result of periodic shedding of coccoliths by the parent organism, or, more probably, in the fecal pellets of organisms that feed on phytoplankton, including coccolithophores. In addition to the coccoliths derived from coccolithophores living in the Gulf of Mexico today, a very considerable number of fossil coccoliths, derived primarily from the erosion of Cretaceous marls and chalks that outcrop in a broad arc across central Texas and Arkansas as well as the eastern side of the Mississippi embayment, are found in fine grained sediment throughout the Gulf of Mexico. These redeposited Cretaceous coccoliths are readily distinguished from the generally more common indigenous forms.

Since the actual source of the reworked Cretaceous coccoliths is far inland, the apparent sources are the various streams that drain the outcrop area and empty into the northern Gulf of Mexico, either directly or through various bays. Sediments carried by these streams and initially deposited chiefly in the bays, estuaries and near the shoreline, are eventually redistributed and deposited over the continental shelf and beyond. Because of their small size resuspended coccoliths may be transported over great distances, and a moving nepheloid layer would be a significant mechanism in the

dispersal of the redeposited Cretaceous forms.

Modern forms, too, can be winnowed and redeposited, however, since no sorting would occur - they are all approximately the same size - the proportion of modern forms to fossil forms would not be altered by this redeposition. It is reasonable, therefore, that the greater number of redeposited Cretaceous coccoliths will occur in areas in which fine detrital sediment is being deposited. Since modern forms are deposited at a relatively constant rate over the area, the proportion of modern specimens to reworked Cretaceous specimens is a strong measure of the dispersal of the stream-borne fine detrital sediment over the continental shelf. In addition, however, the ratio of modern coccoliths to reworked Cretaceous species can be used to characterize the fine grained sediment over the shelf area by means of two readily determinable parameters. These same measures can then be applied to the suspended sediment in the near bottom turbid layer. By comparing the ratio of modern to reworked species in the suspended sediment and the sediment on the bottom, it should be possible to determine whether the suspended sediment in the nepheloid layer was resuspended essentially at its location, or whether it was resuspended elsewhere and has been transported to the location where it was sampled.

COCCOLITH STUDIES

SAMPLING STRATEGY

Surface Sediment Samples

In order to determine the distribution of redeposited Cretaceous coccoliths over the south Texas continental shelf, some 44 core top samples, distributed more or less uniformly over the study area, were analyzed (see Figure IV-8 and Table IV-5). These core top samples were obtained from the collection of the U.S. Geological Survey in Corpus Christi.

Surface sediment samples were analyzed also from around five banks. Twelve samples each are from the two First Priority banks (i.e. Hospital Bank and Southern Bank), and include four primary stations and eight secondary stations at each bank. Fourteen samples are from the three Second Priority banks (i.e. East Flower Garden, 3 samples; 28 Fathom Bank and the immediately adjacent southwest extension, 7 samples; and Stetson Bank, 4 samples). The surface sediment samples from the five banks were obtained by subsampling the surface mineralogy grab samples taken at these banks. (Figures IV-9 to 11; Tables IV-6 to 8).

Suspended Sediment Samples

The proportion of indigenous modern coccoliths to redeposited coccoliths was also determined in the suspended sediment (1) around two banks and (2) across the entire south Texas continental shelf. (1) At the First Priority banks (Hospital Bank and Southern Bank), coccolith ratios were determined at three depths for four primary stations on each bank. These samples were taken during September,

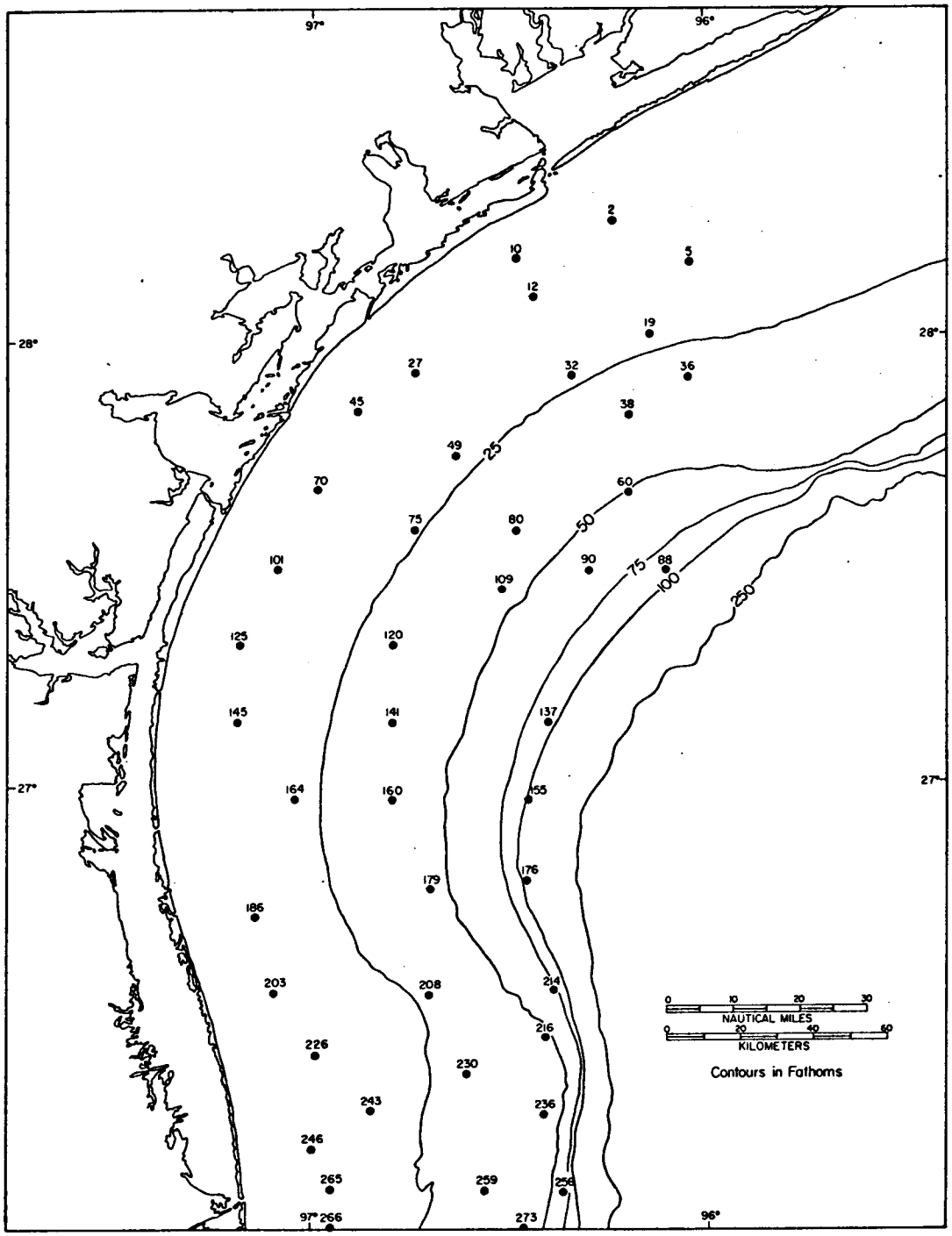


Figure IV-8. Location map for surface sediment samples from the south Texas continental shelf and upper continental slope in which the ratio of total number of coccoliths to redeposited Cretaceous coccoliths were determined.

Figure IV-9. Ratio of total number of coccoliths to redeposited Cretaceous coccoliths in the surface sediments around Hospital Bank. Note the significantly higher proportion of redeposited coccoliths (exponential values of 2 and 3) in a band on the southeast side of the bank. For explanation see text.

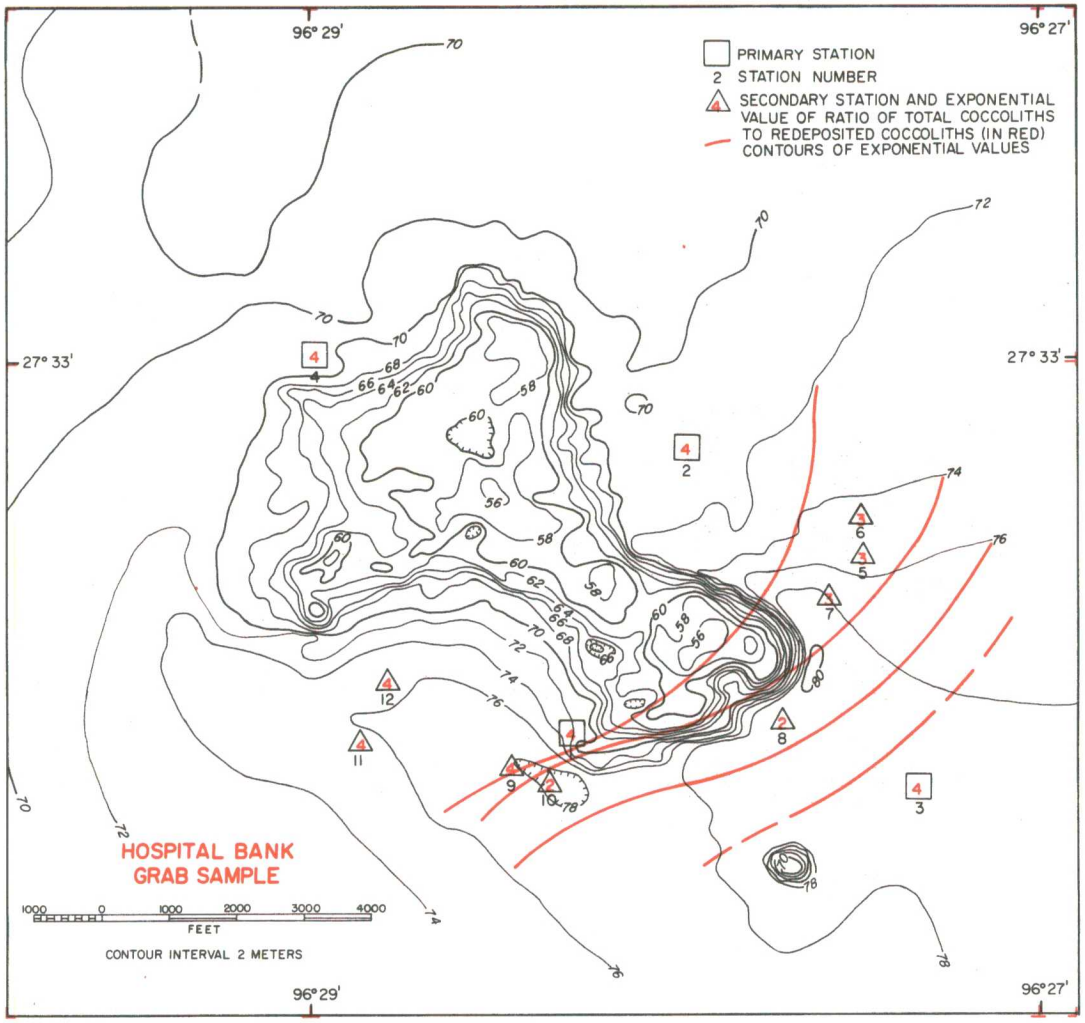

96° 29'
96° 27'
27° 33'
PRIMARY STATION
2 STATION NUMBER
SECONDARY STATION AND EXPONENTIAL VALUE OF RATIO OF TOTAL COCCOLITHS TO REDEPOSITED COCCOLITHS (IN RED)
CONTOURS OF EXPONENTIAL VALUES
HOSPITAL BANK
GRAB SAMPLE
1000 0 1000 2000 3000 4000
FEET
CONTOUR INTERVAL 2 METERS

Figure IV-10. Ratio of total number of coccoliths to redeposited Cretaceous coccoliths in the surface sediments around Southern Bank. The proportion of redeposited coccoliths seems to be highest on the southeast side of the bank and on the northwest flank. Although the pattern is somewhat ambiguous, a relationship to topography may be inferred.

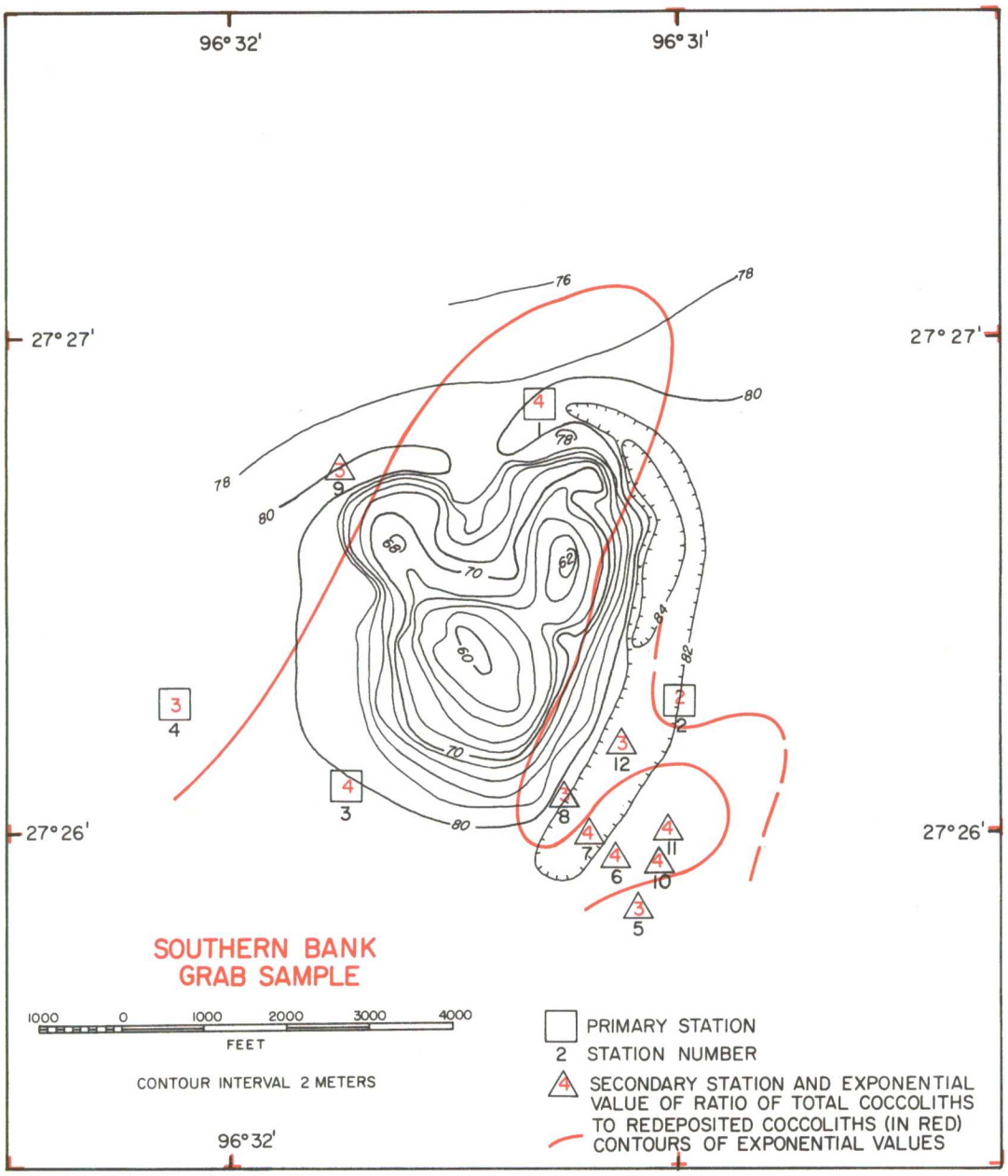
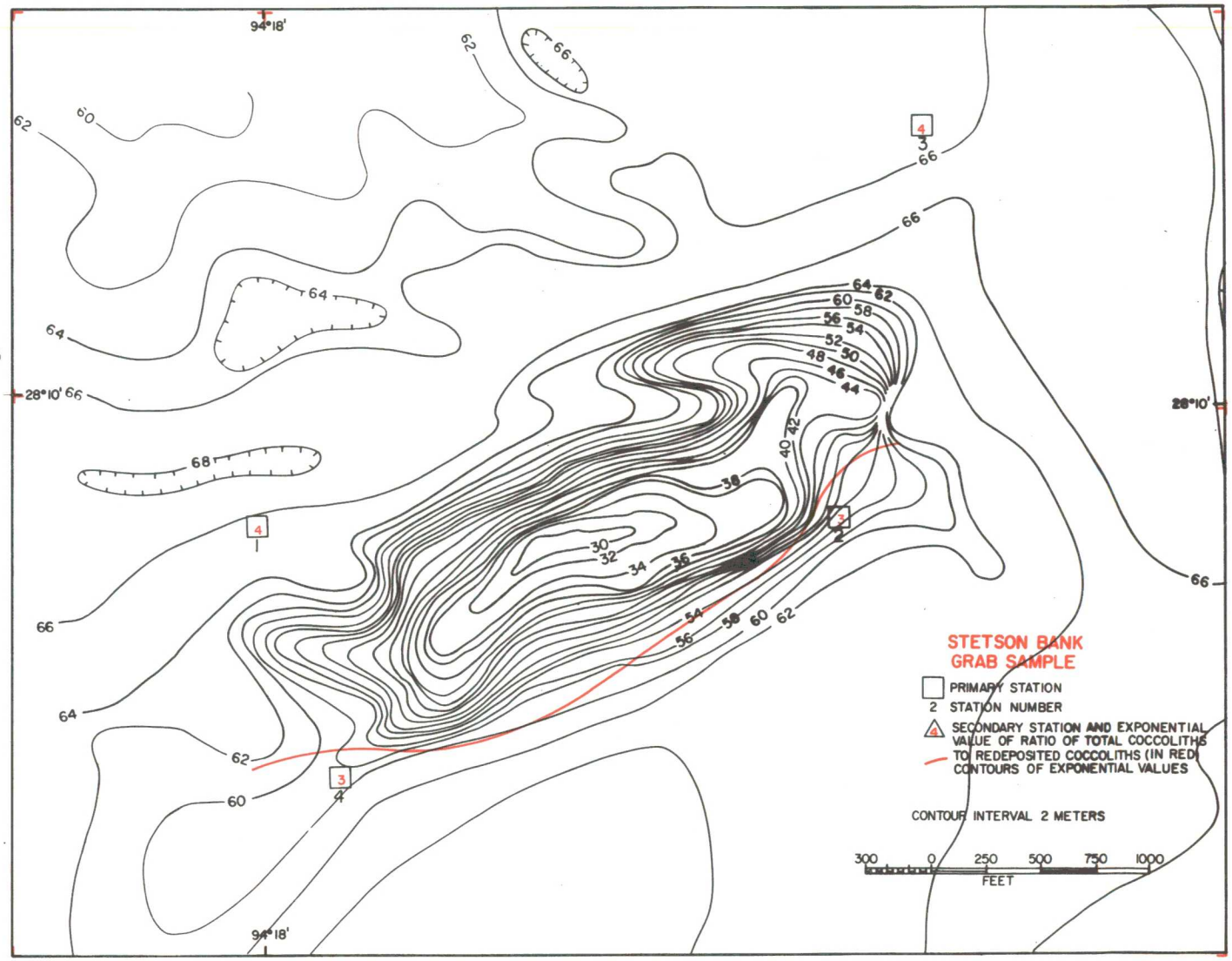

96° 32'
96° 31'
27° 27'
27° 27'
27° 26'
27° 26'
96° 32'
76
78
80
78
80
78
70
70
80
84
82
60
62
68
SOUTHERN BANK
GRAB SAMPLE
1000 0 1000 2000 3000 4000
FEET
CONTOUR INTERVAL 2 METERS
PRIMARY STATION
2 STATION NUMBER
SECONDARY STATION AND EXPONENTIAL VALUE OF RATIO OF TOTAL COCCOLITHS TO REDEPOSITED COCCOLITHS (IN RED)
CONTOURS OF EXPONENTIAL VALUES

Figure IV-11. Ratio of total number of coccoliths to redeposited Cretaceous coccoliths in four surface sediment samples from Stetson Bank.


94°18'
28°10'
STETSON BANK
GRAB SAMPLE
PRIMARY STATION
2 STATION NUMBER
4 SECONDARY STATION AND EXPONENTIAL VALUE OF RATIO OF TOTAL COCCOLITHS TO REDEPOSITED COCCOLITHS (IN RED)
CONTOURS OF EXPONENTIAL VALUES
CONTOUR INTERVAL 2 METERS
300 0 250 500 750 1000
FEET

1976 (Tables IV-9 and 10). In addition suspended sediment samples were analyzed from one station, three depths, on each of these two banks for four additional months during which samples were taken, i.e. March, April, May/June, and November (Tables IV-11 and 12). The September samples are duplicates and appear twice. (2) Over the entire area of the south Texas continental shelf, modern to reworked coccolith ratios were determined at three depths (surface, midwater and near bottom) for 26 transect stations sampled during the spring (March) and summer (June) (Figures IV-12 to 14; Tables IV-13 to 18). Incidentally, suspended sediments from four passes and one river mouth were also studied in order to determine what reworked coccoliths enter the Gulf of Mexico at these points (Table IV-19).

SAMPLE PREPARATION

For microscopic examination all samples were mounted on glass slides. Because of differences in the nature of the samples, bottom sediments and suspended sediments have to be prepared by two different techniques.

(1) Bottom Sediments

Core top samples and grab samples were prepared as follows. A small amount of sediment was suspended in 1 to 2 ml of water to which were added two drops of polyvinyl alcohol solution (PVA). This suspension was thoroughly mixed and spread onto a cover glass. The suspension was dried on a warming plate, thereby depositing a uniform layer of sediment on the cover glass, which was held to the cover glass by a thin film of polyvinyl alcohol. The dry cover glass was mounted on a glass slide with Caedex, a synthetic

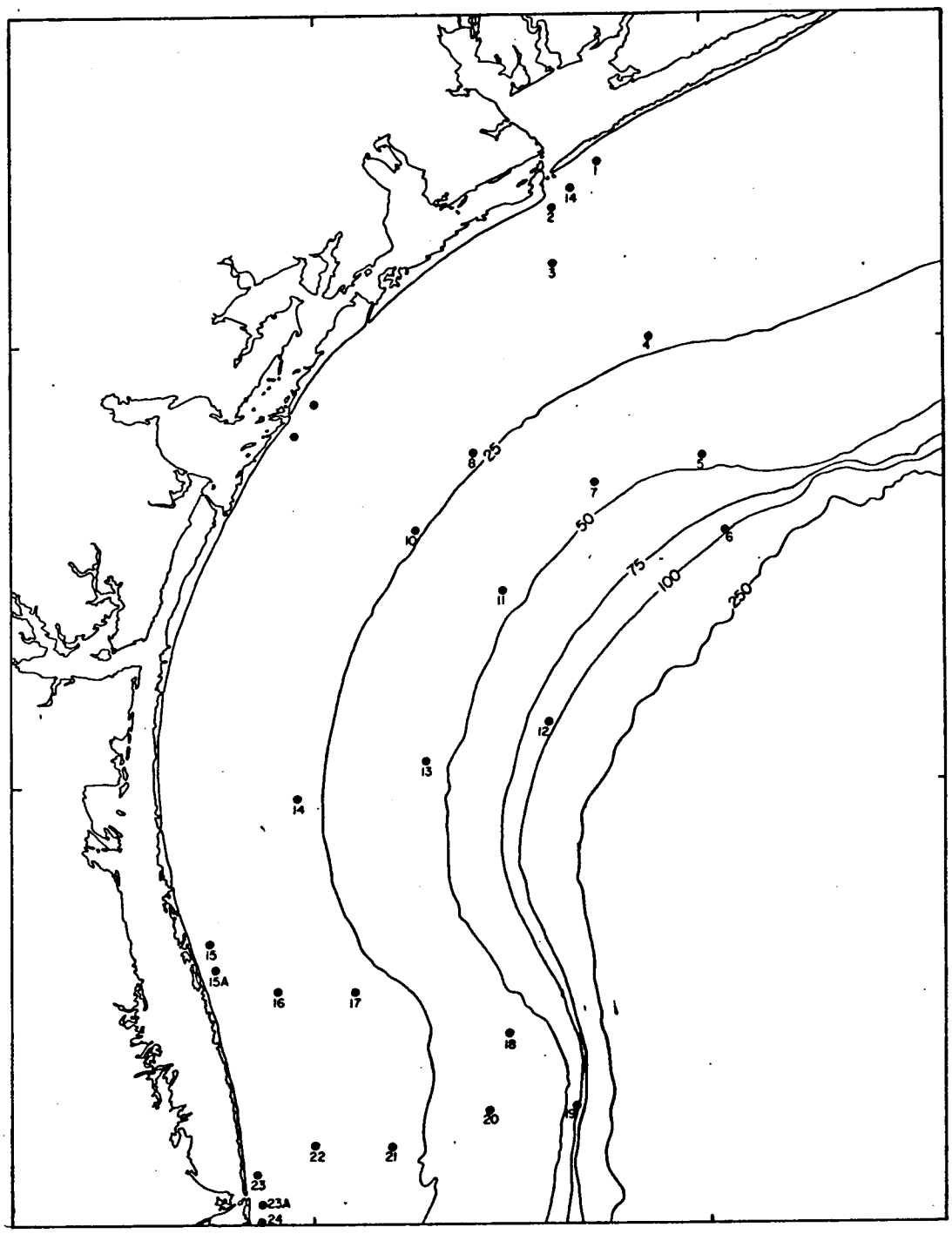


Figure IV-12. Location map of stations from which suspended sediment samples were analyzed for ratios of total coccoliths to redeposited Cretaceous coccoliths.

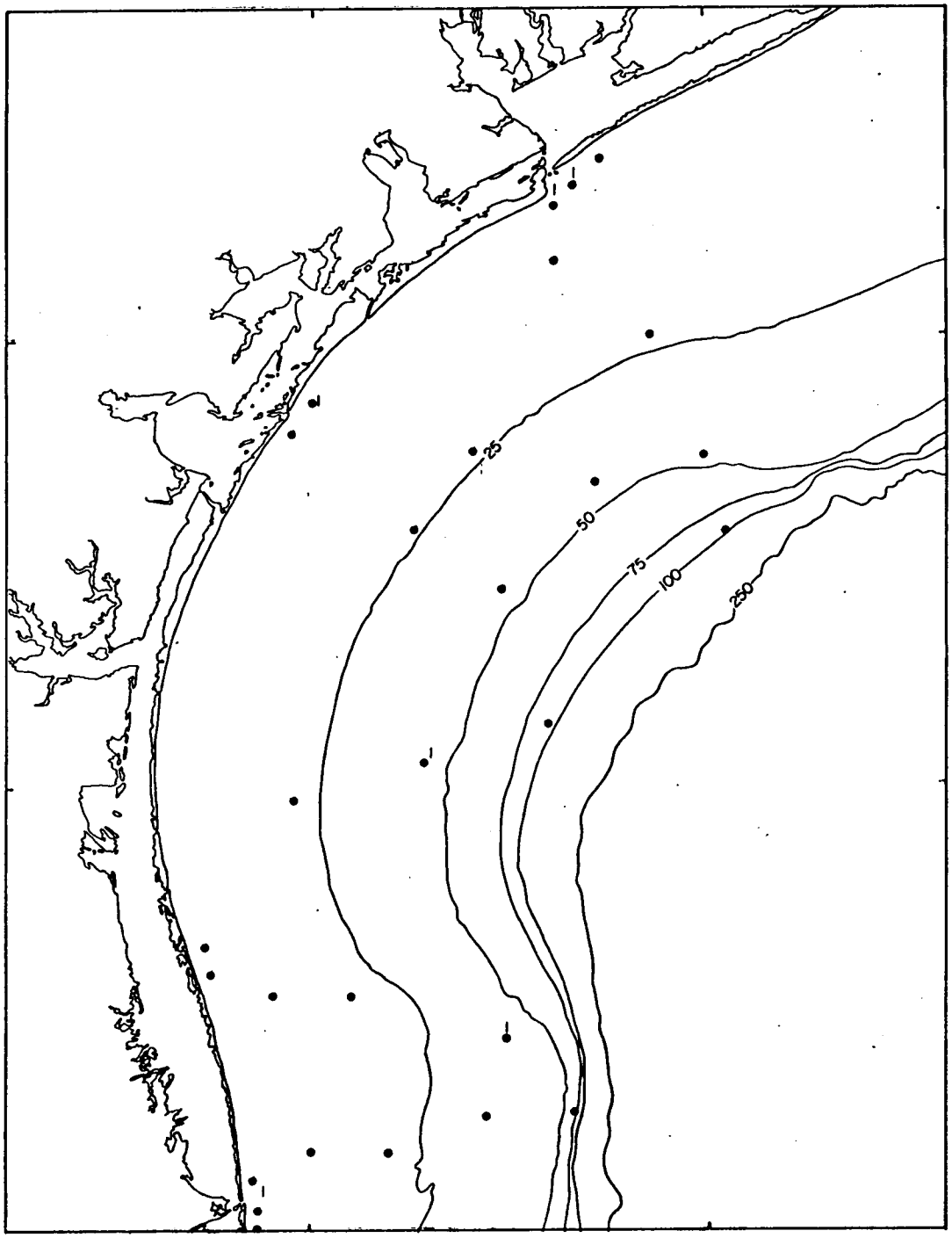


Figure IV-13. Ratio of total coccoliths to redeposited Cretaceous coccoliths in near surface suspended sediment. Only the values near Pass Cavallo, Aransas Pass, and Port Isabel are significant; the two outer shelf stations with high proportions (exponential value of 1) are the result of very low counts, and probably are not significant. Stations for which no values are given generally yielded no coccoliths at all, or very few, poorly preserved indigenous coccoliths and no redeposited coccoliths. For explanation see text.

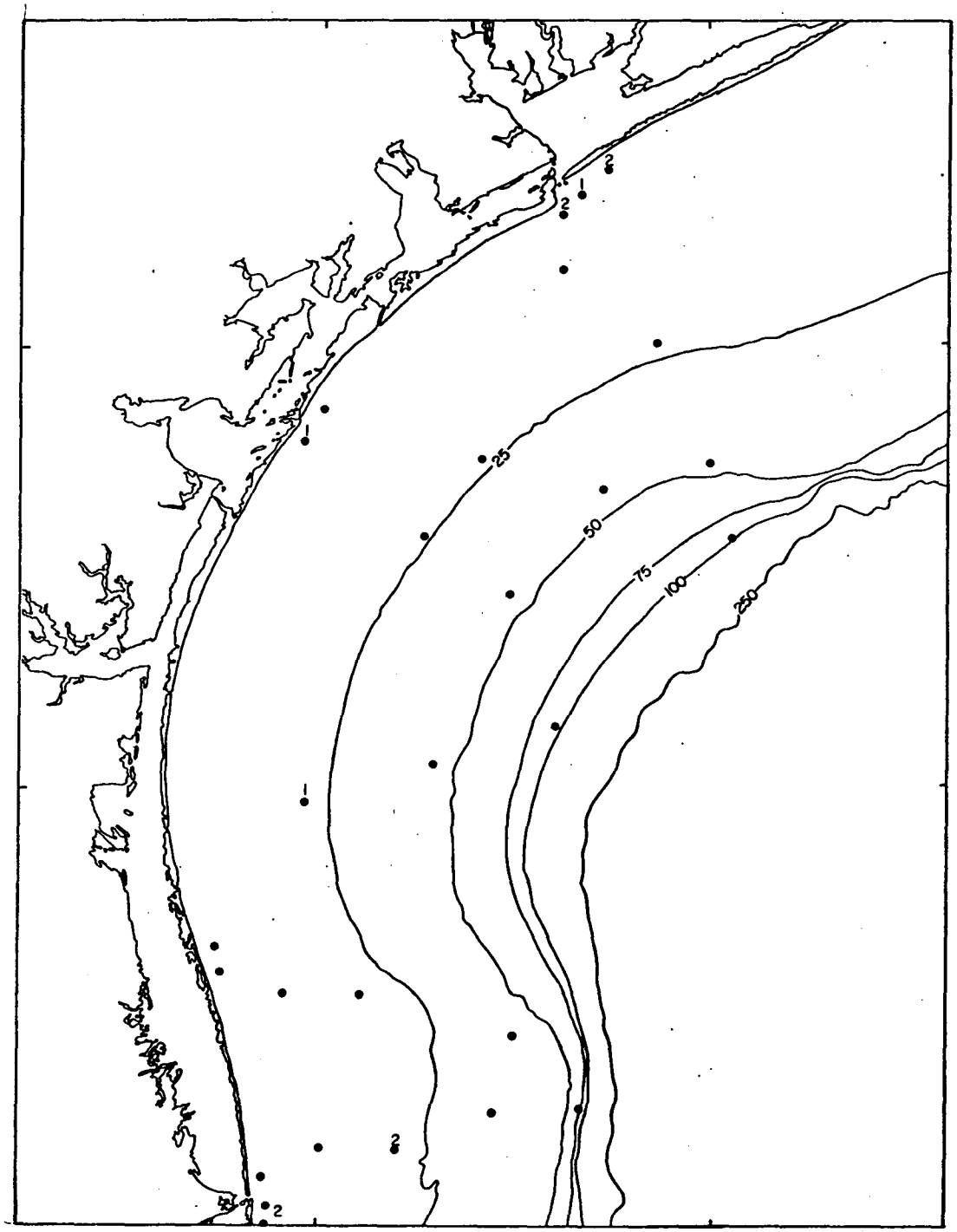


Figure IV-14. Ratio of total coccoliths to redeposited coccoliths in near bottom suspended sediment. Only the stations near Pass Cavallo, Aransas Pass, and Port Isabel yielded significant values. Most samples yielded only very few, poorly preserved modern coccoliths or no coccoliths at all.

resin.

(2) Suspended Sediments

To prepare suspended sediment for microscopic examination, a 47 mm diameter Millipore filter with 0.8 μm pore size was masked so that all filtrate was deposited on a rectangular area measuring 20 mm by 28 mm. One half to one liter of water sample was filtered through this area by drawing a vacuum on the filtering flask. The filter was rinsed of salt by drawing about 50 ml of distilled water through the filter after the water sample. The filter and sediment were then dried at low temperature (100 to 110°F). The rectangular portion of the filter containing the suspended sediment was trimmed, mounted on a glass slide with immersion oil (refractive index = 1.515) and covered with a cover glass. The immersion oil rendered the filter transparent and allowed study of the suspended sediment in transmitted light.

STUDY TECHNIQUES

Abundances of reworked and of modern coccoliths were determined by counting the number of specimens within a given area. Counts were made at 1000X magnification in cross-polarized light. Because the indigenous modern forms were generally much more abundant than reworked Cretaceous species, especially in samples taken towards the edge of the continental shelf, the count for indigenous modern species could be made on one or two fields. In these same samples a much larger area had to be scanned to get a count of the reworked Cretaceous species.

At the outset of this study it was thought that a third

category could be determined, that of reworked discoasters, a group related to coccoliths but restricted to Tertiary sediments. This supposition was based on the occurrence of reworked discoasters in modern sediments around the Mississippi delta. However, on the south Texas continental shelf, redeposited Tertiary nannofossils are exceedingly rare; and, in fact, only one sample yielded redeposited discoasters.

After the counts were made the values were normalized for an equal area. The ratio of total coccoliths to reworked coccoliths was determined from these normalized values. The total coccolith number was used rather than that of indigenous modern species so that the ratio could not be less than 1, even if only reworked coccoliths were encountered, and all of the ratios are represented by number ranging from 1 to ∞. Samples containing no redeposited species yield a ratio of ∞; samples containing one or more redeposited specimens yielded number from 1 to about 65,000. These ratios represent a very large spread and cannot be visualized or pictured readily; therefore ratios were reduced to exponential values of powers of ten. Thus, ratios ranging from 1 to 10 are represented by the exponent 1; ratios between 10 and 100 are represented by the exponent 2; ratios between 100 and 1,000 are represented by the exponent 3; ratios between 1,000 and 10,000 are represented by the exponent 4; and ratios greater than 10,000 (including ∞) are represented by the exponent 5. When reduced to exponential values the ratios can be readily plotted and visualized for interpretation.

RESULTS AND INTERPRETATION

The data resulting from this study are presented in tabular form on Tables IV-5 to 19. Where appropriate the data are also plotted on base maps, Figures IV-8 to IV-15. Because plotting the ratios of the total number of coccoliths to the number of redeposited Cretaceous coccoliths is not very meaningful, the exponential values to base 10 of these ratios were plotted and contoured.

Figure IV-15 represents essentially the relative abundance of redeposited Cretaceous coccoliths in the surface sediment of the south Texas continental shelf. As is to be expected, the greatest concentration of Cretaceous species (represented by the number 1) is along the shoreline in a continuous belt of varying width. The concentration generally decreases offshore towards the shelf edge, although redeposited specimens are still found beyond the shelf break on the upper continental slope. More interesting and important than the gradient of decreasing numbers of redeposited species normal to the coastline are the irregularities in the distribution of the ratio. The most notable of these irregularities is in the northern part of the study area where a tongue of high concentration of redeposited specimens extends eastward across the continental shelf approximately due east of Aransas Pass. Immediately north of this high concentration tongue, and partly outside of the study area, a tongue of low concentration of redeposited specimens appears to extend shoreward at an angle across the continental shelf. In the central part of the study area, minor irregularities occur along the inner part of the continental shelf. Farther off shore a broad tongue of low concentration seem to be extending

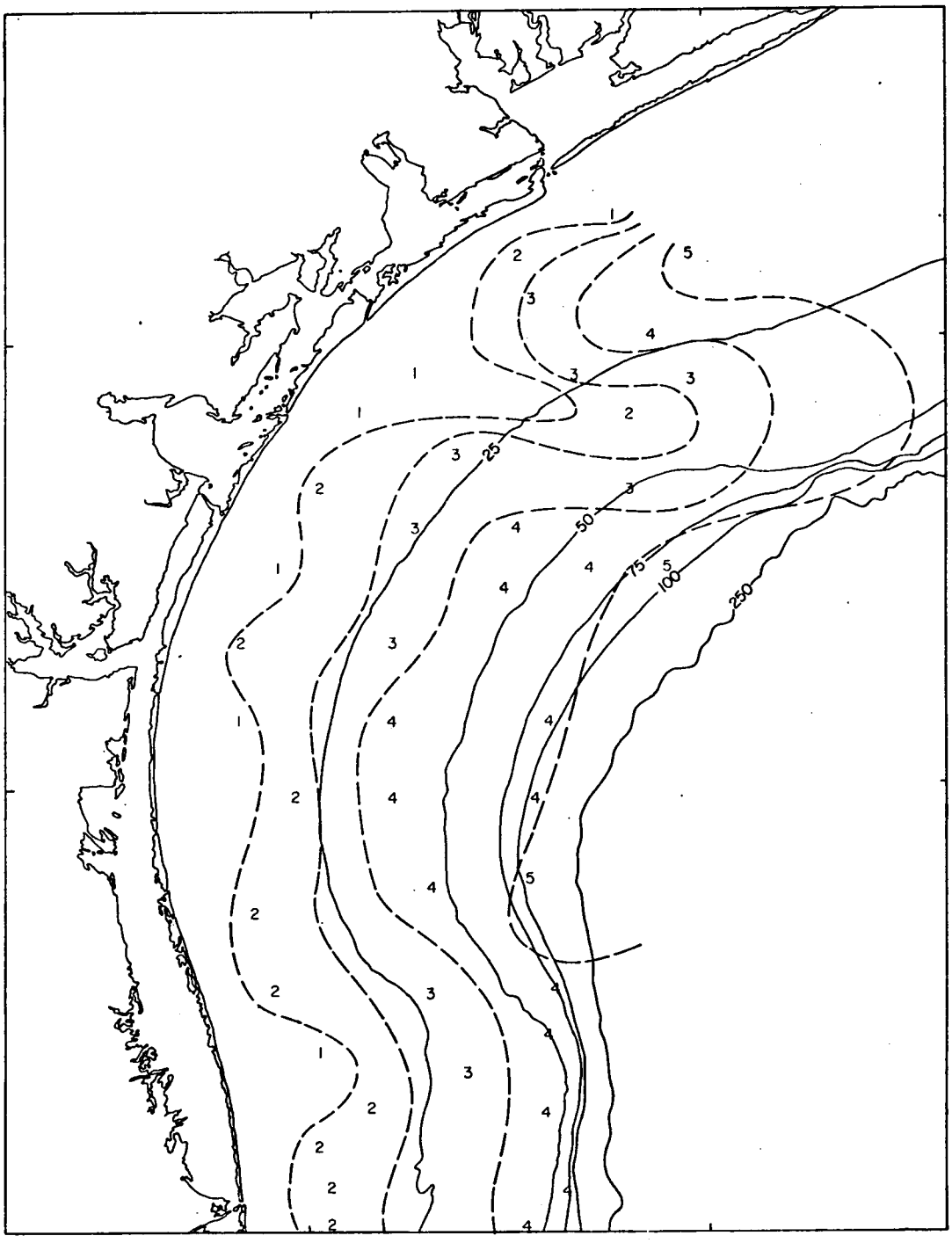


Figure IV-15. The ratio of total number of coccoliths to redeposited Cretaceous coccoliths plotted as the exponential value to base 10 and contoured with dashed lines over a base map. The most significant features are the apparent onshore transport in the northernmost part of the study area, and the strong offshore transport, diagonally across the shelf, immediately to the south of it, and extending due east from Aransas Pass. A broad but poorly offshore directed dispersal pattern also seems to exist in the southernmost part of the study area.

shoreward on the outer continental shelf area. In the southernmost part of the study area a broad and not very sharply defined tongue seemingly extends offshore across the shelf.

The most reasonable interpretation of the distribution of ratios of total coccoliths to redeposited Cretaceous coccoliths is that the areas of low ratios are regions where land-derived fine detrital sediment is most abundant, while the influence of land-derived detrital sediment is least in areas where the ratio is high. The tongue of low ratios or high concentration of land-derived detrital material extending eastward from the Aransas Pass area agrees only in a general way with the circulation pattern inferred for this part of the Gulf of Mexico by Curry (1960) and Van Andel (1960). Van Andel interprets seaward dispersion of sediments to occur much farther south than is indicated by the coccolith data. A better agreement can be seen between the coccolith data and the inferred circulation of shelf water in this area based on temperture, salinity and density data for 1963 to 1965 (Berryhill, et al., 1976). The circulation pattern, although somewhat variable seasonally, shows east and northeast directed currents during the summer months, while a southwest flow seems to dominate during the winter months. It should be noted that the fossil coccolith distribution pattern probably reflects more of an integrated effect of fine sediment dispersal, and is less likely to reflect short term variations in circulation. The pattern therefore indicates a net transport of suspended particles in the fine silt and coarse clay size range.

The coccolith data from the suspended sediment samples (26

transect stations, 3 depths, 2 seasons) are not definitive. Tables IV-13 to 18 show that many of these samples yielded no coccoliths at all, and virtually none of the samples contained reworked Cretaceous coccoliths. This came as a surprise and a disappointment in this study and an answer for the lack of material in these samples is still being sought. Possible suggestions are that the portion of the suspended sediment that would contain coccoliths is very close to the bottom (lowermost part of the nepheloid layer) and, hence, was not sampled even in near bottom water samples. A related possibility is that, although a nepheloid layer is present much of the time, most of the fine silt and coarse clay size particles are in suspension only during episodes of relatively intense bottom water turbulence. A third possibility, and one that cannot be ruled out for some of the samples, is that the calcareous particles in the suspended sediment, including coccoliths, were dissolved by the addition of unbuffered formaldehyde after the samples were taken. In any case, significant numbers of coccoliths were found suspended only at the stations in the vicinity of Aransas Pass and Pass Cavallo.

FOSSIL COCCOLITHS AROUND TOPOGRAPHIC HIGHS

The ratio of the total number of coccoliths to redeposited Cretaceous coccoliths in the sediment around Hospital Bank and Southern Bank shows a pattern that is substantially different from that in the general area in which these banks are located. Both banks are within the broad tongue in the central part of the South Texas continental shelf which is characterized by a relatively low

number of redeposited Cretaceous coccoliths. This same pattern of abundance seemingly prevails directly over both banks (Figures IV-10 and 11.) However, on the margins of the banks, and more specifically on the southeast sides of the banks, generally higher concentrations of redeposited specimens occur. It is tempting to invoke near bottom transport of detrital sediment as the most obvious explanation for this peculiar pattern. Such an interpretation would be most compatible with current movement parallel to the shelf edge (at least locally), where these banks are located. Although this is by no means inconceivable, the evidence is suggestive rather than conclusive. A reasonable alternative that also must be considered is that bottom current activity around the bases of the banks on the basin side are preventing deposition of fine suspended sediment. Consequently much of the exposed sediment is relict material that was deposited when sea level was lower, and when the source for land derived detrital sediments, the mouths of rivers debouching into the northwestern Gulf of Mexico, were much closer to the banks.

Surface sediments were examined from three other topographic highs, all three of them located farther offshore on the Texas/Louisiana continental shelf, and outside of the south Texas continental shelf study area. One of these three banks, Stetson Bank, is located between the 40 and 60 m contours; the other two, Twenty-eight Fathom Bank (and the immediately adjacent southwest extension), and East Flower Garden, are between the 120 and 140 m contours, although the distance to shore from all three banks is not significantly different. It is interesting, therefore, that

the proportion of redeposited Cretaceous species is higher around Stetson Bank than it is around the other two (Table IV-8, Figure IV-12). In this respect, at least, Stetson Bank is similar to Southern and Hospital Banks, both of which rise from approximately the same depth on the continental shelf, though farther to the south and west. Additionally, however, the Stetson Bank sediment yielded significant numbers of reworked Tertiary coccoliths as well as the associated discoasters. This is anomalous in that redeposited Tertiary species were not recorded in any other sample, and very likely a local source in the form of Tertiary sediments outcropping in the area can be inferred.

Suspended sediments from Southern Bank and Hospital Bank also were examined and evaluated with respect to the proportion of redeposited Cretaceous coccoliths present. The data for these samples are given on Tables IV-9 to 12. During August the four primary stations on each bank were sampled at three depths; bottom, near bottom and intermediate or shallow depth. (Actually only one sample, at Station 3 on Hospital Bank, is from near the surface; all other "surface" samples are from mid-depth.) The data from the mid-water and near bottom samples are not very useful in that the number of redeposited Cretaceous specimens was either 1 or 0. The water samples taken nearest to the bottom yielded more realistic counts of redeposited specimens; and although the ratio of indigenous modern specimens to redeposited specimens is uniformly high (exponential value of 4), this value is in good agreement with values obtained from shelf sediments in the general vicinity of the banks, though not with values obtained on and in the immediate

vicinity of the banks. Since even the lowermost samples may have come from some distance above the bottom, it is not surprising that the coccolith ratios reflect the regional trend more than local perturbations in that trend associated with the banks. A reasonable inference can be made, therefore, that the suspended sediments sampled on the bank originate in the general vicinity of the banks, but not from the basinward side of the banks or in areas where the proportion of redeposited Cretaceous coccoliths is appreciably greater.

The monthly water column samples taken from 3 depths at one station on each bank yielded much the same type of pattern, i.e. the proportion of total coccoliths to redeposited Cretaceous coccoliths is very high, much as it is in the shelf sediments in the general vicinity. An exception seems to be the April samples from Southern Bank, and the April and May/June samples from Hospital Bank, at which times the relative abundance of redeposited specimens is much greater. Caution is indicated, however, because these values are based on low total counts, so that the proportions are determined not so much by a large number of redeposited specimens, but rather by an anomalously low number of modern specimens. No obvious explanation has been found for these data, and they may not be significant.

CONCLUSIONS

The distribution of redeposited Cretaceous coccoliths in the surface sediment of the south Texas continental shelf indicates that these fossils can be used to trace the transport of fine silt

and clay size particles in the area. Specifically they indicate that in the northernmost part of the area the net transport of particles is onshore from the east. Immediately to the south of this area the net transport is offshore, extending across the continental shelf approximately due east from Port Aransas, in a long, relatively well defined tongue. In the central area of the south Texas continental shelf there seems to be very little basinward dispersal of land-derived fine silt and coarse clay size material; and if any significant offshore transport occurs in this area, it must be restricted to the very fine clay size fraction. In the southernmost part of the south Texas continental shelf the net transport again seems to be offshore, but the pattern is broad and diffuse and not as sharply defined as it is in the northern part of the study area.

Sediment samples taken on and around various banks, the several topographic highs on the Texas continental shelf, generally yield the same proportion of redeposited Cretaceous coccoliths as do the sediments in the general vicinity, except that on the basinward side of the shallower banks (Southern, Hospital and Stetson) a significantly higher proportion of redeposited specimens is encountered. The two most nearly acceptable explanations for this anomalous distribution around these banks are 1) land derived sediments are being transported parallel to the shelf edge and deposited on the basin side of the banks; 2) the sediments on the basinward side of the banks are relict, possibly deposited during a lower stand of sea level at a time when the shoreline and, hence, the source of the redeposited Cretaceous coccoliths was closer to

these banks.

Analysis of suspended sediment samples for reworked and modern coccoliths yielded less information. Suspended sediment samples from four passes taken during an outgoing tide yielded the expected high number of Cretaceous specimens. In addition, however, these samples contained a surprisingly high number of modern forms. Very probably these modern forms are contributed by species which live in the lagoons behind the barrier islands and in the bays, although some may have been brought into the lagoons and bays by tidal currents. One suspended sediment sample taken at the mouth of the Rio Grande yielded only one modern specimen, but contained a relatively large number of Cretaceous species.

Suspended sediments from the seasonal transect stations produced virtually no information. Useful numbers of redeposited Cretaceous coccoliths were obtained only from water samples taken near inlets to bays and lagoons.

Data from suspended sediment samples taken over topographic highs suggest that the coccolith size fraction of the suspended sediment originates on or in the vicinity of the banks, but that apparently not all parts of the banks are equally subject to having fine sediment resuspended.

TABLE IV-1

MINERALOGY OF CLAY FRACTION (< 2 μm)
(%)

SAMPLE		SMECTITE	ILLITE	KAOLINITE	CHLORITE	OTHERS
28 Fathom Bank, south-west peak	1	60	22	17	T*	Quartz, calcite Hi-Mg calcite
	2	71	20	9	T	Calcite, Hi-Mg calcite
	3	69	19	11	T	Quartz, calcite Hi-Mg calcite
	4	70	19	11	T	Quartz, calcite Hi-Mg calcite
Stetson Bank	1	69	21	9	T	Quartz, calcite
	2	68	20	11	T	Quartz, calcite
	3	69	17	14	T	Quartz, calcite
	4	30	41	28	T	Quartz, calcite
Hospital Bank	1	75	17	9	T	Quartz, calcite aragonite
	2	71	19	10	T	Quartz, calcite
	3	74	15	7	T	Quartz, calcite
	4	77	16	6	T	Quartz, calcite
	5	74	17	10	T	Quartz, calcite
	6	75	16	9	T	Quartz, calcite
	7	76	16	8	T	Quartz, calcite
	8	74	19	7	T	Quartz, calcite
	9	76	17	7	T	Quartz, calcite
	10	77	16	7	T	Quartz, calcite
	11	78	15	7	T	Quartz, calcite
	12	76	17	7	T	Quartz, calcite

* T = trace

TABLE IV-1 (CONTINUED)

MINERALOGY OF CLAY FRACTION (< 2 μm)
(%)

SAMPLE		SMECTITE	ILLITE	KAOLINITE	CHLORITE	OTHERS
East Flower Gardens Bank	1	61	17	12	10	Quartz, calcite Hi-Mg calcite
	2	75	12	7	6	Quartz, calcite
	3	74	14	7	5	Quartz, calcite Hi-Mg calcite
	4	70	15	10	5	Quartz, calcite
28 Fathom Bank	1	64	18	12	7	Calcite
	2	65	19	11	6	Calcite
	3	72	13	15	T*	Calcite, Hi-Mg Calcite
Southern Bank	1	71	16	10	T	Quartz
	2	73	18	10	T	Quartz
	3	76	16	8	T	Quartz
	4	74	17	10	T	Quartz
	5	76	13	6	5	Quartz
	6	76	15	8	T	Quartz
	7	72	15	8	5	Quartz
	8	69	21	10	T	Quartz
	9	72	16	8	T	Quartz
	10	72	19	9	T	Quartz
	11	72	20	7	T	Quartz
	12	73	19	9	T	Quartz

*T = trace

TABLE IV-1 (CONTINUED)

MINERALOGY OF CLAY FRACTION (< 2 μm)
(%)

SAMPLE		SMECTITE	ILLITE	KAOLINITE	CHLORITE	OTHERS
Transect II	1	60	24	16	T*	
	2	61	24	15	--	
	3	56	26	17	T	
	4	61	25	14	--	
	5	61	24	14	T	
	6	56	27	17	--	

* T = trace

TABLE IV-2

MINERALOGY OF WATER SAMPLES COLLECTED AT MAJOR TEXAS COAST PASSES

Port Aransas

Kaolinite > Illite > Smectite

Port O'Connor

Kaolinite ≥ Illite > Smectite

Colorado River (upstream)

Kaolinite > Illite > Smectite

Freeport

Kaolinite ≥ Illite > Smectite (trace chlorite)

Galveston 1 (Buoy 11)

Kaolinite > Illite > Smectite

Galveston 2 (Buoy 7)

Kaolinite ≥ Illite > Smectite

Sabine River Inlet

Kaolinite > Illite > Smectite

Table IV-3

SEDIMENT MODES AND CLASSIFICATION

Bank	Station	Modes: Primary	Secondary	Tertiary	Classification
East Flower Garden	1	Medium Sand	Fine Sand		Muddy Sand
	2	Fine Silt	Clay		Mud
	3	Fine Sand	Clay		Sandy Mud
	4	Medium Sand	Fine Sand		Sand
Stetson Bank	1	Granule	Coarse Sand	Medium Sand	Muddy, sandy Gravel
	2	Medium Sand	Granule	Fine Sand	Muddy, Gravelly Sand
	3	Fine Sand	Clay		Muddy Sand
	4	Granule	Coarse Sand	Very Fine Sand	Sandy Gravel
28 Fathom Bank	1	Coarse Sand	Granule	Coarse Silt	Muddy, Gravelly Sand
	2	Coarse Sand	Very Fine Sand	Granule	Muddy, Gravelly Sand
	3	Medium Sand			Gravelly Sand
	4	Not analysed (Algal nodule cobbles)			
28 Fathom Bank, southwest peak	1	Very Coarse Sand	Grandules	Very Fine Sand	Gravelly, Muddy Sand
	2	Coarse Sand	Granule		Gravelly Sand
	3	Clay	Coarse Silt	Very Fine Sand	Sandy Mud
	4	Fine Sand	Granule		Muddy, Gravelly Sand
Southern Bank	1	Clay	Very Fine Sand		Sandy Mud
	2	Clay			Mud
	3	Coarse Sand	Granule	Clay	Muddy, Gravelly Sand
	4	Coarse Silt	Very Fine Sand		Sandy Mud
	5	Clay			Mud
	6	Clay			Mud

Table IV-3 cont.

Bank	Station	Modes Primary	Secondary	Tertiary	Classification
Southern Bank (cont.)	7	Clay			Mud
	8	Clay			Mud
	9	Clay			Mud
	10	Clay			Mud
	11	Clay			Mud
	12	Clay			Mud
Hospital Bank	1	Coarse Sand	Clay		Mud
	2	Very Fine Silt	Clay		Mud
	3	Clay			Mud
	4	Clay			Mud
	5	Clay			Mud
	6	Sample Lost			
	7	Clay	Very Fine Sand		Mud
	8	Clay			Mud
	9	Sample Lost			
	10	Sample Lost			
	11	Clay			Mud
	12	Clay, Coarse Sand		Very Fine Sand	Sandy Mud

TABLE IV-4

SAND-SIZED CARBONATE X-RAY ANALYSIS
(20-60° 2θ)

SAMPLE		MINERALS (in decreasing relative abundance)
28 Fathom Bank, southwest peak	1	High-Mg calcite, calcite, aragonite, quartz, Low-Mg calcite.
	2	High-Mg calcite, calcite, aragonite, Low-Mg calcite.
	4	Quartz, High-Mg calcite, aragonite, calcite (possibly Low-Mg calcite).
Stetson Bank	1	Quartz, aragonite, calcite, High-Mg calcite.
	2	Quartz, trace amounts of Low- and High-Mg calcite.
	3	Quartz >> aragonite, calcite.
	4	Quartz >> Low-Mg calcite, High-Mg calcite, aragonite.
Hospital Bank	1	High-Mg calcite >> aragonite, calcite (possible trace of quartz).
East Flower Garden Bank	1	High-Mg calcite, quartz, calcite, aragonite.
	4	High-Mg calcite, calcite, aragonite, quartz.
Southern Bank	1	High-Mg calcite, quartz, Low-Mg calcite, aragonite.
	3	High-Mg calcite >> calcite, aragonite, quartz.
28 Fathom Bank	1	High-Mg calcite, calcite, aragonite, quartz.
	2	High-Mg calcite, Low-Mg calcite, aragonite, quartz.
	3	High-Mg calcite >> Low-Mg calcite, aragonite.

Note: Samples missing here from the original 39 analyzed for clay mineralogy did not have enough 62 > μm fraction to be x-rayed.

TABLE IV-5

SAMPLE DATA - CORE TOP SAMPLES

Core No.[1]	Counts of Specimens		Counting Distance (mm)		Normalized Counts		Ratio	Exponential Value
	Reworked	Total	Reworked	Total	Reworked	Total		
2	26	219	26.1	26.1	26	219	8	1
5	0	6	29.0	29.0	0	6	0	5
10	56	1095	27.9	27.9	56	1095	20	2
12	10	2341	27.8	27.8	10	2341	234	3
19	3	230	15.0	1.0	3	3450	1150	4
27	6	37	24.1	24.1	6	37	6	1
32	3	133	15.0	1.0	3	1995	665	3
36	5	193	15.0	1.0	5	2895	579	3
38	4	190	26.1	26.1	4	190	48	2
45	18	36	24.6	24.6	18	36	2	1
49	1	291	23.8	10.0	1	693	693	3
60	4	207	15.0	2.0	4	1552	388	3
70	7	259	27.6	10.0	7	714	102	3
75	6	203	27.8	5.0	6	1128	188	3
80	1	261	20.0	1.0	1	5220	5220	4
88	6	845	20.6	0.2	6	87030	14505	5
90	10	728	25.8	0.2	10	93910	9391	4
101	8	10	23.5	23.5	8	10	1	1
109	4	235	21.4	0.2	4	25.44	6286	4
120	4	109	24.0	1.0	4	2616	654	3
125	60	221	29.0	5.0	60	1260	21	2
137	22	611	25.5	0.2	22	77902	3541	4
141	23	205	28.0	0.2	23	28704	1248	4
145	5	5	15.0	25.0	5	5	1	1
155	12	720	20.0	0.2	12	72000	6000	4
160	8	322	23.0	0.2	8	37032	4629	4
164	15	633	26.0	26.0	15	633	42	2
176	4	490	26.0	0.2	4	63700	15925	5
179	11	263	28.5	0.2	11	37477	3407	4
186	19	259	6.0	6.0	19	259	14	2
203	14	291	5.0	5.0	14	291	21	2
208	3	177	10.0	1.0	3	1770	590	3
214	2	249	10.0	0.2	2	12450	6225	4
216	9	213	10.0	0.2	9	10647	1183	4
226	7	22	30.0	30.0	7	22	3	1
230	8	161	28.0	1.0	8	4512	564	3
236	20	271	23.0	0.2	20	31160	1558	4
243	57	184	25.6	1.0	57	4731	83	2
246	90	145	26.0	1.0	90	3780	42	2
256	18	368	27.0	0.2	18	49680	2760	4
259	19	157	24.1	0.2	19	18924	996	3
265	68	226	25.1	5.0	68	1156	17	2
266	72	231	25.0	3.0	72	1944	27	2
273	13	259	18.8	0.2	13	23959	1843	4

[1] For location see map, Figure 1.

TABLE IV-6

SAMPLE DATA - HOSPITAL BANK GRAB SAMPLES

Station No.[1]	Counts of Specimens		Counting Distance (mm)		Normalized Counts		Ratio	Exponential Value
	Reworked	Total	Reworked	Total	Reworked	Total		
1	4	235	29.2	0.2	4	34310	8578	4
2	6	97	27.8	0.2	6	13483	2247	4
3	3	37	29.5	0.2	3	5458	1819	4
4	15	118	30.0	0.2	15	17700	1180	4
5	5	99	30.0	2.0	5	1485	297	3
6	7	45	30.0	0.2	7	6750	964	3
7	7	96	30.0	3.0	7	960	137	3
8	8	52	30.0	10.0	8	156	20	2
9	7	99	30.0	0.2	7	14850	2121	4
10	20	118	30.0	2.0	20	1770	89	2
11	7	138	30.0	0.2	7	20700	2957	4
12	13	248	29.0	0.2	13	35960	2766	4

Primary Stations - No. 1-4
Secondary Stations - no. 5-12

[1] For location see Figure 3.

TABLE IV-7

SAMPLE DATA - SOUTHERN BANK GRAB SAMPLES

Station No.[1]	Counts of Specimens		Counting Distance (mm)		Normalized Counts		Ratio	Exponential Value
	Reworked	Total	Reworked	Total	Reworked	Total		
1	13	152	29.8	0.2	13	22648	1742	4
2	2	69	29.8	12.0	2	171	86	2
3	7	143	29.8	0.2	7	21307	3044	4
4	2	163	30.0	5.0	2	978	489	3
5	10	79	29.1	0.2	10	11495	1150	4
6	13	96	29.6	0.2	13	14208	1093	4
7	16	107	29.1	0.2	16	24299	1519	4
8	9	195	30.0	5.0	9	1170	130	3
9	8	202	29.2	5.0	8	1180	147	3
10	5	192	27.0	0.2	5	25920	5184	4
11	9	222	29.0	0.2	9	32190	3577	4
12	23	135	29.7	0.2	23	20048	872	3

Primary Stations - No. 1-4
Secondary Stations - No. 5-12

[1] For location see Figure 4.

TABLE IV-8

SAMPLE DATA - 2° BANK GRAB SAMPLES

28FB: 28 Fathom Bank
28FBSW: 28 Fathom Bank Southwest
EFGB: East Flower Garden Bank
STB: Stetson Bank

Station No.	Counts of Specimens		Counting Distance (mm)		Normalized Counts		Ratio	Exponential Value
	Reworked	Total	Reworked	Total	Reworked	Total		
28FB-1	7	930	26.1	0.2	7	121365	17338	5
28FB-2	6	938	28.8	0.2	6	135072	22512	5
28FB-3	4	498	27.0	0.2	4	67230	16808	5
28FBSW-1	2	222	25.6	0.2	2	284.6	14208	5
28FBSW-2	0	151	29.6	3.0	0	1490	0	5
28FBSW-3	1	264	26.0	0.2	1	34320	34320	5
28FBSW-4	5	101	29.0	0.2	5	14645	2929	4
EFGB-2	8	312	26.4	0.2	8	41184	5148	4
EFGB-3	9	351	26.9	0.2	9	47210	5246	4
EFGB-4	6	124	26.9	0.2	6	16678	2780	4
STB-1	6	54	27.6	0.2	6	7452	1242	4
STB-2	14	135	24.0	0.5	14	6480	463	3
STB-3	9	318	26.6	0.2	9	42294	4699	4
STB-4	25	121	26.4	0.2	25	15972	639	3

TABLE IV-9

SAMPLE DATA - HOSPITAL BANK SUMMER CRUISE SUSPENDED SEDIMENT SAMPLES

Sample No. 76G8III	Station Location	Sampling Depth(m)	Counts of Specimens		Counting Distance (mm)		Normalized Counts		Ratio	Exponential Value
			Reworked	Total	Reworked	Total	Reworked	Total		
59	1	27	0	111	24.2	1.0	0	1343	0	5
60	1	69	1	271	25.1	10.0	1	680	680	3
61	1	73	1	149	26.0	1.0	1	3874	3874	4
39	2	23	0	242	24.3	5.0	0	1176	1176	4
40	2	55	0	0	25.0	12.0	0	0	-	-
41	2	67	4	161	25.4	0.2	4	20404	5101	4
19	3	3	1	189	25.4	3.0	1	1597	1597	4
20	3	55	1	145	26.4	5.0	1	763	763	3
21	3	74	0	0	24.2	7.0	0	0	-	-
63	4	27	0	157	24.0	4.0	0	942	0	5
64	4	65	1	389	24.1	9.0	1	1042	1042	4
65	4	69	10	290	24.5	0.2	10	35550	3555	4

TABLE IV-10

SAMPLE DATA - SOUTHERN BANK SUMMER CRUISE SUSPENDED SEDIMENT SAMPLES

Sample No. 76G8III	Station Location	Sampling Depth(m)	Counts of Specimens		Counting Distance (mm)		Normalized Counts		Ratio	Exponential Value
			Reworked	Total	Reworked	Total	Reworked	Total		
67	1	30	1	268	25.0	5.0	1	1340	1340	4
68	1	69	1	190	24.8	0.5	1	9399	9399	4
69	1	70	3	198	26.0	0.2	3	25740	8580	4
71	2	30	1	100	24.1	1.0	1	24.0	2410	4
72	2	70	0	154	24.2	2.0	0	1863	0	5
73	2	76	4	114	25.9	0.2	4	14763	3691	4
99	3	30	0	130	23.7	1.0	0	3081	0	5
100	3	69	1	220	24.5	1.0	1	5390	5390	4
101	3	76	4	183	25.1	0.2	4	22967	5742	4
91	4	30	0	158	25.2	1.0	0	3982	0	5
92	4	70	0	165	25.4	5.0	0	838	0	5
93	4	76	3	88	25.6	0.2	3	11264	3755	4

TABLE IV-11

SAMPLE DATA - SUSPENDED SEDIMENT MONTHLY BANK SAMPLES
SOUTHERN BANK

Sample No.	Sampling Month	Sampling Depth(m)	Counts of Specimens		Counting Distance(mm)		Normalized Counts		Ratio	Exponential Value
			Reworked	Total	Reworked	Total	Reworked	Total		
76LM20 19	March	1	0	13	30.1	5.0	0	78	∞	5
76LM20 20	March	71	0	24	28.4	10.0	0	67	∞	5
76LM20 21	March	35	9	644	24.0	0.2	9	77280	8587	4
76L3 22	April	1	0	0	28.5	28.5	0	0	-	-
76L3 23	April	45	1	20	27.4	27.4	1	20	20	2
76L3 25	April	80	1	56	30.0	5.0	1	336	336	3
76L5 19	May/June	2	0	105	24.4	15.0	0	171	∞	5
76L5 20	May/June	36	1	149	24.0	3.0	1	1192	1192	4
76L5 21	May/June	74	0	1	24.0	24.0	0	1	∞	5
76G8 67	Sept.	30	1	268	25.0	5.0	1	1340	1340	4
76G8 68	Sept.	69	1	190	24.8	0.5	1	9399	9399	4
76G8 69	Sept.	70	3	198	26.0	0.2	3	25740	8580	4
76L40 7	Nov.	5	0	89	25.4	0.2	0	11303	∞	5
76L40 8	Nov.	20	0	113	26.9	0.2	0	15199	∞	5
76L40 9	Nov.	80	0	155	25.9	0.2	0	20073	∞	5

TABLE IV-12

SAMPLE DATA - SUSPENDED SEDIMENT MONTHLY BANK SAMPLES
HOSPITAL BANK

Sample No.	Sampling Month	Sampling Depth(m)	Counts of Specimens		Counting Distance(mm)		Normalized Counts		Ratio	Exponential Value
			Reworked	Total	Reworked	Total	Reworked	Total		
76LM20 25	March	1	0	0	26.9	26.9	0	0	-	-
76LM20 26	March	35	1	108	24.4	0.2	1	13176	13176	5
76LM20 27	March	70	1	60	30.0	10.0	1	180	180	3
76L3 30	April	1	2	6	30.0	15.0	2	12	6	1
76L3 31	April	40	1	1	30.0	30.0	1	1	1	1
76L3 33	April	74	1	142	29.0	15.0	1	275	275	3
76L5 28	May/June	1	1	2	24.1	16.0	1	3	3	1
76L5 30	May/June	69	1	158	24.0	10.0	1	379	279	3
76G8 59	Sept.	27	0	111	24.2	2.0	0	1343	∞	5
76G8 60	Sept.	69	1	271	25.1	10.0	1	680	680	3
76G8 61	Sept.	73	1	149	26.0	1.0	1	3874	3814	4
76L40 4	Nov.	5	1	551	23.7	0.2	1	65294	65294	5
76L40 5	Nov.	35	0	171	25.0	0.2	0	21375	∞	5
76L40 6	Nov.	75	1	261	24.0	0.2	1	31320	31320	5

TABLE IV-13

SAMPLE DATA - SEASONAL TRANSECT STATION SUSPENDED SEDIMENT SAMPLES

SPRING - MARCH

Top(near surface water)

Station No.[1]	Counts of Specimens		Counting Distance(mm)		Normalized Counts		Ratio	Exponential Value
	Reworked	Total	Reworked	Total	Reworked	Total		
1	0	0	28.0	28.0	0	0	-	-
1A	0	0	27.8	27.8	0	0	-	-
2	0	0	28.6	28.6	0	0	-	-
3	0	0	27.1	27.1	0	0	-	-
4	0	0	28.1	28.1	0	0	-	-
5	0	0	28.0	28.0	0	0	-	-
6	0	0	28.2	28.2	0	0	-	-
7	0	0	26.9	26.9	0	0	-	-
8	0	0	28.5	28.5	0	0	-	-
9	0	0	28.6	28.6	0	0	-	-
9A	0	0	27.0	27.0	0	0	-	-
10	0	0	26.9	26.9	0	0	-	-
11	0	0	27.1	27.1	0	0	-	-
12	0	0	24.8	24.8	0	0	-	-
13	0	0	26.8	26.8	0	0	-	-
14	0	0	27.5	17.5	0	0	-	-
16	0	0	26.4	26.4	0	0	-	-
17	0	0	28.6	28.6	0	0	-	-
18	0	0	26.8	26.8	0	0	-	-
19	0	0	28.1	28.1	0	0	-	-
20	0	0	28.0	28.0	0	0	-	-
21	0	0	28.0	28.0	0	0	-	-
22	0	0	24.0	24.0	0	0	-	-
23	0	0	27.0	27.0	0	0	-	-
23A	0	0	27.0	27.0	0	0	-	-
24	0	0	27.0	27.0	0	0	-	-

[1] For station location see Figure 6.

TABLE IV-14

SAMPLE DATA - SEASONAL TRANSECT STATION SUSPENDED SEDIMENT SAMPLES

SPRING - MARCH

Midwater

Station No.[1]	Counts of Specimens		Counting Distance(mm)		Normalized Counts		Ratio	Exponential Value
	Reworked	Total	Reworked	Total	Reworked	Total		
1	6	6	27.1	27.1	6	6	1	1
1A	0	0	28.1	28.1	0	0	-	-
2	0	0	27.8	27.8	0	0	-	-
3	0	0	27.5	27.5	0	0	-	-
4	0	0	26.9	26.9	0	0	-	-
5	0	0	29.0	29.0	0	0	-	-
6	0	0	27.8	27.8	0	0	-	-
7	0	0	27.8	27.8	0	0	-	-
8	0	0	28.5	28.5	0	0	-	-
9	0	0	27.0	27.0	0	0	-	-
9A	0	0	26.9	26.9	0	0	-	-
10	0	0	26.1	26.1	0	0	-	-
11	0	0	27.8	27.8	0	0	-	-
12	0	0	27.0	27.0	0	0	-	-
13	0	0	28.1	28.1	0	0	-	-
14	0	0	27.8	27.8	0	0	-	-
16	0	0	28.1	28.1	0	0	-	-
17	0	0	28.5	28.5	0	0	-	-
18	0	0	27.4	27.4	0	0	-	-
19	0	0	27.0	27.0	0	0	-	-
20	0	0	27.0	27.0	0	0	-	-
21	0	0	27.3	27.3	0	0	-	-
22	0	0	27.2	27.2	0	0	-	-
23	0	0	29.9	29.9	0	0	-	-
23A	13	99	27.5	27.5	13	99	8	1
24	0	0	26.4	26.4	0	0	-	-

[1] For station location see Figure 6.

TABLE IV-15

SAMPLE DATA - SEASONAL TRANSECT STATION SUSPENDED SEDIMENT SAMPLES

SPRING - MARCH

Bottom Water

Station No.[1]	Counts of Specimens		Counting Distance (mm)		Normalized Counts		Ratio	Exponential Value
	Reworked	Total	Reworked	Total	Reworked	Total		
1	0	4	29.0	29.0	0	4	∞	5
1A	0	0	28.5	28.5	0	0	-	-
2	0	0	28.6	28.6	0	0	-	-
3	0	0	27.9	27.9	0	0	-	-
4	0	0	28.7	28.7	0	0	-	-
5	0	0	27.0	27.0	0	0	-	-
6	0	0	29.0	29.0	0	0	-	-
7	0	0	27.8	27.8	0	0	-	-
8	0	0	29.0	29.0	0	0	-	-
9	0	0	26.9	26.0	0	0	-	-
9A	3	3	27.0	27.0	3	3	1	1
10	0	0	27.0	27.0	0	0	-	-
11	0	0	27.0	27.0	0	0	-	-
12	0	0	27.0	27.0	0	0	-	-
13	0	0	27.0	27.0	0	0	-	-
14	0	0	27.0	27.0	0	0	-	-
16	0	0	27.0	27.0	0	0	-	-
17	0	0	27.0	27.0	0	0	-	-
18	0	0	27.8	27.8	0	0	-	-
19	0	0	27.8	27.8	0	0	-	-
20	0	0	27.8	27.8	0	0	-	-
21	0	0	27.1	27.1	0	0	-	-
22	0	0	27.1	27.1	0	0	-	-
23	5	27	28.2	28.2	5	27	5	1
23A	0	0	28.2	28.2	0	0	-	-
24	0	0	28.2	28.2	0	0	-	-

[1] For station location see Figure 6.

TABLE IV-16

SAMPLE DATA - SEASONAL TRANSECT STATION SUSPENDED SEDIMENT SAMPLES

SUMMER - JUNE

Top (near surface water)

Station No.[1]	Counts of Specimens		Counting Distance(mm)		Normalized Counts		Ratio	Exponential Value
	Reworked	Total	Reworked	Total	Reworked	Total		
1	0	2	24.1	18.0	0	3	∞	5
1A	5	8	24.5	24.5	5	8	2	1
2	11	28	23.9	20.0	11	33	3	1
3	1	2	23.8	20.0	1	2	2	1
4	0	0	23.2	23.2	0	0	-	-
5	0	0	25.0	25.0	0	0	-	-
6	0	0	24.4	24.4	0	0	-	-
7	0	4	20.8	18.0	0	5	∞	5
8	0	0	25.1	25.1	0	0	-	-
9	0	1	23.1	20.0	0	1	∞	5
9A	1	2	24.0	17.0	1	3	3	1
10	0	0	24.3	24.3	0	0	-	-
11	0	0	23.3	23.2	0	0	-	-
12	0	0	24.2	24.2	0	0	-	-
13	1	1	23.0	20.0	1	1	1	1
14	0	81	22.0	20.0	0	93	∞	5
16	0	56	22.7	20.0	0	64	∞	5
17	0	105	24.5	21.0	0	123	∞	5
18	1	5	22.1	22.0	1	5	5	1
19	0	0	20.4	20.4	0	0	-	-
20	0	3	24.0	21.0	0	3	-	-
21	0	0	23.8	23.8	0	0	-	-
22	0	1	23.6	20.0	0	1	∞	5
23	1	1	22.8	20.0	1	1	1	1
23A	0	2	23.2	20.0	0	2	∞	5
24	0	0	23.4	23.4	0	0	-	-

[1] For station location see Figure 6.

TABLE IV-17

SAMPLE DATA - SEASONAL TRANSECT STATION SUSPENDED SEDIMENT SAMPLES

SUMMER - JUNE

Midwater

Station No.[1]	Counts of Specimens		Counting Distance(mm)		Normalized Counts		Ratio	Exponential Value
	Reworked	Total	Reworked	Total	Reworked	Total		
1	1	1	23.8	23.8	1	1	1	1
1A	0	0	24.6	24.6	0	0	-	-
2	0	1	24.6	24.6	0	1	∞	5
3	0	0	24.3	24.3	0	0	-	-
4	0	10	25.5	25.5	0	10	∞	5
5	0	0	22.2	22.2	0	0	-	-
6	0	0	24.0	24.0	0	3	∞	5
7	0	0	21.9	21.0	0	0	-	-
8	0	0	24.1	24.1	0	0	-	-
9	0	0	26.0	26.0	0	0	-	-
9A	0	0	23.2	23.2	0	0	-	-
10	0	0	21.5	21.5	0	0	-	-
11	0	1	22.5	22.5	0	1	∞	5
12	0	8	23.4	23.4	0	8	∞	5
13	0	0	23.4	23.4	0	0	-	-
14	0	91	24.0	22.0	0	99	∞	5
16	0	0	24.8	24.8	0	0	-	-
17	0	0	22.8	22.8	0	0	-	-
18	0	0	23.8	23.8	0	0	-	-
19	0	22	23.8	20.0	0	26	∞	5
20	0	0	23.3	23.3	0	0	-	-
21	0	0	23.2	23.2	0	0	-	-
22	0	0	23.4	23.4	0	0	-	-
23	0	2	23.4	23.4	0	2	∞	5
23A	0	0	23.6	23.6	0	0	-	-
24	0	0	23.0	23.0	0	0	-	-

[1] For station location see Figure 6.

TABLE IV-18

SAMPLE DATA - SEASONAL TRANSECT STATION SUSPENDED SEDIMENT SAMPLES

SUMMER - JUNE

Bottom water

Station No.[1]	Counts of Specimens		Counting Distance (mm)		Normalized Counts		Ratio	Exponential Value
	Reworked	Total	Reworked	Total	Reworked	Total		
1	50	116	23.7	5.0	50	550	11	2
1A	40	64	23.6	10.0	40	151	4	1
2	13	96	23.8	5.0	13	457	35	2
3	0	0	23.6	23.6	0	0	-	-
4	0	0	24.2	24.2	0	0	-	-
5	0	0	23.0	23.9	0	0	-	-
6	0	0	20.2	20.2	0	0	-	-
7	0	0	21.6	21.6	0	0	-	-
8	0	0	23.2	23.2	0	0	-	-
9	0	0	23.8	23.8	0	0	-	-
9A	13	70	24.0	22.0	13	76	6	1
10	0	0	24.7	24.7	0	0	-	-
11	0	1	23.9	23.9	0	1	∞	5
12	0	0	24.7	24.7	0	0	-	-
13	0	0	24.6	24.6	0	0	-	-
14	2	4	23.0	23.0	2	4	2	1
16	0	0	23.0	23.0	0	0	-	-
17	0	0	24.1	24.0	0	0	-	-
18	0	1	22.8	22.8	0	1	∞	5
19	0	0	24.2	24.2	0	0	-	-
20	0	0	23.6	23.6	0	0	-	-
21	3	91	23.0	21.0	3	100	33	2
22	0	1	24.6	24.6	0	1	∞	5
23	0	3	23.7	23.7	0	3	∞	5
23A	16	220	23.4	20.0	16	257	16	2
24	0	0	23.1	23.1	0	0	-	-

[1] For station location see Figure 6.

TABLE IV-19

Suspended Sediment Samples from South Texas Passes

and the Mouth of the Rio Grande

Sampling Location	Date	Time	Specimen counts		Counting Distance(mm)		Normalized Counts		Ratio	Exponen-tial Value
			Reworked	Total	Reworked	Total	Reworked	Total		
Port Isabel Jetty	5/24/76	7:10PM	34	64	21.4	1.0	34	1370	40	2
Pass Cajallo	5/22/76	5:30PM	53	91	23.6	2.0	53	1074	20	2
Matagorda Pass Jetties	5/21/76	5:15PM	21	76	23.4	2.0	31	889	42	2
Port Aransas Jetty	5/22/76	5:49PM	8	73	24.1	5.0	8	352	44	2
Mouth of Rio Grande	5/24/76	6:00PM	28	29	23.8	23.8	28	29	1	1

CHAPTER V

SHELLED MICROZOOPLANKTON, GENERAL MICROPLANKTON AND SHELLED MICROZOOBENTHON

SHELLED MICROZOOPLANKTON, GENERAL MICROPLANKTON AND SHELLED MICROZOOBENTHON

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INTRODUCTION

PURPOSE

This component of the BLM-topographic highs project was charged with a baseline inventory and monitoring of the shelled microzooplankton, general microplankton and shelled microzoobenthon and the correlation of these with other biological, chemical, physical and geological oceanographic data of the topographic highs. These highs and their abbreviations used in this report are: Hospital Rock Bank (HR) and Southern Bank (SB) which are primary banks (studied in detail); and, East Flower Garden Bank (EFG), Stetson Bank (STB), 28 Fathom Bank (28FB) and 28 Fathom Bank, southwest peak (28 FSW) which are secondary banks (studied in less detail than the primary banks, herein only shelled microzoobenthon).

Since this component is a small part of the total topographic highs project, and most of the work has been on the primary stations that are most closely related (at least geographically) to the BLM south Texas outer continental shelf (BLM-STOCS) study, and since the data collected and reported upon in this report are much more meaningful when considered in relation to the larger study (BLM-STOCS) the reader is referred to the Final Reports of Casey et al. (1977 and 1978).

The secondary banks are fully dealt with in this report. Appendix II, Table V-1 includes the pertinent data from the secondary banks.

METHODS AND MATERIALS

COLLECTING PROCEDURES

Nansen tows (integrated samples)

Nansen tows were taken at line stations 1-3 of all transects (12 primary South Texas outer continental shelf (STOCS) stations), and at bank shelf stations HR 1/1 and SB 1/1 (15 stations) during the seasonal sampling, and at line stations 1-3, Transect II, and at bank stations HR 1/1 and SB 1/1 (7 stations) during the monthly sampling (see Figure V-1). At all Nansen stations, a Nansen net of a mouth opening of 30 centimeters with a mesh size of 76 micrometers was placed on the wire as illustrated on Figure V-2, lowered to just off the bottom and towed slowly (about 20 m/min.) to the surface. The net was then washed down with seawater from the outside of the mesh, and the material in the cod end was preserved in a 500 ml Nalgene bottle with a 5% solution of formalin containing sodium borate and strontium chloride and rose Bengal (this solution is prepared in the following manner: 3.79 l of 37% (stock) formaldehyde + 80 gm sodium borate + 18.2 gm strontium chloride + 2 gm rose Bengal).

Niskin bottle samples (discrete samples)

Niskin samples were taken at depths of 10 m and one-half the depth of the photic zone (as determined with a Secchi disk or photometer) at line stations 1 and 2, transect II (8 stations); and at depths of 10 m, one-half the depth of the photic zone, the photic zone, and one-half the distance between the bottom of the photic zone and bottom or just off the sea floor at line station 3, transect

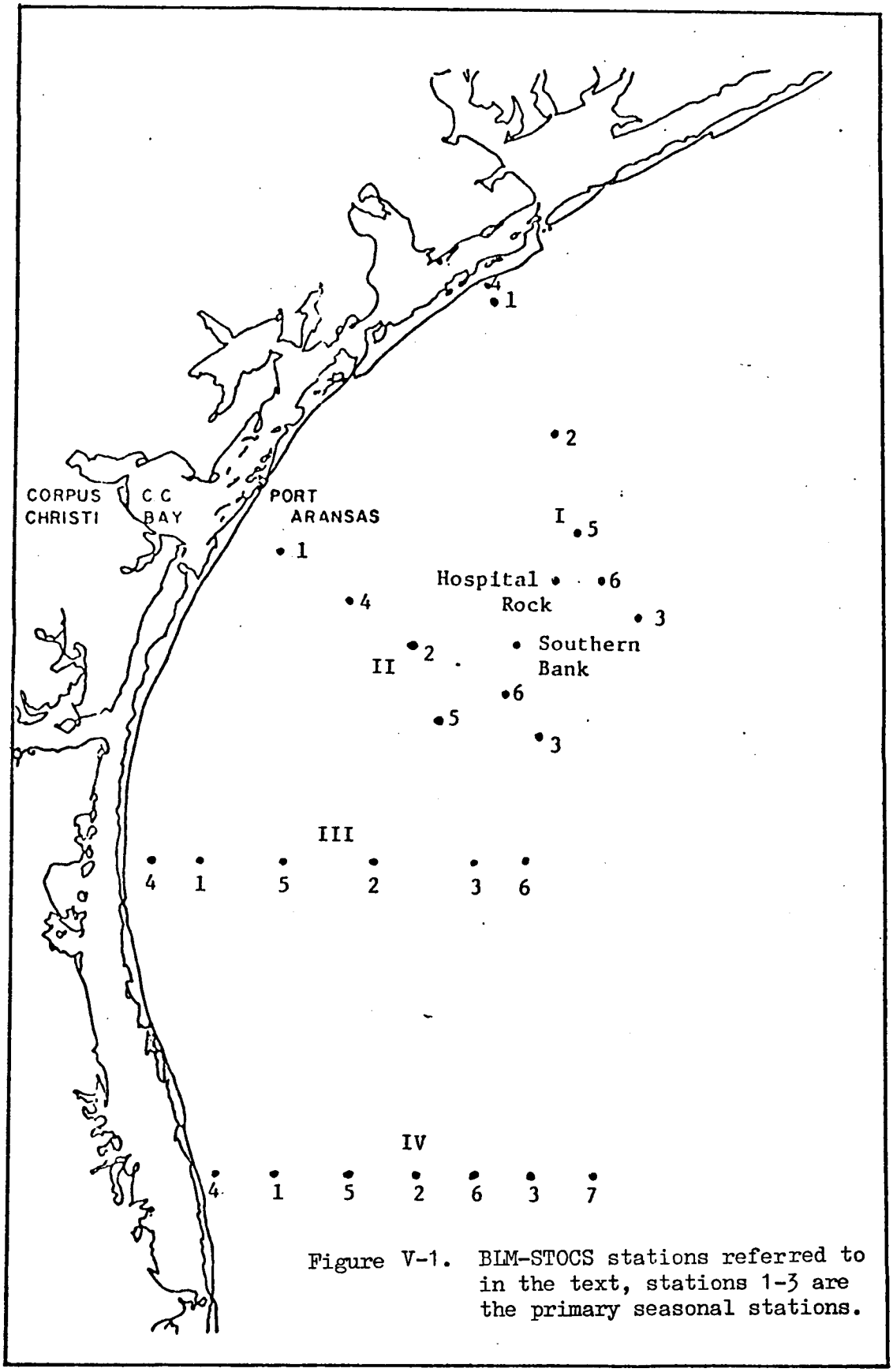


Figure V-1. BLM-STOCS stations referred to in the text, stations 1-3 are the primary seasonal stations.

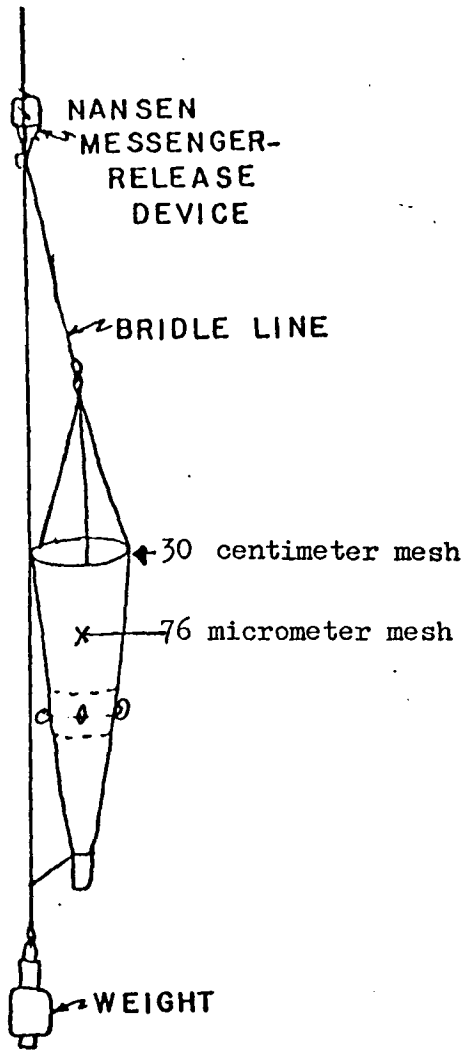


Figure V-2. Rigging of Nansen net.

II, and at the bank stations HR 1/1 and SB 1/1 (8 stations) during the monthly sampling. At every Niskin cast, one liter was tapped off for an extra archive and possible future use, and the remaining 29 liters were filtered through a 38 micrometer mesh screen. The microplankton on the filter mesh screen were washed into a 500 ml. Nalgene bottle and preserved in a 2 to 3% solution as described for Nansen tows, the only exception being that no rose Bengal was used.

Bottom sediment sample for shelled microzoobenthon (foraminiferans)

Bottom samples were obtained by subsampling the Smith-McIntyre grabs at the priority 2 Banks (15 samples were taken, the 16th sample asked for in the contract from 28 Fathom Bank was not recovered due to bottom conditions, sample locations may be seen on Figure V-3), and at bank stations HR 2/2 and SB 2/2 (29 stations) during seasonal sampling, and at line stations 1-6, Transect II, and bank stations HR 2/2 and SB 2/2 (10 stations) during the monthly sampling. Subsampling was accomplished by inserting a 65mm or a 35 mm coring tube at least 5 cm into the sediment from the sediment surface. The sample was then placed into a container, and 25 cc of formalin solution (the same solution as described under the Nansen collecting techniques) was added to the sample (with sea water if needed) and the bottle was sealed and shaken to mix sediment and solution.

POST-COLLECTING PROCEDURES

Nansen samples

The samples were halved for identification and archived using a plankton splitter. The samples were then either hand picked on micropaleontology slides using a breaking pipette and a plankton

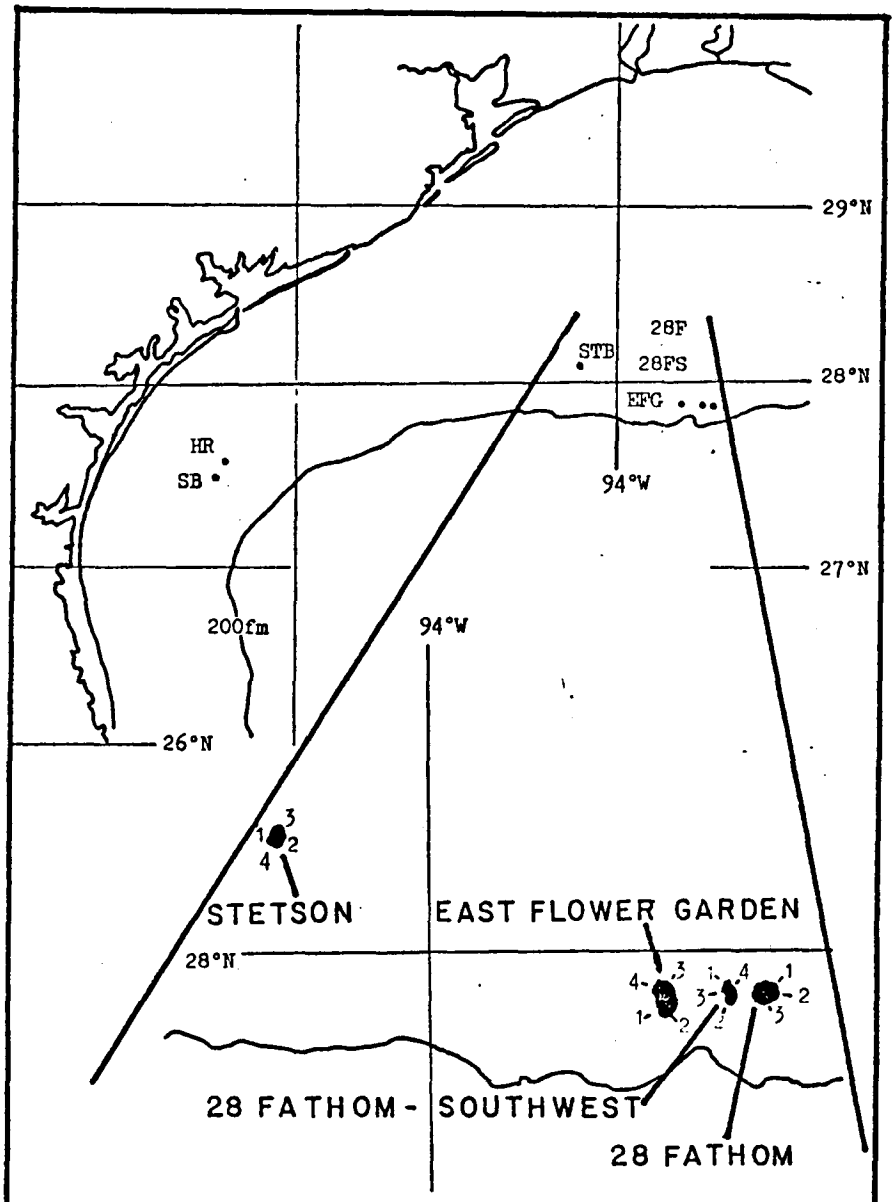


Figure V-3. Small scale shows locations of primary banks. Blow-up scale shows location of stations around banks.

microscope (1-3/all transects).

The other Nansen stations (all other stations) were processed by taking a 1/20th aliquot of the original sample identified and counted by use of a plankton microscope. All the working samples and slides were saved. These data are placed on computer cards and cluster analyses performed on the seasonal data of the 12 main stations, resulting in a dendrogram. These dendrograms and radiolarian seasonal density and diversity plots were then compared to other correlative data.

Niskin Samples

The entire sample was allowed to settle for at least two days in its original collection bottle. The supernatant was decanted and saved for archiving; the residue was placed in a plankton counting chamber. The plankton counting chamber was placed on a modified stage of a plankton microscope. The first one hundred organisms (or fecal pellets) were identified and counted starting at the top of the chamber, and the amount of area of the chamber traversed during the count was recorded. The residue and supernatant were combined and archived. These data were placed on computer cards and cluster analysis was performed on the seasonal data of the 12 main stations (1-3/all transects) resulting in a dendrogram. This dendrogram, seasonal density data, etc. are then compared to other correlative data.

Microzoobenthon Samples

Samples were mixed and split in large plankton splitter. One-half was archived, the other half was washed through a 63 μm screen,

and the sand remaining on the screen was dried in an oven at 70 degrees C. If little material were present, the sample was ready to be picked or identified. If considerable non-organic material was present, the sample was floated, as described below. A 400 ml beaker was filled with 200 ml of carbon tetrachloride, covered by a 500 mesh screen and the dried sands sprinkled through the screen. The floating fraction was then decanted off into a paper towel folded as a filter. The residue (at the bottom of the 400 ml beaker) was swirled to suspend the lighter material, allowed to stand for a few seconds and decanted. (This process was repeated a number of times if needed to process a large sample in aliquots). The paper towel plus sample was dried in an oven (70 degrees C). The residue was also dried in the same manner and both processed samples were placed in labeled bottles.

The seasonal samples for the 12 main stations (1-3/ all transects) were hand picked under a dissecting microscope for live foraminiferans, and any other live shelled microzoobenthon, and placed on cardboard micropaleontological slides. These picked organisms were then identified to species, if possible, and counted. These data were placed on computer cards and cluster analysis was performed on the seasonal data of the 12 main stations, resulting in a dendrogram. This dendrogram, seasonal density plots, and seasonal faunal maps are then compared to other correlative data. The remaining bottom stations

(other than the main 12) were processed as above except that they were not hand picked, but identified and counted in the processed sample for dominant foraminiferians.

RESULTS AND DISCUSSION

WATER MASS AND CIRCULATION PATTERNS FOR THE BLM-STOCS DURING THE SEASONS OF 1976

A brief review of the water mass and circulation patterns suggested for 1976 follows. A more detailed treatment may be found in Casey, et al., (1977). The water masses delineated may be seen on Figure V-4; the generalized patterns of circulation, on Figure V-5.

There appeared to be a net transport to the southwest during the winter which was most probably related to the general northern winds and Northern. There appeared to be a drift along the shelf, with perhaps enough coriolis effect to produce an upwelling of deep shelf waters onto the shelf. During the spring, there appeared to be a strong "estuarine upwelling" (surface "fresh" water moving offshore with offshore water moving inshore along the bottom). The summer appeared to show the effects of an anticyclonic gyre or ring impinging on the shelf with a resulting north-directed transport of entrained offshore and perhaps deep water at midshelf. The near-shore currents during the summer appeared to alternate between north and south movements related to the onshore alternating wind patterns. The evidence for the mid-shelf north transport during the summer (or summer-fall) is dealt with in detail in the sections on the results of the shelled microzooplankton and shelled microzoobenthon. See Figure V-5 for a generalized picture of the

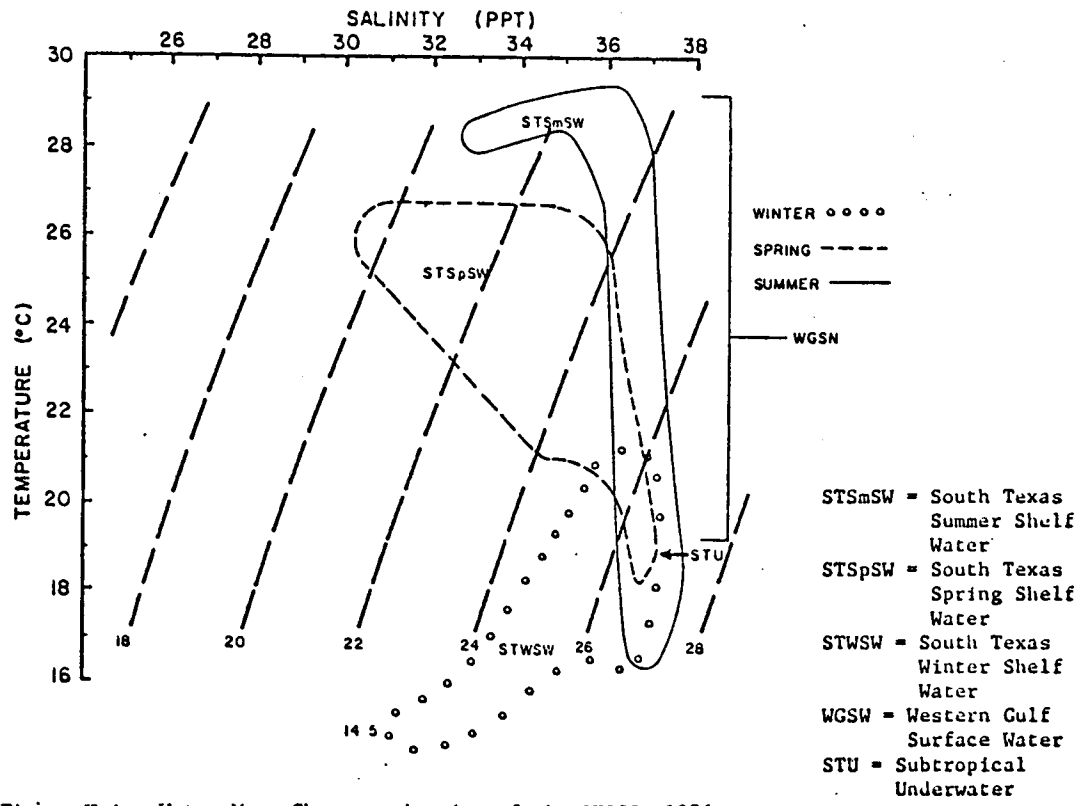


Figure V-4. Water Mass Characterization of the STOCS, 1976.

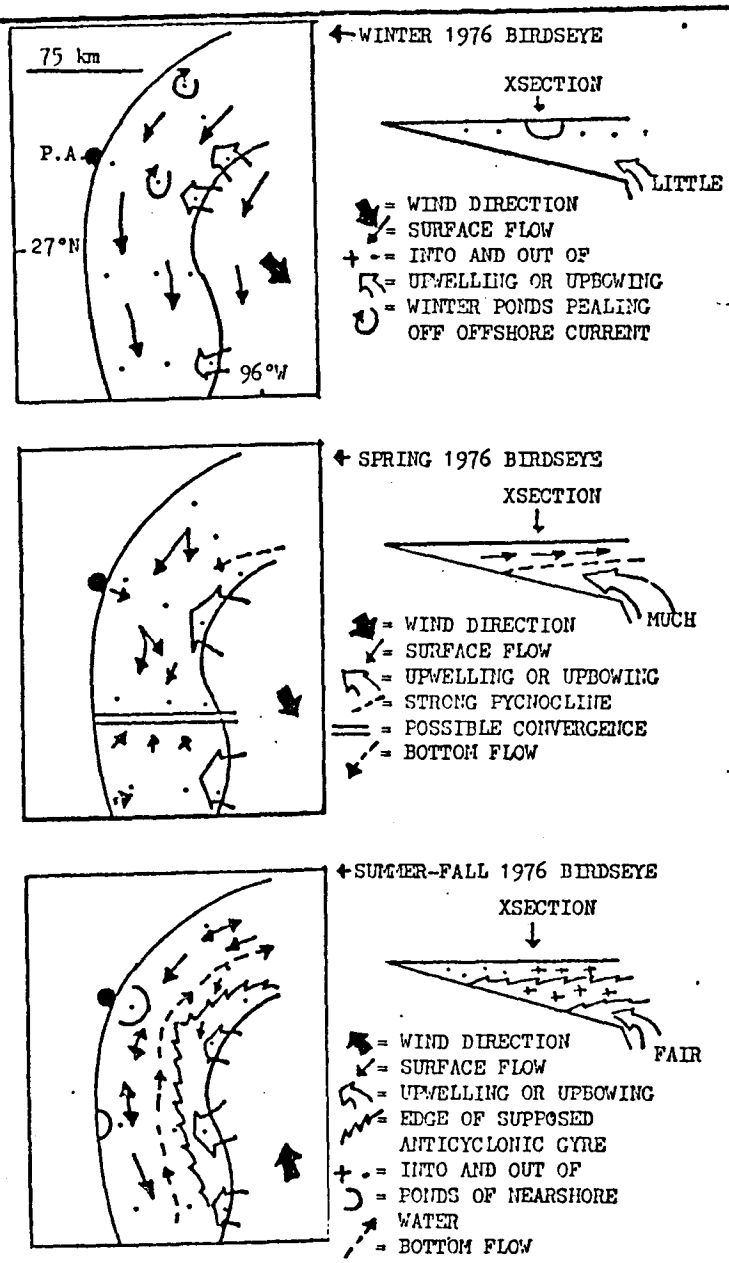


Figure V-5. Generalized Picture of the Seasonal Circulation Patterns of the STOCS During 1976.

seasonal circulation patterns of the STOCS area during 1976.

DETAILED COMPARISON OF MICROPLANKTON FROM NANSEN SAMPLES WITH PHYSICAL OCEANOGRAPHY ALONG TRANSECT II INCLUDING HOSPITAL ROCK AND SOUTHERN BANKS FOR PORTIONS OF 1976

Smith et al., (1977) recorded inner shelf water out to Station 4 for the February seasonal cruise. This corresponded with a dominant component of dinoflagellates in the Niskin cast at Station 1 and decline of dinoflagellates at Stations 2 and 3 (Figure V-6). This recognition resulted in the addition of general microplankton counts in the remaining Nansen tows which proved to show significant small scale trends.

In March (first monthly sampling), an "eddy" was described by Smith between Stations 2 and 3 (Figure V-6). This "eddy" appeared to be a pond of offshore-shallow water with a significant component of planktonic foraminiferans and radiolarians indicative of this ponding. The occurrences of Hexalonche anamimandri and Actinoma B indicated that this water possessed a component of underwater (maybe subtropical underwater) (McMillen, 1976). This same fauna was not found at Stations 3 or HR, but was present at Station 5 and SB, suggesting that this was an elongate pond of offshore water with dimensions of about 20 km wide and 40 km long elongated in a north-south direction.

Smith recorded a tongue of relatively low salinity water in April extending from the shore out beyond Station 2 (Figure V-6). The absence of planktonic foraminiferans (usually restricted to offshore shallow waters) with the presence of spumellarian

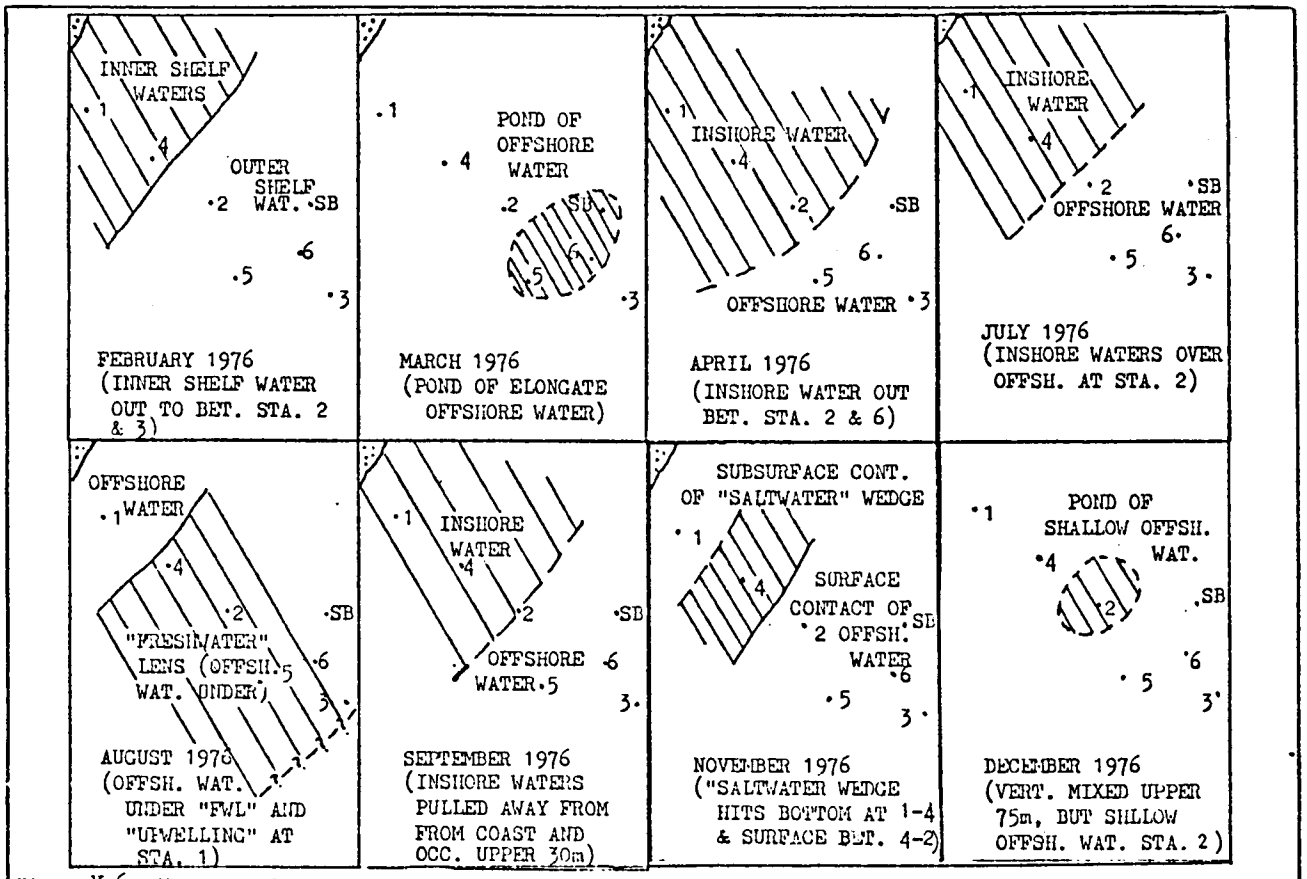


Figure V-6. Nansen and Niskin Microplankton Data Related to the Physical Oceanography Data of Smith From BLM-STOCS Quarterly Reports and Quarterly Conferences.

radiolarians (spumellerian radiolarians come closer to shore than nassellarian radiolarians) indicated that typical mid-shelf water was wedged under this shallow water (probably below the pycnocline). The presence of planktonic foraminiferans and both spumellerians and nassellarians at Station 3 suggest an incursion of offshore Gulf water (probably along the bottom). Smith suggested inshore water in July extending past Station 4 and perhaps to Station 2 (Figure V-6).

The presence of Spongotrochus glacialis and the lack of planktonic foraminiferans at Station I/1 suggested an exclusion of shallow offshore water (no foraminiferans) but a definite presence of deep offshore (upwelled) water moving along the bottom and present as far inshore as Station 1 (presence of S. glacialis). These forms were rare because this offshore water was probably very mixed. However, at Station 2 (below depths of 40 meters) planktonic foraminifera, spumellarians and nassellarians were all present in about the deepest 4 or 5 meters of this station. At Stations 3, HR and SB, planktonic foraminiferans, spumellarians and nassellarians were all common, indicating offshore water incursion during this time. Comparing densities of these forms in the water column, it appeared that only about 4 or 5 meters of water (the deepest portion most likely) contain the planktonic foraminifera, spumellarians and nassellarians at Station 2.

Smith recorded a displaced shallow lens of inshore water in August, 30 km from the coast (Figure V-6). We recorded planktonic foraminifera, spumellarians and nassellarians at all stations along this transect in our Nansen tows, suggesting offshore water

penetrating below this lens, and perhaps completely replacing it at Station 1. Dinoflagellates were common in all stations except Station 1, suggesting that this lens was indeed detached from the coast and extended out to Station 3.

Smith suggested offshore water moving in along Transect II in September, with lower salinities being pulled away from the coast through the inner three stations. Planktonic foraminiferans, spumellarians and nassellarians were collected at Station 2, which agree with Smith's data (Figure V-6).

Smith suggested cool water moving out from the coast in November, with its outer surface limit between Stations 4 and 2 and its subsurface extent intersecting the bottom between Stations 1 and 4 (Figure V-6). Our data showed no planktonic foraminiferans, spumellarians or nassellarinas at Station 1, but presence of all these groups at Stations 2 and 3 agrees with the physical oceanography of Smith.

Smith suggested a slight fresh water runoff in December with a strong vertical overturning (perhaps an open-ocean shelf type of estuarine-type upwelling), and an eddy of water at Station 2 (Figure V-6). Our data agree with this, showing high diatom counts at Stations 1 and 2 (overturn) and a mixed pond of offshore water at Station 2 (or perhaps an ecotone).

COMPARISON OF HOSPITAL ROCK AND SOUTHERN BANK WITH THE 12 MAIN SEASONAL STATIONS

From the Nansen data, Hospital Rock and Southern Bank stations were more similar to outer shelf Station 3/II than mid-shelf

Station 2/II. They differ from outer shelf Station 3/II in that the standing crop of diatoms at Hospital Rock and Southern Bank stations was usually higher than Station 3/II, with Hospital Rock being usually about twice as high, and Southern Bank about four times as high. The common occurrence of radiolarians suggests these bank stations were receiving offshore waters, and the presence of species such as Spongotrochus glacialis in April at Southern Bank suggests upwelling. Both of these (higher diatom standing crops and offshore "upwelling water" at the bank stations) suggest that these topographic highs perhaps act as obstructions for obstruction-type upwelling of offshore waters (water coming toward the surface due to drag past, or pushing up over, an obstruction); or these banks might act as small "islands" with an island mass effect, resulting in upwelling and high productivity.

DETAILED COMPARISON OF MONTHLY NISKIN AND NANSEN DATA WITH THE PHYSICAL OCEANOGRAPHY FOR PORTIONS OF 1976

The combination of monthly Niskin samples (from transect II) along with Nansen tows taken at the same time depicts what may be best small scale trends noted.

Smith recorded inner shelf water in February out past Station 2. This corresponds well with a dominant component of dinoflagellates at Station 1 and a decline of dinoflagellates at 2 and 3. The winter of 1976 clusters (Table V-1) reflect this condition.

Smith described an "eddy" in March between Stations 2 and 3. This eddy appears to be a pond of offshore shallow water with a significant portion of planktonic foraminiferans and radiolarians

Table V-1.1976 NISKIN DATA CLUSTER COMPOSITION

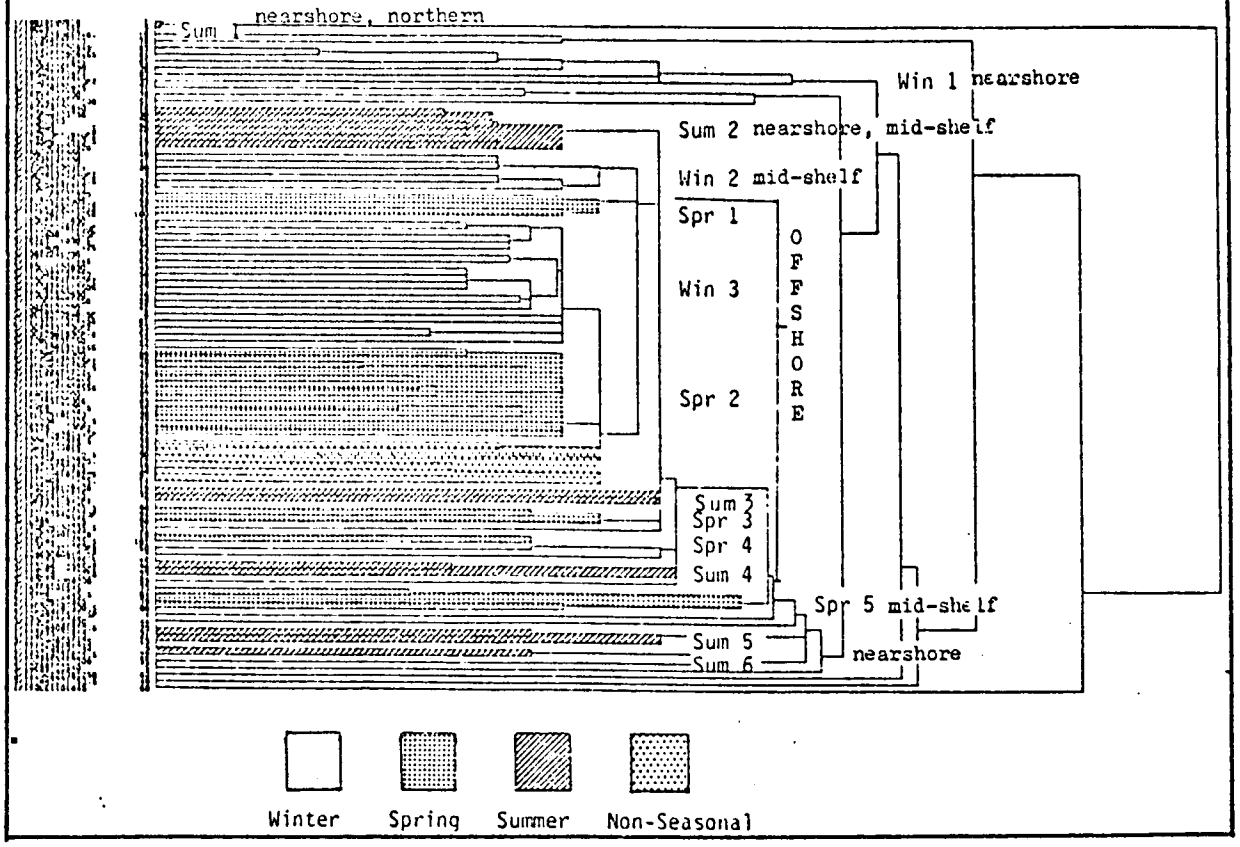
	WINTER			SPRING					SUMMER					
	Win 1	Win 2	Win 3	Spr 5	Spr 2	Spr 4	Spr 1	Spr 3	Sum 3	Sum 5	Sum 4	Sum 2	Sum 6	Sum 1
Cal Copepods	2	2	10	9	5	2	4	10	6	2	4	1		
Naupliar Larvae	7	5	16	19	15	5	8	22	20	3	11	6	2	2
Cen Sol Diatoms	26	32	24	27	30	20	37	33	19	45	18	32	63	7
Pen Sol Diatoms	4	6	10	6	13	6	4	5	2	9	16	16	4	2
Cen Col Diatoms	4	8	12	4	8	32	17	1	19	10	37	17	24	82
Pen Col Diatoms	1	9	7	2	1	23	12	1		3	2	6	2	3
Fecal Pellets	11	17	5	1	1	1	2		1		1	2		
Tintinnids	1	2	1	10	11	2	5	1	5		1	2		1
Chaetognaths			1	7	3		1	1	3	1				
Trichodesmium			1	2		2	1	1	2	19	1	3		2
Shelled Pteropods			1	2		1								
Eggs						1	1	1						
Cyclop Copepods					1		1	1	1					
Clams	1			3										
Silicoflagellates				5	1		1							
Dinoflagellates	1		2	1	1			2	1					
Ceratium	6	6	3	1	6	2	2	8	5	3	1	2	3	
Peridinium	6	1			1			1	1					
Dinophysis	10	1				1			1		1			
Noctiluca	7	2							1	1				
Gonyaulax	9	4						2	2					
Holop Polychaetes		1												
Merop Polychaetes									1		1			
Coelenterates	2									2				
Plank Forams	1	1	3					1	2			1		
Spumellarians								1						
Nasellarians								1	1					
Acantharians			1				1				3	11		
Salp (Doliolum)								1						
Echinoderms										1				
Ostracods								1						
Ben Forams											1			

present in the Niskin samples and Nansen tows. The occurrences of the radiolarians (Hexalonche anamimandri and Actinoma sp. in Nansen tows indicate that this pond of water possesses a component of underwater (McMillen, 1976).

Smith recorded a tongue of relatively low salinity water in April, extending beyond Station 2. The absence of planktonic foraminiferans, usually restricted to the upper 50 m in offshore shallow waters, with the presence of radiolarians indicates typically mid-shelf waters wedged under this shallow water. The presence of planktonic foraminiferans along with both radiolarian groups at Station 3 suggests an incursion of offshore Gulf water.

Smith suggested that nearshore waters; extended out to Station 2 in July. The Niskin and Nansen data suggest an exclusion of shallow offshore water (no foraminiferans), but a definite presence of deep offshore (upwelled) water moving along the bottom and present into Station 1 (Spongotrochus glacialis present). As further evidence cluster Spr 1 (Figure V-2) was composed of bottom samples at Station 3 and 10 m samples at Station 1, suggesting that the assemblages at these different locales may be the same. At Station 2, planktonic foraminiferans, spumellarians, and nassellarians were all present in the Niskin and Nansen data, probably below the lens of nearshore water. At Station 3, spumellarians, nassellarians, and planktonic foraminiferans were all common indicating the incursion of offshore waters during this time. The presence of these groups (up to 25% of the total counts in some samples) in very large numbers in the shallow Niskin casts suggests that the presence of an anticyclomic ring, as postulated

FIGURE V-7. Q-MODE ANALYSIS OF 1976 NISKIN DATA



earlier, was well established at this time.

Smith recorded the same lens of nearshore water mentioned above to be displaced in August some 30 km from the coast. The presence of planktonic foraminiferans, spumellarians, and nassellarians at all stations on Transect II in both the Niskin and Nansen samples suggests that offshore water may have penetrated below this lens, perhaps completely displacing it at Station 1. Further evidence for this was the abundance of dinoflagellates at Stations 2 and 3, but not Station 1 (the opposite of the normal case). Cluster Sum 3 (Table V-1) seems to reflect this condition with a generally offshore biological composition (nassellarians and planktonic foraminiferans present) occurring simultaneously with a nearshore assemblage (dinoflagellate totals are high at 11%).

Smith suggested offshore water in September still moving in along Transect II, with lower salinity water being pulled away from the coast through the inner three stations. Planktonic foraminiferans, spumellarians, and nassellarians were all present at Station 2 in the Niskin and Nansen data, again agreeing well with Smith's data.

SUMMARY MONTHLY NISKIN DATA FOR TRANSECT II

It is very encouraging that general groups of microplankton from both the Nansen and Niskin sampling appear to be good indicators of small scale physical oceanographic conditions. Comparison of discrete Niskin sample data with Nansen tows (channel samples) allow the following generalizations, originally made with Nansen data alone, to be reinforced by Niskin data.

1) nearshore waters are characterized by the absence or sparseness of planktonic foraminiferans, spumellarians, and nassellarians, while diatoms and dinoflagellates are abundant.
2) shallow offshore waters are characterized by abundant planktonic foraminiferans, spumellarians, and relatively high numbers of copepods and naupliar larvae.
3) deeper offshore waters are characterized by an abundance of nassellarians and copepod-naupliar larvae group, with spumellarians and planktonic forams both still common.

EVALUATION OF NISKIN SAMPLES FROM TRANSECT II AND HOSPITAL ROCK AND SOUTHERN BANK USING COMPUTER TECHNIQUES

104 Niskin samples were collected at Stations 1, 2, and 3 of Transect II, and at Hospital Rock and Southern Bank. These samples were collected on a monthly basis from February through December, for 1976. The samples came from discrete depths: 1/2 PZ, photic zone, 10 m, 1/2 way between PZ and bottom, and the bottom.

The samples were found to contain high numbers of 14 types of organism groups or variables. These groups were centric solitary diatoms, centric colonial diatoms, pennate solitary diatoms, pennate colonial diatoms, trichodesmiums, peridiniums, ceratiums, spumellarians, acantharians, planktonic foraminiferans, tintinnids, calanoid copepods, naupliar larvae, and fecal pellets.

The variables were analyzed for similarity to each other from one sample to the next by way of R-mode clustering. The samples were analyzed for similarity to each other by way of Q-mode

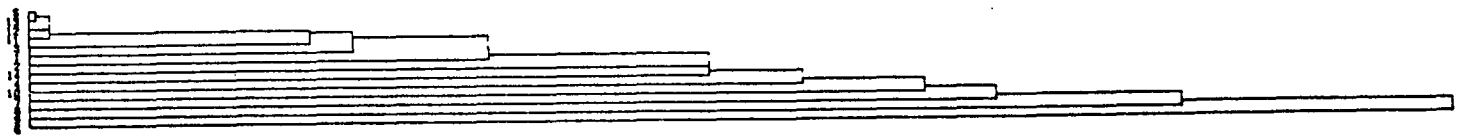
clustering. The clustering method used relatively scaled data, the unweighted pair group linkage method, and Sorenson's similarity index (all described by Sokal and Sneath, 1963) to group together variables, or samples that showed similarity in presence of their components.

The results of the R-mode dendrogram (Figure V-8) produced by the clustering process showed that trichodesmiums and naupliar larvae were present with each other in 59% of all samples; calanoid copepods and tintinnids shared a similarity of 58%; pennate solitary diatoms were found in consistent association with the above mentioned organisms in only 50% of the samples; the least sociable variables were the radiolarians and the peridinums, having less than 23% similarity with all other variables; and the remaining variables fell in between the range of 23% - 50% similarity.

The conclusions drawn from these results are: (1) the crustaceans, centric solitary and pennate solitary diatoms, tintinnids and trichodesmiums are all found together in at least 50% of the samples collected, leaving approximately 50% of the samples to vary in the presence of these groups and (2) that planktonic foraminiferans, radiolarians, and dinoflagellates have less than 30% chance of occurring together with other variables. These latter organisms are usually not associated with diatoms, crustaceans, and fecal pellets.

Analysis of the Q-mode reveals samples which group together due to high similarity in presence of either diatoms, crustaceans, fecal pellets, or ceratiums. The samples are found to cluster mostly by season and in some cases by depth and position offshore

FIGURE V-8. MICRO—PLANKTON OF 1976 II STATIONS, HOSPITAL ROCK, AND SOUTHERN BANK, RMODE



VARIABLES IN GROUP

5	TRICHODESMIUM
13	NAUPLIAR LARVAE
12	CAL COPEPODS
11	TINTINNIDS
3	PEN SOL DIATOMS
1	CEN SOL DIATOMS
2	CEN COL DIATOMS
14	FECAL PELLETS
4	PEN COL DIATOMS
10	PLANK FORAMS
7	CERATIUM
8	SPUMELLARIANS
9	ACANTHARIANS
6	PERIDINIUM

along the transect.

There are 2 levels of clustering visible in the Q-mode dendrogram (Figure V-9). The levels are represented by different percentages of similarity of the samples to each other. In the 64-72% range of similarity are found 9 clusters. Cluster 1 has four September and November samples, from 1/2 PZ and ten meters, all from Transect II. Ceratiums are consistently present in high numbers in this cluster. Cluster 2 is composed of six nearshore samples, ranging from February through April. Fecal pellets and centric solidary diatoms are most common and abundant in these samples. Cluster 3 has high representations of centric solitary and centric colonial diatoms. The 11 samples show no monthly or seasonal trend, but are year-long. In cluster 4, the 11 samples, also year-long, show a common representation of pennate colonial diatoms. In this cluster, only Hospital Rock and Southern Bank and Station 3's samples are included. Cluster 5 has 16 samples of mostly June and August. All stations and depths are represented. Centric solitary diatoms were abundant and common to all samples of this cluster. Cluster 6 is small, consisting of only 3 samples, all of which were taken in November. In this cluster, pennate solitary diatoms are common. Cluster 7 is a July grouping having a high similarity due to the naupliar larvae present. Cluster 8 is a grouping of 3 stations and Hospital Rock stations. Common to this grouping of February and March samples are calanoid copepods and naupliar larvae. Cluster 9 represents samples of 1/2 photic zone of the month of December; centric colonial diatoms were extremely common to this cluster.

FIGURE V-9. MICRO — PLANKTON OF 1976 II STATIONS, HOSPITAL ROCK, AND SOUTHERN BANK. QMODE.

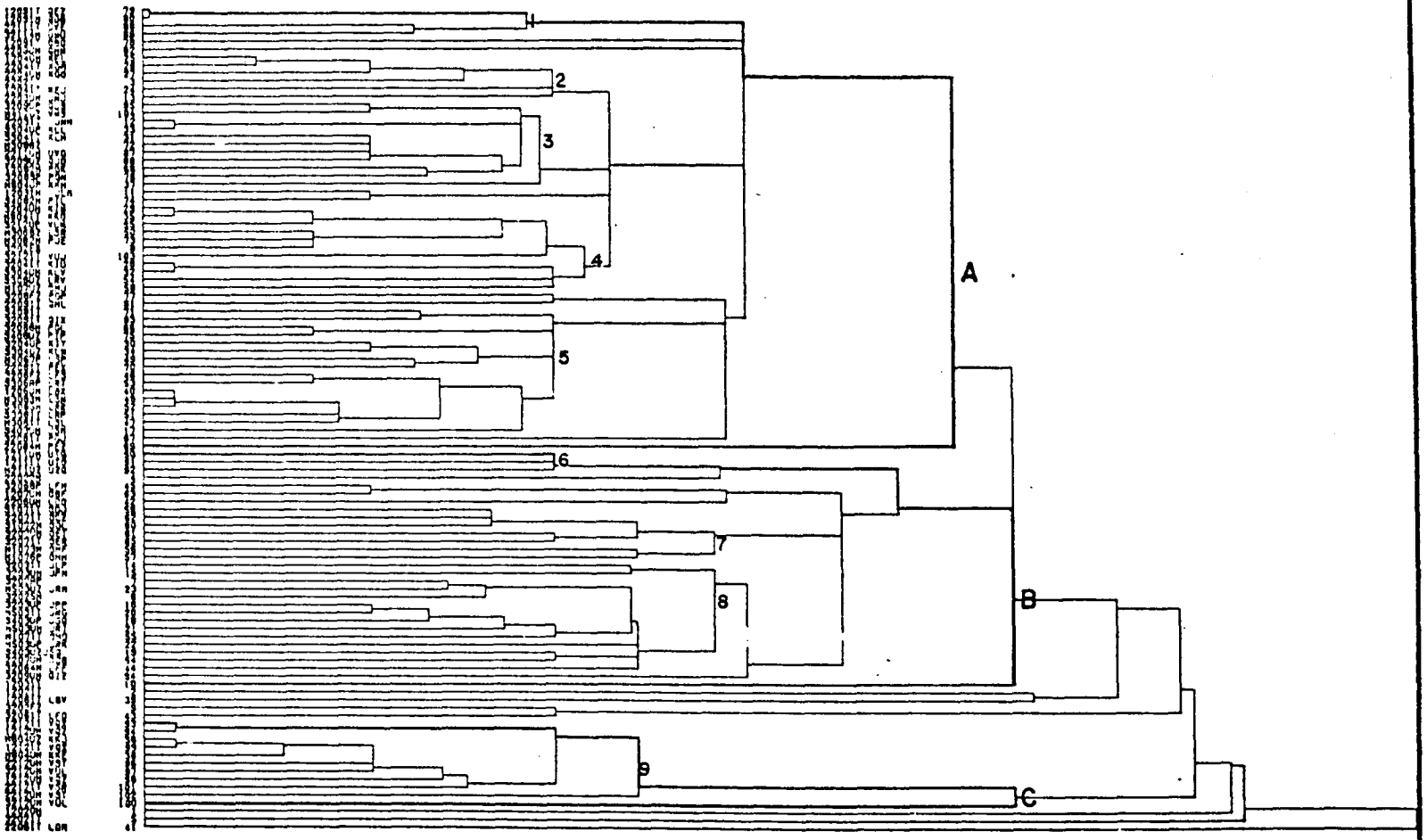


Figure V-9, continued

... Micro-plankton of 1976 II stations, Hospital Rock, and Southern Bank. Q mode.

Legend for Sample Names in Q-mode Dendrogram

The 6-digit alphanumeric code is translated as follows:

Digit 1: Station number--1,2,3, or S for Southern Bank, and H for Hospital Rock.

Digit 2: Track number--2 for all samples except Southern Bank and Hospital Rock. These samples were given the digit of their triplet codes (4 for HR4, for example).

Dgt. 3,4: Month number.

Digit 5: Depth range. Code is as follows:

0	for	0 - 5 m.
1	for	6 -10 m.
2	for	11 -15 m.
3	for	16 -20 m.
4	for	21 -25 m.
5	"	26 -30 m.
6	"	31 -35 m.
7	"	36 -40 m.
8	"	41 -45 m.
9	"	46 -50 m.
A	"	51 -60 m.
B	"	61 -70 m.
C	"	71 -80 m.
D	"	81 -90 m.
E	"	91-100 m.
F	"	100 plus
U	"	unknown

Digit 6: Photic Zone Code, as follows:

T for 10 meters
H for ½ photic zone
P for photic zone
B for ½-way between photic zone and bottom
Z for bottom

Figure V-9.cont.

Q-mode Labels
(as they appear in dendrogram)

Number	Sample Name	Number	Sample Name	Number	Sample Name
79	12091T QEZ	40	1206UH LBX	97	3212UH VUL
80	12091H QGB	48	H3063H LSN	98	1212UH VQZ
88	22111T UVE	52	S3065H LRR	101	22121T VSR
89	32114H UNU	51	S3061T LRP	102	2212UH VST
78	12091T OBD	47	H3061T LSL	100	3212UH VUL
82	2209UH QHN	17	S403UH JSM	1	12020H GSQ
25	1204UH KEL	67	32081T PGJ	5	32021T GWL
26	22041T KGM	69	22084H PEZ	41	22061T LDM
27	2204UH KCO	90	1211UH UTQ		
3	22021T GUH	91	12111T UTO		
24	12041T KEJ	92	H211UZ UZQ		
13	2203UH JNJ	4	22022H GUJ		
85	3209UP QJB	45	32068P LFH		
104	H412UZ VWS	63	1207UH OBF		
12	22031T JNJ	42	2206UH LDO		
33	S304UP KLL	59	S1071T OGJ		
31	S3041T KLH	62	22071T OCZ		
72	H308PZ	60	S1072H OGL		
87	2211UH UVG	61	3207UH OET		
86	3209UZ QJD	65	32071T OER		
68	12082H PDK	56	H1073H OHF		
76	3208BP PGN	57	H1076P OHH		
37	H804UP KKH	14	32031T JLP		
11	12031H JLM	15	3203UH JPN		
74	S4082H PIL	7	3203AP GCJ		
29	3204UH KIW	23	H503UZ JRM		
35	H8041T KKD	6	32025H GWN		
95	3212UP VUN	16	3203UP JPP		
50	H306BZ LSR	20	H5031T JRG		
73	H3082H PJE	18	S403UP JSQ		
8	3202EB GCL	21	H503UH JRI		
103	32121T VUJ	55	H1071T OHD		
28	32041T KIU	22	H503UP JRK		
32	S304UH KLV	19	S403UZ JSQ		
54	S306UZ LRV	64	2207UH ODB		
58	H107UZ OHJ	44	32064H LFF		
77	3208FZ PGP	84	3209UH QIZ		
81	22091T QHL	10	12031T JLK		
71	S4081T	2	12021T GSD		
83	32091T QIX	39	12061T LBV		
66	32086H PGL	9	3203FZ GCN		
75	S408UZ PIP	43	32061T LFD		
30	3204UP KIY	93	121211 VQX		
34	S304UZ KLN	94	1212UH VQZ		
49	H3067P LSF	38	H804UZ KKJ		
70	22081T PEX	99	12121T VQX		
46	3206FZ LFS	36	H804UH KKE		
53	S306AP LRT	96	2212UH VST		

On a lower level of similarity, the dendrogram breaks down into 3 clusters, of 52% - 55% similarity. Cluster A has no grouping by month or season, station or depth (Table V-2), though it contains 5 subclusters having their own trends (1 through 5 mentioned earlier); cluster A clusters due to the presence of centric solitary diatoms in all samples. It differs from cluster B in that cluster B seems to be a mode of Southern Bank, Hospital Rock and Station 3 samples, all more related in their similarity of naupliar larvae than in their similarity to colonial solitary diatoms. Furthermore, these samples of cluster B are from early spring to late summer. The final cluster, C, consists of December samples of 1/2 photic zone and no trend in station position. These samples are most similar in their common occurrences of centric colonial diatoms.

In summary, the major trends affecting most samples are as follows. In most months or seasons of 1976, one would expect to find similar moderate abundances of centric colonial and centric solitary diatoms from one sample to the next, as is indicated in cluster A. Centric colonial diatoms would predominate in samples of December, but not through the entire winter. Throughout early spring to late summer, naupliar larvae are quite abundant at the offshore stations (Station 3, Hospital Rock, Southern Bank). Common to clusters of fewer samples of higher similarity are the trends summarized in Table V-2. The statistics for these results are presented in Table V-3.

Table V-2.

Trends common to each Q mode, microplankton II stations, hospital rock, and Southern Bank.

Cluster	% Similarity	Season	Depth	Stations	Dominant Groups
1	72	Sept.&Nov.	½ P.Z. 10m	no trend	Ceratium
2	70	April	½ P.Z. 10m	1 & 2 stations	Fecal Pellets Centric solitary diatoms
3	72	no trend	no trend	no trend	Centric solitary diatoms and centric colonial diatoms
4	70	no trend	no trend	Hosp. rock, So. Bank, 3 stations.	Pennate colonial diatoms
5	69	June&Aug.	no trend	Hosp. rock, So. Bank, 3 stations.	Centric solitary diatoms
6	70	November	no trend	no trend	Pennate solitary diatoms
7	65	July	½ P.Z. 10 m	no near-shore (1) sttns. rep.	Naupliar Larvae
8	64	Feb.-Mar.	no trend	Hosp. rock, So. Bank, 3 stations.	Calanoid Copepods and Naupliar Larvae
9	67	December	½ P.Z. 10 m	no trend	Centric colonial diatoms
A	54	no trend	no trend	no trend	Centric solitary diatoms
B	52	early spr.-late summer	no trend	H.R.,S.B. 3 sttns.	Naupliar Larvae
C	52	December	½P.Z. 10 m	no trend	Centric colonial diatoms

Table V-3.

Statistical Data for Cluster 1
There are four samples in this run and they are listed as follows:
12091T QEZ, 12091H QGB, 22111T UVE, 32114H UWU.

		MAX.	MIN.	MEAN	STD. DEV.	COEF. VAR.	# OCR.	MEAN PRES.	SUM PRES.
1	Cen.Sol. Diatoms	49.00	21.00	35.25	13.82	0.39	4	35.25	141.
2	Cen.Col. Diatoms	21.00	11.00	15.00	4.90	0.33	4	15.00	60.
3	Pen.Sol. Diatoms	28.00	9.00	18.50	9.88	0.53	4	18.50	74.
4	Pen.Col. Diatoms	6.00	2.00	4.25	1.71	0.40	4	4.25	17.
12	Ceratium	18.00	9.00	15.25	4.27	0.28	4	15.25	61.
27	Cal. Copepods	3.00	0.0	1.50	1.29	0.86	3	2.00	6.
35	Fecal Pellets	0.0	0.0	0.0	0.0	0.0	0	0.0	0.
30	Naupliar Larvae	12.00	3.00	6.25	4.03	0.64	4	6.25	25.

GENERAL SUMMARY OF NANSEN AND NISKIN DATA

In summary, it is very encouraging that the general groups appear to be indicative of small scale physical oceanographic conditions and, in fact, can indicate these conditions as biological indicators now that we know these relationships.

The general biological indicators and what they indicate are as follows: inshore waters = absence of, or sparseness of planktonic foraminiferans, spumellarians and nassellarians but, abundances of diatoms and dinoflagellates; shallow offshore waters = abundance of planktonic foraminiferans and spumellarians; deeper offshore water = abundance of nassellarians with planktonic foraminiferans and spumellarians common.

SHELLED MICROZOOBENTHON, LIVING BENTHONIC FORAMINIFERANS, 12 MAIN STATIONS

The shelled microzoobenthon (benthonic foraminiferans) showed greater differences when comparing them with the rest of the BLM-STOCS area than did the plankton when comparing them with the rest of the BLM-STOCS area. This difference is probably due to the benthonic foraminiferans having a longer residence time in a given spot than the plankton that are carried over the bank areas in a matter of days or even hours. The average standing crop of benthonic foraminiferans for the 12 primary seasonal stations throughout the year of 1976 was 55.28 individuals/10 cm^2. This value was lower than during 1975 (the same 12 stations, but sampled only in winter and spring) as reported by Anepohl (1976) which was 75 individuals/10 cm^2. Average values for shelf and marginal marine environments are 50 to

200 individuals/10 cm^2 (Murray, 1973). However, Phleger (1956), studying approximately the same area as the BLM-STOCS study area, reported an average from 21 individuals/10 cm^2 for his southern transect (a transect that extended from about between Station 1/II and 1/III to 3/III), to 61 individuals/10 cm^2 for a more northerly transect which ran from about midway between BLM-STOCS Stations 1/I and 1/II terminating offshore at about Station 3/II.

The average standing crop for all stations during the winter of 1976 was 94.38 individuals/10 cm^2, 50.4 for spring and 21.06 for summer. Combining Transects I and II as a northern section, and Transects III and IV as a southern section, the northern section had a greater standing crop in the winter (129.58 vs 59.18) and summer (39.90 vs 2.2) and standing crops were of similar densities in the spring (43.36 vs 46.4). The higher standing crops of benthonic foraminiferans along the northern transects were probably representative of the greater productivity of the overlying waters (more eutrophic conditions) noted continuously from the first cruises of the BLM-STOCS study. There probably is a lag time between plankton productivity (both primary and secondary) and benthonic foraminiferan productivity (represented by standing crop), however, monthly data suggest that the highest standing crop along Transect II appeared in April during the spring bloom. Phleger (1956), studying approximately the same area as the BLM-STOCS study area mentioned before, reported an average from 21 individuals/10 cm^2 for his southern transect and 61 individuals/10 cm^2 for his more northerly transect. Phleger's samples were collected in late June which was closest seasonally to the BLM-STOCS spring collecting period.

Perhaps the most obvious correlations of species and standing crop distributions were with depth. Ammonia beccarri, Bolovina lowmani and Nonionella basiloba were dominant at inner and mid-shelf during both years. Fursenkoina pontoni, and perhaps Reophax comprima, were seemingly indicative of the mid-shelf, but the major bathymetric break in the benthonic foraminiferan populations appeared to be about 60 to 70 m as was first noted for the study area by Phleger (1956). Outer shelf depths were indicated by the occurrence of Uvigerina peregrina, Bulimina marginata, Bolivinia sub-spinescens, and Brizalina spinata at the species level, and more generally by increases in Cibicides, Siphonina and other species of Brizalina and Bolivina

The-R-mode cluster analysis dendrograms for benthonic foraminiferans for 1976 and 1975 is given as Figure V-10. Clustering was predominantly influenced by depth and secondarily by seasonality. Depth appears to be the dominant factor controlling the distribution of benthonic foraminiferans in the STOCS study area. Nearshore forms showed a greater seasonality than mid or outer-shelf forms. Mid and outer-shelf forms generally occurred in inner-shelf samples and were designated as mid or outer-shelf forms primarily because standing crops were maintained in deeper waters whereas forms designated more nearshore decreased in standing crop.

The dominant nearshore (Stations 1 and 4) species were Ammonia beccarii, Bulliminella elegantissima, Florilus grateloupi, Nonionella cf. basiloba, Bulliminiella cf. bassendorfensis, Virgulinella sp. and Quinqueloculina sp. Ammonia beccarii and Bulliminella elegantissima were dominant mainly along northern transects (I and II)

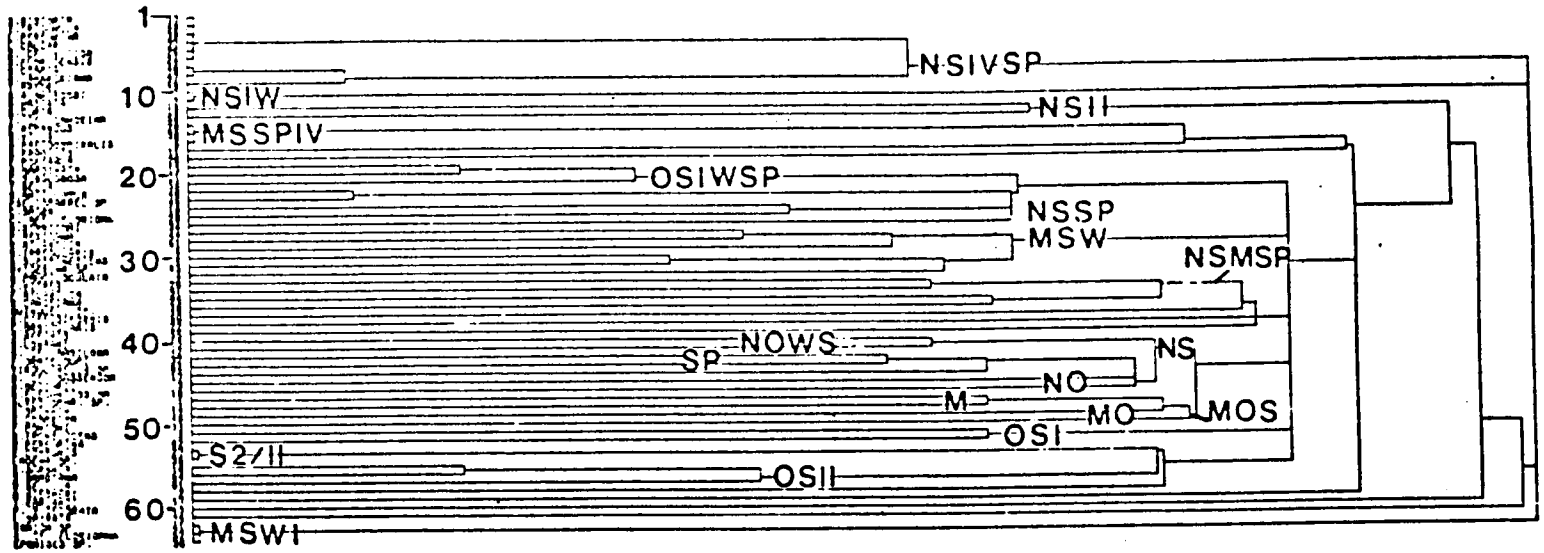


Figure V-10. R-Mode Analysis of Benthonic Foraminifera, 1976. (See Key on Next Page.)

Figure V-10. Key to R-Mode Benthonic Foraminifera, 1976.

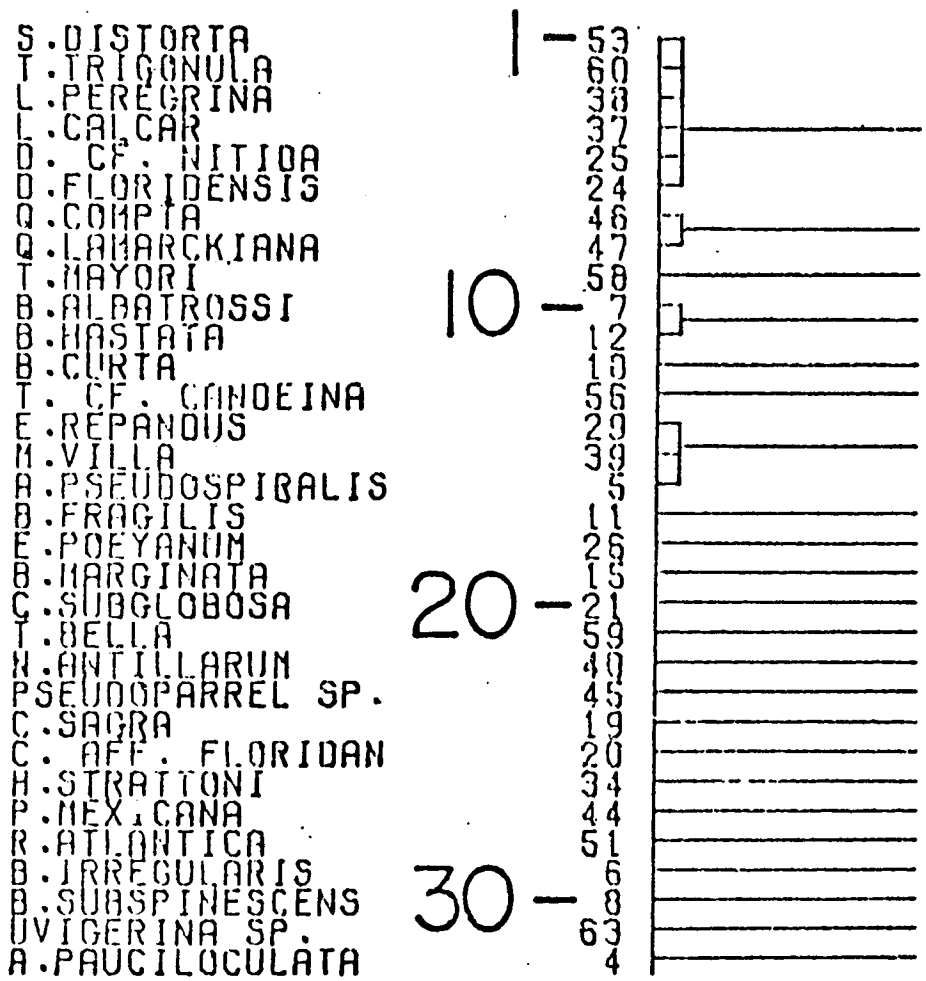
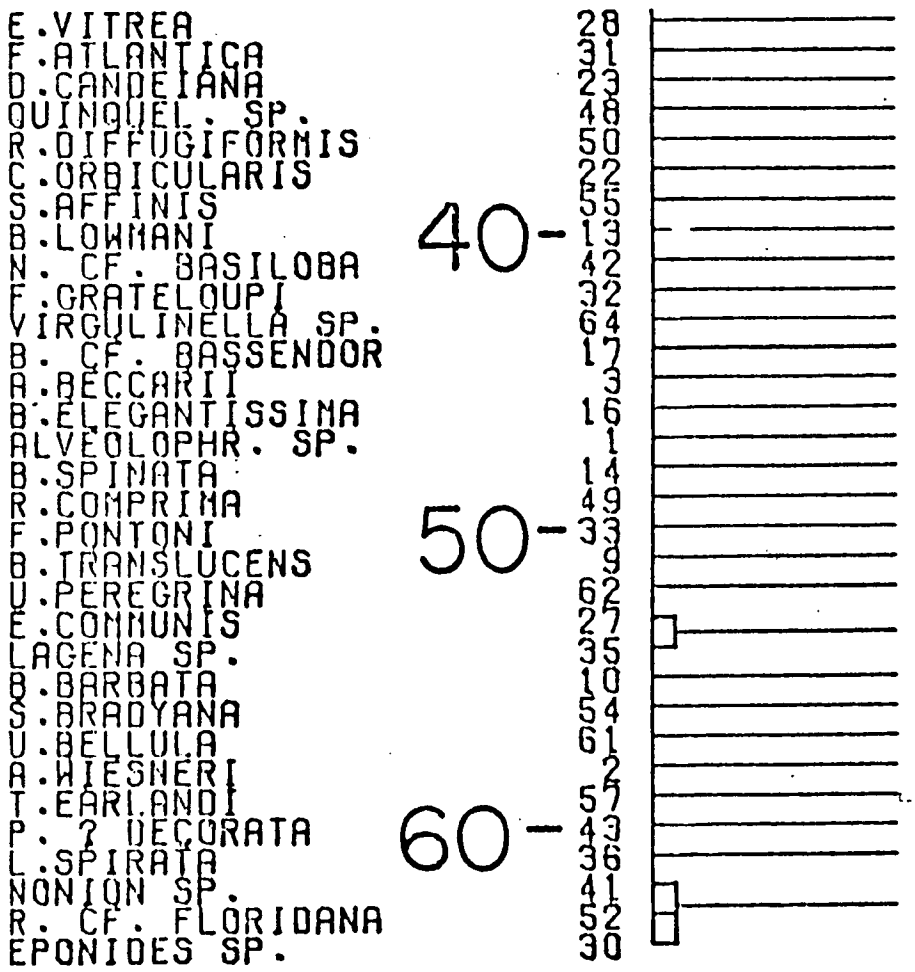


Figure V-10. Key Continued.



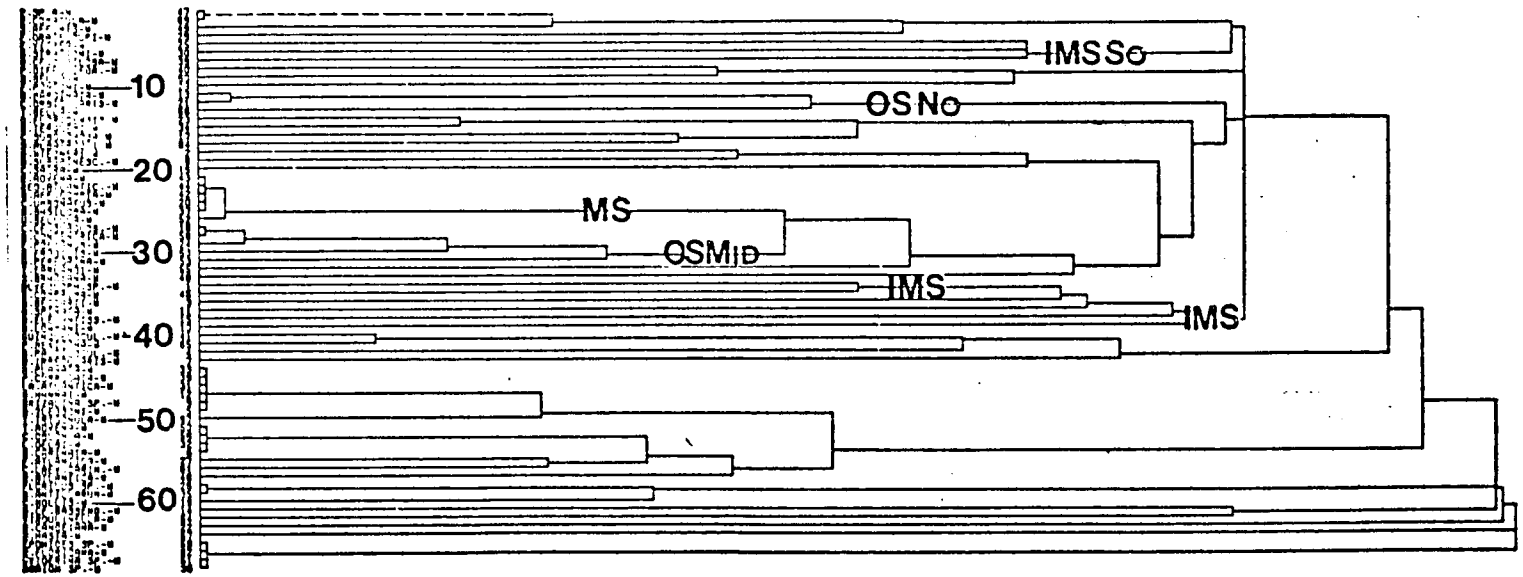
with A. beccarii dominating in the winter and B. elegantissima in the spring. In Figure V-10, these nearshore species (except for Quinqueloculina which is composed of four rare, but separate species) comprise the cluster labeled NS (nearshore). This cluster was subdivided into three subclusters, NOWS, SP and NO. The NOWS cluster (northern-winter-summer) was composed of B. lowmani and N. basiloba which, respectively, were indicative of winter and summer conditions at the nearshore, northern stations. F. grateloupe and Virgulinella sp. were indicative of nearshore spring and were labeled as an SP subcluster of the larger NS cluster. The last NS subcluster, NO (northern) was composed of A. beccarii and B. elegantissima. Immediately below the NS cluster on Figure V-10 is a cluster labeled MOS which was attached to the NS cluster at a low level of similarity. This MOS cluster was composed of two subclusters, M and MO. The MO subcluster was composed of the mid- and outer-shelf species Alveolophragnium sp. and B. spinata, and the M subcluster was composed of the mid-shelf species Fursenkoina pontoni and Reophax comprima. Immediately below this cluster was the OSI (outer shelf, Transect I) cluster composed of the outer-shelf species Uvigerina peregrina and Bolivina translucens. The above-named clusters were the most diagnostic. Other clusters on Figure V-10 were: NSIVSP (nearshore-Transect IV-spring); NSIW (nearshore-Transect I-winter); NSII (nearshore-Transect II); MSSPIV (mid-shelf-spring-Transect IV); OSIWSP (outer-shelf-Transect I-winter-spring); NSSP (nearshore-spring); MSW (mid-shelf-winter); NSMSP (nearshore-mid-shelf-spring); S2/II (summer-Station 2-Transect II); OSII (outer-shelf-Transect II); and, MSWI (mid-shelf-winter-Transect I). Most of these clusters

appeared to cluster as to season and transect due to a few common species occurrences.

The above text and figures have been only slightly modified from our previous reports (Casey et al., 1977 and 1978), but review of this material was necessary in order to evaluate the samples worked for this report and to allow this report to be read without reading the previous reports (Casey et al., 1978). Specifically for this report, we have produced four cluster dendrograms. Three dendrograms have been produced by using all 29 stations for each season (Figure V-11 for winter 1976, Figure V-12 for spring 1976 and Figure V-13 for summer-fall 1976), and one dendrogram for the monthly samples along Transect II (Figure V-14 exclusive of the seasonal-monthly samples). Our cluster program does not have the capacity to handle more samples so we could not combine all 1976 seasonal or all 1976 Transect II monthly data into dendrograms.

The winter 1976 seasonal dendrogram (Figure V-11) can be divided into the following cluster groups: a weak inner-mid shelf southern transect group (IMSSo); a outer shelf northern transects group (OSNo); a mid-shelf (MS) strong group including arenaceous foraminifera; an outer shelf mid transect (OSMid) association; and, a loose inner and mid shelf group (IMS). The absence of a tight inner and mid shelf or distinct inner shelf (stations 1 and 4) cluster found in the other seasons may be due to the mixing of assemblages due to the "isothermal conditions" of the winter season mentioned before. Figure V-15 shows Bolivina lowmani (a component of these tight inner and mid shelf clusters of the other seasons) as a dominant in outer shelf stations during the winter season. We

FIG. V-11. ***BENTHONIC FORAMINIFERA,WINTER 1976***



IMSSo = inner-mid shelf southern transects
OSNo = outer shelf northern transects
MS = mid-shelf
OSMid = outer shelf mid transect
IMS = inner and mid shelf

Figure V-11. Key to Benthonic foraminifera winter, 1976 dendrogram.

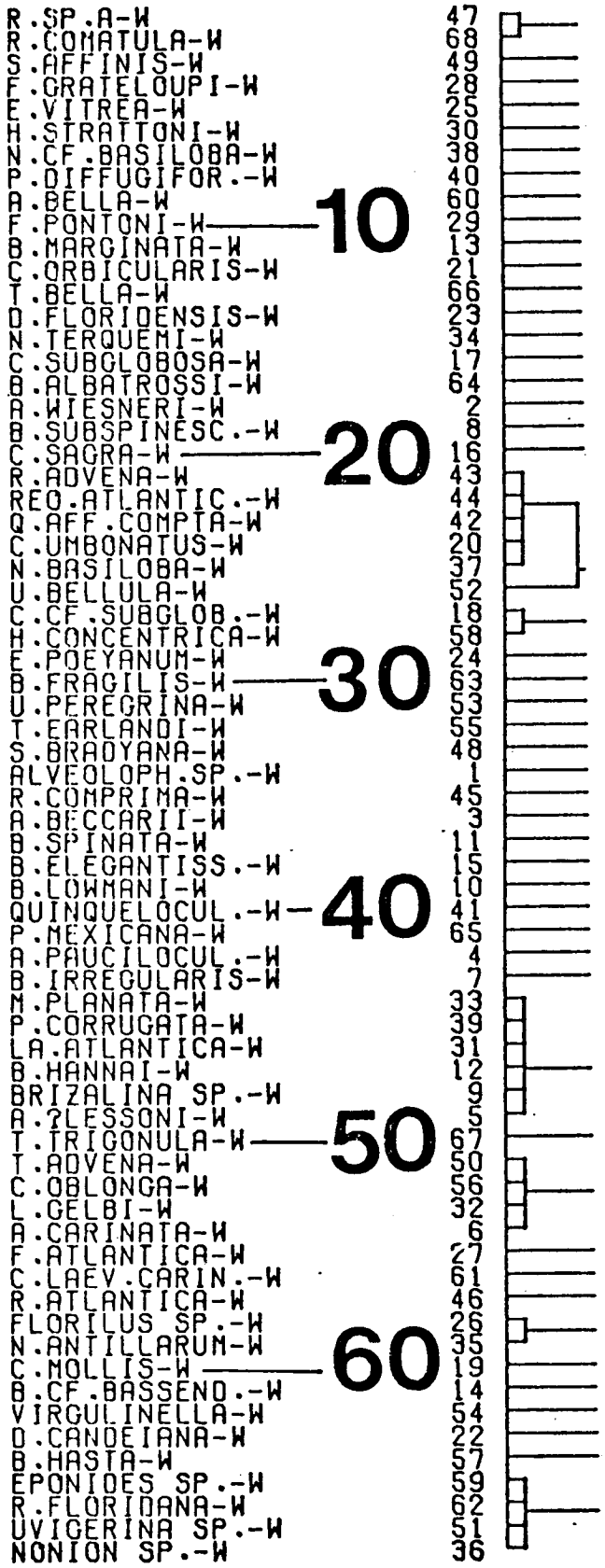
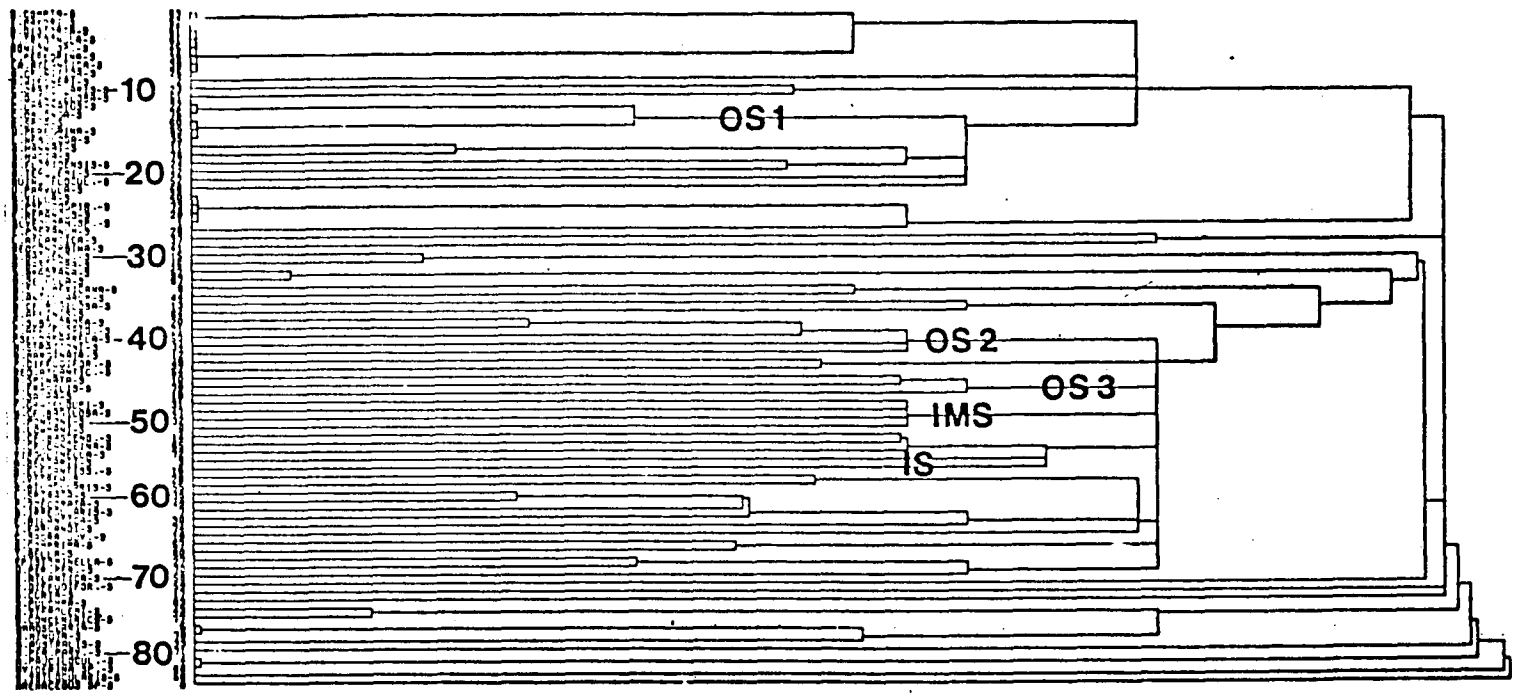


FIG. V-12. ***BENTHONIC FORAMINIFERA.SPRING 1976***



OS 1 = outer shelf group 1
OS 2 = outer shelf group 2
OS 3 = outer shelf group 3

IMS = inner and mid shelf group
IS = inner shelf group

Figure V-12. Key to Benthonic foraminifera spring, 1976 dendrogram

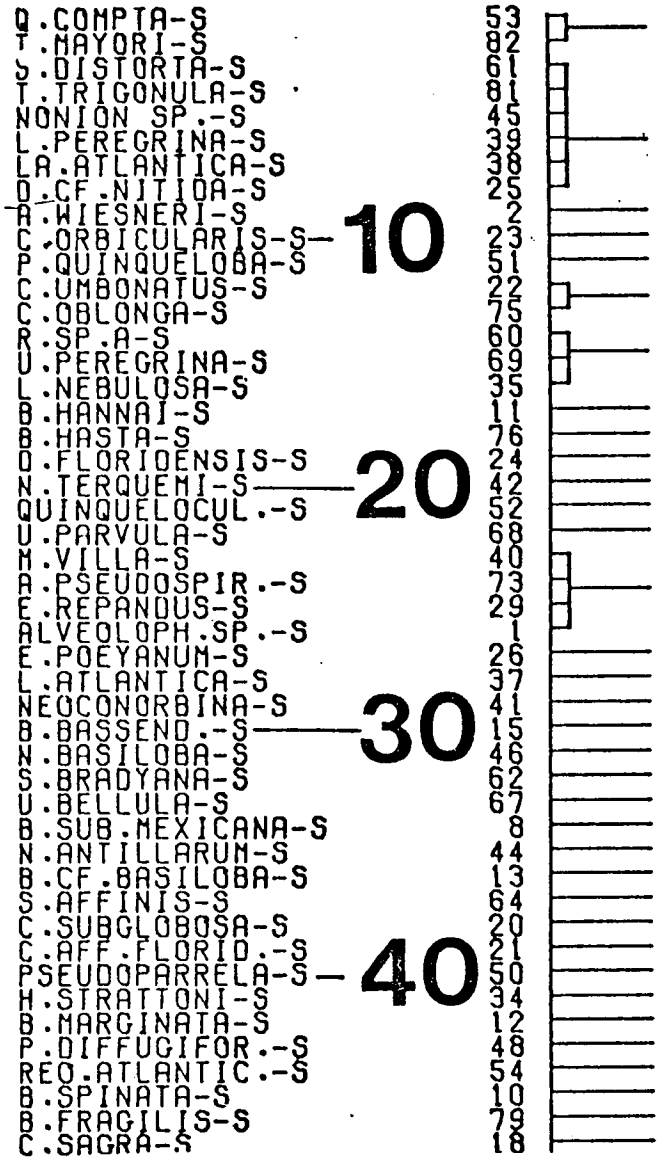


Figure V-12. cont

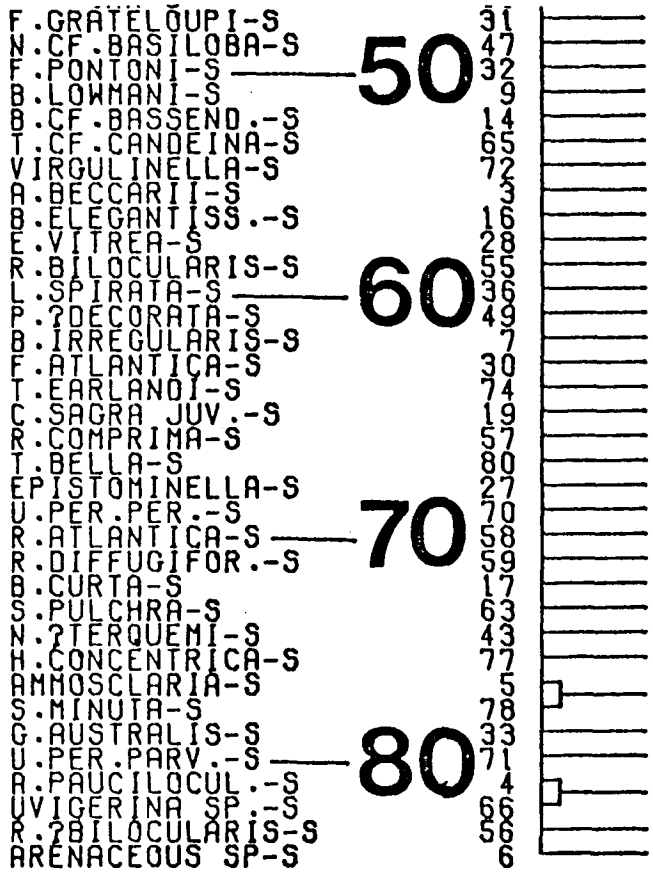
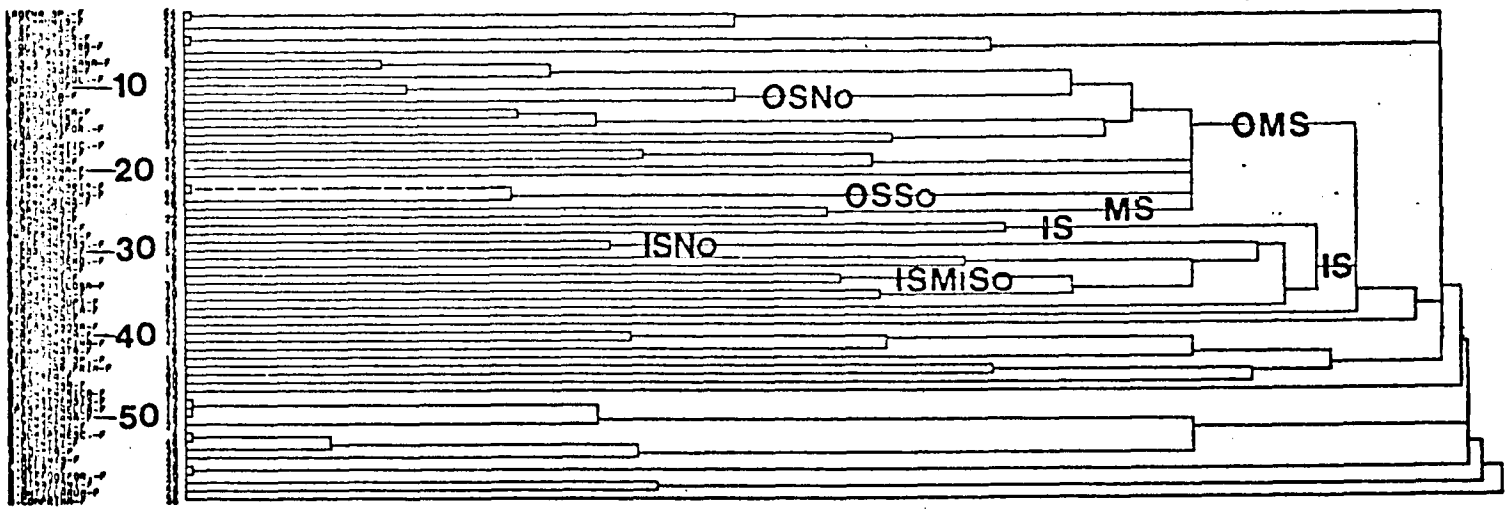


FIG. V-13. ***BENTHONIC FORAMINIFERA.SUMMER/FALL 1976***



OMS = outer-mid shelf group
OSNo = outer shelf northern transects
OSSo = outer shelf southern transects

MS = mid-shelf group
IS = inner shelf group
ISNo = inner shelf northern transects group
ISMiSo = inner shelf mid and southern transects

Figure V-13. Key to Benthonic foraminifera summer-fall, 1976

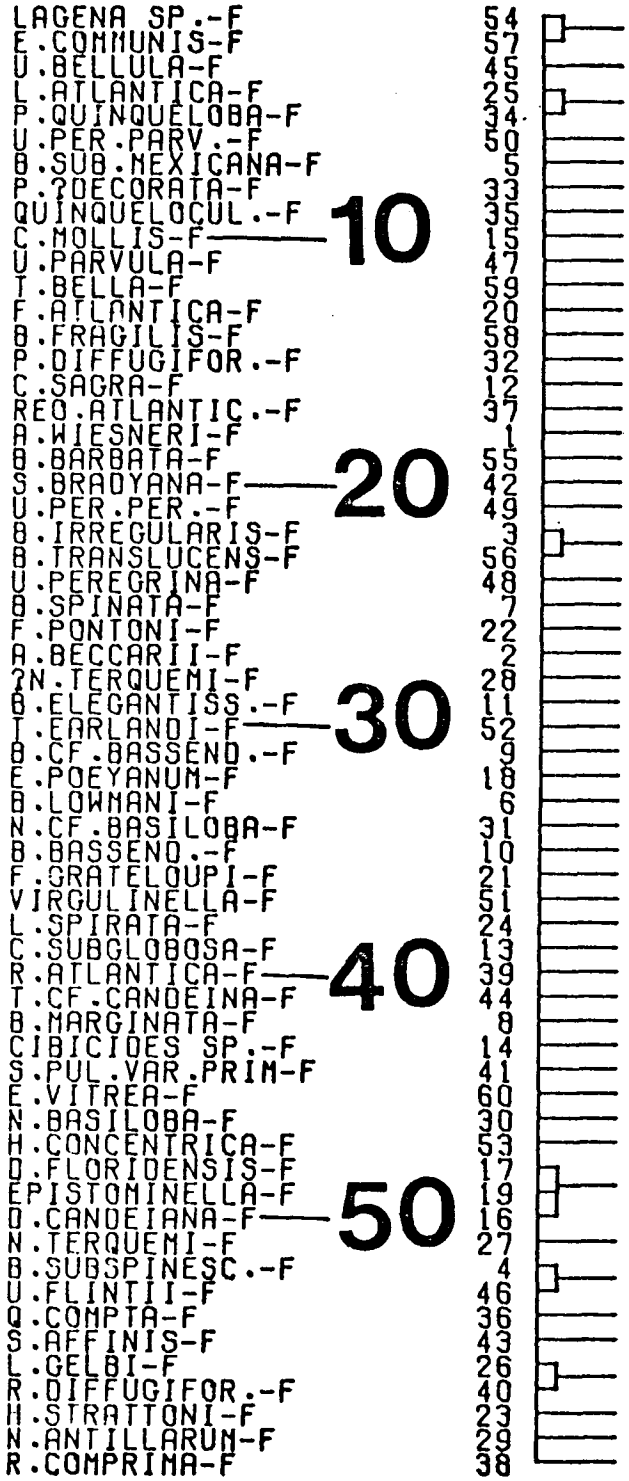
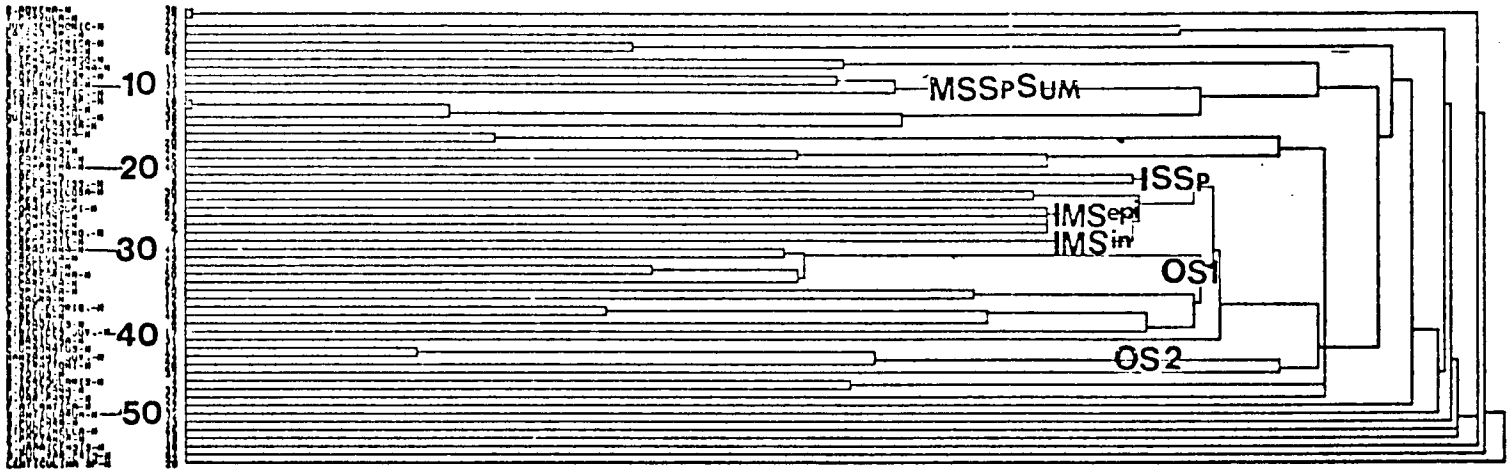
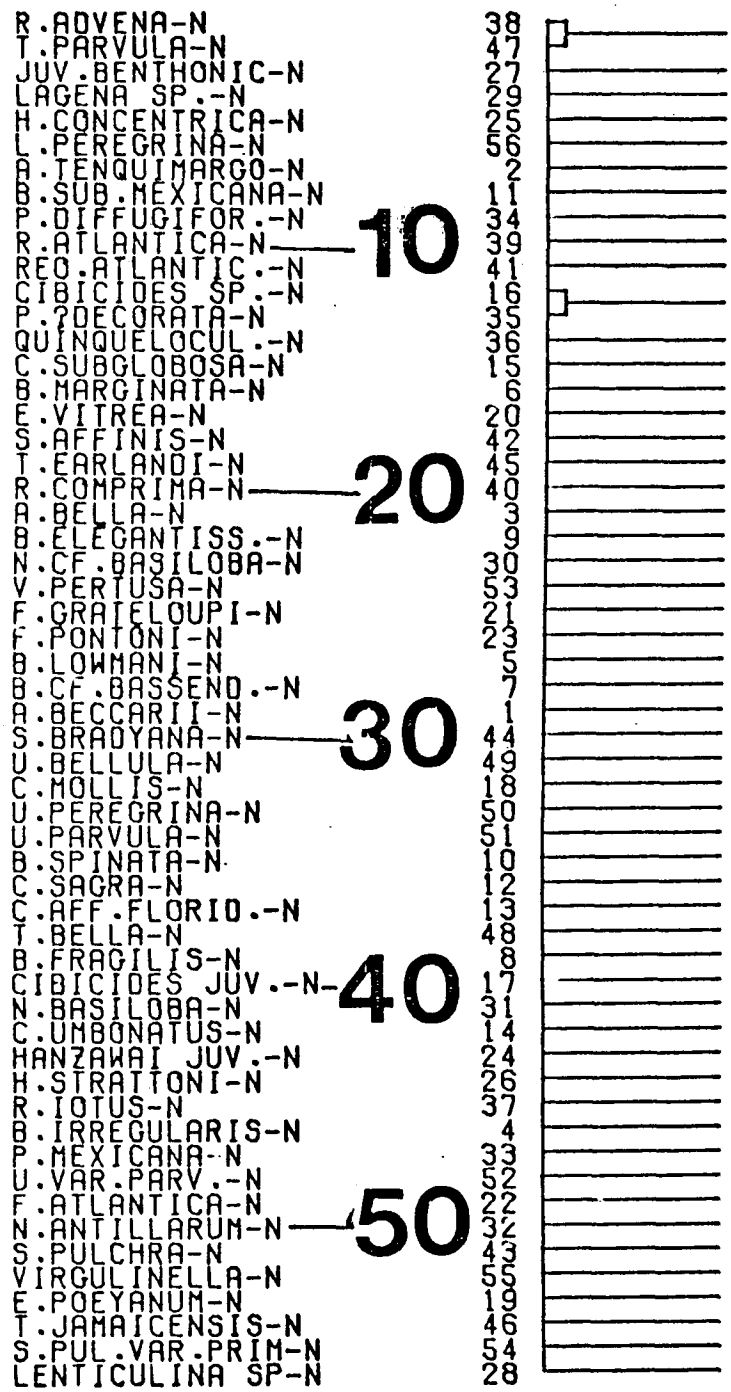


FIG. V-14. *****BENTHONIC FORAMINIFERA monthly SAMPLES 1976******



MSSpSum = mid shelf spring and summer group
ISSp = inner shelf spring group
IMSepi = inner mid shelf epibenthic
IMSin = inner mid shelf inbenthic
OS 1 = outer shelf group 1
OS 2 = outer shelf group 2

Figure V-14. Key to Benthonic foraminifera monthly samples dendrogram



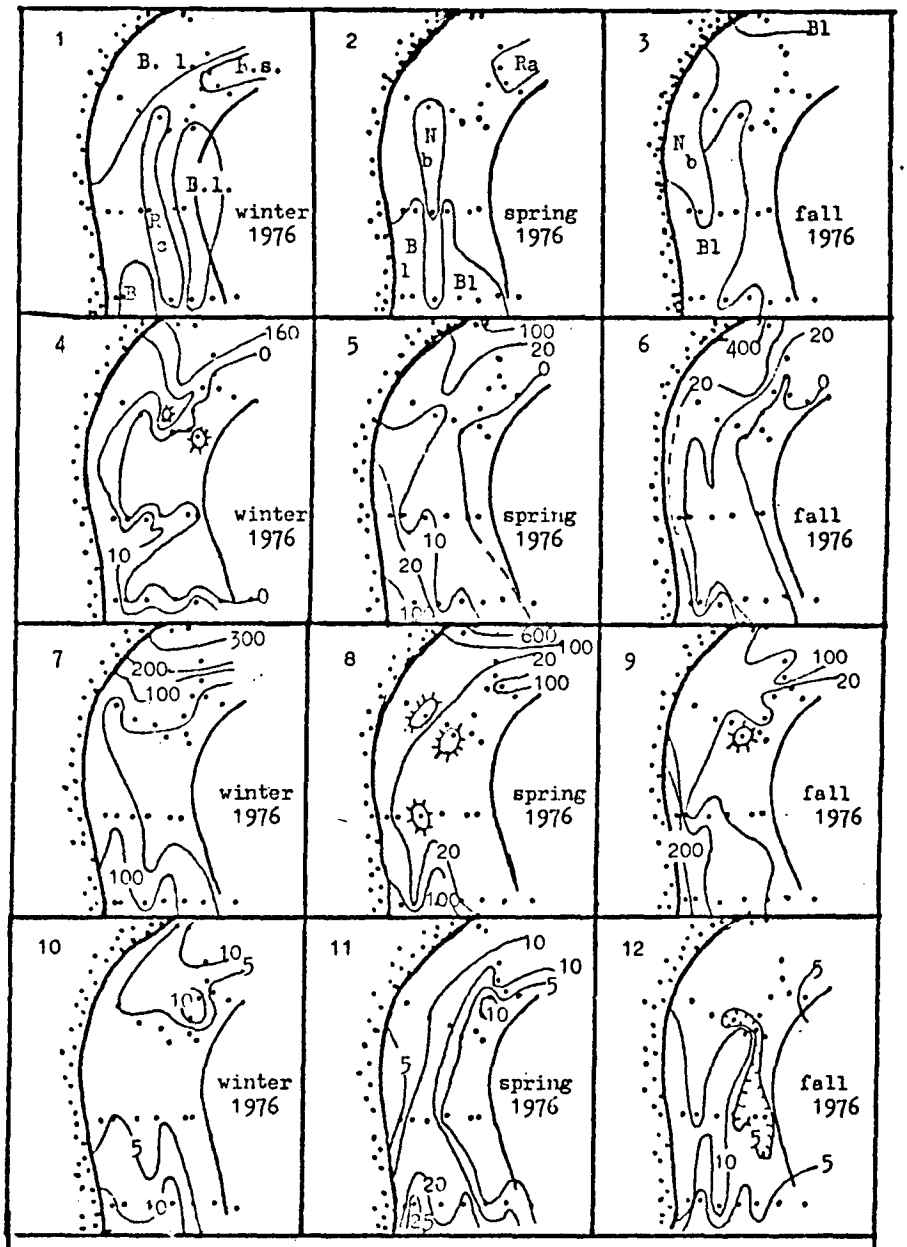


Figure V-15. Dominant species (maps 1,2 and 3 - contour of dominant species in adjacent samples); Density of Bolivina lowmani #/10 cm^2 (4,5 and 6); total density (7,8 and 9); Richness (10, 11, 12)

interpret this to indicate that this meroplanktonic species can reach the bottom in a reasonable time (so it is still very viable) during these winter isothermal periods.

The spring 1976 seasonal dendrogram (Figure V-12) can be divided into the following cluster groups: three strong outer shelf groups (OS1, OS2 and OS3); a strong inner and mid shelf group (IMS); and a strong inner shelf group (IS). The presence of strong well developed outer shelf clusters probably represents the incursion of offshore waters so that these shared-dominance, deep-water faunas are well established at the shelf edge and move into the mid section (Transects II and III) modern mud blanket and occasionally into the inner shelf region (stations 1 and 4) during the spring (Casey et al., 1977). The spring also exhibits the greatest number of living benthonic species probably due to the addition of species from the upper slope environment due to the incursion of deep offshore waters. We believe this incursion to be due to the effects of open ocean estuarine type upwelling bringing these deeper faunal components in with the "salt water wedge" bottom water intrusion.

The summer-fall 1976 dendrogram (Figure V-13) can be divided into: outer-mid shelf (OMS) with a northern offshore (OSNo), a southern offshore (OSSo), and mid-shelf (MS) subgroups; and, an inner shelf cluster (IS) with northern (ISNo), and mid and southern (ISMiSo) subgroups. Here the inner (essentially stations 1 and 4), mid (essentially 2 and 5) and outer (essentially 3,6 and 7) appear to show their greatest "individuality". We believe this to be due to the relatively calm bottom conditions of summer-fall. These calm bottom conditions are due to: the "grounding of a detached loop ring

pushing into the mid-shelf stations", little runoff, a relatively weak southerly wind system, and a strong thermocline over the area.

These general groups shown in the dendrograms complement the interpretations of the seasonal data presented on Figure V-15. Figure V-15 illustrates the dominant benthonic foraminiferan species (maps 1,2 and 3), the density of Bolovina lowmani (maps 4,5 and 6), the total density of benthonic foraminiferans (maps 7,8 and 9), and the richness of benthonic foraminiferans (maps 10,11 and 12).

The dominance maps (Figure V-15, 1, 2 and 3) are constructed by contouring the species dominant in more than one adjoining station. This method allows the visual presentation of the main dominants in the area seasonally. From these dominance maps, it can be seen that B. lowmani (the most abundant benthonic foraminiferan on the STOCS) exhibits a very interesting pattern; showing dominance over most of the shelf in winter including the outer shelf stations, and showing greatest dominance in the area of the northern stations. In the spring (Figure V-15, map 2) the dominance of B. lowmani switches to the south, and in the summer-fall it appears to "invade" the north via a mid-shelf route from the south. This same sequence can be seen in the 1975 sampling period (Figure V-16, maps 1, 2 and 3).

The density of Bolivina lowmani show somewhat the same pattern with a high density in the northern transects during winter (Figure V-15, map 4), an increase in the south in spring (Figure V-15, map 5) and an indication of the northern "invasion" in the summer-fall (Figure V-15, map 6, the 5 contour). We believe this is due to B. lowmani being meroplanktonic and moving to the outer shelf in the

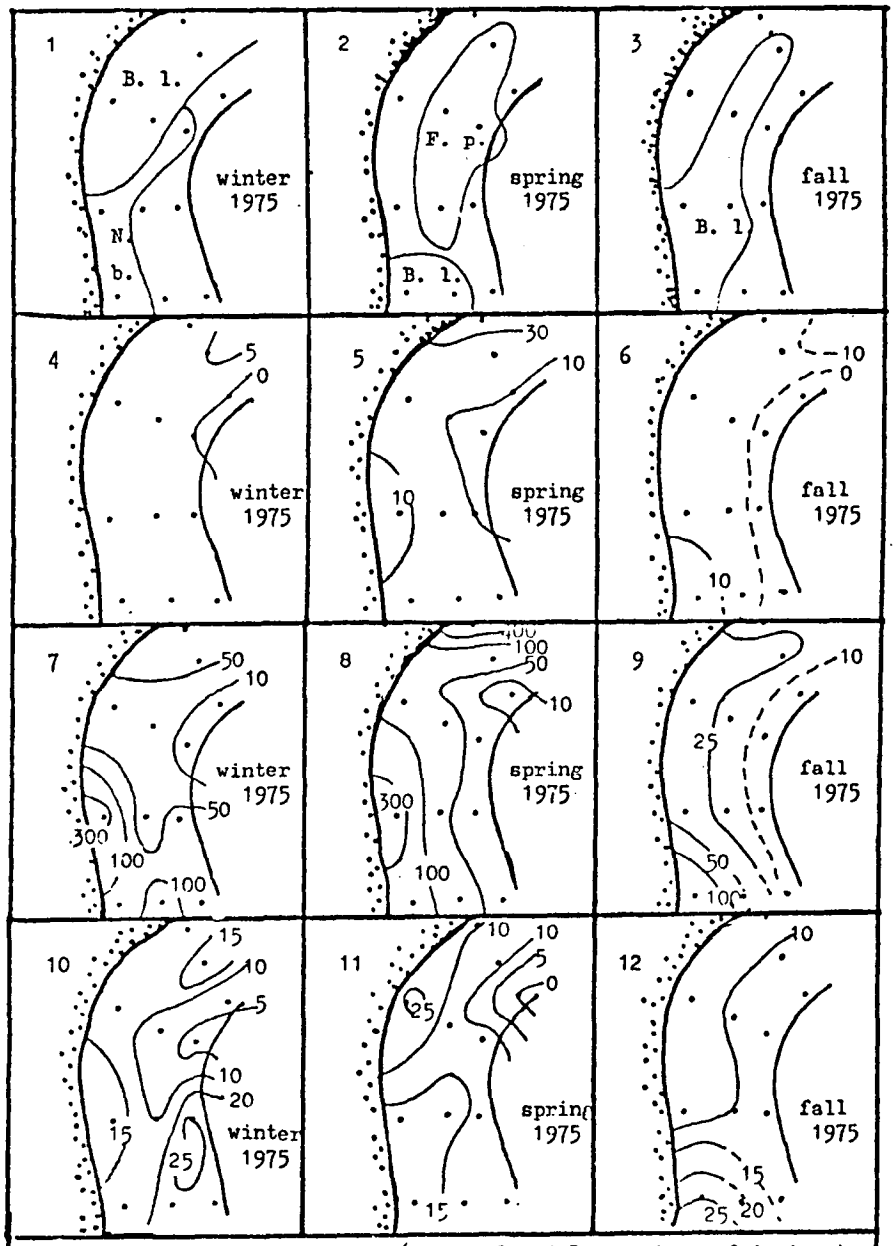


Figure V-16. Dominant species (maps 1,2 and 3 - contour of dominant species in adjacent samples); Density of Bolovina lowmani #/10 cm^2 (4,5 and 6); Total density (7,8 and 9); Richness (10, 11 and 12)

winter water column mixing; somewhat eutrophic or mesotrophic and establishing itself in the south during opportune times in the spring; and being an indicator of general bottom circulation and reflecting the bottom water movement to the north along mid shelf in the summer-fall with the northerly directed arm of the spiral of the anticyclonic gyre that grounded on the shelf at that time as mentioned before. Figure 10 shows this movement of water from the south to the north inferred from the microplanktonic and physical and oceanographic data.

The maps of total benthonic foraminiferan density (Figure V-15, maps 7, 8 and 9) are useful in deliniating the modern mid shelf mud blanket which is roughly outlined by the 20 individual/10 cm^2 contour for 1976. When comparing the total densities for 1976 (Figure V-15) with 1975 (Figure V-16, maps 7, 8 and 9), it appears that the low density mud blanket fauna of 1975 can not be defined by the same contour. In 1975, there was a greater richness of the modern mud blanket than in 1976 (Figure V-15, maps 10, 11 and 12) which can be defined by the 10 species contour for 1976, but not so for 1975 (Figure V-16, maps 10, 11 and 12) where the richness appears to be greater in the mud blanket, but the richness in other areas appears to be similar in 1975 and 1976.

The same parameters of dominance, density of Bolivina lowmani, total benthonic foraminiferan density, and richness compiled for the seasonal data for 1976 and 1975 were compiled for the nine monthly sampling of Transect II in 1976, as was a dendrogram of the Transect II monthly samples exclusive of the seasonal samples.

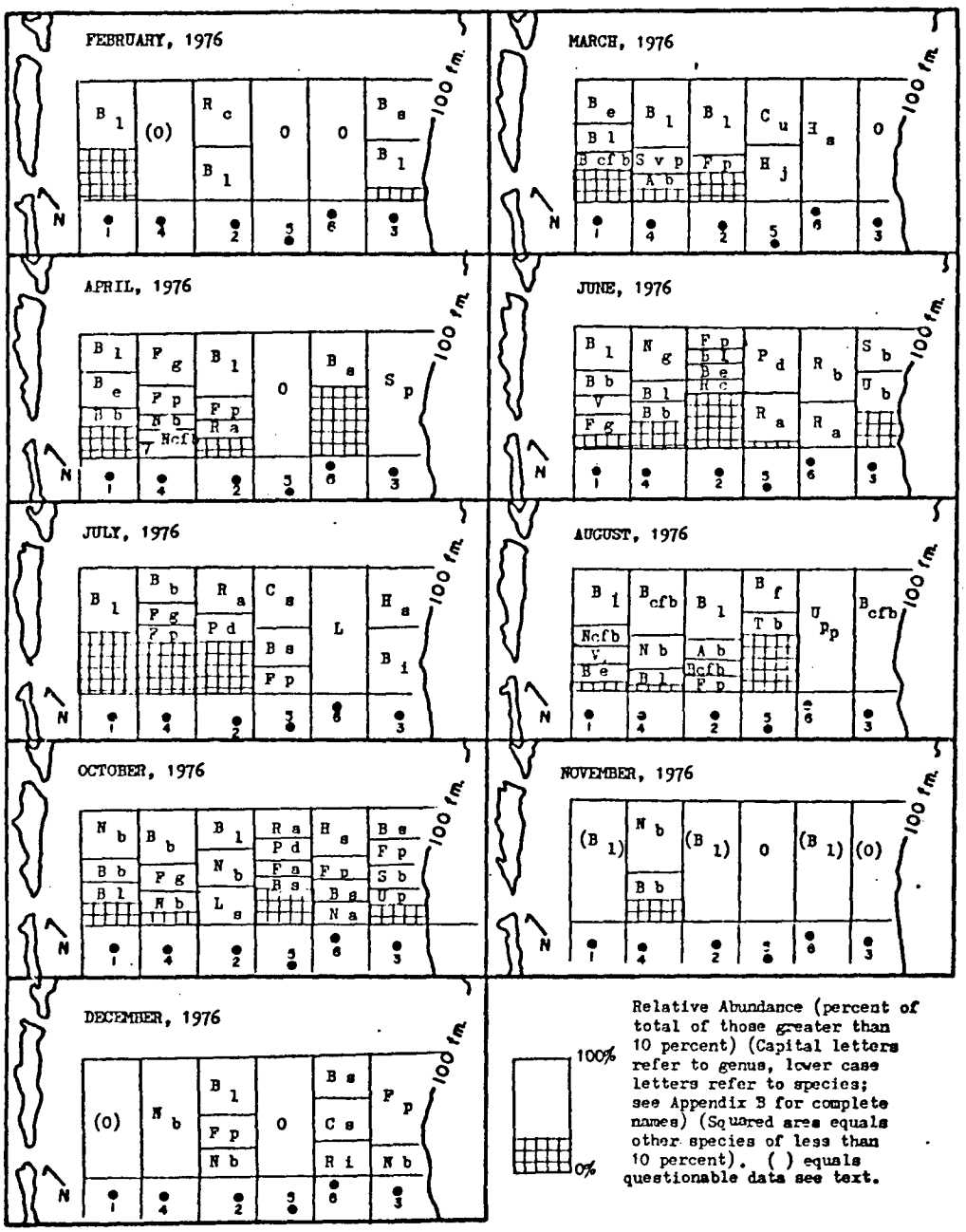
This dendrogram (Figure V-14) can be divided into the following

groups: a mid shelf spring and summer fauna (MSSpSu); an inner shelf spring fauna (ISSp); an inner and mid shelf fauna (IMS) that is subdivided into a possible epibenthic (IMSepi) and inbenthic (IMSin) groups; and two outer shelf groups (OS1 and OS2). These groups agree with the dominance groups for each of the nine month percent dominance maps (Figure V-17). Ammonia beccarii (the IMSin individual on Figure V-14) is the only benthonic foraminiferan from the study area to be known as an infaunal member from the literature (Brooks, 1967), and it is suspected that those considered epifaunal (IMSepi on Figure V-14) are indeed epifaunal due to their common appearance in plankton samples in the BLM-STOCS area (Casey et al., 1978) and this difference is suggested from separation on the dendrogram (Figure V-14).

Figure V-17 illustrates the percentages of the various benthonic foraminiferans at each of the nine monthly stations on Transect II, and Figure V-18 illustrates the density of Bolivina lowmani at each of these stations. These data agree well with the seasonal maps on Figure V-15. During winter there is a dominance of and a higher density of B. lowmani in the inner and mid shelf and a high percentage on the outer shelf (Figures V-17 and V-18, February maps), a low point in B. lowmani dominance and density in late spring (Figure V-15, map 2; and, Figure V-17 and V-18, June and July), a slight increase in B. lowmani dominance and density in late summer and fall (Figure V-15, map 5; and Figures V-17 and V-18, August), and the beginning of a reestablishment of B. lowmani in winter (Figure 18, maps 3 and 6; and, Figures V-17 and V-18, November and December).

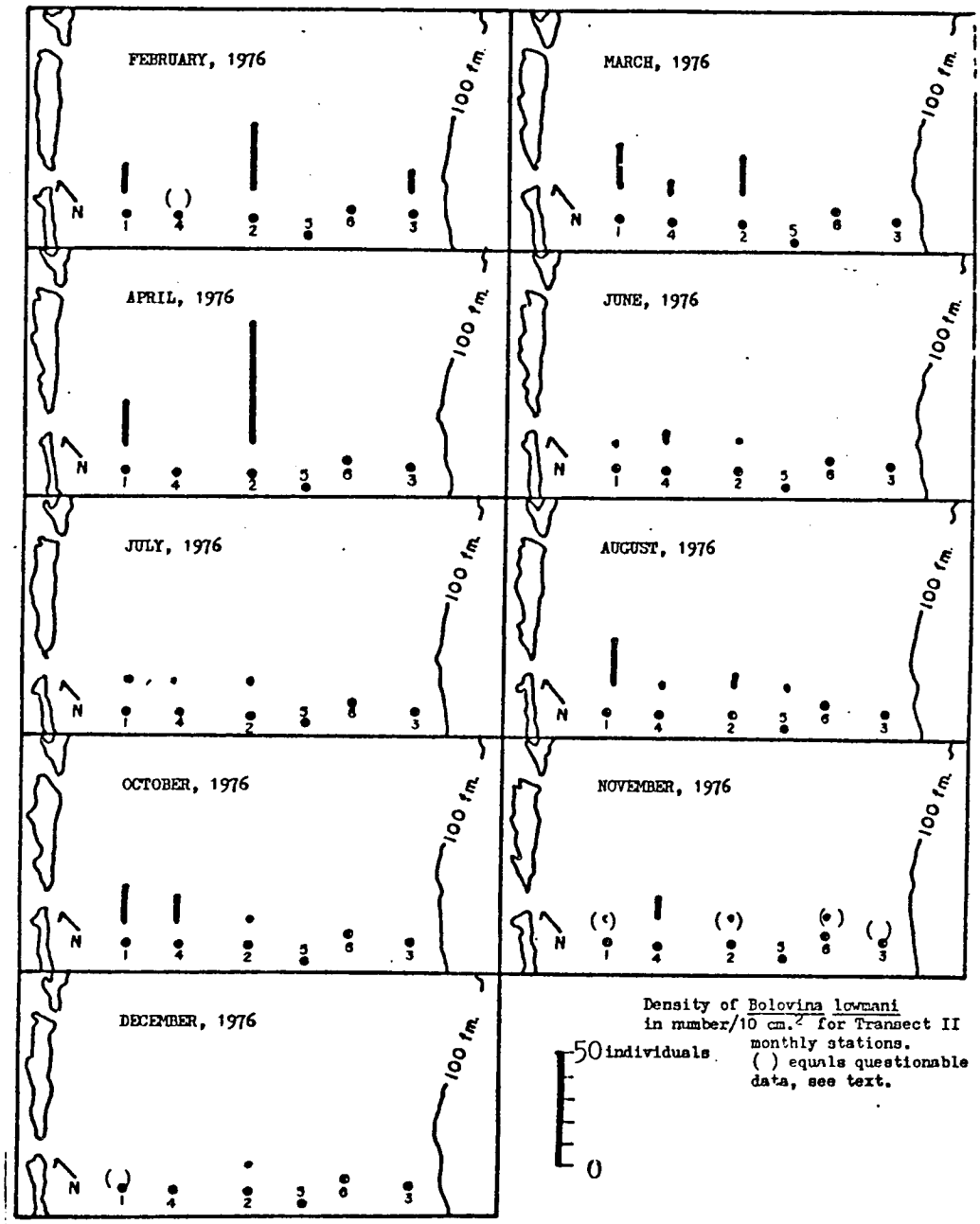
Figures V-19 and V-20 illustrate the total density of benthonic

Figure V-17.



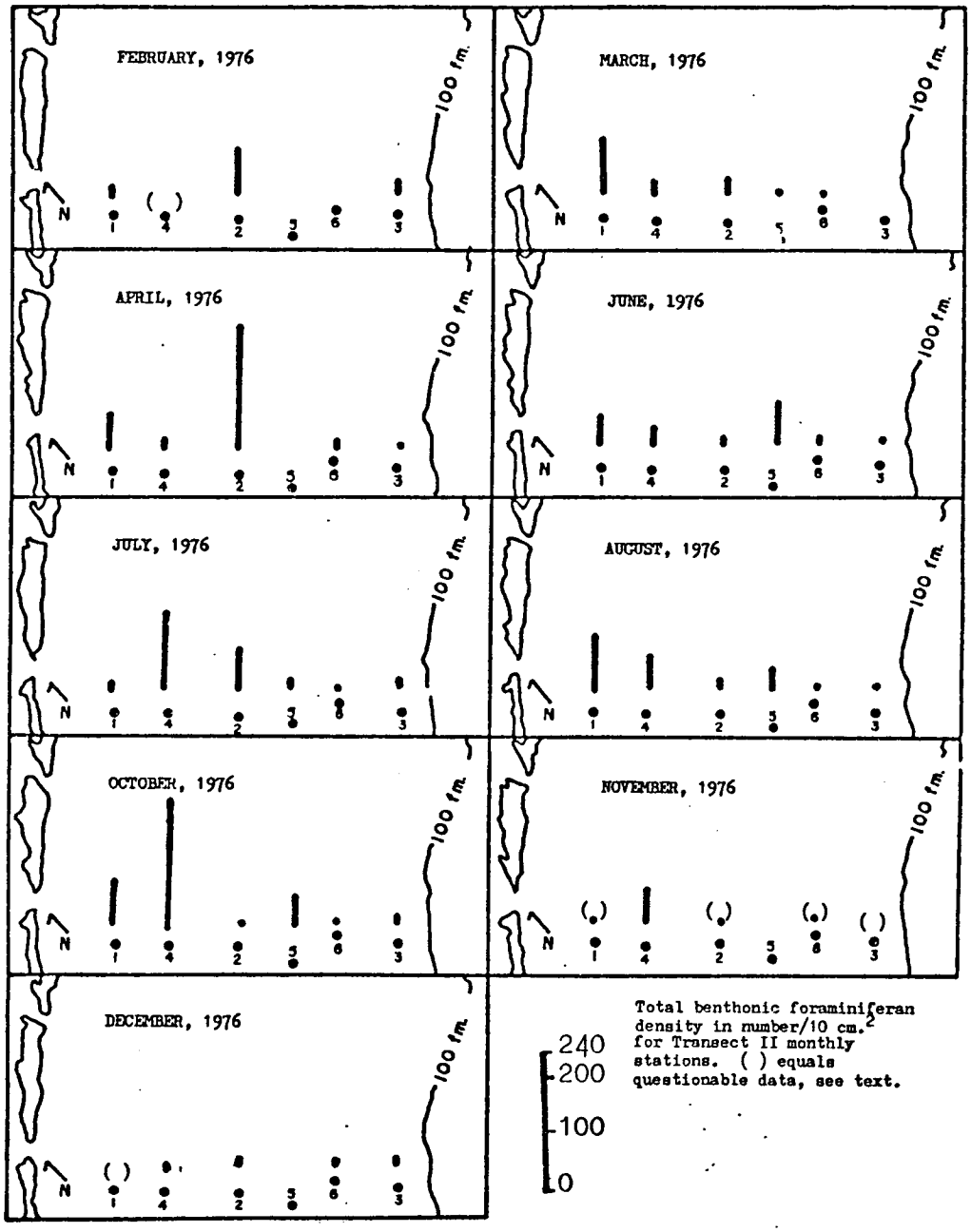
Relative Abundance (percent of total of those greater than 10 percent) (Capital letters refer to genus, lower case letters refer to species; see Appendix B for complete names) (Squared area equals other species of less than 10 percent). ( ) equals questionable data see text.

Figure V-18.



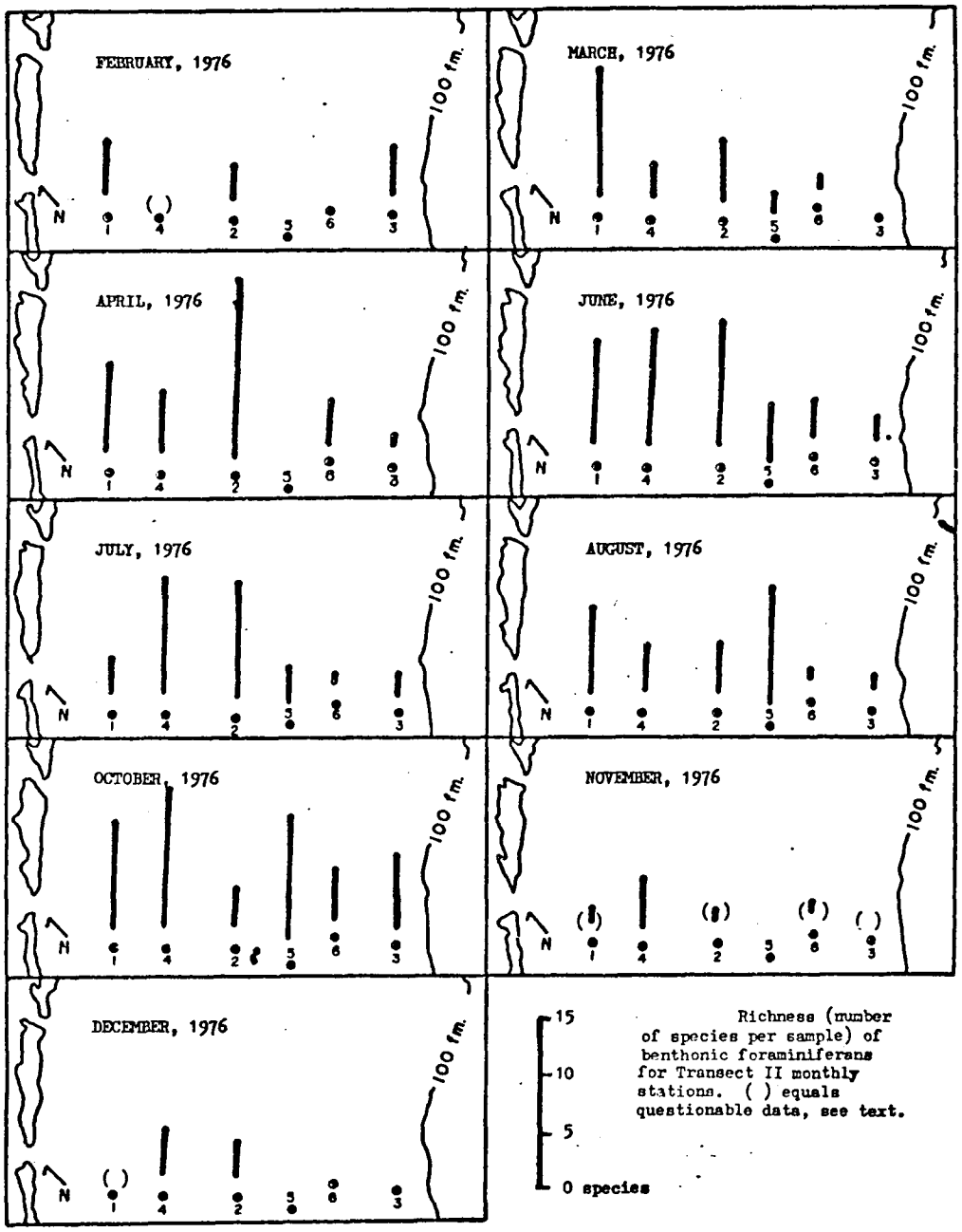
Density of Bolovina lowmani in number/10 cm.^{2} for Transect II monthly stations. ( ) equals questionable data, see text.

Figure V-19.



Total benthonic foraminiferan density in number/10 cm.^{2} for Transect II monthly stations. ( ) equals questionable data, see text.

Figure V-20.


FEBRUARY, 1976
MARCH, 1976
APRIL, 1976
JUNE, 1976
JULY, 1976
AUGUST, 1976
OCTOBER, 1976
NOVEMBER, 1976
DECEMBER, 1976
100 fm.
N
15
10
5
0 species
Richness (number of species per sample) of benthonic foraminiferans for Transect II monthly stations. ( ) equals questionable data, see text.

foraminiferans and the richness respectively for these nine monthly samplings on Transect II. There generally appears to be a positive correlation between total density and richness on both a monthly Transect II (Figures V-19 and V-20) and STOCS seasonal (Figure V-15) level. In general, both rich (many species) and high density collections are from the sand as opposed to the modern mud blanket areas (Figure V-15, maps 7 through 12). This generality holds for Transect II (Figures V-19 and V-20) except during April (when there was an increase in richness and total density) at Station 2 followed by a drastic decline in density but not richness in May. This trend appears again (but not as dramatically) at Station 2 from July to August. These trends may represent a succession on a sub-seasonal level that may have to do with different times of reproduction for different benthonic foraminiferan species.

HOSPITAL ROCK AND SOUTHERN BANK STATIONS (FIRST PRIORITY BANKS)

Figures V-21, V-22, and V-23 illustrate the dominant species, richness and total densities of benthonic foraminiferans of the Hospital Rock and Southern Bank stations in relation to the surrounding stations of Transect I and II. In general, the bank stations exhibit a less diverse fauna (an average of 4.6 species at HR and 4.7 species at SB) than the Transect stations (an average of 5.36 species). The densities are slightly lower (an average of 36.7 individual/10 cm^2 at HR and 37.8 at SB) than the surrounding stations (an average of 38.2). There appear to be a greater number of Ammonia beccarii and arrenaceous species

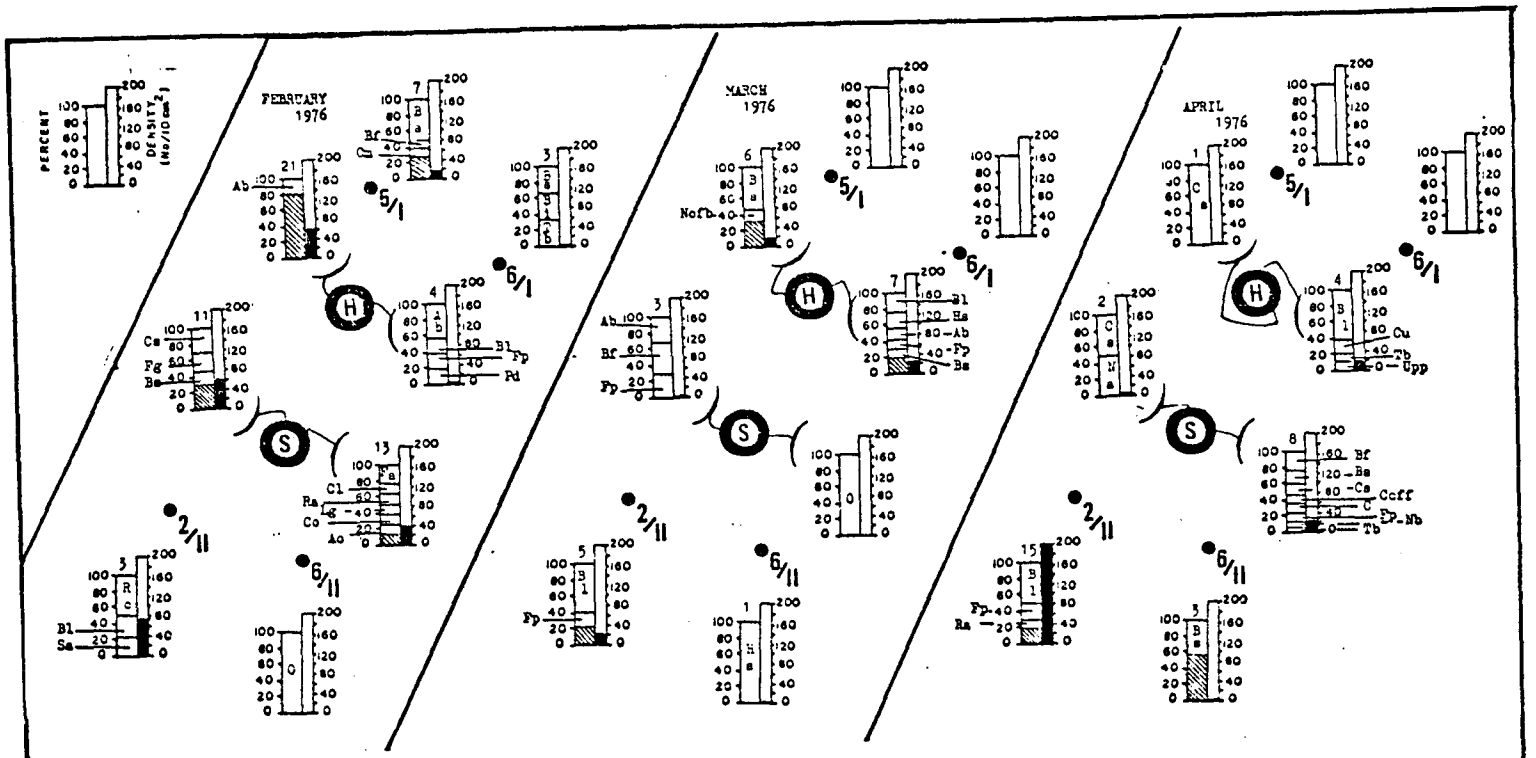


Figure V-21. PERCENT ABUNDANCE OF BENTHONIC FORAMINIFERANS GREATER THAN 10%, AND DENSITIES AT THE MONTHLY SAMPLING OF THE BANK STATIONS (H = HOSPITAL, S = SOUTHERN) AND STATIONS 5 AND 6 OF TRANSECT I, AND STATIONS 2 AND 6 OF TRANSECT II. THE LINES JOINING THE BANK STATION AND THE PERCENT AND DENSITY PLOTS SHOW THE APPROXIMATE STATION LOCATION IN RELATION TO THE BANK. ( ) EQUALS QUESTIONABLE DATA, SEE TEXT.

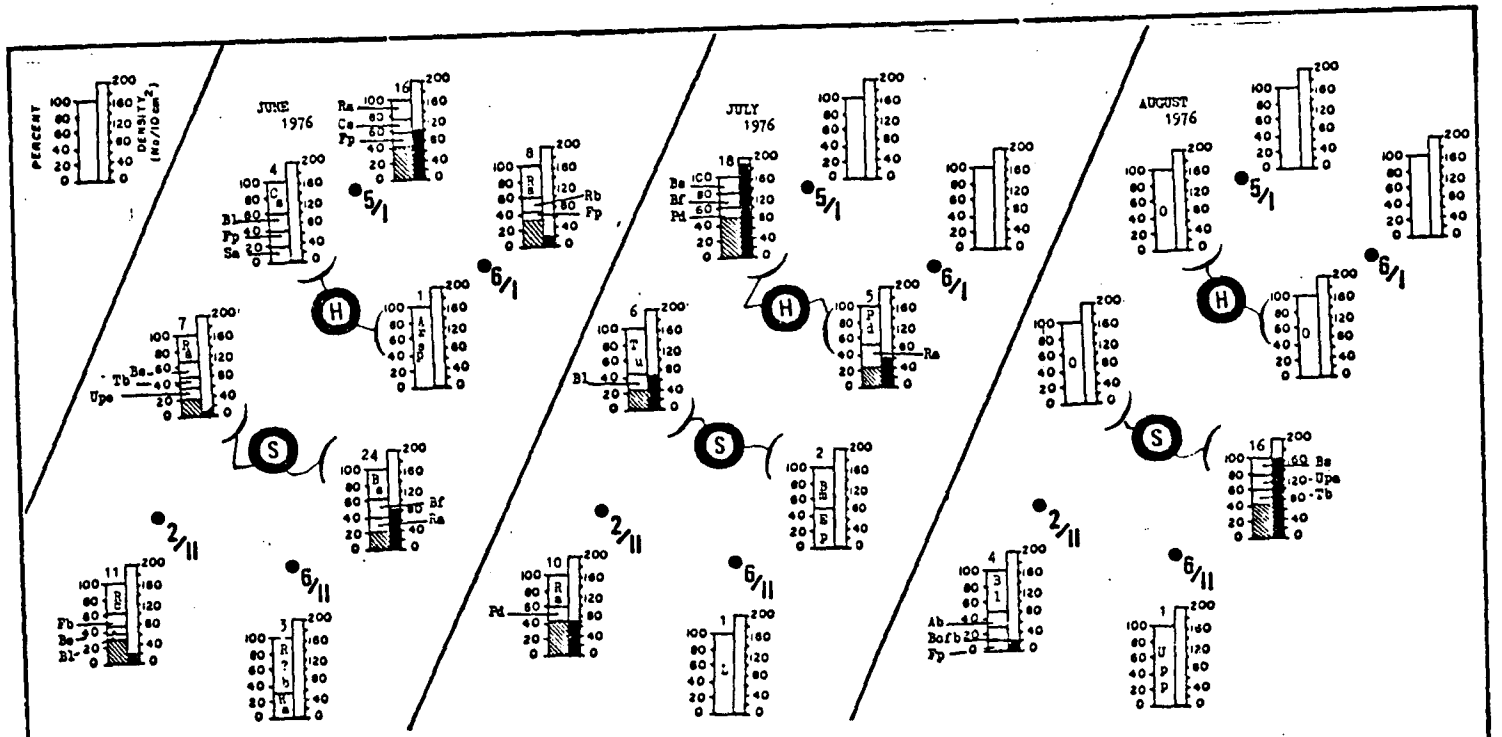


Figure V-22. PERCENT ABUNDANCE OF BENTHONIC FORAMINIFERANS GREATER THAN 10%, AND DENSITIES AT THE MONTHLY SAMPLING OF THE BANK STATIONS (H - HOSPITAL, S - SOUTHERN) AND STATIONS 5 AND 6 OF TRANSECT I, AND STATIONS 2 AND 6 OF TRANSECT II. THE LINES JOINING THE BANK STATION AND THE PERCENT AND DENSITY PLOTS SHOW THE APPROXIMATE STATION LOCATION IN RELATION TO THE BANK. ( ) EQUALS QUESTIONABLE DATA, SEE TEXT.

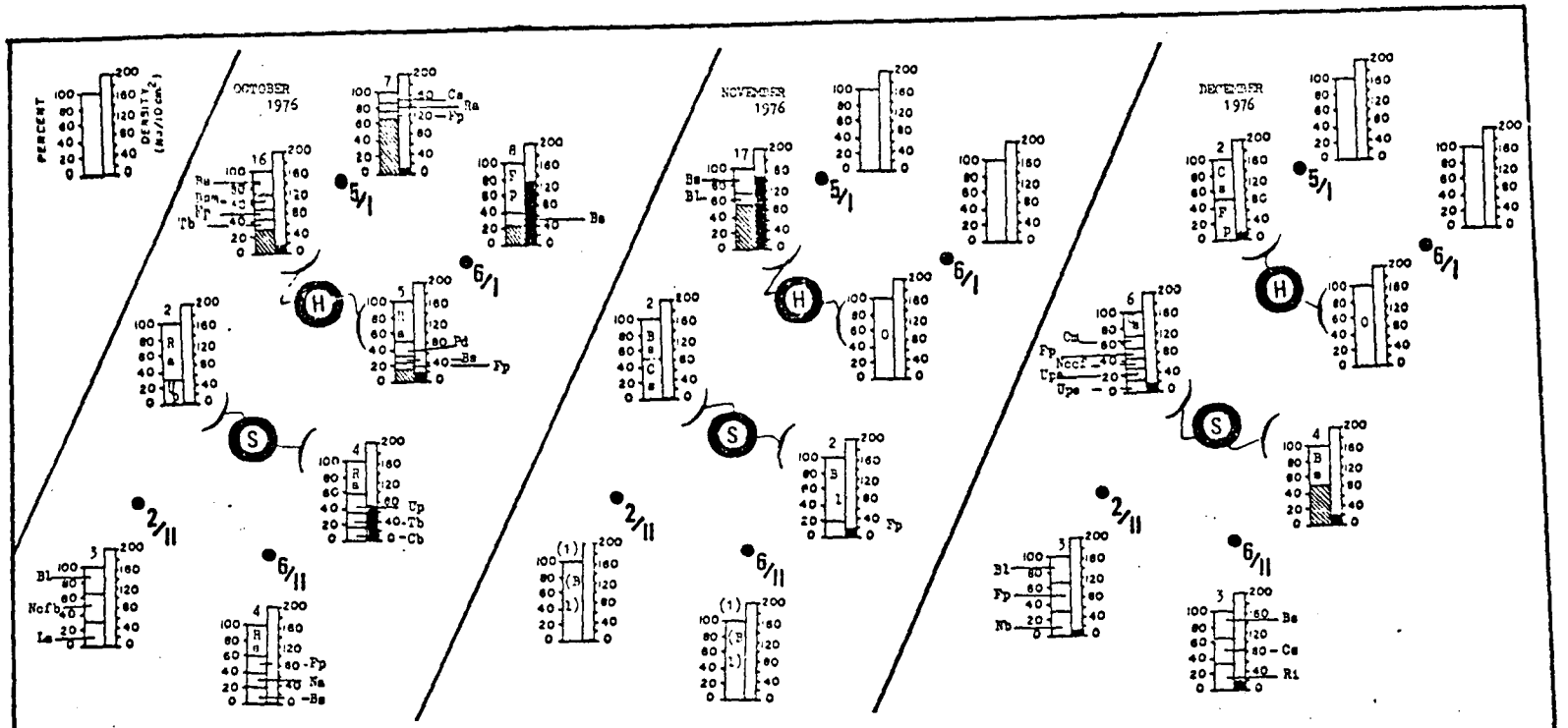


Figure V-23. PERCENT ABUNDANCE OF BENTHONIC FORAMINIFERANS GREATER THAN 10%, AND DENSITIES AT THE MONTHLY SAMPLING OF THE BANK STATIONS (H = HOSPITAL, S = SOUTHERN) AND STATIONS 5 AND 6 OF TRANSECT I, AND STATIONS 2 AND 6 OF TRANSECT II. THE LINES JOINING THE BANK STATION AND THE PERCENT AND DENSITY PLOTS SHOW THE APPROXIMATE STATION LOCATION IN RELATION TO THE BANK. ( ) EQUALS QUESTIONABLE DATA, SEE TEXT.

in the banks than the surrounding stations.

The bank stations do not appear to respond to the patterns of Bolivina lowmani dominance and migration that were mentioned earlier.

The bank regions are regions of relatively great relief and considerable variability in sediment texture. The variability in sediment texture may account for presence of Ammonia beccarii (which are usually a nearshore infaunal component) existing in the coarse sediment regions of the banks. The great local relief (plus the sediment variability) may account for the common occurrences of deep and shallow forms; and, mud and sand facies members.

The peaks in density appear to mainly occur in February and July at both banks. Up current and down current trends were looked for, but have not been found in the benthonic foraminiferans of these banks to date.

STETSON, EAST FLOWER GARDEN, 28 FATHOM AND SOUTHWEST PEAK BANKS

Figure V-24 illustrates the locations and benthonic foraminiferan dominants, richness and density of the 15 samples from the second priority bank stations. These banks were sampled in late August and early September of 1976. Eleven of the 15 samples taken were studied in detail and the remaining four were investigated for dominant species and densities (richness was also measured but indicated in parenthesis in Figure V-24). At least two samples from each of these second priority banks were

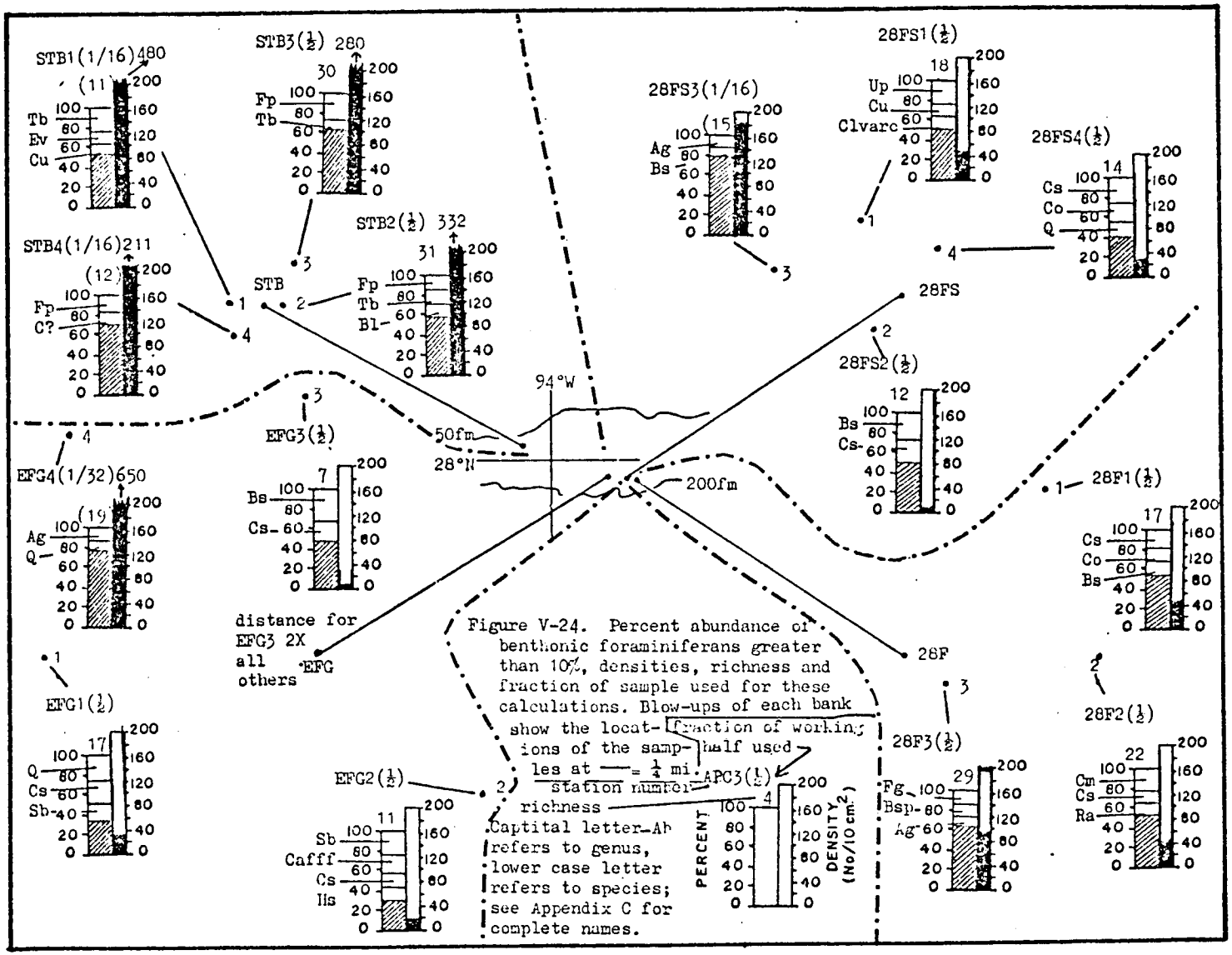


Figure V-24. Percent abundance of benthonic foraminiferans greater than 10%, densities, richness and fraction of sample used for these calculations. Blow-ups of each bank show the locations of the samples at $\frac{\text{fraction of working half used}}{\text{station number}} = \frac{1}{4}$ mi. richness. Captital letter-Ab refers to genus, lower case letter refers to species; see Appendix C for complete names.

studied in detail and are indicated in Figure V-24 be 1/2 in the fraction of working half used.

Of the samples studied in detail the richness, densities and dominants were compared. Stetson Bank exhibited the greatest richness (an average of 30.5 species), followed by 28 Fathom Bank (22.7), 28 Fathom Southwest Bank (14.6) and East Flower Garden Bank (11.6) in order of decreasing richness. Stetson Bank also exhibited the greatest density (an average of 306.3 individuals/10 cm^2), followed by 28 Fathom Bank (63.6), 28 Fathom Bank, southwest peak (31.8) and East Flower Garden Bank (19.4). Stetson Bank appears to illustrate the greatest stability in dominants with Fursenkoina pontoni in greatest number followed by Trifarina bella in both samples studied in detail. None of the other second priority bank stations exhibited the same dominant pair or even the same dominant in any two samples studied in detail even though three samples from each of these stations was worked in detail.

From the samples we received Stetson Bank and 28 Fathom Bank sediments were mainly coarse sand (mainly shell hash), 28 Fathom Bank southwest peak was a combination of sand and shell hash and the East Flower Garden Bank samples were mainly sand. The samples from Stetson Bank were taken in about 50 to 55 meters of water, 28 Fathom Bank Stations averaged about 90 meters and averages of over 100 meters were recorded for both 28 Fathom Bank, southwest peak and East Flower Garden Bank Stations. It appears that the shallower and coarser sediment banks maintain richer and denser benthonic foraminiferan assemblages, with richness and density decreasing with increasing depth of banks.

The second priority banks are much richer (an average of 19.9 species) and maintain a more dense (an average of 105.3 individuals/10 cm^2) benthonic foraminiferan assemblage than do Hospital Rock and Southern Bank (an average of both primary banks of 4.7 species and 37.3 individuals/10 cm^2), in fact one of the greatest number of living species (richness) that we have recorded from the Texas shelf (STOCS and bank studies) was recorded at one of the Stetson Bank stations (31 species). Some of the species found in the second priority banks are different than those of the first priority banks but of greatest interest is the presence of species of the genus Quinqueloculina in greater abundance in the second priority banks. Species of this genus are almost absent in the first priority banks and rarely found in the STOCS area (usually in small numbers in the inner stations). Murray (1973) characterizes this genus as being indicative of inner-shelf sediments in a high energy environments (usually sandy beaches with normal marine salinities). Quinqueloculina is most abundant (somethimes greater than 10% of the fauna, see Figure V-24) in the deeper and more sandy second priority banks (East Flower Garden Bank and 28 Fathom Bank southwest peak) and in fact the dominant species in one of the East Flower Garden Bank samples. The conditions that favor Quinqueloculina are probably "duplicated" on these sandy, deep banks.

These second priority banks contain a more "tropical type" of a benthonic foraminiferan assemblage than do the first priority banks. For example a sample from the East Flower Garden Bank (EFG4) contained live specimens of Archaias, Calcarina and

Planorbulinella all characteristic of tropical coral reefs.

CONCLUSIONS

The first priority banks appear to be quite similar to the surrounding shelf regions. It appears that the higher standing crops of diatoms and ceratiums at the banks are due to obstruction upwelling caused by the presence of the banks. The benthonic foraminiferans do show some differences when comparing the primary banks with the surrounding bottom. These banks possess fewer species and a lower density of benthonic foraminiferan species than do the surrounding sediments. These banks do possess both shallow water and deep water components of benthonic foraminiferans however.

The second priority banks are quite different than the first priority banks in that they possess a much greater richness of species, different species (some of a more tropical nature) and a greater density of benthonic foraminiferans than do the first priority banks.

Of special interest on the second priority banks are living (or more likely very recently dead so that the protoplasm still stained with rose Bengal) shelled microplankton that were found at EFG 4 and 28FS 3 stations in the sediments. These shelled microplankton were mainly planktonic foraminiferans but also included diatoms at both stations and pteropods at 28FS 3. Both of these stations are slightly north of due west of each of these stations, which is "down-current" to the main drift of the stations. This is very interesting because it suggests that the banks are influencing

the plankton by either causing a rapid reproduction of plankton and therefore an abnormally high fall out of living forms, or that they (the banks) have a deleterious effect on at least the shelled microplankton (and presumably other plankton) causing a mass moratility of the plankton as it moves over the banks. Perhaps cause of death is due to the releasing of exmetabolites into the water. These same two stations also possessed greater standing crops of benthonic foraminiferans than did the other bank stations as did station STB 1(which is also just west of a bank). These higher standing crops might represent that the lee side of these banks are a "sink" for organic matter (coming out of the water column due to mortality as mentioned or due to higher standing crops of plankton caused by obstruction upwelling as seen over the primary banks). These preliminary observations should be looked into in detail and, if documented, they should be investigated so that they are not confused with man's possible further pertubations.

Further monitoring of these banks might most economically be done by the use of benthonic foraminiferans (or other bottom dwelling species) as opposed to the use of shelled or general microplankton (or other plankton species) since the benthonic foraminiferans have a longer residence time on, in (infaunal) and around the banks than do the plankton. This is especially true of the second priority banks where silting might increase the number of Bolivina lowmani and decrease the number of Quinqueloculina, or an increase in organic compounds might increase the number of Bolivina lowmani and decrease the general richness of the benthonic foraminiferan fauna.

CHAPTER VI

MEIOFAUNA AND MACROINFAUNA

THE MEIOFAUNA AND MACROINFAUNA FROM SUBMARINE BANKS IN THE GULF OF MEXICO

Principal Investigator: W.E. Pequegnat

Research Associate: W. Sikora

Research Assistant: R. Britton

INTRODUCTION

OBJECTIVES OF THE STUDY

For the most part the exploitation of petroleum and gas reserves beneath the continental shelf of the northern Gulf of Mexico has been concentrated off the Louisiana coast. Prior to initiation of this development in 1927, few studies of the marine biota were carried out in areas now supporting thousands of production platforms. Accordingly, we lack definitive data from which one might be able to make comparisons with present findings, and thereby judge the long-term impacts of mineral recovery processes on the biota of the continental shelf. Faced with a presumed rapid dwindling of domestic reserves of oil and gas at a time when consumption has shown a steady increase, the Government has pressed for more rapid exploitation of reserves off the coasts of all states bordering the Gulf of Mexico. Fortunately, BLM and, to a lesser extent, other agencies (e.g., U. S. Geological Survey) have been given funds to conduct scientific studies prior to exploration for or production of minerals, especially in those areas where little information is available in published form. Increasingly, however, doubts are arising that the studies presently underway (1) are necessary in their entirety, and (2) are yielding information critical to the decision making processes required of the agencies by their charter. In other words, can one actually interpret the data in such a manner as to be confident that proper executive decisions can be made. It seems quite likely that certain studies carried out with a more

penetrating scope could simplify the achieving of agency objectives. There are sound reasons espoused by many scientists competent to judge the case that meiofaunal studies, when properly devised and carried out, can contribute critical data to the achieving of an understanding of basic and subtle environmental impacts. One cogent reason for this view is the fact that, whereas other biotal entities such as fishes, corals, and other epifauna are themselves harvested and otherwise profoundly affected by activities of man not associated with mineral extraction, the meiofauna and, to a lesser extent, the macroinfauna are not.

The principal objective of the present study is to provide some conception of the nature of the meiofauna and macroinfauna of the flanks of four so-called hardbanks, viz., Stetson Bank, East Flower Garden Bank, 28 Fathom Bank, and 28 Fathom Bank, southwest peak, that are located on the outer continental shelf off the Texas coast. It is our belief also that the meiofauna and macroinfauna provide excellent subjects for judging the impacts of sedimental and other environmental changes that will eventuate from discovery and production of oil and gas. It is emphasized again that if this study were to yield critical data, a study of the levels of labile carbon compounds in the sediments should be undertaken.

BACKGROUND

Definitions

The term meiofauna refers to a taxonomically diverse and

numerically abundant assemblage of animals that are further described by their small size. In early studies the meiofauna was separated from the macroinfauna by means of sieves having a mesh opening of 1.0 mm; more recently, however, the upper limit of size is taken as 0.5 mm (McIntyre, 1964; Tietjen, 1969, 1971; Coull, 1970; McIntyre and Murison, 1973; and Gettleson and Pequegnat, 1976). The lower limit has also been variable, but 0.062 mm is now the usual mesh size employed for extraction. Accordingly, the meiofauna in this study is defined by passage through a 0.5 mm and retention on a 62-micron sieve, whereas all other organisms taken by the grab and retained on the 0.5 mm sieve are designated as macrofauna.

Permanent and Temporary Meiofauna

The meiofauna is composed of both a permanent, and more numerically stable set of organisms as well as a temporary, numerically variable group composed of juvenile macroinfaunal forms (McIntyre, 1961, 1964; Thorson, 1966). The permanent or true meiofauna differs from the macroinfauna not only in size, but also in regard to number, average generation time, and morphological adaptations to their environment. Some protozoans meet the size requirements of the meiofauna but, as Thiel (1975) points out, the Foraminifera have been excluded from most investigations on deep water meiofauna. Up to now, the foraminifers are grouped together with the multicellular meiofauna in only three publications (Wigley and McIntyre, 1964; Tietjen, 1971; and Thiel, 1975). There are several reasons for this

deletion, among them being the difficulty of separating live from dead individuals because material in the tests other than protoplasm may stain red with rose bengal. On the basis of numbers alone, it would appear that they should be included in meiofaunal studies. The present study, as well as the work of others (Wigley and McIntyre, 1964; Tietjen, 1971; and Thiel, 1975), shows that the Foraminifera often are either the most numerous group or the second in abundance behind the nematodes.

Even so, in this report, the metazoan meiofauna are placed in the category of "true" meiofauna (all of which are permanent) and the Foraminifera and temporary meiofauna are lumped into a second category.

The Macroinfauna

The macroinfauna is characterized by two factors, namely, size and biotope within the substratum. As indicated above, these organisms are upwards of 0.5 mm in length or diameter. For the most part, infaunal organisms live burrowed or buried in sediments. Some may live only partially buried at the water/sediment interface. By contrast, those animals that live on the surface of either hard or soft bottoms constitute the epifauna. Both the macrofauna and the meiofauna have some infaunal and epifaunal components.

Previous work

As Thiel notes, effective work on offshore meiofauna was

started as late as 1964 when Wigley and McIntyre (loc. cit.) obtained quantitative samples from a transect on the North American Atlantic shelf and down the continental slope to about 600 m. In addition, quantitative samples were taken from slope to abyss by McIntyre from DISCOVERY (Warwick, 1973) and by Thiel from METEOR (Thiel, 1966) both in 1964/1965 in the Arabian Sea.

The meiofauna has received very little attention in the sublittoral of the Gulf of Mexico. Pequegnat and Gettleson (1974) listed the number of individuals in major meiofaunal and macroinfaunal taxa from five stations in the vicinity of Stetson Bank. In 1976, they examined meiofaunal-sediment correlations from 24 stations located on the outer continental shelf of south Texas. Gettleson and Pequegnat (1976) reported on an intensive study of the wet weight and abundance of the meiofauna and macroinfauna taken from 10 stations on the outer continental shelf of east Texas. Prior to this report, there have been only a limited number of sublittoral studies in which the wet weight and/or abundance of the meiofauna and macroinfauna have been compared. Krogh and Spärck (1936) described the fauna contained within several cores taken in Copenhagen Harbor; Mare (1942) examined the flora and fauna of a small area in the English Channel; Sanders (1958) examined the macroinfauna and Wieser (1960) the meiofauna of three stations in Buzzards Bay, Massachusetts; McIntyre (1961, 1964) studied two areas off Scotland (Loch Nevis and Fladden Ground, North Sea); Wigley and McIntyre (1964) analyzed ten samples from a transect (40 to 567 m off Massachusetts); Guille and Soyer (1968, 1974) studied the fauna off the French Banyuls-sur-Mer coast (Mediterranean); Stripp (1969)

examined samples from the Helgoland Bight (North Sea); Ankar and Jansson (1973), Elmgren (1972), Ankar and Elmgren (1975), and Jansson and Wulff (1977) analyzed samples from the Baltic Sea.

Nematodes usually dominate the meiofauna; however, their systematics and ecology have been neglected to a great extent. Only six known papers have been published on Gulf of Mexico nematology, and all of the material was from the littoral zone (Chitwood, 1951; Chitwood and Timm, 1954; Hopper, 1961a, 1961b, and 1963; King, 1962). Hulings (1967) reviewed previous papers dealing with the systematics and ecology of podocopid and platycopid ostracods in the Gulf of Mexico. Disregarding the foraminiferans, no other published reports on the components of the permanent meiofauna of the sublittoral Gulf are known. There are, however, a number of papers describing the living, soft-bottom foraminiferans of the Gulf. Phleger's (1951) study dealt with an area similar to that of the present study, but his total number of identified living forms was very low (16) due to the unreliable biuret test used to distinguish living from dead individuals. Phleger (1956) used the more accurate rose bengal method to detect living forams. Walton (1964) in a study of the central Texas coast and continental shelf was able to discriminate among four depth-related assemblages on the shelf. Other foraminiferal studies in the Gulf of Mexico have also resulted in depth-related biofacies. Phleger (1951) recognized six depth facies, Bandy (1954) three within water depths of 8 to 37 m, Parker (1954) six in the northeast Gulf, and Bandy (1956) described five major facies also in the northeast Gulf. Phleger (1960) reviewed much of the Gulf of Mexico foram work. Other studies of

living, sublittoral, Gulf of Mexico foraminiferal distributions since 1960 include Walton (1964), Loep (1965), Lankford (1966), Greiner (1970), Poag and Sweet (1972), and Buzas (1967, 1972).

According to Valentine (1963), Pulley (1952) divided the Atlantic and Gulf coasts into eleven provinces based on macroinfaunal pelecypod distributions that were correlated with mean maximum and minimum land temperature differences. Pulley proposed four biotic provinces within the Gulf, and the present study area is included within his "Offshore West Indian Province." Parker (1960) sampled the molluscan macroinfauna of the Texas-Louisiana shelf and utilizing the climatic zones proposed by Hedgpeth (1953) in addition to physical boundaries (e.g., sediment type), he divided the area into five provinces. The "West Louisiana" province encompassed the longitude of the present region of study, but Parker's provinces generally extended to only twenty meters of depth. Parker (1975) presented a schematic diagram of the Gulf of Mexico that included the climate, hydrography, sediment, and measures of benthic community structure such as species diversity. He divided the Gulf into six major areas, but only on the basis of data collected from bays and estuaries.

Hulings (1955) established a transect of 51 stations that extended from the shore near Sabine Pass, Texas to a point approximately 28 kilometers seaward. Water depth along the transect did not exceed twenty meters. Grabs, dredges, and coring gear were utilized for sample collection. Two hundred and twelve species were identified and 72% were mollusks, most of which were dead. The sampling methods allowed only qualitative interpretation of the data,

and while assemblages were not specifically determined the data could have been interpreted in such a manner.

Parker (1956) sampled 280 stations that were located within the east Mississippi Delta region, using an orange-peel bucket grab as well as several dredges and trawls. Three hundred and fourteen species were identified of which greater than 70% were mollusks. He described seven assemblages that ranged from the delta marshes to the inner and outer continental shelf and were based on the predominantly dead mollusks. The outer shelf assemblage was described as "distinct," but of the 122 species identified only 17% were living at the time of collection.

Kennedy (1959) collected samples at 18 stations along a transect that extended across the continental shelf from a point near shore that was midway between Galveston Bay and Sabine Lake. His Stations 14 and 15 were within the present area of investigation. He identified 245 species of mollusks from dredge samples. The species were divided into three major assemblages: a shallow shelf group, a deep shelf biofacies, and a transitional zone at intermediate depths. Of the 170 species occurring on the deep shelf, 62% were restricted to that assemblage. One hundred species were listed as characteristic of the assemblage, but only two were alive when collected. The author stated that the three major assemblages might easily be subdivided into smaller groups. The deepest of the 18 stations was, it seemed to Kennedy, distinct from the remainder of the outer shelf assemblages.

Parker (1960) collected 300 samples on the continental shelf and upper slope off Mobile, Alabama to Port Isabel, Texas. Sampling

gear included van Veen and orange-peel grabs, dredges, and trawls. Samples were washed through a 1.0 mm mesh screen. Though no precise positions were given for the stations, it appears that two or three of the stations may have been within the present sampling area. Four soft bottom shelf assemblages were recognized by Parker as follows: inner shelf, intermediate shelf, outer shelf, and pro delta. Parker (1960) showed that the intermediate shelf assemblage was actually composed of two distinct faunal groups, one existing within silt-clay bottoms and the other within sandy bottoms. However, the two groups had enough forms in common to be considered a single assemblage by Parker. The assemblages were composed of mainly dead mollusks as only 37 living individuals were encountered in 13 samples collected from depths of 37 to 73 meters. Because so few living individuals were collected, Parker correctly stated that it would be impossible to locate exact boundaries for the assemblages.

Neumann (1958) in a primarily geological study of Stetson Bank, which lies within the study area, identified mostly dead mollusks that were obtained by washing the contents of a van Veen grab through a 0.635 mm screen. He proposed an "on-bank" and an "off-bank" assemblage of the mollusk species.

Keith and Hulings (1965) reported major differences in the species composition of the fauna inhabiting sand and mud bottoms. The samples were collected in approximately two meters of water in an area from Sabine Pass to Bolivar Point.

Harper (1970), utilizing a dredge, collected seasonal samples from water depths of three to eleven meters in an area off Galveston

Island. The samples were washed through a 1.0 mm mesh sieve and 64 species were identified from the sandy, mixed, and muddy sediments. Harper used numerical dominance and restricted substrate preference to delineate certain species groups that were characteristic of the three bottom types. He found that Parker's (1960) inner shelf assemblage should have been subdivided into three more natural groups that corresponded to the sediment types in the Galveston area, viz., Sandy Bottom, Muddy Bottom and Mixed Bottom.

Based on the analysis of 146 trawl samples collected primarily on the shelf of the northern Gulf of Mexico, Defenbaugh (1976) established twelve faunal assemblages on the shelf and upper slope of the northern Gulf of Mexico. Defenbaugh established inner, intermediate, and outer shelf assemblages, dividing them longitudinally into Louisiana-Texas and West Florida shelf portions. In addition, he established a pro-delta fan and sound assemblages and two submarine bank assemblages, again subdividing them into Louisiana-Texas and West Florida shelf units, as he does the upper slope assemblage.

Holland (1977), by the use of cluster analysis, found, on the south Texas continental shelf, three faunal zones, shallow, mid-depth and deep station zones, which shifted slightly seasonally. However, he considered the mid-depth station zone to be a depauperate extension of the shallow faunal assemblage because it has no unique species but shared many species unique to the shallow zone as well as ubiquitous species from both shallow and deep zones. Sediment type was also considered; however, the cluster analysis indicated that depth, or the more stable physical environment associated with depth, was

more important than substrate in regulating infaunal distribution over wide areas of the shelf.

Conversely, Holland (op. cit.) found at two bank locations two basically different sediment types in near bank area to which he ascribes considerable impact on infauna. One type, a primarily shelly bottom, was found at two stations located on the southwestern side of Hospital Rock and Southern Bank, which had large amounts of gravel-sized rubble and shell material. The other sediment type found at the remaining near bank stations was silt/clay. The communities at the shelly stations were found to be different in species composition, much more diverse and contained far greater numbers of individuals than the silt/clay stations. The silt/clay stations on the other hand were comprised of the more ubiquitous species found in the STOCS area and the general community structure was not significantly different than that expected of normal soft-bottom communities of the Gulf.

METHODS AND MATERIALS

SAMPLING STATIONS

Both the meiofaunal and macroinfaunal samples were collected by means of a Smith-McIntyre grab that encompasses 0.1024 m^2 of the bottom. Two studies (Smith and Howard, 1972; Dickinson and Carey, 1975) have shown that the Smith McIntyre grab is a reasonably effective sampler of the macroinfauna living in the upper 5 or so centimeters of the sediments. Because a very high percentage of the meiofauna

occur in this stratum, the grab is an even more efficient sampler of this group.

Four sampling stations were established on each of the four banks, i.e., Stetson, East Flower Gardens, 28 Fathom and 28 Fathom, southwest peak Banks. Attempts were made to establish both upstream and downstream stations, but this was not entirely successful, as will be discussed later. On the basis of the limited data available, it was assumed that the principal flow of bottom water was to the southwest. The stations were sampled only on one occasion, in August and early September of 1976.

Sample Processing

On deck all meiofauna samples were taken from the grab by means of a plexiglass core tube of 3.42 cm diameter (internal area = 9.187 cm^2) that was pushed into the sediment to a depth of 5 cm. Four such cores were taken and the enclosed sediment was extruded into 8 oz. glass jars. One sample was frozen immediately. The remaining three samples were anesthetized in isotonic $MgCl_2$ for 10 minutes and then placed in 10 % buffered formalin. Only two of the three samples were to be sorted and these received rose bengal in the formalin.

Six grab samples for macroinfauna were taken at each station. The entire contents of each grab was sieved aboard ship. A small amount of sediment was taken immediately from all samples for grain size analysis. The remainder of the sediment was then washed through a series of nested sieves (6.35, 1.0, and 0.5 mm). The material on each sieve was placed immediately in 0.15 % propylene phenoxetol for 15 minutes to anesthetize the organisms. They were then transferred

to 7% buffered formalin.

In the laboratory the stained meiofauna samples were sieved through 8-inch diameter 500 and 62 micron mesh sieves. The material retained on the smaller sieving was washed into 2 oz. squat jars with 10% buffered formalin, to which 10 ml of rose bengal in formalin (200 mg/l) was added. After the sample had been allowed to stain for between 24 and 48 hours, it was washed in a 3-inch diameter, 62-micron sieve to remove excess stain and then aliquoted into an 80 x 40 mm rectangular sorting dish marked off in a 7 mm square grid. The whole sample was then examined microscopically and the sorted animals placed in vials. When the number of nematodes exceeded 150, the 150 were vialed and the remainder were only counted and archived.

The macroinfauna samples were sugar floated with a saturated water-sugar solution in order to obtain the lighter organisms promptly. The sediment mixture was then stained with rose bengal and again sorted for bivalves and those animals not recovered during flotation. Finally, the remaining material was examined microscopically for extraction of the smallest organisms.

RESULTS

NUMERICAL DOMINANCE AMONG MEIOFAUNA TAXA

Nematodes are the dominant true meiofauna group on all of the hard banks studied, averaging 63% of the total individuals per station (Appendix II, Table VI-1) or about 160,300 individuals per m^2 of surface

sampled to a depth of 5 cm. The harpacticoid copepods are a poor second averaging 19% of the total individuals or 48,300 individuals per m^2 of surface sampled to a depth of 5 cm. Excluding the nauplii, the kinorhynchs are third in importance, but they range from a high of 14,150 individuals per m^2 on shallow banks (Stetson) to a low of $540/m^2$. In general, the nematodes form a smaller percentage and the harpacticoids and kinorhynchs a higher percentage of the total meiofauna of banks than they do of the level bottom stations on transects. For instance, Pequegnat (1976) found nematodes to average over 89% of the meiofauna populations on level bottoms off Corpus Christi, Texas, whereas harpacticoids averaged only 2.25%.

The foraminiferans and polychaetes are the numerically dominant groups among the other meiofauna (Appendix II, Table VI-1). On Stetson Bank only, the peracarid crustacea are third in numbers. All groups are substantially less abundant on the deeper banks.

MEIOFAUNA POPULATIONS

Total Populations of Banks

Considering all taxa of the true meiofauna, Stetson Bank stations yielded the highest number of individuals and 28 Fathom Southwest Bank the smallest number (Table VI-1). When the temporary meiofauna were included, 28 Fathom Bank had the smallest number of individuals by a small margin. Actually, except for Stetson Bank, the values are remarkably close. Very likely, depth is a major factor in that Stetson Bank rises from the shelf at a depth of about

57 m, whereas the others rise from 110 m.

TABLE VI-1

A. THE MEANS OF INDIVIDUALS OF TRUE MEIOFAUNA (ADJUSTED TO 10 CM^2) TAKEN AT FOUR BANK STATIONS.

B. SIMILAR DATA FOR FORAMINIFERA AND TEMPORARY MEIOFAUNA

SAMPLING PERIOD	BANK			
August 1976	Stetson	East Flower Garden	28 Fathom	28 Fathom, SW Peak
A. True Meiofauna	528	181	141	139
B. Other Meiofauna	219	22	35	57
TOTALS	747	203	176	196

The Upcurrent-Downcurrent Effect on Populations

Results of our population studies have led us to assume that the bottom current in this region is flowing primarily to the southwest. Based on this assumption, both Stetson Bank and East Flower Garden show definitely higher meiofaunal populations downstream of the bank proper than upstream (Table VI-2). Unfortunately, the 28 Fathom-28 Fathom, southwest peak, complex, due to positioning of the stations, does not lend itself to clear upstream-downstream analysis. Nevertheless, it appears likely that the downstream increases observed on Stetson Bank and East Flower Garden result from inputs of organic materials from the epifauna on the reef tops. This is compatible with our previous observation that harpacticoid populations may be positively correlated with organic content of sediments. Note in

Table VI-2 that harpacticoid populations are significantly higher at downstream stations than upstream stations on Stetson Bank and East Flower Garden. The effect is particularly evident on the shallower reef (Stetson), since harpacticoids tend to avoid deeper waters.

TABLE VI-2

SUMS OF TOTAL MEIOFAUNA (MEANS OF REPLICATE SAMPLES ADJUSTED TO 10 CM^2) AT UPCURRENT AND DOWNCURRENT STATIONS HARPACTICOID COPEPOD POPULATIONS IN PARENTHESES

STETSON BANK		EAST FLOWER GARDEN BANK	
UPCURRENT	DOWNCURRENT	UPCURRENT	DOWNCURRENT
1. 117 (8)	2. 1015 (163)	2. 48 (1)	1. 211 (3)
3. 777 (74)	4. 1080 (371)	3. 18 (0)	4. 535 (38)
894	2095	66	746

Comparison of Bank and Level Bottom Meiofauna

In order to make a meaningful comparison between the bank and level bottom meiofauna populations, two factors must be taken into account. Pequegnat and Sikora (1977) have demonstrated marked seasonal variations in meiofaunal populations on the shelf with large populations present in August. Also, it is now well established by the senior author that depth is a major factor in meiofauna distribution. Accordingly, since the bank samples were taken in August-September, it is necessary to limit the comparison to level bottom samples taken in the same period and at the same depth. The shelf surrounding Stetson Bank has a depth of about 57 m; the closest station depth on Transect II (of the South Texas Outer Continental

Shelf Baseline Study) is that of Station 2 at a depth of 49 m. The shelf area where the rest of the banks are located (East Flower Garden, 28 Fathom and 28 Fathom Bank, southwest peak) lies at a depth of about 110 m. The closest match on Transect II is Station 6 at a depth of 98 m.

In each case, the mean population values for each bank (mean of stations on the bank) were higher than that of the comparable shelf station (Tables VI-3 and VI-4). The tables also show that all bank station means for total meiofauna were higher than comparable shelf means for total meiofauna except two, Stetson Bank 1 (Table VI-3) and East Flower Garden 3 (Table VI-4).

TABLE VI-3

MEAN MEIOFAUNA POPULATION VALUES AT FOUR STATIONS ON STETSON BANK COMPARED WITH THE MEAN OF TWO REPLICATES FROM STATION 2 OF TRANSECT II (OFF CORPUS CHRISTI, TEXAS). ALL SAMPLES COLLECTED IN AUGUST 1976. CORRECTED TO 10 CM^2, 5 CM DEEP.

STETSON BANK				SHELF TRANSECT II
STATIONS				STATION 2
1	2	3	4	
117	1015	777	1080	201

Station 1 is well off the reef and in a position where a southwesterly current would not bring much organic detrital material to it from reef sources. Thus, it is particularly noteworthy that harpacticoid copepods average only 8 individuals per 10 cm^2 at Station 1, as compared with about 370 at Station 4 in a direct line downstream of the shallowest parts of the reef or bank.

TABLE VI-4

MEAN MEIOFAUNA POPULATION VALUES AT STATIONS ON THREE BANKS COMPARED WITH THE MEAN OF TWO REPLICATES FROM STATION 6 OF TRANSECT II (OFF CORPUS CHRISTI, TEXAS). ALL SAMPLES COLLECTED IN AUGUST 1976. CORRECTED TO 10 CM^2, 5 CM DEEP.

BANK	STATIONS					SHELF TRANSECT II
	1	2	3	4	$\bar{x}$	STATION 6
East Flower Garden	211	48	18	535	203	29
28 Fathom	177	194	158	---	176	29
28 Fathom, sw peak	162	261	90	272	196	29

Here again, we see that the bank meiofaunal populations are substantially larger, by a factor of 7, than those of the adjacent level bottom. It is noteworthy, however, that the most significant increase is accounted for by the harpacticoids. For instance, the highest count of harpacticoids on Stetson Bank was 558 per 10 cm^2 at Station 4, whereas it was 9 per 10 cm^2 at Station 2 on Transect II. In like manner, the highest counts of harpacticoids per 10 cm^2 on East Flower Garden, 28 Fathom, and 28 Fathom, southwest peak, were 47, 55, and 124, respectively, as compared with 1 per 10 cm^2 at Station 6 on Transect II at comparable depths.

Harpacticoid:Nematode Ratio

The ratio of harpacticoids to nematodes differs markedly between the banks and the corresponding shelf stations:

		Station 2, Transect II
Stetson Bank	0.56	0.07

		Station 6, Transect II
East Flower Garden	0.11	0.03
28 Fathom Bank	0.23	0.03
28 Fathom Bank, sw peak	0.42	0.03

The ratio for the five stations of Transect II, which range in depth from 22 to 98 m, is 0.09, indicating again that harpacticoids are shallow water organisms and that they are much more abundant around banks than on level bottom.

NUMERICAL DOMINANCE AMONG MACROINFAUNAL TAXA

The numerically dominant macroinfauna groups differ somewhat among the four banks (Table VI-5 and Appendix II, Table VI-5).

TABLE VI-5

THE FIVE MOST ABUNDANT MACROINFAUNA TAXA ON EACH BANK

Taxon	Average Number of Individuals per Grab	Average Number Of Individuals per m^2
	STETSON BANK	
Polychaeta	71.04	694
Bivalvia	22.46	219
Sipunculida	22.21	217
Tanaidacea	4.83	47
Gammaridea	4.75	46
	EAST FLOWER GARDEN BANK	
Polychaeta	13.00	127
Ostracoda	8.88	87
Nematoda	8.32	81
Sipunculida	8.13	79
Bivalvia	2.84	28

28 FATHOM BANK

Polychaeta	81.34	795
Sipunculida	49.89	487
Nematoda	28.17	275
Ostracoda	15.50	151
Copepoda	9.00	88

28 FATHOM BANK, SOUTHWEST PEAK

Polychaeta	73.25	716
Sipunculida	34.04	333
Bivalvia	13.83	135
Copepoda	5.50	54
Tanaidacea	4.59	45

Thus, the numerical rank order of the macroinfaunal organisms of the four banks is:

	Frequency of Dominance x Average/Grab
1. Polychaeta	1193
2. Sipunculida	371
3. Bivalvia	78
4. Nematoda	55
5. Ostracoda	37
6. Copepoda	11
7. Tanaidacea	7
8. Gammaridea	1

This is essentially the same ranking on Stetson Bank established earlier by Pequegnat and Gettleson. The polychaetes exceed the sipunculids in abundance by a factor of 3.2 and the latter exceed the bivalves by a factor of 4.8. Some 90% of the individuals of the macroinfauna species on these banks are accounted for by first four groups. This is a normal expectation for soft bottom assemblages.

MACROINFAUNAL POPULATIONS

Total Populations of Banks

Considering all taxa, 28 Fathom Bank yielded the highest number of individuals per 0.1 m^2 and East Flower Garden Bank the smallest number (Table VI-6).

TABLE VI-6

THE MEAN NUMBER OF INDIVIDUALS PER 0.1 M^2 OF MACROINFAUNA TAKEN AT FOUR BANK STATIONS BY MEANS OF THE SMITH-MCINTYRE GRAB DURING AUGUST 1976

STATION	BANK			
	STETSON	EAST FLOWER GARDEN	28 FATHOM	28 FATHOM, SW PEAK
1	127.33	31.67	23.83	154.00
2	231.67	19.17	74.83	261.67
3	85.33	23.83	523.67	99.17
4	150.33	100.67	------	99.50
TOTAL	594.66	175.34	622.33	614.34
$\bar{x}$	149	44	207	154

Compared with the meiofauna, two facts stand out immediately: (1) depth is apparently not a major factor controlling the size of macroinfaunal populations, since the populations of Stetson Bank are essentially the same size as those of 28 Fathom and 28 Fathom, southwest peak, and (2) the populations of the flanks of East Flower Garden Bank are unexpectedly low. The substantial differences in numbers among the stations appear to be related to the position of the station on the reef in relation to the direction of the bottom current.

The Upcurrent-Downcurrent Effect on Populations

All four banks show definitely higher macroinfaunal populations downstream of the bank proper than upstream (Table VI-7).

It seems likely that the larger macroinfaunal populations at the downcurrent stations can be attributed to enrichment of the sediments with organic detritus, as in the case of the harpacticoids of the meiofauna. Unfortunately, we have not been granted the opportunity to investigate the labile carbon compounds in the sediments.

Taxonomical Considerations

Nematoda. Ninety-eight taxa of nematodes were found on the flanks of the four banks. At least five of these represent new genera and an undetermined number of new species. 28 Fathom Bank has the most abundant and diverse nematode assemblage, having 55 taxa and a large number of individuals. 28 Fathom Bank, southwest peak had the smallest group, having some 30 taxa and only 74 individuals. Second place was mixed, since Stetson Bank had 47 taxa with 232 individuals and East Flower Garden Bank had 40 taxa with 268 individuals.

The four banks are characterized by different predominant taxa (see also Appendix II, Table VI-9).

TABLE VI-7

MEAN MACROINFAUNA POPULATIONS FROM SIX 0.1 M^2 GRABS PER STATION ARRANGED ACCORDING TO UPCURRENT OR DOWNCURRENT POSITION ON THE REEF SMITH-McINTYRE GRABS IN AUGUST 1977.

STETSON BANK		EAST FLOWER GARDEN BANK		28 FATHOM BANK		28 FATHOM BANK, SOUTHWEST PEAK	
Upcurrent	Downcurrent	Upcurrent	Downcurrent	Upcurrent	Downcurrent	Upcurrent	Downcurrent
1. 127.33	2. 231.67	2. 19.17	1. 31.67	1. 23.83	3. 523.67	3. 99.17	1. 154.00
3. 85.33	4. 150.33	3. 23.83	4. 100.67	2. 74.83	------	4. 99.50	2. 261.67
212.66	382.00	43.00	132.34	98.66	523.67	198.67	415.67

28 Fathom Bank		28 Fathom Bank, sw peak
1. *Mesacanthoides*		1. *Tricoma*
2. *Chromaspirina*		2. *Richtersia*
3. Stilbonematids		3. *Acanthopharynx*
4. *Sabatieria*		4. *Phanodermopsis*
5. *Epacanthion*		5. *Zalonema*
TOTAL TAXA	55	30
UNIQUE TAXA	18	3

Stetson Bank		East Flower Garden
1. *Viscosia*		1. *Sabatieria*
2. *Spilophorella*		2. Stilbonematids
3. *Sabatieria*		3. *Epacanthion*
4. *Perspira*		4. *Phanodermopsis*
5. *Quadricoma*		5. *Richtersia*
TOTAL TAXA	47	40
UNIQUE TAXA	13	10

Polychaeta. As noted elsewhere in this report (e.g., Table VI-5), the polychaetes were the predominant macroinfaunal group found on the flanks of the banks. However, the polychaetes did not exhibit as much of a difference between upstream and downstream stations as was true of, say, the nematodes. For instance, on Stetson Bank a total of 96 polychaete taxa was found at the upstream versus 98 at the downstream stations. The number of individuals was also close, being 407 at upstream versus 409 at the downstream stations.

The numerically dominant polychaete species were (for a more complete list of polychaetes, see Appendix II, Table VI-10):

Lumbrineris parvapedata
Paraonis gracilis
Notomastus hemipodus
Notomastus latericeus
Maldane sarsi
Lumbrineris coccinea
Aedicira bebgicae
Magelona rioja
Dodecaceria dicera
Nephtys picta

Non-selective deposit feeders tended to predominate followed by predators, omnivores, and selective deposit feeders.

It is interesting to compare the polychaete assemblages away from the banks (Hubbard, 1977) with those on the flanks. Hubbard found that level bottoms west of Claypile Bank, for example, had somewhat more abundant and diverse polychaete assemblages than those that we found around Stetson Bank at a similar depth. And, although the two areas shared many species, the number of species not found at the banks was substantial. Interestingly, many of these were selective deposit feeders.

Cumacea. The cumacean fauna of the banks is very diverse. Some 21 species in 9 genera were found in the bank samples. Apparently all but three of these are undescribed species (Table VI-8). Also, two of the genera have not been previously recorded from the Gulf of Mexico (viz., *Leucon* and *Pseudoleucon*).

TABLE VI-8

THE DISTRIBUTION OF TAXA OF CUMACEA AMONG THE BANKS

SPECIES	EFG				STETSON				28F (SW)				28F		
Stations	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
Cumella clavicauda										X					X
Cumella sp. B															
Cumella sp. C															
Cumella sp. D			X			X							X	X	
Cumella sp. E					X	X		X							
Cumella sp. F						X	X	X		X					
Cumella sp. G												X			
Cumella sp. H						X									
Vaunthompsonia minor						X		X							
Vaunthompsonia sp. B			X		X	X	X					X			X
Vaunthompsonia sp. C		X													
Eudorella sp. A						X	X				X				X
Diastylis sp. A						X		X							
Makrokylinrus sp. A						X									
Makrokylinrus sp. B											X				
Cyclaspis cf. *unicornis*														X	X
Cyclaspis sp. G						X									
Campylaspis sp. C			X				X								
Campylaspis sp. D	X		X						X			X			X
Campylaspis sp. E								X							
Campylaspis sp. F			X									X			X
Leucon sp. A	X		X			X			X		X	X			
Pseudoleucon sp. A									X					X	
Campylaspis spp.										X					
Cumella spp.						X				X					
Bodotriidae A	X														
Total Number of Individuals	14				103				47				36		
Total Taxa	8				14				13				8		

With the exception of *Eudorella monodon* described from Grand Isle, no leuconids have been reported from the Gulf of Mexico. *Leucon* sp. A appears to be most closely related to an Atlantic coast species. The overall composition of the hard banks cumacean assemblages seems to be unique. Some species occur in the eastern Gulf as well as the Atlantic coast but others, particularly the nannastacids and leuconids have not been reported from either.

Two very distinct apparently undescribed species of the genus *Makrokylinrus* are present on 28 Fathom Bank, southwest peak and Stetson Bank. Also, the fact that a new species of *Diastylis* was taken from Stetson Bank is interesting in that the family Diastylidae is abundant in colder waters but is only occasional in tropical or subtropical areas.

The genus *Cumella* is a large one with several species described from the Gulf of Mexico and Caribbean, but the six species other than *C. clavicauda* are undescribed.

Amphipoda. Twenty-six taxa of amphipods were collected from the flanks of the banks. Twenty-one of these were found at Stetson Bank and only five at East Flower Garden (Table VI-9).

The above species may be categorized into four ecological groups based upon their habitat, as follows:

Burrowers (soft bottom): *Heterophoxus, Photis,* Lysianassidae, *Monoculodes, Synchelidium, Aora, Unciola*

Epiphytic (hard bottom, but may not be extensive): *Carinobatea, Ceradocus, Stenothoe, Maera, Lembos*

TABLE VI-9

AMPHIPOD CRUSTACEANS COLLECTED AT THE BANK STATIONS
NUMBERS ARE TOTAL OF INDIVIDUALS

TAXA	STETSON BANK	28-FATHOM BANK	28-FATHOM, SW PEAK	EAST FLOWER GARDEN
Heterophoxus oculatus	57	1	2	1
Ampelisca verrilli	9	0	3	0
Ampelisca agassizi	11	0	0	3
Ampelisca abdita	4	0	6	0
Ampelisca venetiensis	4	2	0	0
Synchelidium americanum	3	2	0	0
Monoculodes edwardsi	7	0	0	0
Leucothoe spinicarpa	17	0	0	0
Ceradocus sheardi	3	0	8	1
Carinobatea carinata	10	3	0	0
Colomastix pusilla	3	0	0	0
Colomastix n. sp.	5	0	0	0
Stenothoe gallensis	1	0	0	0
Photis sp. B	1	0	3	0
Listriella n. sp.	2	1	0	0
Aora sp.	2	5	0	0
Seba n. sp.	1	0	0	0
Lembos sp.	1	0	1	0
Corophidae	7	9	8	0
Lysionassidae	3	0	0	4
Unknown amphipod	1	0	0	0
Ampelisca sp.	0	2	0	0
Oedicerotidae	0	1	0	0
Unciola irrorata	0	0	18	1
Maera sp.	0	0	2	0
Liljeborgia n. sp.	0	0	1	0
TOTAL INDIVIDUALS	152	26	52	10
TOTAL TAXA	21	9	10	5

Inquilines (sponges, ascidians, polychaete tubes): *Listriella* - polychaete tubes, *Leucothoe spinicarpa* - sponges, ascidians, *Colomastix pusilla* - sponges, *Seba* - sponges, ascidians

Tube builders on soft bottoms: *Ampelisca*

Isopoda. Twenty-four taxa of isopods were collected from the flanks of the four banks, including two new genera and eight new species. Seventeen species were recorded from 28 Fathom Bank and again, as with other crustacean, East Flower Garden had the least with only five species (Appendix II, Table VI-11).

Tanaidacea. Tanaid research in the Gulf of Mexico is in its infancy and the present study has added substantially to the body of knowledge. Four of the species of *Apseudes* and the species of *Kalliapseudes* are undescribed. The genus *Typhlotanais* and *Metapseudes* were previously represented by single specimens each. Twelve tanaid taxa were collected, eleven of which were collected from Stetson Bank. East Flower Garden had the lowest total number of individuals and only four taxa while 28 Fathom Bank, southwest peak had only three taxa (Appendix II, VI-12).

Decapoda. The information on the decapod crustaceans found on the banks is summarized in Table VI-10. It was impossible to identify the majority to species because, for the most part, they were immature.

TABLE VI-10

DECAPOD CRUSTACEANS COLLECTED AT THE BANK STATIONS
NUMBERS ARE TOTALS OF INDIVIDUALS

TAXA	STETSON BANK	28-FATHOM BANK	28-FATHOM, SW PEAK	EAST FLOWER GARDEN
Leptochela bermudensis	4	53	29	1
Automate evermanni	10	7	10	2
Callianassa marginata	23	7	1	10
Callianassa latispina	1	0	2	3
Callianassa mirim	1	0	0	0
Callianassa batei	1	0	0	0
Callianassa sp.	1	3	0	1
Upogebia offinis	1	1	0	0
Synalpheus townsendi	4	0	1	0
Processa sp.	3	1	0	1
Galathea rostrata	2	0	0	0
Heterocrypta sp.	1	0	0	0
Chasmocarcinus	0	0	1	0
Pinnixia sp.	1	0	0	0
Leucosiidae	1	0	0	0
Goneplacidae	28	2	4	0
Ocypodidae	1	0	0	0
Darippidae	0	2	4	0
Majidae	0	0	1	0
Paguridae	136	17	10	0
Axiidae	10	2	0	0
Diogeninae	2	0	0	0
Ocypodidae	1	0	0	0
Palaemonida	2	0	1	0
TOTAL INDIVIDUALS	234	95	64	18
TOTAL TAXA	20	10	11	6

Nevertheless, the same general patterns of diversity and relative abundance among the banks are observed in this group as in the others. Stetson Bank exceeds all others in both categories, whereas East Flower Garden Bank has the most depauparete fauna.

Comparison of Bank and Level Bottom Macroinfauna

As in the case of the meiofauna, the macroinfauna on balance shows larger populations on the flanks of the hard banks than on the level bottoms of the adjacent continental shelf. However, the differences are not as marked; and, indeed, more bank stations have mean population values lower than that of the Transect II station of comparable depth. Here again, Stetson Bank stations, averaging about 57 m in depth, are compared with Station 2 values from 49 m. The values from the other three banks are compared with Station 2 values from 49 m. The values from the other three banks are compared with Station 5 at 98 m. In Table VI-11 the mean of the bank station averages are compared with the transect station, whereas in Table VI-12, the station values are presented individually.

In Table VI-11 we see that, in general, bank stations gave higher populations than the depth-equivalent transect station. It is noted, however, that those of East Flower Garden and Station 6 are essentially equal.

TABLE VI-11

THE MEAN OF THE AVERAGES OF SIX SMITH-McINTYRE GRABS FROM FOUR STATIONS ON (A) STETSON BANK AND (B) FROM FOUR STATIONS EACH ON EAST FLOWER GARDEN AND 28 FATHOM SOUTHWEST PEAK AND THREE FROM 28 FATHOM BANK COMPARED WITH LEVEL BOTTOM SAMPLES. SAMPLED IN AUGUST 1976. AREA = 0.1024 M^2.

MEAN OF POPULATION MEANS OF SIX GRABS		
BANK	MEAN	TRANSECT MEAN
		STATION 2
STETSON BANK	149	77
		STATION 6
EAST FLOWER GARDEN	44	42
28 FATHOM	207	42
28 FATHOM SW PEAK	154	42

TABLE VI-12

MEAN MACROINFAUNAL POPULATION VALUES AT FOUR STATIONS ON STETSON BANK COMPARED WITH THE MEAN OF SIX REPLICATE GRABS FROM STATION 2 OF TRANSECT I (OFF CORPUS CHRISTI, TEXAS). AVERAGE DEPTH OF BANK STATIONS, 57 m; STATION 2 DEPTH = 49 m. AREA = 0.1024 m^2.

A. STETSON BANK				SHELF TRANSECT II
STATIONS				
1	2	3	4	STATION 2
Upcurrent	Downcurrent	Upcurrent	Downcurrent	
127	232	85	150	77

B. THE SAME FOR THE STATIONS ON OTHER BANKS

BANK	STATIONS				SHELF TRANSECT II
EAST FLOWER GARDEN	1	2	3	4	STATION 6
EAST FLOWER GARDEN	32	19	24	101	42
28 FATHOM BANK	24	75	524	---	42
28 FATHOM SW PEAK	154	262	99	100	42

DISCUSSION

QUANTITATIVE COMPARISONS TO OTHER INVESTIGATIONS

In addition to sampling and processing differences, the magnitude of seasonal variations in benthic populations should be recognized when comparisons are made between different investigations. In this study the community was examined at a single temporal point (Aug.); and, therefore, the full extent of time dependent variation is not known. However, August could well be nearer a high point than a low point in view of the fact that Pequegnat and Sikora (1977) have demonstrated that July-August is a peak period for meiofaunal populations at similar and at deeper depths on the Texas continental shelf. Also, the results in Figures VI-1 through VI-4 show large numbers of small macroinfaunal individuals, many of which are juveniles. There are no known published results for seasonal studies of the macroinfauna on the middle and outer shelf of the Gulf, although Lie (1968), Lie and Evans (1973), Buchanan and Warwick, (1974), and Watling and Maurer (1975) indicated for other places seasonal changes in macroinfauna abundance at depths similar to those of this study.

Meiofauna

Tietjen (1969, 1971), Coull (1970, 1973), and McIntyre (1969, 1971) have published summaries of sublittoral meiofauna abundances in various regions. These and other studies revealed that meiofaunal

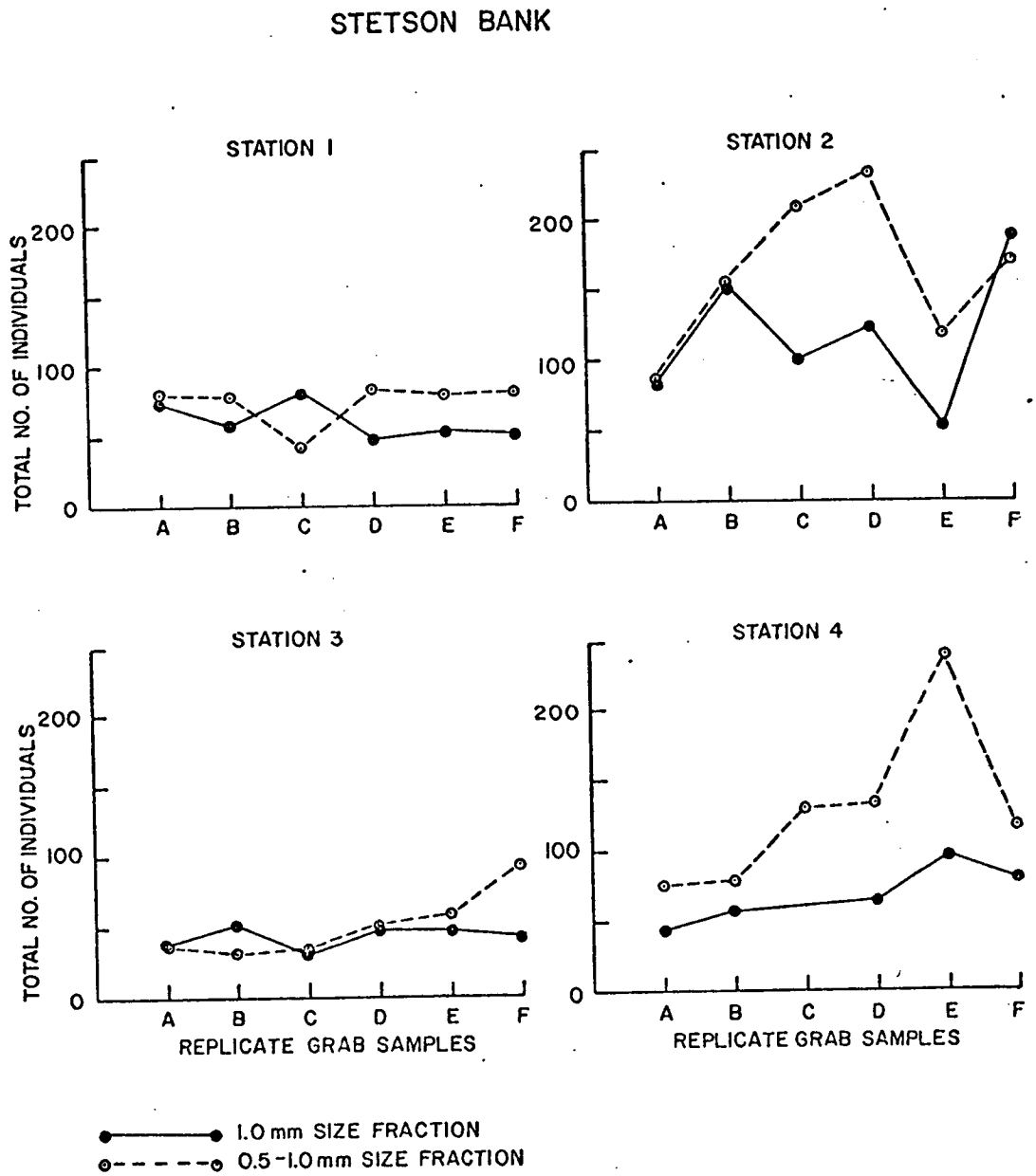


Figure VI-1. Numbers of large and small individuals of macroinfauna species distributed among the six replicate Smith-McIntyre grabs (area = 0.1024 m^2) at the four stations on Stetson Bank. Some, but not all of the individuals in the 0.5-1.00 size fraction, are immature.

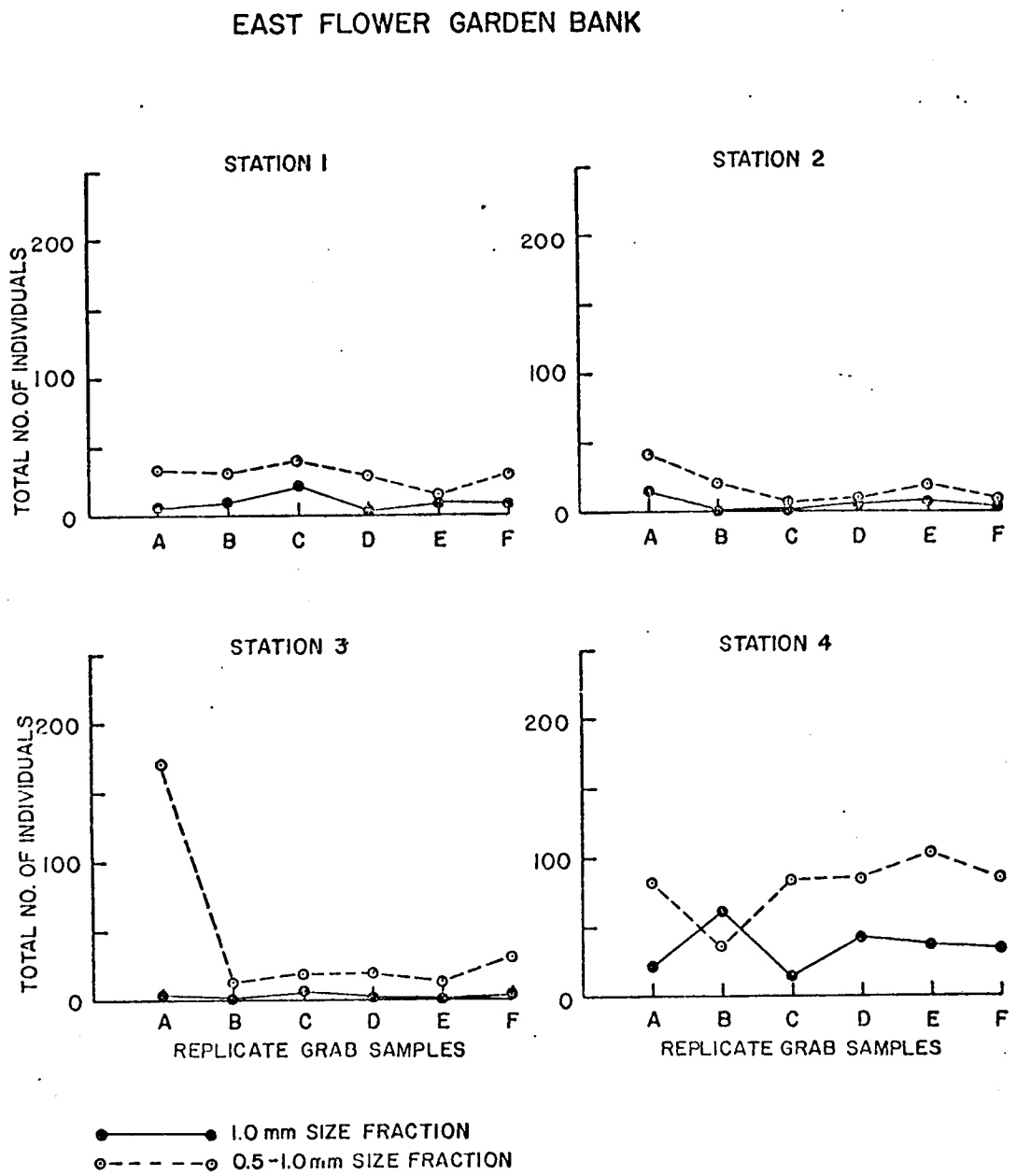


Figure VI-2. Numbers of large and small individuals of macroinfauna species distributed among the six replicate Smith-McIntyre grabs (area = 0.1024 m^2) at the four stations on East Flower Garden Bank. Some, but not all of the individuals in the 0.5-1.00 size fraction, are immature.

28 FATHOM BANK

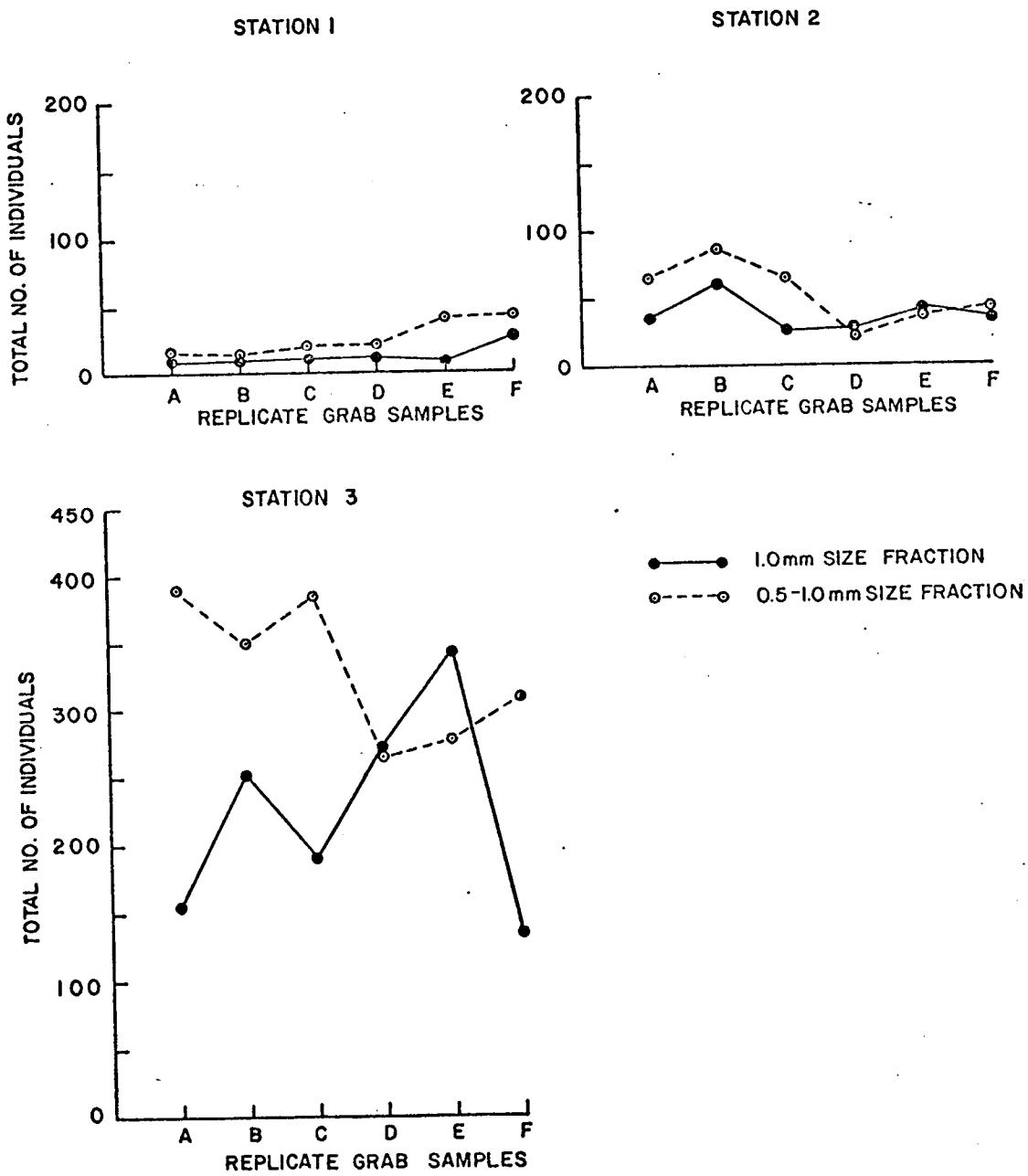


Figure VI-3. Numbers of large and small individuals of macroinfauna species distributed among the six replicate Smith-McIntyre grabs (area = 0.1024 m^2) at the three stations on 28 Fathom Bank. Some, but not all of the individuals in the 0.5-1.00 size fraction, are immature.

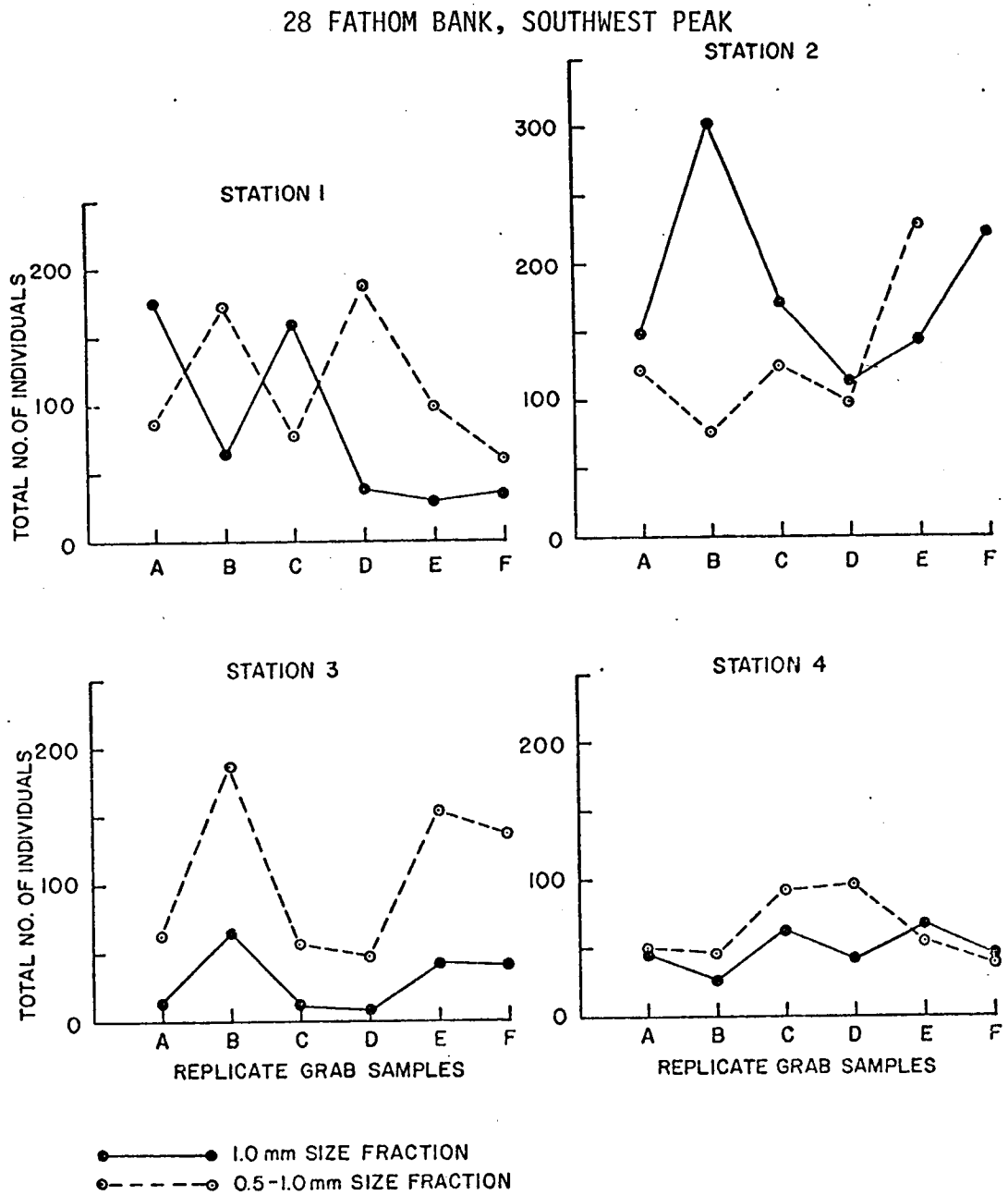


Figure VI-4. Numbers of large and small individuals of macroinfauna species distributed among the six replicate Smith-McIntyre grabs (area = 0.1024 m^2) at the four stations on 28 Fathom Bank, southwest peak. Some, but not all of the individuals in the 0.5-1.00 size fraction, are immature.

abundance ranges from 10^1 to 10^3 individuals per 10 cm^2, that a general decline in meiofaunal abundance occurs with increasing water depth, and that nematodes are always the dominant taxon. Data on meiofaunal abundance (Appendix II, Tables VI-1 through VI-4) show that a similar range of abundance occurs here and that nematodes are the dominant taxon. Although the present study was not designed to deal with the effect of depth on meiofaunal populations, data in Tables VI-3 and VI-6 show that the meiofauna population on Transect II at a depth of 49 m (Station 2) is about 7 times larger than that at 98 m (Station 6). Regarding the dominant taxon, it should be mentioned that Parker (1975) and Marcotte and Coull (1974) found higher numbers of copepods than nematodes in organically enriched waters and that Dinet (1973), found very high numbers of meiofauna at the great depth of 2800 m.

Macroinfauna

Macroinfaunal abundance is usually highest in shallow waters, and lowest in the abyssal zone with continental shelves having intermediate values (Rowe et al., 1974). Lists of the results of the present macroinfaunal study are found in Appendix II, Tables VI-5 through VI-8.

On balance, the enumerated individuals in this study are comparable to those of other Gulf studies. However, it must be noted that only in two cases do Gulf values attain even the low end of the range of Long Island populations.

Data from the present study and from Rowe et al. (1974) seem to indicate that the northern Gulf of Mexico continental shelf is depauperate in macroinfauna density, and Gettleson (1976) notes a low standing crop. However, meiofaunal levels are of a similar order of magnitude relative to comparable depths in other regions. There is no generally acceptable explanation for the lower values for macroinfauna if, indeed, such proves to be the case. However, among contributing factors one might cite that warmer waters appear to elicit faster growth, resulting in smaller size and a greater turnover rate of the macroinfauna (Nicol, 1964; Wade, 1972). Gettleson (1976) notes that the Gulf of Mexico shelf supports a macroinfaunal population composed of individuals about a third smaller than those sampled in Long Island Sound. Turnover and annual production data are inadequate for the macroinfauna; even so, Sanders (1956) has proposed that macroinfaunal annual production is probably 2 to 5 times the standing crop. Edwards (1973) calculated that the annual production in 4 to 16 m of water off Venezuela was 4.1 times the standing crop. These data seem to indicate a higher turnover rate in tropical waters, but the rate for the Gulf of Mexico is unknown.

It seems that the meiofauna would also be affected by the warmer waters but, as Gettleson (1976) points out, the meiofaunal standing crop of the Gulf is similar to that of other known areas. If food is a limiting resource in the present study area, the relatively high level of the meiofauna might indicate that either the meiofauna is utilizing a different food source or that, if the meiofauna is competing with the macroinfauna for food, it is better

able to adapt or utilize the food that is present.

There is some justification for believing that the meiofauna annual production in the Gulf is anywhere from two to five times greater than that of the macroinfauna. This is based on Gettleson's (1976) finding that the standing crops of meiofauna and macroinfauna are essentially the same, and on Gerlach's (1971) estimates that the turnover rate of the meiofauna is approximately nine times per year compared with two to five times for the macroinfauna.

Ratio of True Meiofauna to Macroinfauna

Pequegnat and Gettleson (1974) reported the meiofauna to macroinfauna ratio of individuals on the flanks of Stetson Bank to be 495:1, based on total individuals of meiofaunal size. In the present study, the average of the three typical stations on Stetson Bank yields a ratio of 465:1, based only on the total of true meiofauna. If the temporary meiofauna are added to the total, the ratio is raised to 535:1, which is remarkably close to the 1974 study, considering that different sampling gear was used and that sampling was carried out in August instead of June.

As was pointed out by Pequegnat and Gettleson (1974), the ratio between the meiofauna and the macroinfauna is sufficiently stable that if the sediment cover is carefully defined, the ratio can be used as a baseline parameter for judging degrees of environmental impacts. It would be expected also that each bank would have a signature ratio that could differ substantially from that of other banks. We now have additional hard data with which to test this

hypothesis. Thus, East Flower Garden Bank has an average ratio of 442:1; 28 Fathom Bank has a ration of 74:1; and 28 Fathom Bank, southwest peak has a ratio of 103:1. Obviously, these ratios apply to the flanks of the banks where the sediment cover is sufficiently thick to permit taking a sample at least 5 cm in thickness.

Variability of Banks and Samples Taken at the Banks

In regard to macroinfaunal populations, ANOVA computations revealed that the four stations of each bank were much more variable than were the six grabs at each station. One contributing factor here is probably the position of the station vis à vis the mass of the reef and the mean current direction, as mentioned earlier. This may also help in explaining the fact that stations at any given bank were more variable than were the banks.

Interestingly enough, ANOVA calculations showed that in the case of the meiofauna, the banks were more variable than stations within the banks. In part, this may be explained by the greater sensitivity of some meiofaunal taxa to depth than is generally true of the macroinfauna. Thus, the major depth difference between Stetson and the other banks is important. It was also found that meiofaunal populations were much more variable among stations than between cores from a single grab. This might be a logical expectation, but it does not always hold, and the fact that it does here may be due to the fact that the ship was on occasion permitted to drift between grabs.

Correlative Relationships of Macroinfauna to Meiofauna

Correlation coefficients were derived for some macroinfaunal meiofaunal populations. The factors involved are the totals of each of the categories observed in Table VI-13. Here we see that the peracarid crustaceans (amphipods, isopods, cumaceans, and tanaidaceans) and the polychaetes are related to the meiofauna in much the same way. The fact that the polychaetes are less strongly related than the peracarids may result from the greater feeding diversity possessed by the polychaetes over the latter. It is possible that the nematodes are least related to both the peracarids and the polychaetes because some species of both feed on them.

Bivalves are strongly related to nematodes, but not at all to harpacticoids (Table VI-13). It cannot be proved from available data, but the reason for this may be the fact that both bivalves and nematodes tend to be strongly correlated with sediment grain size, whereas harpacticoids tend not to be. This is supported by the good correlation between bivalves and total and true meiofauna (dominated by nematodes) and the weak correlation with the temporary meiofauna (Table VI-13).

Sipunculids seem not to be related to the meiofauna; however, the negative correlations could mean that they are feeding upon some components of the meiofauna (Table VI-13).

The total macroinfauna appears, as a category, to be unrelated to the meiofauna, but this could be accounted for by the fact that the meiofauna are much more sensitive to grain size than many of the macroinfauna (Table VI-13). This is supported by the observation that

TABLE VI-13

RELATIONSHIPS OF MACROINFAUNA TO MEIOFAUNA

CORRELATION COEFFICIENTS (r).

Peracarid Crustaceans

r	
.69	Harpacticoids
.63	Foraminifers
.57	Temporary Meiofauna
.51	Total Meiofauna
.44	True Meiofauna
.13	Nematodes

Polychaetes

r	
.31	Harpacticoids
.28	Foraminifers
.19	Temporary Meiofauna
.16	Total Meiofauna
.10	True Meiofauna
-.11	Nematodes

Sipunculids

r	
-.11	True Meiofauna
-.11	Temporary Meiofauna
-.11	Nematodes
-.08	Total Meiofauna
-.08	Harpacticoids
-.02	Foraminifers

Bivalves

r	
.59	Nematodes
.58	Foraminifers
.50	Total Meiofauna
.50	True Meiofauna
.31	Temporary Meiofauna
.18	Harpacticoids

Total Macrofauna

r	
.25	Foraminifers
.22	Harpacticoids
.14	Total Meiofauna
.14	Temporary Meiofauna
.10	True Meiofauna
-.05	Nematodes

the total is more strongly correlated with the forams, which respond only weakly to sediment categories, than to the nematodes which are sensitive to grain size.

Correlations Between Various Meiofauna Groups

The nematodes are strongly correlated with the true meiofauna because they are the numerically dominant taxon of this category. The nematodes are not correlated with the harpacticoids because they appear to be responding to different critical environmental parameters (Table VI-14).

The harpacticoids are very strongly related to the temporary meiofauna, i.e., essentially to the juvenile polychaetes, and to a lesser extent, the bivalves.

The foraminifers are most closely related to the total meiofauna and least to the nematodes.

Correlations Between Various Macroinfauna Groups

Polychaetes and peracarid crustaceans are related in nearly the same way (Table VI-15). The peracarid crustaceans are most closely related to the polychaetes than to the sipunculids and bivalves. The polychaetes are more closely related to the sipunculids than they are to the bivalves. The bivalves are only weakly related to any of the macroinfauna groups.

TABLE VI-14

CORRELATIONS BETWEEN VARIOUS MEIOFAUNA GROUPS DERIVED WITH DATA FROM ALL OF THE BANKS.

NEMATODES

r	
.89	True meiofauna
.83	Total meiofauna
.63	Foraminifers
.58	Temporary meiofauna
.41	Harpacticoids

HARPACTICOIDS

r	
.97	Temporary meiofauna
.85	Foraminifers
.84	Total meiofauna
.78	True meiofauna
.41	Nematodes

FORAMINIFERS

r	
.92	Total meiofauna
.90	Temporary meiofauna
.85	True meiofauna
.85	Harpacticoids
.63	Nematodes

TRUE MEIOFAUNA

r	
.99	Total meiofauna
.89	Nematodes
.87	Temporary meiofauna
.85	Foraminifers
.78	Harpacticoids

TOTAL MEIOFAUNA

r	
.99	True meiofauna
.93	Temporary meiofauna
.92	Foraminifers
.84	Harpacticoids
.83	Nematodes

TEMPORARY MEIOFAUNA

r	
.97	Harpacticoids
.93	Total meiofauna
.90	Foraminifers
.87	True meiofauna
.58	Nematodes

Sediment/Infauna Interactions

Certain sediment/infauna correlations appear to be relatively constant. In general, the meiofauna and macroinfauna vary in much the same way with percentage changes in the four sediment types dealt with in this study, viz., gravel (in this case very coarse), sand, silt, and clay. However, it is most instructive to discuss each separately by bank.

28 Fathom Bank, southwest peak. The sediment compositions at the four stations of the bank are shown in Figure VI-5. The two stations having the greatest sediment contrast, viz., Stations 2 and 3, also have the greatest contrast in composition of both meiofauna and macroinfauna.

Meiofauna - On 28 Fathom Bank, southwest peak the stations having the highest number of individuals are Stations 2 and 4 and the lowest is Station 3, as shown below:

Station	1	2	3	4
No./10 cm^2	161.7	206.7	89.8	271.6

Station 2 has a high level of sand, moderate levels of gravel, and very low levels of silt and clay. The high meiofaunal counts result from high levels of harpacticoids, nematodes, ostracods, and polychaetes. Station 3 has a low percentage of sand and gravel but very high levels of silt and clay. It is exceedingly low in harpacticoids and ostracods, and moderately low in nematodes and polychaetes. Station 1 has intermediate levels of all sediment categories and also of meiofauna taxa.

TABLE VI-15

RELATIONSHIPS OF MACROINFAUNA TO MACROINFAUNA

PERACARID CRUSTACEANS

r	
.86	Polychaetes
.79	Total macrofauna
.39	Sipunculids
.27	Bivalves

POLYCHAETES

r	
.95	Total macrofauna
.86	Peracarid crustaceans
.61	Sipunculids
.30	Bivalves

SIPUNCULIDS

r	
.81	Total macrofauna
.61	Polychaetes
.39	Peracarid crustaceans
.24	Bivalves

BIVALVES

r	
.34	Total macrofauna
.30	Polychaetes
.27	Peracarid crustaceans
.24	Sipunculids

28 FATHOM BANK, SOUTHWEST PEAK

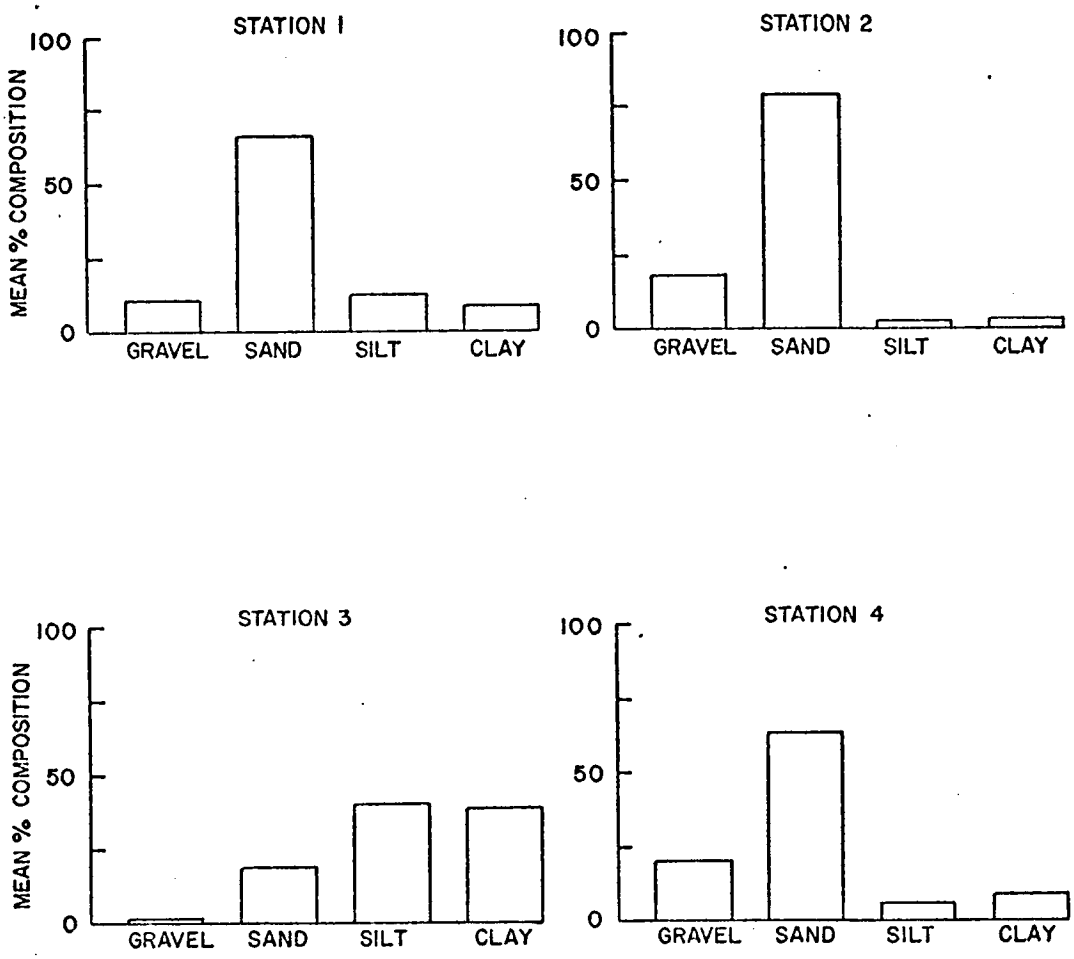


Figure VI-5. Percentages of the four sediment types found at the four stations of 28 Fathom Bank, southwest peak. Note the distinctive contrast between Stations 2 and 4. These are reflected in significant shifts in composition of both meiofauna and macroinfauna. (See text).

Macroinfauna - There are some similarities and some significant differences between the responses of the macroinfauna and the meiofauna to sediment constitution. The mean number of individuals per grab (0.1024 m^2) are shown below:

Station	1	2	3	4
No./grab	154.00	267.67	99.17	99.50

The similarity in numerical position between Stations 2 (high) and 3 (low) with the situation in the meiofauna is very striking. Station 2 is high in polychaetes but very low in sipunculids, whereas Station 3 is very low in polychaetes and high in sipunculids. The determining factor seems to be that the polychaete species involved here do not prefer silt and clay, whereas sipunculids do. Supported by the analytical results for Station 4 which, unlike the situation in which the meiofauna had highest numbers, has very low macroinfauna. Bivalves are high and polychaetes are intermediate, but with relatively low levels of silt and clay. The sipunculids are very low.

East Flower Garden Bank. The textural compositions of the sediments at the four stations on East Flower Garden Bank are shown in Figure VI-6. Again, as at 28 Fathom Bank, southwest peak, two natural pairs of stations exhibit sharp contrasts in composition. Note that Stations 1 and 4, and Stations 2 and 3 form contrasting pairs. All four stations have low gravel components, but 1 and 4 have high percentages of sand and low percentages of silt and clay, whereas 2 and 3 are relatively low in sand and high in silt and clay. Marked numerical and compositional differences accompany these sediment differences in both the meiofauna and macroinfauna.

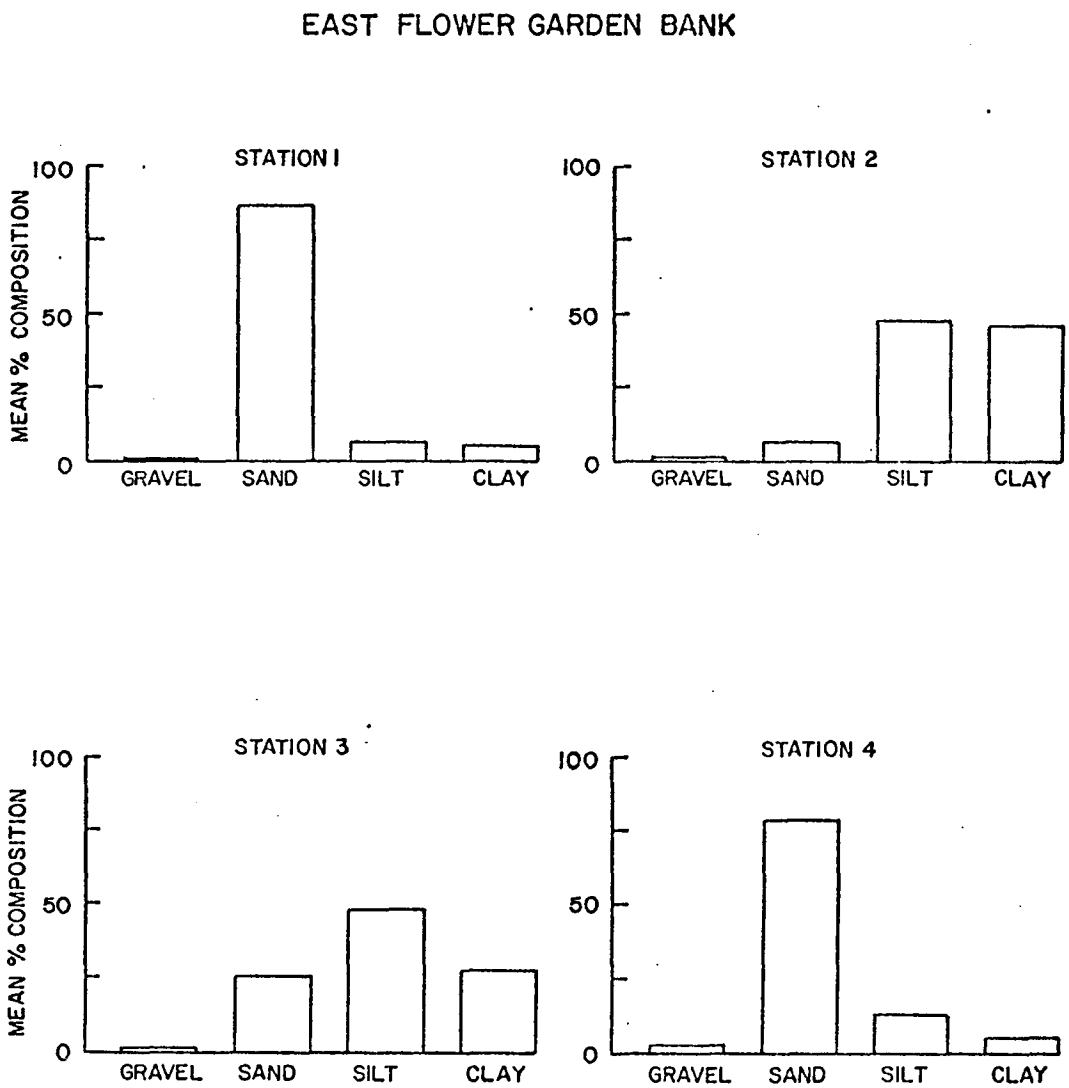


Figure VI-6. Percentages of the four sediment types found at the four stations of East Flower Garden Bank. Note the similarities between Stations 1 and 4 and between Stations 2 and 3, and the sharp differences between the pairs. Although all of the stations of this bank have relatively small populations, there are notable faunal differences between the station pairs (See text).

Meiofauna - On East Flower Garden, Stations 1 and 4 have the highest number of meiofaunal individuals and Stations 2 and 3 have the smallest, as shown below:

Station	1	2	3	4
No./10 cm^2	210.6	48.4	18.0	535.0

Station 4 has high sand, some silt and very little gravel and clay. Its large population is accounted for by many nematodes, harpacticoids, forams, and polychaetes. Station 1, the second highest, has fairly large numbers of nematodes but few harpacticoids and polychaetes. Stations 2 and 3 have little sand, much silt and clay and low populations because of the reduced frequency or complete absence of some or all of the above groups.

Macroinfauna - The populations of macroinfauna on East Flower Garden roughly follow the same pattern noted in the meiofauna. Thus, Stations 1 and especially 4 have relatively large populations, whereas Stations 2 and 3 do not. It should be noted, however, that all four station populations are small compared with those of the other banks, as noted below:

Station	1	2	3	4
No./0.1024 m^2	31.67	19.17	23.83	100.67

These populations are small not only because of reduced numbers of individuals in the polychaetes and especially the sipunculids, but also because of the reduced number of taxa represented in the samples.

28 Fathom Bank. The rather uniform textural compositions of the three stations located on the flanks of 28 Fathom Bank are shown in Figure VI-7. Gravels are essentially the same throughout,

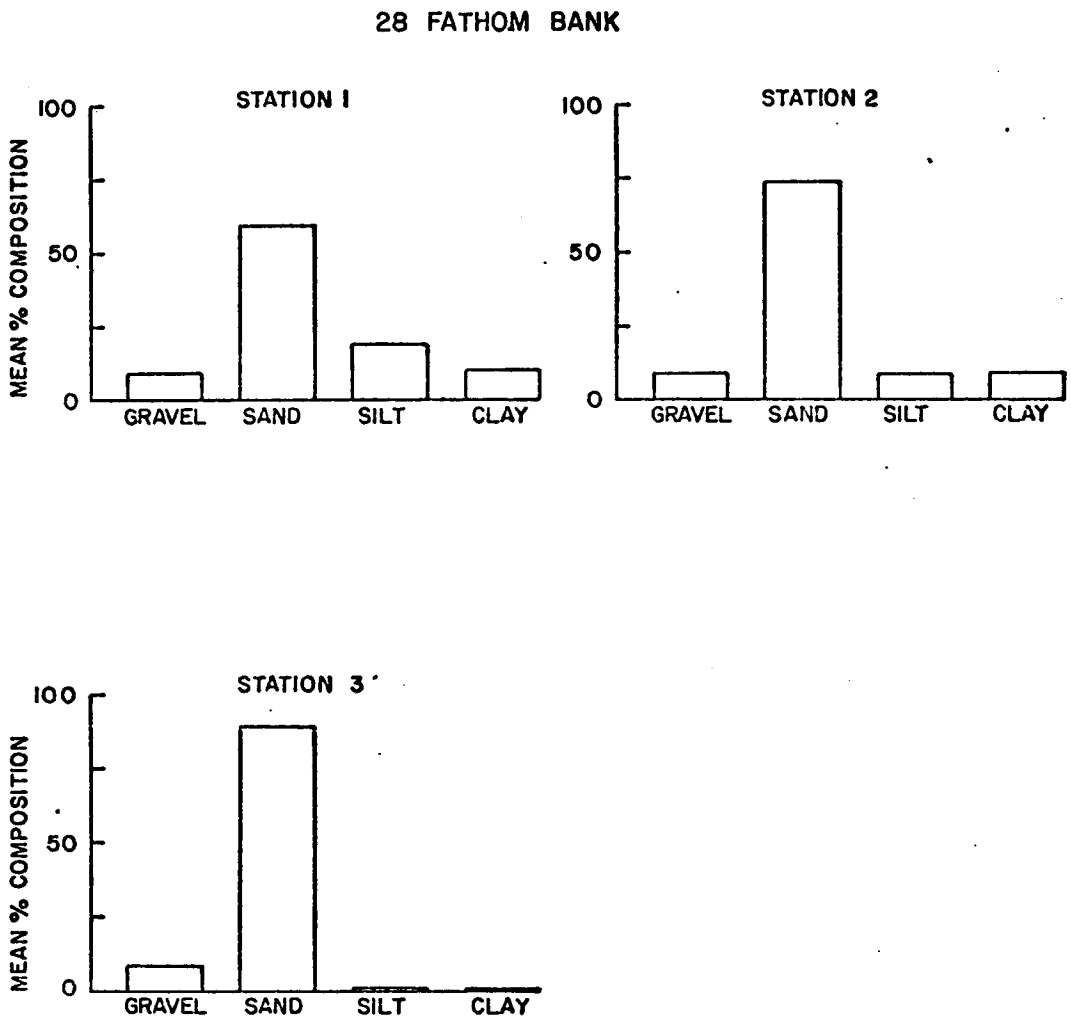


Figure VI-7. Percentages of the four sediment types found at the three stations of 28 Fathom Bank. Note that these stations have greater sedimental similarity than has been true of the previous two banks. Gravel is much the same among the three, but sand increases from Station 1 to 3, whereas silt ard clay decrease. The macroinfaunal differences noted here are very likely biologically controlled.

but the sand increases from Station 1 to 3, whereas the silt and clay components decrease.

Meiofauna - Interestingly enough, the meiofaunal populations of the three stations are very much alike in overall numbers. However, the population of Station 3 is somewhat lower than the other two. It does, however, have rather higher harpacticoid and turbellarian populations.

Station	1	2	3
No./10 cm^2	176.9	194.3	157.8

Macroinfauna - The disparity among total numbers of the macroinfaunal populations is a sharp contrast to conditions in the meiofauna.

Station	1	2	3
No./0.1024 m^2	23.83	74.83	523.67

The interesting things about these populations is the fact that the number of macroinfaunal organisms at Station 3 is greater than the other two by a factor of more than 10. The principal controls of population size here may be biological, but the relationship of the stations to the current and the main mass of the bank are very likely involved as well. Here again, it would be most valuable to obtain values of the labile carbon compounds in these sediments.

Stetson Bank. This bank is much shallower than the preceding three, so that comparisons are not particularly meaningful. However, except for Station 1, this bank supports a very rich meiofauna and a moderately rich and varied macroinfauna (Figure VI-8).

Meiofauna - The meiofauna of Stetson Bank is largely due to the

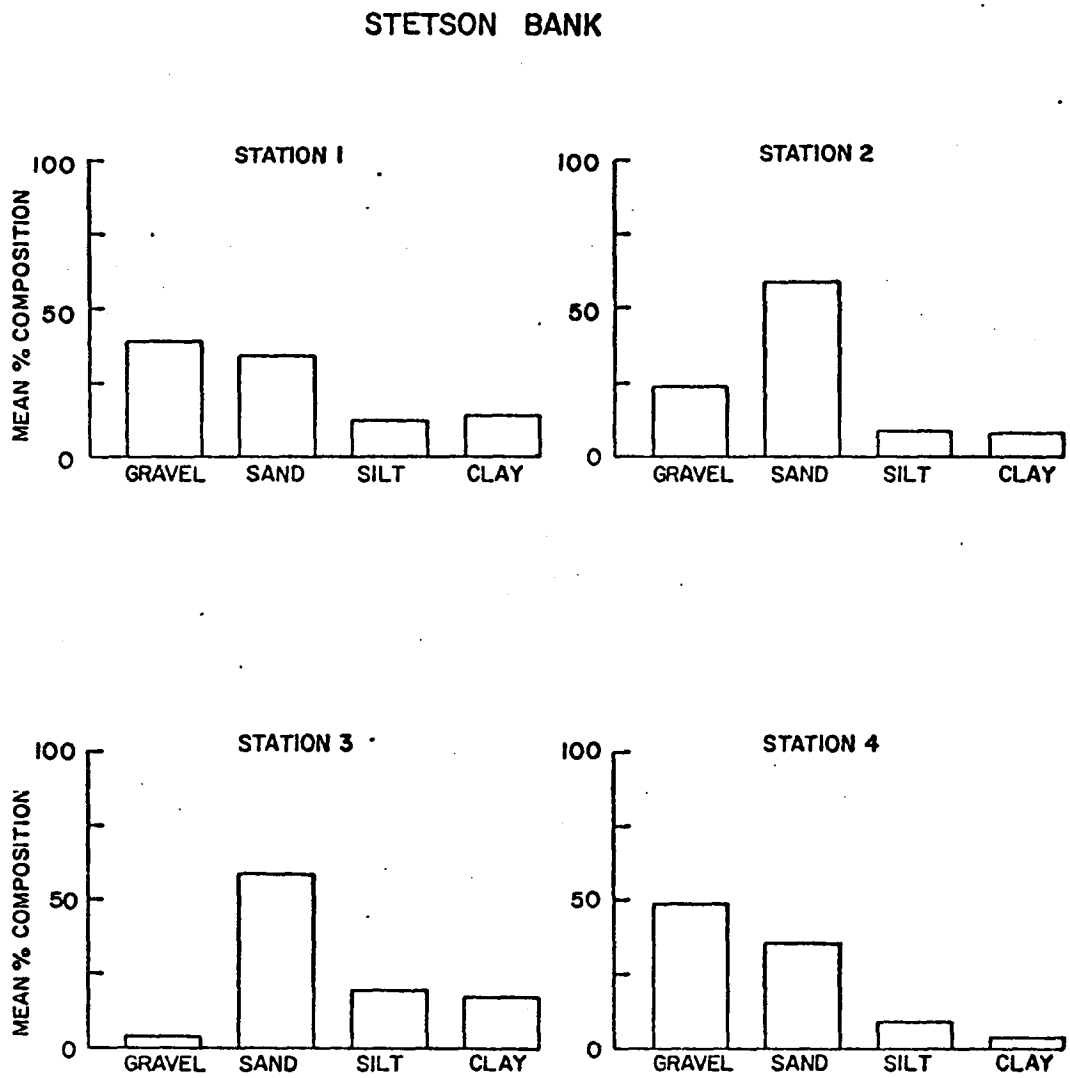


Figure VI-8. Percentages of the four sediment types found at the four stations of Stetson Bank. This bank is much shallower than the three preceding ones. Note that the gravel has a marked range of values and is much more prevalent than previously noted. Sand is rather uniform.

high populations of nematodes and especially harpacticoids, kinorhynchs, and polychaetes. Some of this is attributable to the shallow depth; in that kinorhynchs and harpacticoids are much more prevalent here.

Station	1	2	3	4
No./10 cm^2	117.0	1015.1	776.7	1079.9

Macroinfauna - The macroinfaunal populations here are not particularly large, but their size is much more uniform than that of the meiofauna. However, the diversity of major taxa represented is much larger than at the deeper banks.

Station	1	2	3	4
No./0.1024 m^2	127.33	231.67	85.33	150.33

As was true for the meiofauna, Stations 2 and 4 have the largest populations, but for reasons apparently not connected with sediment texture.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

1. The meiofauna of the flanks of the hard banks off the Texas coast form a stable community that varies in regard to depth, orientation downcurrent of the main mass of the bank, sediment grain size and, presumably, in regard to the amount of labile carbon compounds in the sediments, although the latter has not been tested.

2. The bank meiofaunal populations are, on balance, substantially higher than those on the adjacent level bottoms of the outer continental shelf. This may be a reflection of greater inputs of organic materials into the sediments from bank debris and detritus, but again, this is as yet untested. The latter is suspected, however, because harpacticoid copepods, which respond positively to organic inputs, are significantly more abundant on banks than on level bottoms in this area.

3. It is noted that the harpacticoid:nematode ratio is significantly greater at the banks than at transect stations. Also, the ratio differs predictably among banks, indicating that banks have a signature ratio that will identify its condition of health. Whereas environmental impacts can be measured among the macro-epifauna, primarily by death or no death, such impacts can be estimated and predicted by ratio changes among these two components of the meiofauna.

4. The macroinfauna of the flanks of the hard banks off the Texas coast also form a stable community that varies less than the meiofauna in the depth range of this study. However, as in the case of the meiofauna, it is more abundant downstream of the bank proper, and it is significantly more abundant on the bank flanks than on the level bottoms of the transects.

5. The meiofaunal annual production in the Gulf is believed to be two to five times greater than the macroinfauna.

6. The true meiofauna:macroinfauna ratio is considered to be another important signature marker of individual banks. It appears to be stable from year to year.

7. Both the meiofauna and the macroinfauna respond to changes in the characteristics of the sediment bed. However, it appears that the usual division of sediments into gravel, sand, silt and clay is too gross. Rather, the individual grain sizes should be divided into at least 16 categories and percentages for each derived.

RECOMMENDATIONS

1. It is strongly recommended that the meiofauna study of the hard banks be continued, but with certain important changes.

2. It is strongly recommended that the number of stations around and adjacent to at least one bank be increased and carefully positioned in regard to the best possible bottom current information.

3. It is strongly recommended that some stations be located upcurrent and some downcurrent of the bank mass, and that the downcurrent stations be aligned on a transect of increasing distance from the bank.

4. It is strongly recommended that the meiofauna samples be taken

when the ship is either anchored or held at station by the ship in the power-on mode.

5. Sufficient data are now in hand to fully justify determining the labile carbon content of the sediments grab-for-grab with the taking of the meiofauna samples.

ACKNOWLEDGMENTS

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CHAPTER VII

DESCRIPTIVE BIOLOGICAL RECONNAISSANCE STUDIES

DESCRIPTIVE BIOLOGICAL RECONNAISSANCE STUDIES

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INTRODUCTION

Descriptive reconnaissance surveys were completed in 1976 for Texas outer continental shelf fishing banks which could not be adequately documented in 1975 due to time and budgetary constraints (i.e. Aransas Bank, Blackfish Ridge and Mysterious Bank, Fig. VII-1). In late 1975, after our field work was completed, a management need developed for baseline information on 28 Fathom Bank, southwest peak, a knoll some 2000 meters south of the main crest of 28 Fathom Bank. We performed the necessary survey in September, 1976 and reported preliminary results to BLM verbally and in writing during October. Reconnaissance information on Claypile Bank was not called for in the 1976 contract. The 1977 contract specifies an account of Claypile Bank based on existing data, not on new field work. Insofar as the material is presently available for such an account, we have included a description of the bank in this report on the assumption that the sooner the BLM has the information, the better.

28 FATHOM BANK

Abbott and Bright (1975) reported observations made at 28 Fathom Bank during 1974 as follows:

> The crest of 28 Fathom Bank (Figs. VII-2 & 3) is below a depth at which one would expect to encounter major hermatypic coral growth using the East and West

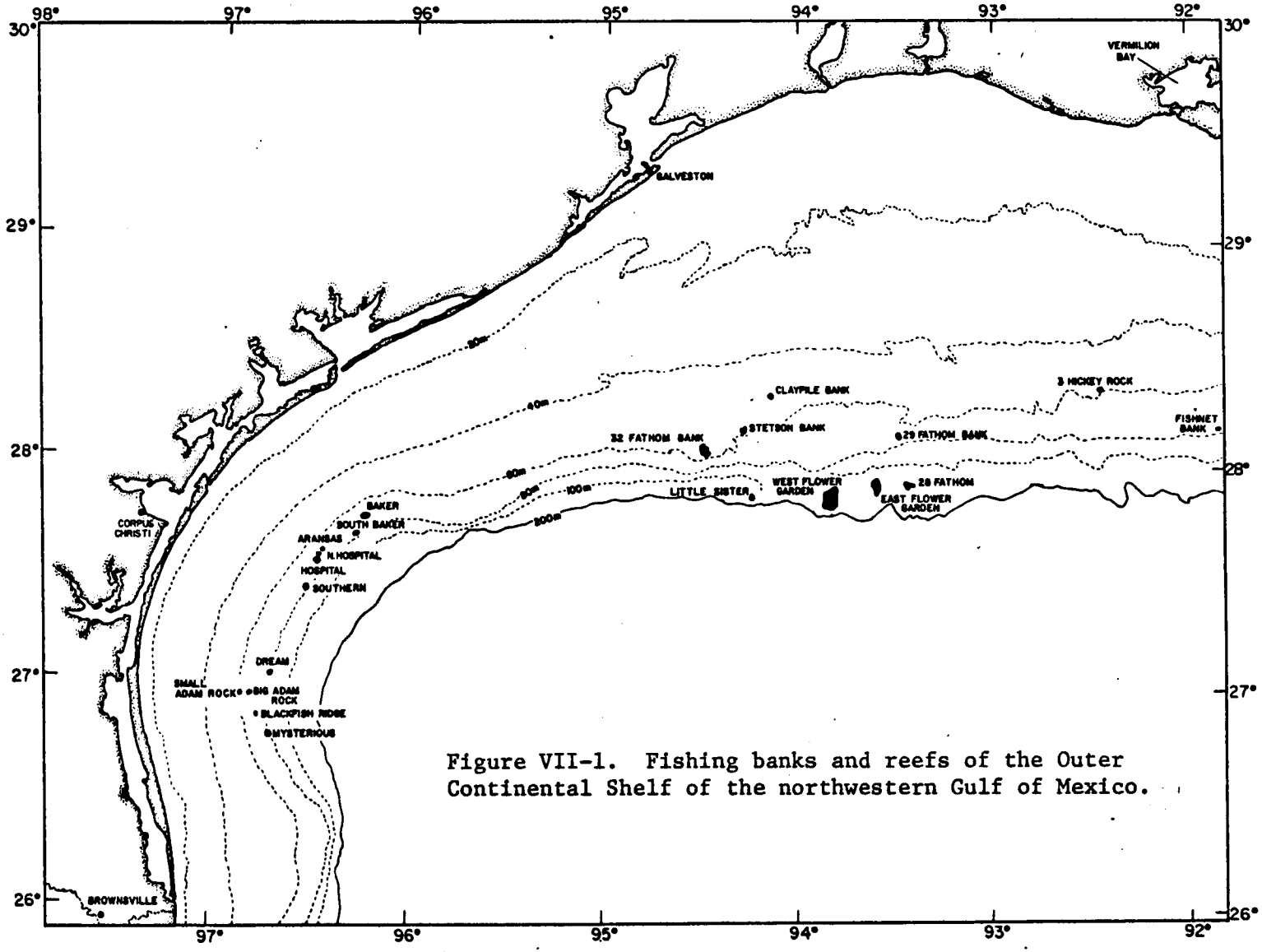


Figure VII-1. Fishing banks and reefs of the Outer Continental Shelf of the northwestern Gulf of Mexico.

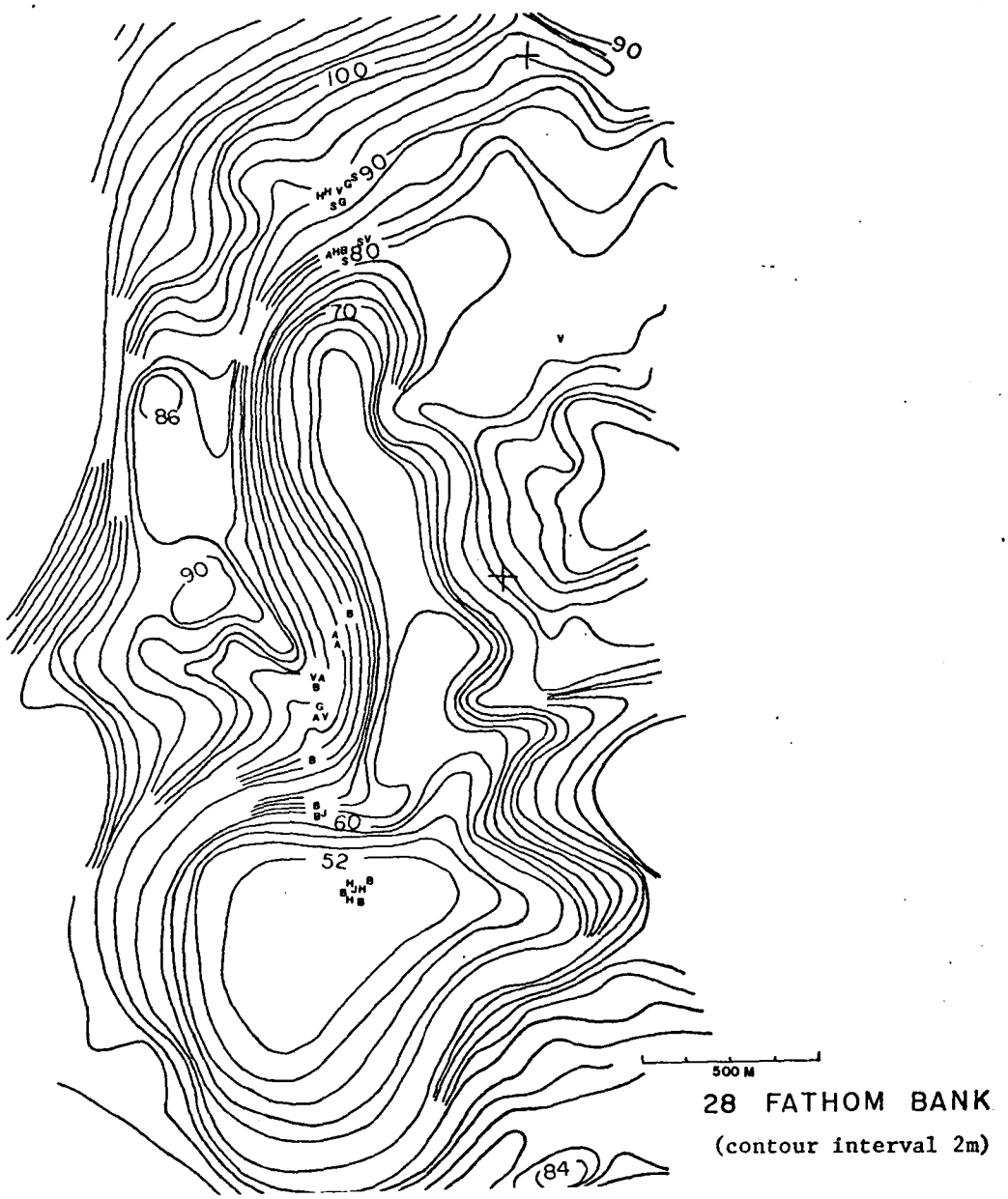


Figure VII-2. Sightings of fish at 28 Fathom Bank

A. Reef fish A
B. Reef butterflyfish (Chaetodon sedentarius)
C. Burrowing fish C
G. Groupers (Mycteroperca spp.)
H. Spotfin hogfish (Bodianus pulchellus)
S. school of Red snapper
s. Red snapper (Lutjanus campechanus)
J. Amberjack (Seriola spp.)

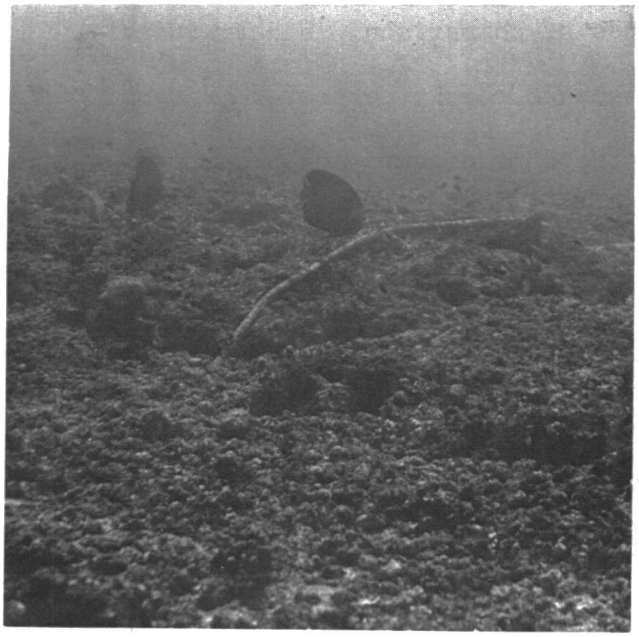


Figure VII-3. General view of part of the top of 28 Fathom Bank.

Figure VII-4. Algal nodules and leafy algae atop 28 Fathom Bank. Coarse calcareous sand, left center.

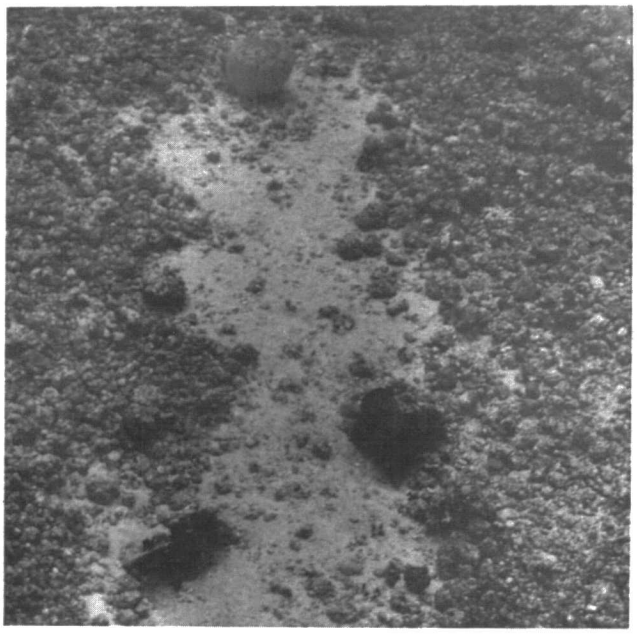


Figure VII-5. Apparent anchor scar at top of 28 Fathom Bank.

Figure VII-6. Reef butterflyfishes (Chaetodon sedentarius), Yellowtail reeffishes (Chromis enchrysurus), and Squirrelfish (Holocentrus sp.) above rock at top of 28 Fathom Bank.

Flower Gardens as standards of comparison. Understandably, therefore, we have not observed coral reefs at 28 Fathom Bank. The entire top of the bank appears to be covered by a thin layer of algal nodules underlain by coarse white calcareous sand or hard bottom in a fashion nearly identical to the East and West Flower Garden Banks between 45 m and approximately 76 m depth (Fig. VII-4). Outcrops seen by us were generally low (0.5 m to 1 m or so in height,) but fairly numerous. The flanks of 28 Fathom Bank are steep where we examined them (possibly 30° slope,) but we have made observations to a depth of only 92 m, which is above the lower limit of distribution of algal encrusted rubble. Water clarity was very good, with visibility exceeding 15 m.

The benthic biotal assemblage above 92 m depth at 28 Fathom Bank comprises an Algal-Sponge Zone, harboring communities nearly identical to those of the Algal-Sponge Zones occurring at the East and West Flower Gardens, though extending somewhat deeper. Some of the conspicuous benthic macrofauna of 28 Fathom Bank observed from the research submarine DR/V DIAPHUS are listed in Table VII-1, along with depths of observations (at end of chapter).

The algal nodule cover above 61 m depth is extensive (80 to 100% in most areas), except where the substratum has been disturbed by burrowing Sand tilefish, Malacanthus plumieri, or man. Conical

tilefish burrows, generally 1 m or so across at the top and approximately one-third m deep with piles of algal nodules associated with them, are so abundant in places on the shallower part of the bank as to make the bottom "look pitted as though it's an old battlefield". Apparent anchor scars (15 cm deep and 35 cm or so wide) resembling those seen at the East Flower Garden at similar depths were encountered near the top of the bank (Fig. VII-5). Such disturbances shift and pile the nodules and reveal the white sand or bare rock beneath. Downslope from the edge of the bank, the nodule and encrusted rubble cover diminishes to about 50% at 82 to 85 m depth and less at 92 m (the lower limit of our visual observations), where coarse calcareous sand predominates.

As on the other biostromal banks visited, the greatest concentration of fishes occurred around and above the low outcrops which frequently rise a meter or so above the surrounding bottom (Fig. VII-6). *Chromis enchrysurus* seems by far the most abundant of the easily seen fishes at 28 Fathom Bank, being almost everywhere on the bank. Large schools of Creolefishes, *Parathias furcifer*, are particularly conspicuous; Red Snappers, *Lutjanus campechanus*, and groupers, *Mycteroperca* spp., are encountered as frequently.

Of the important conspicuous invertebrates seen

(Table VII-1), Neofibularia (Fig. VII-7) is abundant above 61 m depth. Comatulid crinoids are well represented between 67 and 92 m depths, and probably deeper. The characteristic white corkscrew-shaped antipatharian sea whips, Cirripathes, are abundant from the crest of the bank down to at least 82 m depth. The large anemones, Condylactis, encountered so frequently in the East Flower Garden Algal-Sponge Zone are also abundant here above 61 m. Likewise, leafy algae are moderately abundant above 67 m.

Gas seeps (Fig. VII-8) were encountered on the west side of 28 Fathom Bank. Some of the seeps were described by Sweet (Sept. 1974) as follows: "A large bubble field consisting of a dozen or more holes and covering an area of 5 or 6 square m was located in an area of boulders. Some of the holes were located on a ridge and the rest slightly down the slope from the ridge. The rate of seepage varied from hole to hole. Some emitted bursts of a few bubbles at various intervals of time. Other holes emitted 8 to 10 or more bubbles in a burst. Some holes gave vent to steady streams of bubbles for extended periods, and many of the holes would stop bubbling for short intervals. Also at times the entire field would stop bubbling. Although there appeared to be an aperiodicity to the rate of seepage, timed observations over a longer interval

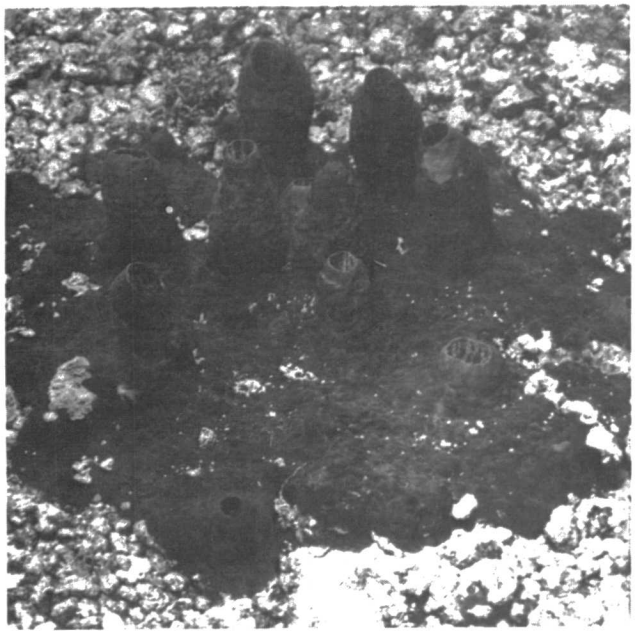


Figure VII-7. The sponge Neofibularia atop 28 Fathom Bank.

Figure VII-8. Gas seep, right center, at top of 28 Fathom Bank.

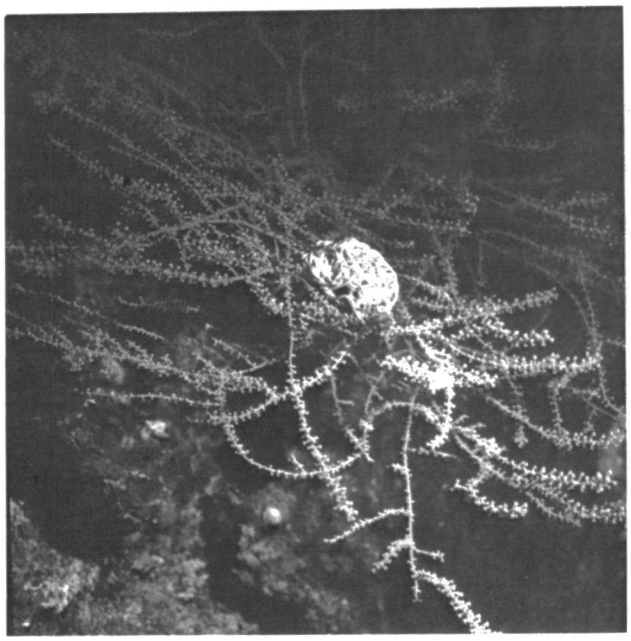


Figure VII-9. Gorgonocephalan basket star, balled up in center, clinging to branching octocoral.

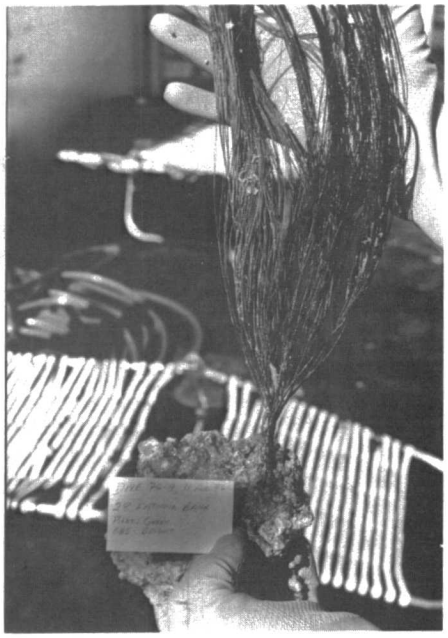


Figure VII-10. Specimen of the branching antipatharian Antipathes.

might reveal a certain rhythm".

Where the bubbles left the bottom, there was virtually no visible evidence that plants or animals were affected in any way, nor was there any evidence that the substratum differed from that of the surrounding area. Fishes seemed neither attracted nor repelled by the gas and their behavior in the presence of bubble streams seemed normal, even though the streams were observed to issue from the bottom directly adjacent to the territories of certain damselfishes (Pomacentridae) and squirrelfishes (Holocentridae). Bubbles seen to rise through fish schools elicited no apparent overt response from the fish.

Research submersible observations made on 28 Fathom Bank by Bright in Sept. 1976 revealed nearly identical conditions of community structure, apparent population levels (a subjective judgement) and condition or "health" of the biota. The 1976 dive resulted in a considerable expansion of our list of species known to inhabit the bank (Table VII-1). Particularly, a large population of Spondylus americanus was detected; Basket stars (Gorgonocephalidae) were observed clinging to branches of alcyonarians (Fig. VII- 9); the "saucer-shaped agariciid", several species of Madracis and a number of solitary corals were collected; and a large population of branching antipatharians was recognized (Fig. VII-10). Atop the bank we detected a population of unique stichodactyline anemones which we had never encountered before.

An interesting specimen of the alcyonacean, Nidalia occidentalis was taken in a grab sample from 100 m depth at 28 Fathom Bank. This is a new record for this species in the Gulf of Mexico (specimen identified by Mr. Charles Giammona).

Essentially, substratum and biota of the southwest peak of 28 Fathom Bank are the same as those described above, though we were surprised to find only one living Spondylus (Table VII-2). Although Figure VII-11 was constructed on the basis of information gathered during several submersible dives on the southwest peak, it can be taken as representative of the entire 28 Fathom Bank biotic community. Likewise, Figures VII-3 to 10, which were taken on 28 Fathom Bank also represent conditions found at the southwest peak. We noticed a considerable population of large asteroids and holothuroids (Figs. VII-12 and 13) within the Algal-Sponge Zone at the southwest peak and the branching antipatharian, Antipathes sp., was abundant, as were Cirripathes and alcyonarians of various types (Fig. VII-14). Outcrops on top of the bank are heavily encrusted with coralline algae which extend in significant quantities to depths of slightly over 90 m. Algal nodules were found on the slopes of the bank down to 100 m depth, but only minute patches of live coralline algae were seen on them. It is probable that these nodules were moved off the top of the bank by wave action and subsequently have worked their way down slope to depths below which the algae thrive. No leafy algae were seen below 93 m depth. The fish population at the southwest peak is comparable to that seen on 28 Fathom Bank (Figs. VII-11 and 16). Commercial snappers and groupers are quite abundant. The as yet

Figure VII-11A. 28 FATHOM BANK, SOUTHWEST PEAK

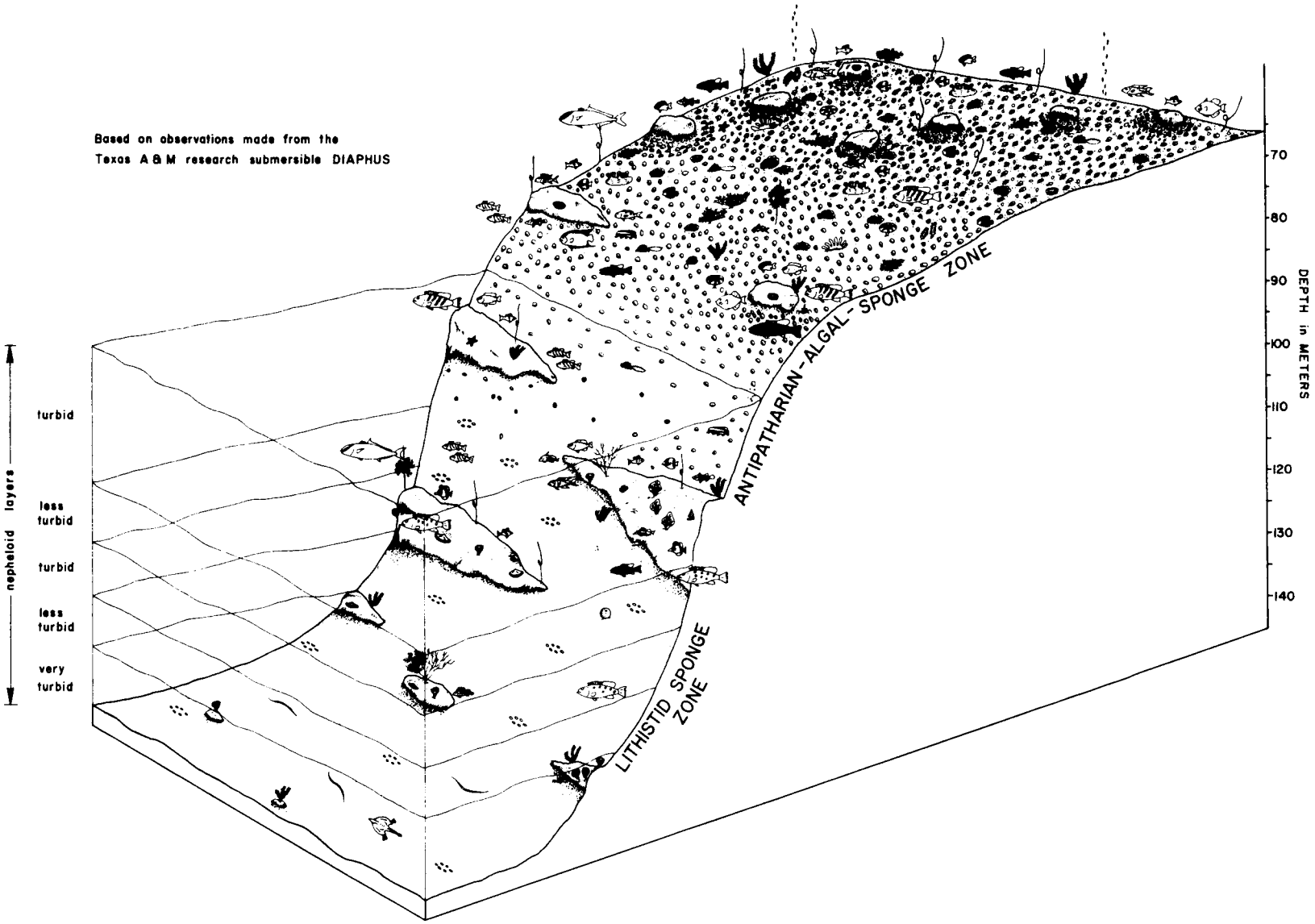


Figure VII-11B.

gas seep

silt and clay

carbonate sand

algal nodules

tracks and trails

patterned burrows

Lobophora (and other leafy algae)

Comatulid (crinoid)

bushy Antipatharian

Scleracis (Alcyonarian)

Hypnogorgia (Alcyonarian)

Antipatharian

Alcyonarian

Condylactis (Anemone)

Madracis

Oxysmilia (solitary coral)

Agaricia

Geodea

Corallistes (hard sponge)

Stichodactyline Anemone

Neofibularia (sponge)

starfish

Astrocyclus (basket star)

Diadema antillarum (black urchin)

Isostichopus (sea cucumber)

Entemnotrochus (slit-shell)

Spondylus americanus

Stenorynchus seticornis (arrow crab)

Malacanthus plumieri burrow (sand tilefish)

Centropyge argi (cherubfish)

Chromis enchrysurus (damselfish)

Xanthichthys ringens (sargassum triggerfish)

Holocentrus (squirrelfish)

Serranus annularis (orangeback bass)

Canthigaster rostrata (sharpnose puffer)

Lutjanus campechanus (red snapper)

Rhomboplites aurorubens (vermilion snapper)

Bodianus pulchellus (spotfin hogfish)

Paranthias furcifer (creolefish)

Mycteroperca (grouper)

Priacanthidae (bigeye)

Liopropoma (basslet)

Chaetodon sedentarius (reef butterflyfish)

Equetus acuminatus (cubbyu)

Triglidae (sea robin)

Epinephelus sp. (snowy grouper)

Scorpaenidae (scorpionfish)

Chaetodon aya (bank butterflyfish)

Seriola dumerili (amberjack)

Ogcocephalidae (batfish)

Holacanthus bermudensis (blue angelfish)

Pseudupeneus maculatus (spotted goatfish)

reef fish "A"

Figure VII-12. Asteroid (possibly Chaetaster) at 75 m depth on 28 Fathom Bank.

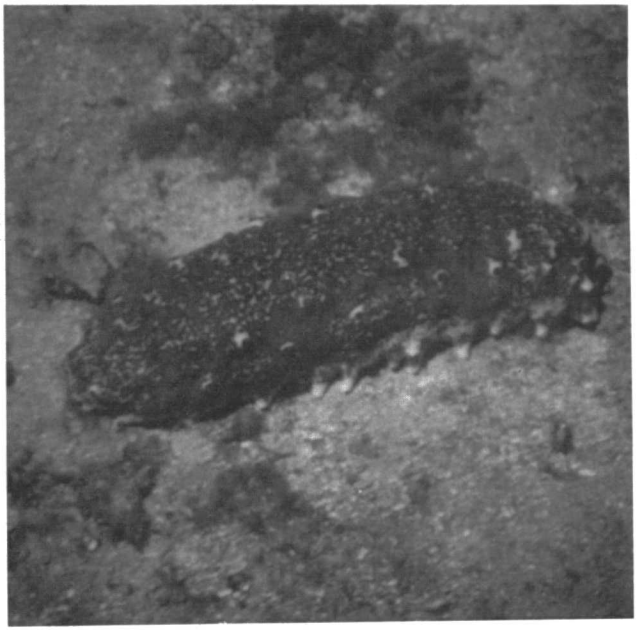


Figure VII-13. The sea cucumber Isostichopus at approximately 75 m depth on 28 Fathom Bank.

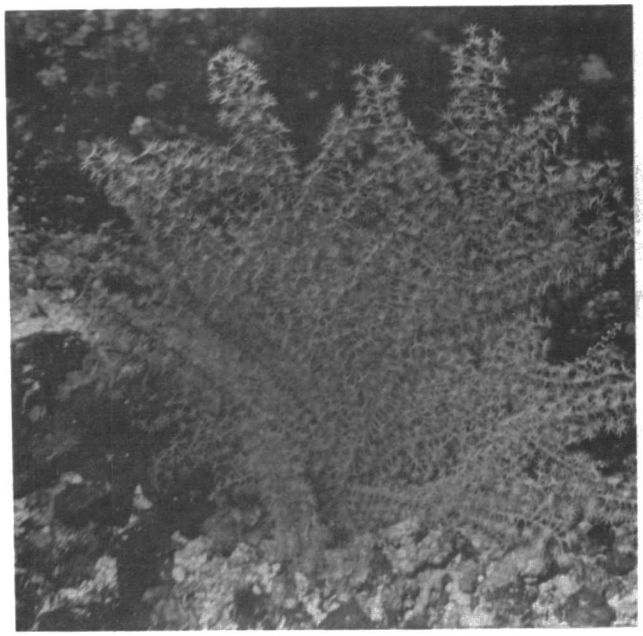


Figure VII-14. The alcyonarian octocoral Scleracis at approximately 75 m depth on 28 Fathom Bank.

Figure VII-15. Reef fish A above large "reef patch" near the top of 28 Fathom Bank.

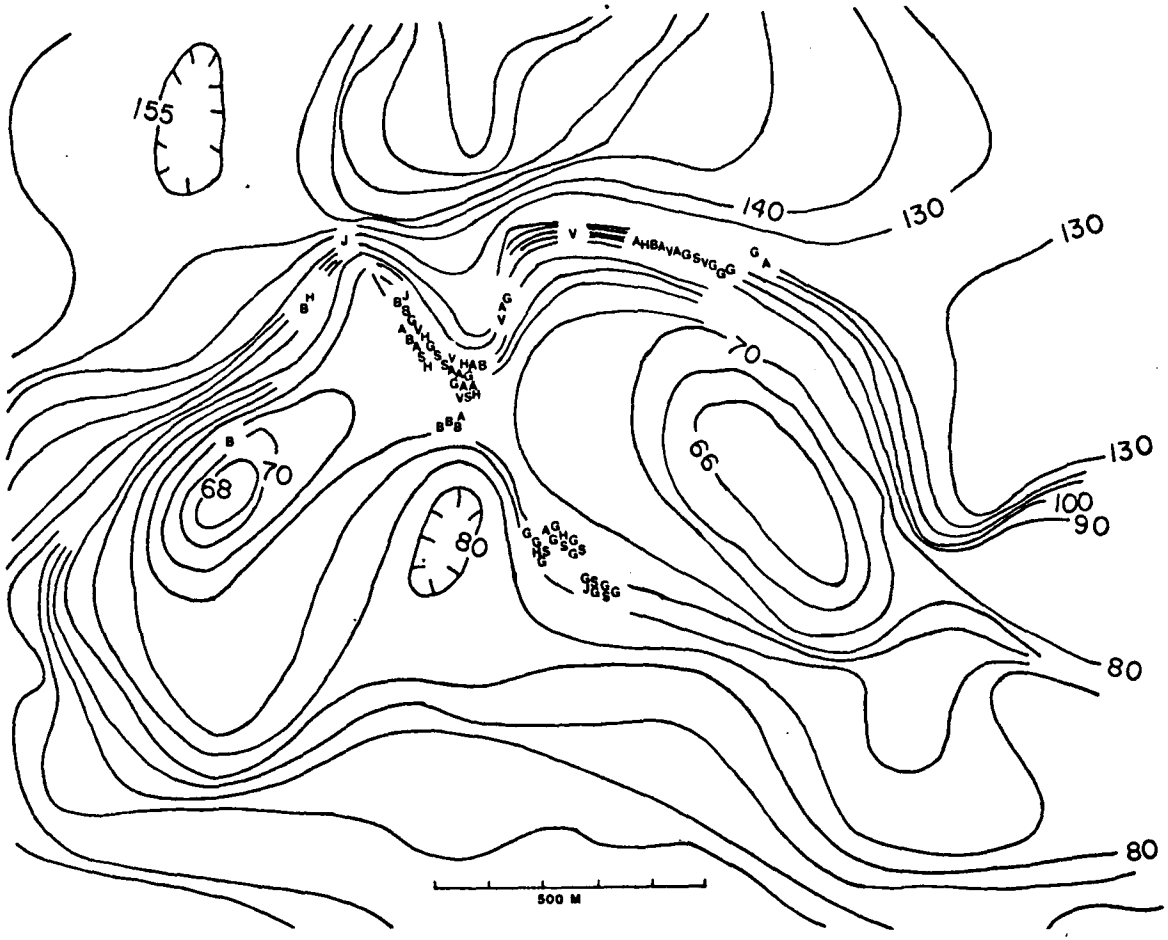


Figure VII-16. Sightings of fish at 28 Fathom Bank, Southwest Peak.

A. Reef fish A
B. Reef butterflyfish (Chaetodon sedentarius)
C. Burrowing fish C
G. Groupers (Mycteroperca spp.)
H. Spotfin hogfish (Bodianus pulchellus)
S. school of Red snapper
s. Red snapper (Lutjanus campechanus)
J. Amberjack (Seriola spp.)

unidentified "Reef fish A" (Fig. VII-15) is numerous from the crest to at least 115 m depth.

The stepped, scarp-like nature of the north flank of the southwest peak provided an excellent opportunity to view vertical zonational changes in biota and to correlate them to some extent with observed conditions of turbidity and sediment cover. Whereas the top of the southwest peak, with its highly diverse and lush populations of algae, epifauna and fishes, was bathed in extremely clear water, nepheloid layers covered the northern flank of the peak from the top of the "scarp" (80 m depth) downward (Fig. VII-11). Three turbid layers were separated by two strata of relatively clear water at about 110 to 130 m depth. The most turbid water was encountered below 130 m depth. There was a general increase in sediment cover on the protruding rock (presumably old algal reef remnants) with increasing depth. The "drowned" reefs comprising the rocky portions of the "scarp" protrude from a generally steep slope covered with unconsolidated surficial sediment which grades from coarse carbonate sand to very fine particles near the base of the bank. Patterned burrows, tracks and trails are everywhere.

In general, the biotic zonational change from the top of the "scarp" downward is one of decreasing diversity and abundance of algae and epifauna. The conspicuous organisms at 97 m depth are Cirripathes, a few alcyonarians such as Muricea and Scleracis, comatulid crinoids, Reef fish A, Red and Vermilion snappers and a few other remnants of the rich biota occupying the top of the bank. At about this depth, however, components of a deeper hard-

bank community heretofore not distinguished as such by us, begin to appear (Fig. VII-11, Table VII-2). At 97 m depth we observed a slit shell, Entemnotrochus (Fig. VII-17), previously seen only at the West Flower Garden between 91 and 122 m depth (Entemnotrochus is valued as "rare" by shell collectors). Snowy Groupers (Fig. VII-18) were recorded below 100 m depth, as were red colored sea robins and scorpionfishes. The Bank butterflyfish, Chaetodon aya (Fig. VII-19), was seen at 105 and 108 m depth. Most notable, however, was the occurrence below 120 m depth of comparatively substantial populations of the hard bodied lithistid sponge, Corallistes sp. (Fig. VII-20) and the large solitary coral, Oxysmilia rotundifolia. With increasing depth, Corallistes becomes more-or-less the most conspicuous epifaunal organism attached to old reefrock, which at this depth is heavily laden with fine sediment. Other organisms seemingly unique to the deeper bank slopes include the lithistid sponge, Geodia gibberosa, and, probably, the alcyonacean referred to earlier, Nidalia occidentalis.

Comatulid crinoids, Muricea, small paramuricid sea fans and Cirripathes continue to be conspicuous at the greater depths. Small paramuricid fans grow rather consistently in an orientation parallel to the slope of the bank. In shallower water, such orientation of sea-fan populations has been taken to indicate the prevalent direction of water movement (the fans orient themselves perpendicular to the prevailing direction of current or wave motion). The paramuricid population of the "scarp" on the northern flank of the southwest peak would seem, therefore, to indicate that currents typically run "along-scarp" (that is eastward or

Figure VII-17. Slit shell, Entemnotrochus sp., at 91 m depth on 28 Fathom Bank.

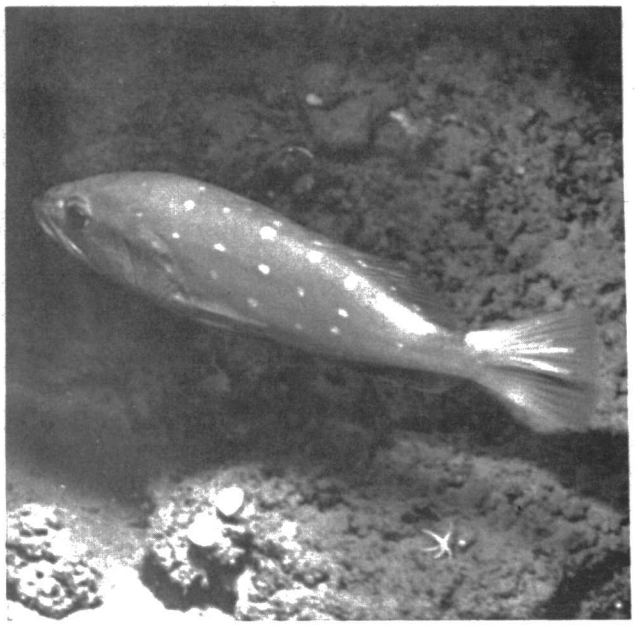


Figure VII-18. Snowy grouper, Epinephelus sp., at 100 m depth on 28 Fathom Bank.

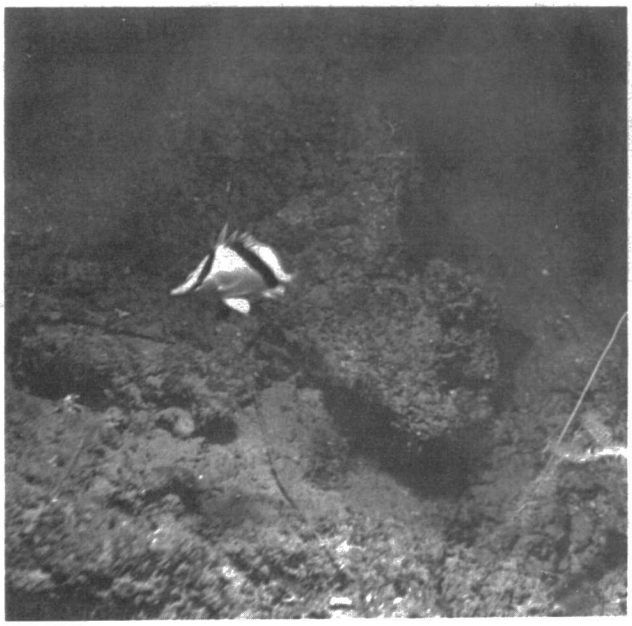


Figure VII-19. Bank butterflyfish, Chaetodon aya, at 105 m depth on 28 Fathom Bank.

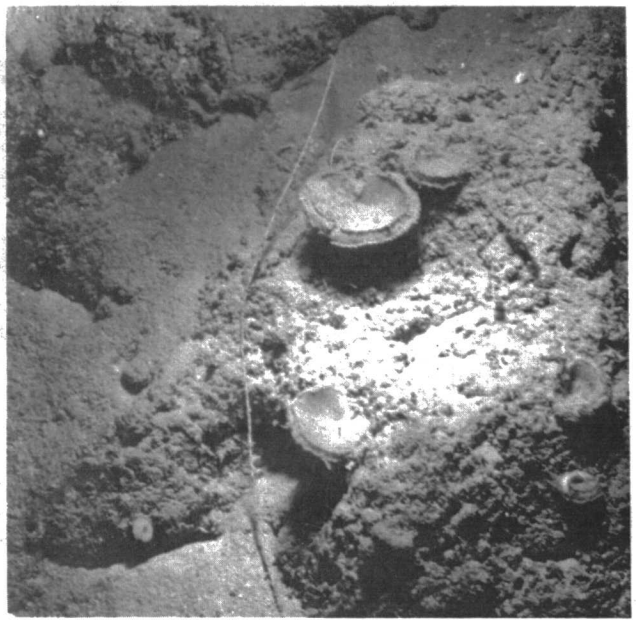


Figure VII-20. Bracket-like lithistid sponges, Corallistes sp., at 120 m depth on 28 Fathom Bank.

westward on a north facing slope).

It is obvious that 28 Fathom Bank, and particularly the southwest peak, bears a significant and highly diverse clear water biotic community above 80 m depth. Below that, a very interesting vertical succession results in a unique turbid water community composed in part of a number of rare species. The commercial fish populations of these peaks are considerable. Groupers of the genus Mycteroperca are abundant and quite large. Some of the largest Red snappers seen by us were at 28 Fathom Bank. These fish occurred both in and out of the nepheloid layers, particularly near the "scarp" of the southwest peak (Fig. VII-16). There is no question but that the biota of 28 Fathom Bank should be classed among those about which there is primary environmental concern.

CLAYPILE BANK

Poag and Sweet (1971) describe Claypile Bank as: "a submarine prominence of low relief located 112 km southeast of Galveston on the Texas Continental Shelf (Fig. VII-1). It rises from a low point of 60 m depth to a crest of 42 m with an average water depth over the bank of 56 m. It is nearly symmetrical along its north-south axis and appears as a flat-topped dome a little more than 1.6 km long with similar slopes at both ends. More complex topography can be seen along the east and west flanks where a steep scarp appears on the southern extremity and the upper surface is rougher. Claypile Bank is a diapiric structure caused by vertical salt intrusion." Gas seeps are common at the bank.

The author has made three research submersible dives at

Claypile. Topographically, the bank is predominantly flat on top with occasional low outcrops of what appear to be rock similar to that seen at Stetson Bank (siltstone and claystone) (Fig. VII-21). Occasional beds a few cm or less thick were seen rising slightly above the generally flattish bottom. The bank is everywhere covered with a thin veneer of sediment varying in size from very fine to rather coarse "shale chips" and shell fragments. Coarser material predominates on the broad top of the bank grading to very fine clay-mud around its base.

The predominant organisms occupying the broad top platform of Claypile Bank are low-growing mats and clumps of leafy algae (Fig. VII-22) (Table VII-3). Near the edge of the platform, where the slope increases and shallow depressions tend to occur, detached clusters of these algae were seen swashing back and forth in depressions, presumably responding to wave action.

What are apparently meadows of Sargassum standing a meter or so high were seen on the uppermost portion of the bank in June 1972. We have not encountered Sargassum growing on the bottom since then. Quite possibly, the occurrence of algal populations such as these is irregular or seasonal or both. Where such high-standing seaweed beds do occur they provide a zone of shelter for numerous fishes of various sizes and species. An alga appearing to be Padina or a close relative was found covering a truck tire lying on the bottom (Fig. VII-23).

Sponges are conspicuous all over the bank, particularly Neofibularia growths (Fig. VII-24), around which congregate many species of reef fishes typical of the shallower portions of

Figure VII-21. CLAYPILE BANK

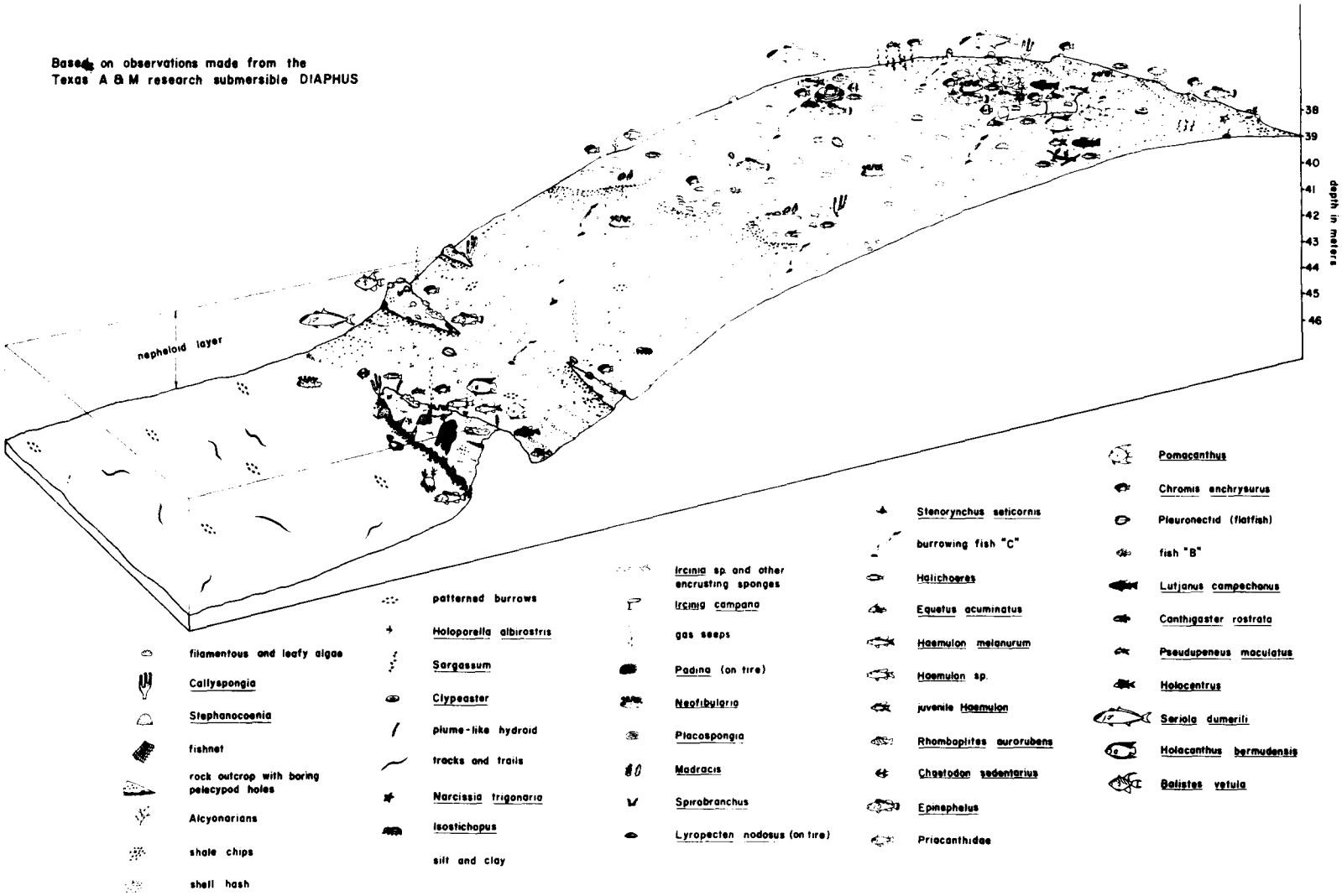


Figure VII-22. Cover of leafy and filamentous algae typical of the shallower part of Claypile Bank, 35 m depth.

Figure VII-23. Old tire covered with heavy growth of Padina-like algae on top of Claypile Bank, 35 m depth.

Figure VII-24. Neofibularia sponge on top of Claypile Bank. Squirrelfish, Bank butterflyfish, small wrasses and grunts, 35 m depth.

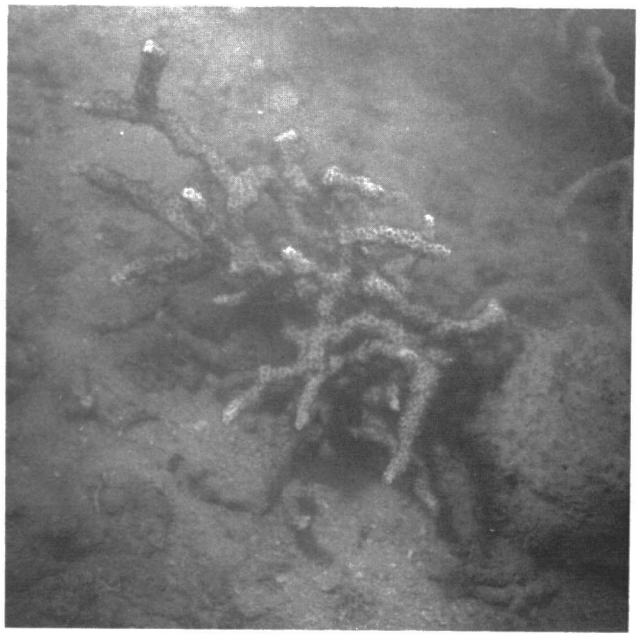


Figure VII-25. A species of Callyspongia near the edge of Claypile Bank in turbid water. Approximately 45 m depth.

the Texas-Louisiana reefs, banks and oil platforms. Callyspongia (Fig. VII-25) and Ircinia are major components of the Claypile Bank sponge fauna. One reddish encrusting-branching sponge, Placospongia, often grows in a form which mimics brain coral (Fig. VII-26), but it is not as abundant as the genera mentioned above.

Hermatypic corals are present in limited quantity at least on the flanks of the bank. Those shown in Figures VII-27 and 28 appear to be Stephanocoenia, a genus which is possibly more widespread in the northwestern Gulf of Mexico than any other massive, head-forming coral due to its apparent ability to exist in somewhat deeper and more turbid waters than varieties of Montastrea, Diploria and other reef forming types. Siderastrea occurs at Claypile as small heads less than 20 cm or so in diameter. Small solitary corals such as Paracyathus are established on outcrops.

Other particularly conspicuous epifaunal organisms are serpulid worms of the genus Spirobranchus, plume-like hydroids and the large branching bryozoan Holoporella (Figs. VII-29 to 31).

Except for the algae, these epibenthic organisms appear to thrive within the heavy nepheloid layer at the edge of the bank (Fig. VII-21), as well as on the relatively clear platform-like top of the bank. The same could be said for the moderately diverse fish population. In fact, Red snappers and large groupers of the genus Mycteroperca were seen in greater numbers on the flank of the bank around some of the outcrops, which tend to be larger there than elsewhere. The fishes tend to congregate around

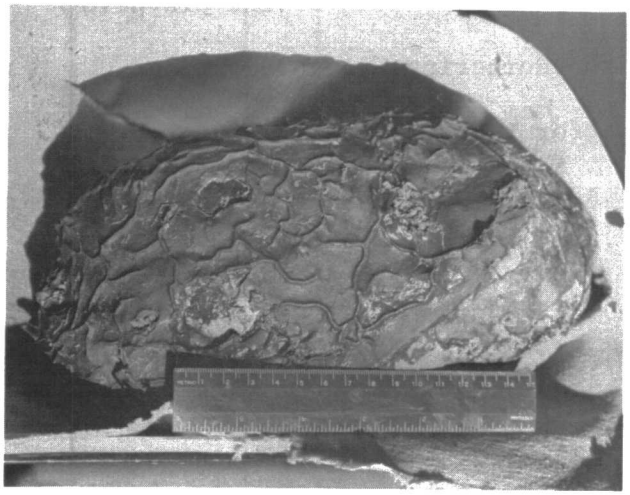


Figure VII-26. Specimen of the sponge Placospongia taken at 45 m depth on Claypile Bank.

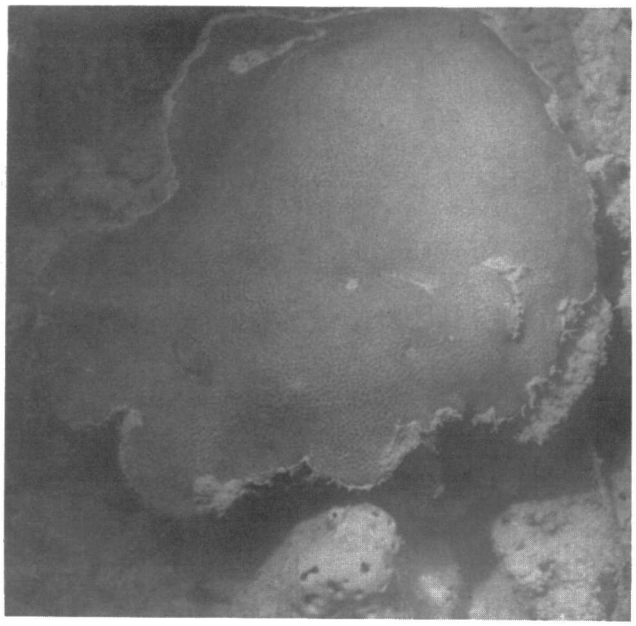


Figure VII-27. Stephanocoenia head at edge of Claypile Bank, 43 m depth.

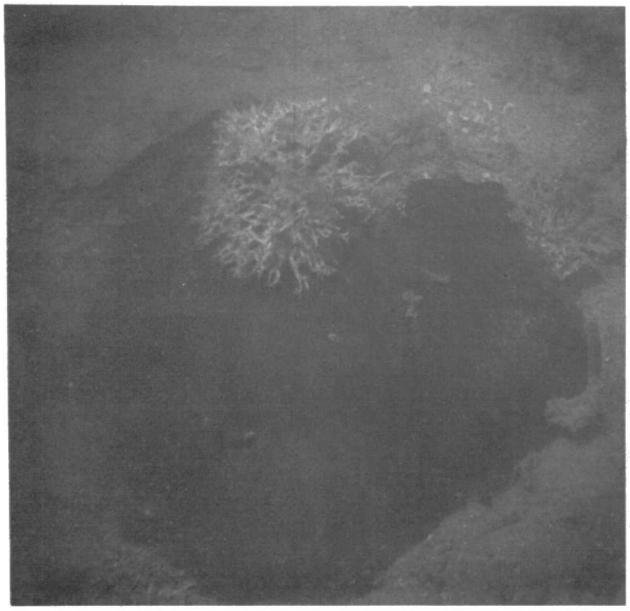


Figure VII-28. Stephanocoenia head very near the one shown in Fig. VII-27. Branching growth may be serpulid worm.

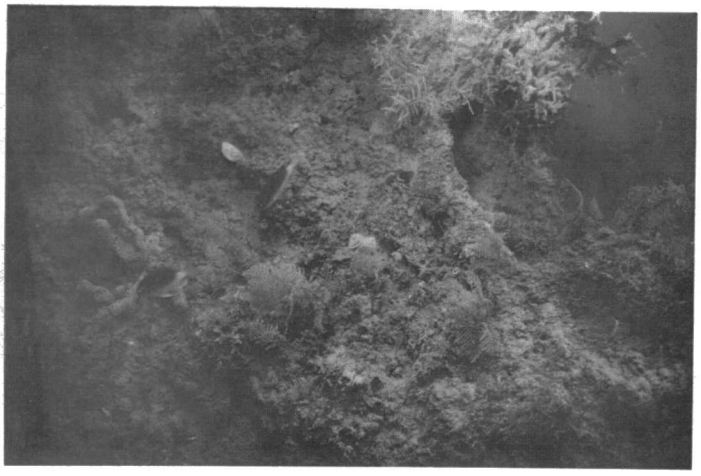


Figure VII-29. Epifauna on bank-edge outcrop at Claypile Bank. Holoporella in upper right, plume-like hydroids, sponges, 42 m depth.

Figure VII-30. Grunts and Chromis enchrysurus at shelf-edge outcrop, 40 m depth at Claypile Bank.

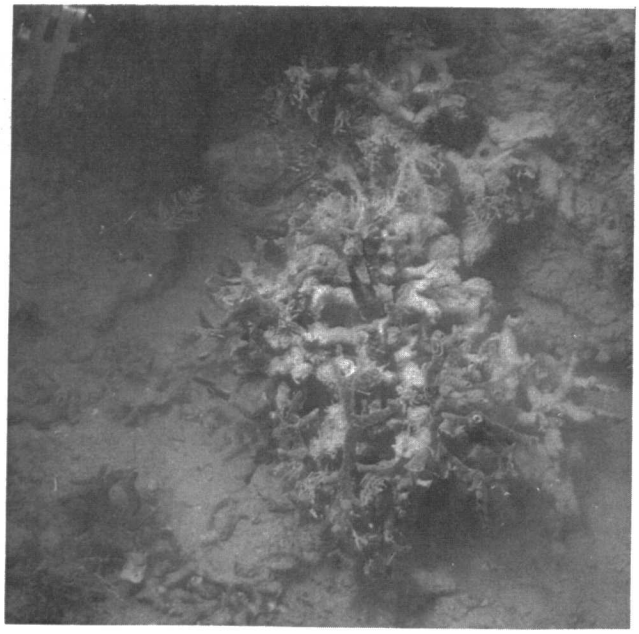


Figure VII-31. Large branching colony of the bryozoan Holoporella, heavily encrusted with other epifauna. 45 m depth at edge of Claypile Bank.

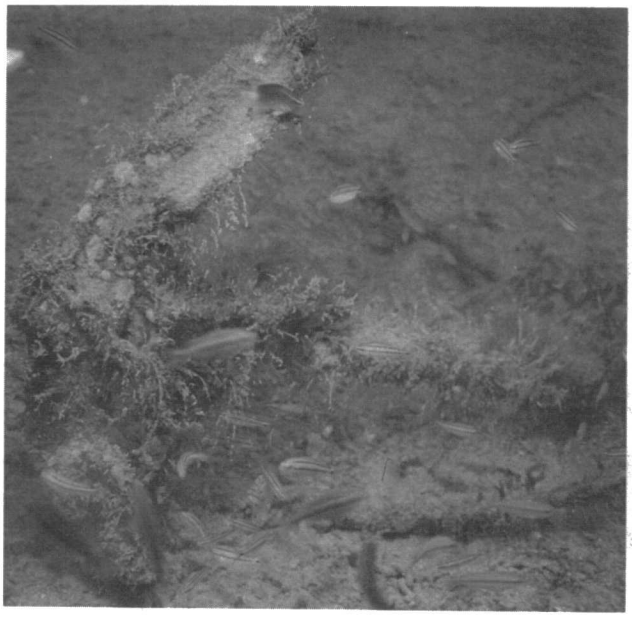


Figure VII-32. Anchor encrusted with epifauna and attracting small fishes at 30 m depth at Claypile Bank.

Figure VII-33. Rock hind atop large pipe at 30 m depth on Claypile Bank.

outcrops and other bottom features such as large sponges and Sargassum meadows. There is a great deal of "junk" on the platform of Claypile Bank which presumably was jettisoned during past drilling operations and fishing activities (Figs. VII-32 to 35). Except for the fishing nets (Fig. VII-35), which seemingly would retard the growth and development of normal epibenthic communities on outcrops, this debris is probably beneficial, supplying elevated hard "artificial reef" substratum on a bank which is severly lacking in the topographic irregularities necessary for the development of substantial epibenthic and reef-fish populations.

In addition to the commercial snappers, Lutjanus compechanus and Rhomboplites aurorubens; groupers of the genus Mycteroperca, and the Greater amberjack, Seriola dumerili; Claypile Bank harbors sizeable populations of the Rock hind, Epinephelus adscensionis (Fig. VII-33); Yellowtail reeffish, Chromis enchrysurus (Fig. VII-30); grunts, Pomadasyidae (Fig. VII-30); Cottonwick, Haemulon melanurum (Fig. VII-36); Cubbyu, Equetus umbrosus; French angelfish, Pomacanthus paru (Fig. VII-37); Bigeye, Priacanthus sp.; butterflyfishes of the genus Chaetodon (Fig. VII-34); damselfishes of the genus Eupomacentrus; Squirrelfishes of the genus Holocentrus (Fig. VII-24) and other typical shallow-water bank fishes of the Texas-Louisiana Outer Continental Shelf (Table VII-3).

One fish deserving particular attention because of its pervasive nature on the upper bank platform is an as yet unidentified species, temporarily designated "Burrowing fish C". This species occurs on all banks visited by us in the northwestern Gulf, but at Claypile the population is possibly larger and

Figure VII-34. Other fishes, Cubbyu, Reef butterflyfish, small grunts, attracted to same pipe shown in Fig. VII-33. Note "shale chips" at base of pipe.

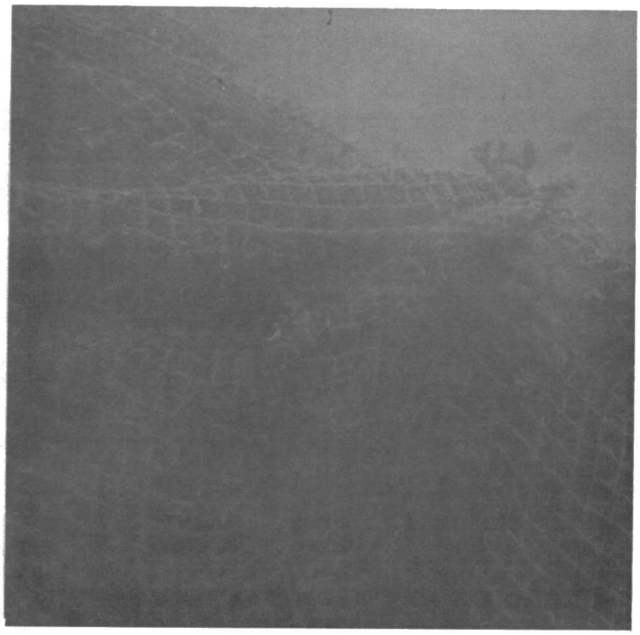


Figure VII-35. Shrimp net on shelf-edge outcrop at Claypile Bank, 40 m depth. Holoporella growing through net.

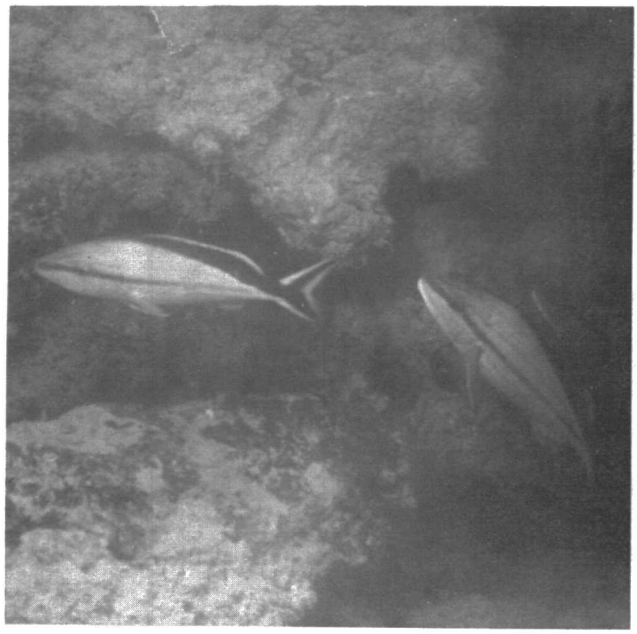


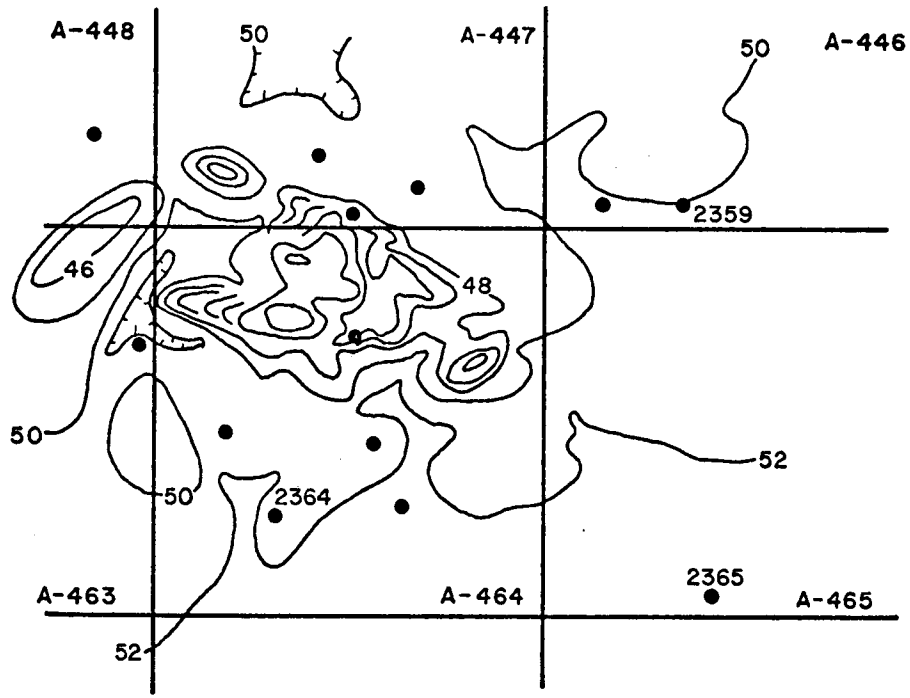
Figure VII-36. Cottonwick at bank-edge outcrop on Claypile Bank, 40 m depth.

Figure VII-37. Young French angelfish at 35 m depth on Claypile Bank.

certainly more conspicuous. At times, a dozen or more of these fish could be seen from the submersible hanging 33 cm or so above their burrows at about a 45° angle, from which position they would dart into the hole as the submersible approached.

Although the biotic communities of Claypile Bank seem relatively less diverse and less abundant than those occupying other nearby banks of comparable depth, they are nevertheless unique and worthy of environmental concern, particularly from the standpoint of the algal population occupying the upper bank platform. It may be worthwile, in fact, to consider the possible consequences of a controlled program of habitat enhancement at Claypile which would involve placement of large, unwanted pieces of oil field debris on the bank platform.

A number of wells were drilled in the vicinity of Claypile Bank a decade or more ago (Fig. VII-38). Several of these were in very close proximity to the bank, and one was either on the platform or just adjacent to it. It is impossible to determine from our data what the impact of such activities may have been on the biota there. One wonders if the debris of obvious oil field origin found atop the bank now marks the position of a capped well. If so, there is little evidence that biota of the sea bottom in the immediate vicinity of the debris differs from that one-half mile or more away. One could speculate, under these circumstances, that the net impact of drilling activities at Claypile may have been beneficial due to the "artificial reef" effect of the debris left behind.



CLAYPILE BANK

(contour interval 2 m)

Figure VII-38. Portions of 9 lease blocks in the vicinity of Claypile Bank. The lease block numbers are prefaced by "A". Drill sites are marked by black dots.

ARANSAS BANK

Biotically, physiographically and hydrographically, Aransas Bank is a typical high-relief South Texas fishing bank. The following biotic characterization was made by Dr. Joyce Teerling after a submersible dive at the bank (Fig. VII-39):

> "On the top of the bank inside the 58 m curve there was a "field" of white sea fans, Muricea (Table VII-4). Interspersed between the sea fans were numerous antipatharians, Cirripathes (Fig. VII-40). The sea fans were limited to only the very top portion of the bank, though the antipatharians went on down to around 65 m depth. Almost all of the sea fans had from 1 to 3 basket stars attached and both color phases were represented (light and dark). There appeared to be a considerable amount of coralline algae. The general surface of the top of the bank was hard, with little sediment except where there were cracks or ravine-like hollows. These cracks in the substratum were usually less than 2 to 3 m in length. There was a slight difference in elevation between the two sides of the cracks. Numerous encrusting sponges were in the area. On the top of the bank were several large Ircinia campana (the large whitish, conulose sponges, often having a central top depression) and Ircinia species A (small, conulose, globular, often purple or maroon in patches and light cream in other areas of the specimen). This species may be I. fasciculata insofar

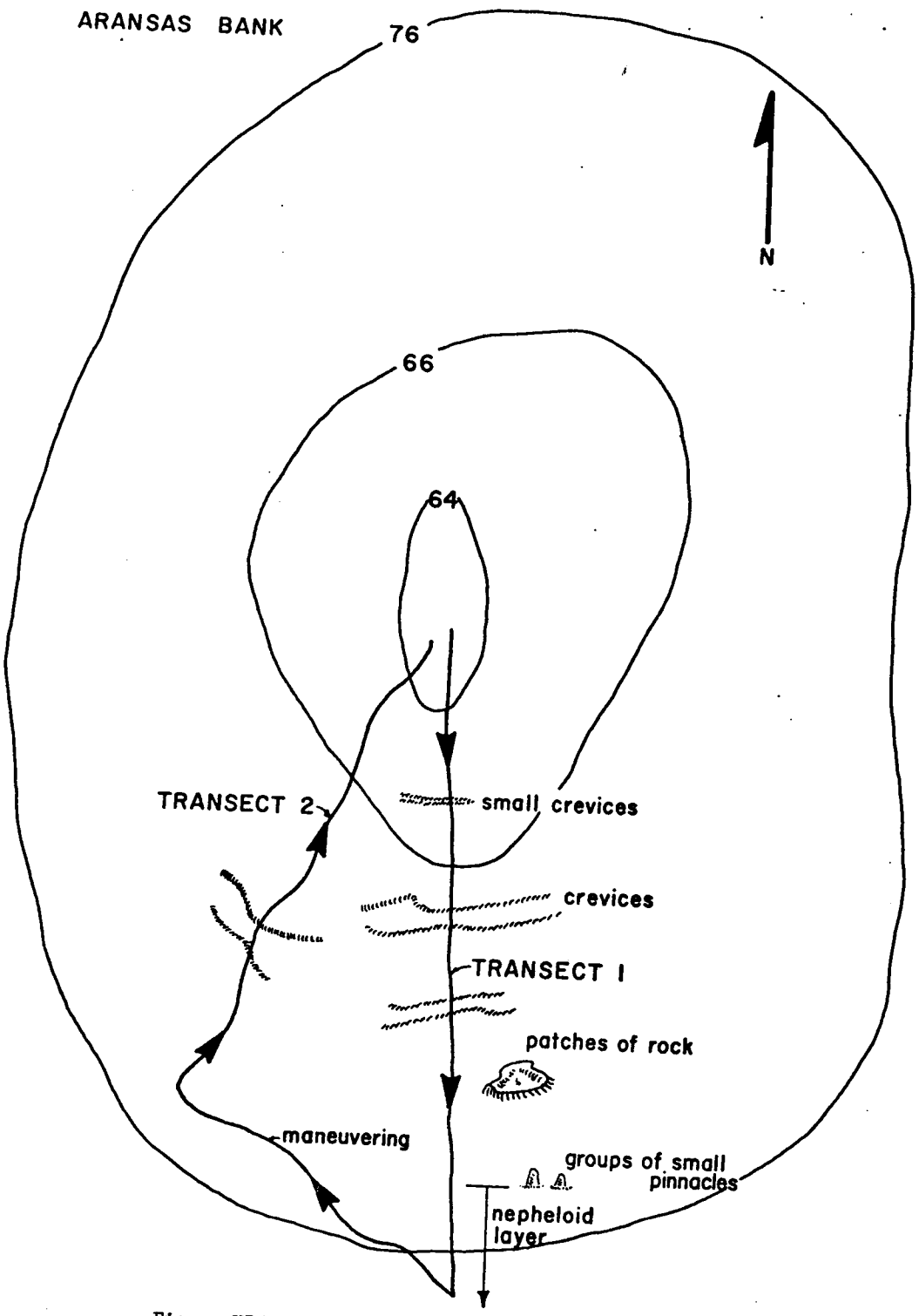
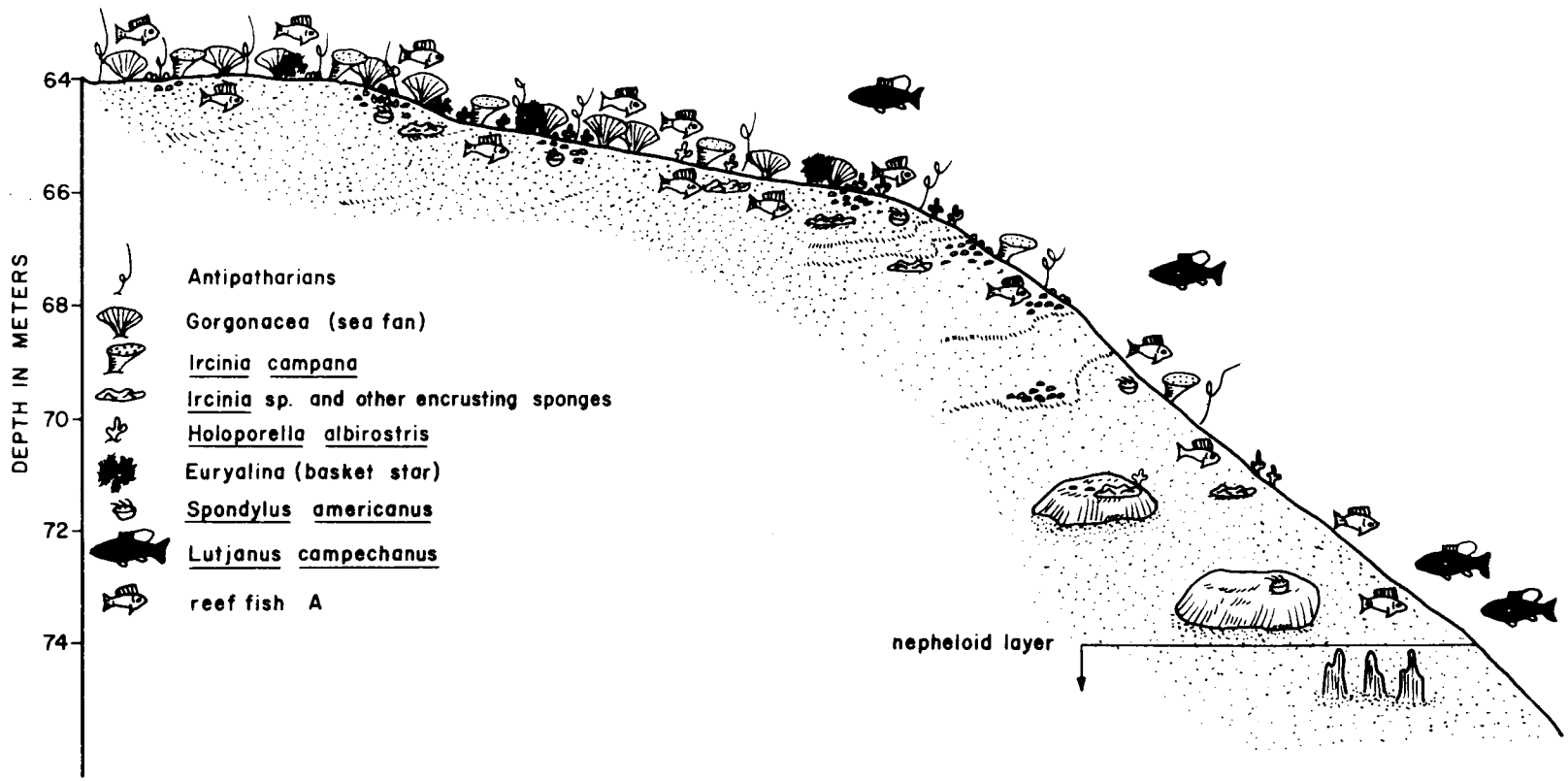


Figure VII-39. Aransas Bank submersible transects made by Teerling.

Figure VII-40. **ARANSAS BANK**



as some of the individual fist sized specimens had tubular projecting oscules instead of the apparently normal non-projecting oscules. Some of this species were grouped together in colonial-looking form while others occurred singly. Also sighted were several patches of Siphonodictyon coralliphagum, a burrowing sponge that has a bright yellow oscular opening extending above the substratum surface. Many Spondylus were seen and it was noticed that many had sponges (Ircinia) on the top valve. There were many dead cone shells, but we were unable to collect any. Also noted were Busycon contrarium, Fasciolaria sp., a tun shell with a hermit crab inside and three anemones on the shell (collected). Many hydroids were scattered around the top of the bank. the reef fish were more concentrated at the top around the crevices and outcrop-like areas than out over the open areas of the bank. Sighted were Blue angel, Holocanthus bermudensis; Reef butterflyfish, Chaetodon sedentarius; 2 species of squirrelfish, Holocentrus spp.; High hat, Equetus sp.; Calamus sp.; Serranus phoebe (formerly Species B); Reef fish A Chromis enchrysurus; and 2 species of Priacanthus. Also observed were occasional areas of piled up pelecypod valves, similar to what an octopus whould leave outside its entrance.

As we started down the bank, the sea fans phased out and were replaced by more antipatharians. As the

sea fans diminished so did the basket stars. The presence of the saucer-shaped agariciid coral and some digitate bryozoans, Holoporella, dimished as we went down to the 66 to 68 m depth contour. At this contour there is more sediment, and the ravines mentioned previously appear. These ravines are about 20 to 40 cm deep and 1 to 2 m wide. In the ravine bottom there are numerous tracks and burrows in the thicker sediment. The tracks are not large, nor are they uplifted. The burrows were usually in groups of 6 to 10 holes in an area (patterned burrows). Further on, there would be another grouping of holes. For a while on the transect that we made going south (180°) (Fig. VII-39), it appeared that the ravines were elongated and were in an east-west direction. Possibly they went all around the bank so that, in any direction of a transect, you would cross them perpendicularly. The Ircinia campana population declined with increased depth. The surface of the bank, from around the 66 m depth contour down, increased its pock-marked appearance and became more barren. The Cirripathes population decreased to nil before entering the nepheloid layer. It seemed that there was only a 6 to 8 m or so relief from the top of the bank to the nepheloid layer (Fig. VII-40). Below 66 m depth the hard substratum gave way to large patches of rock with ravines between, as mentioned above. Near the top of the nepheloid

layer, the large patches of rock became small irregular patches or groups of small pinnacles about 50 to 10 cm in diameter and 20 to 30 cm in height (Fig. VII-39).

While stopped at the interface between the nepheloid layer and the non-nepheloid area, the majority of the game fish were observed (Figs. VII-40 and 41). These include: Blue runner, Caranx fusus; (I don't think it was a Rainbow runner, Elagatis bipinnulata); a large Lutjanus sp.; several smaller Red snapper, Lutjanus campechanus (1 to 1.5 kg); groupers, Mycteroperca; grunts, Pomadasyidae; jacks, Carangidae; and amberjack, Seriola sp. Spondylus americanus were present in fewer numbers. A few were sighted attached to the tops of the patchy substrate near the top of the nepheloid layer. Below the 66 to 68 m depth contour, the sediment layer increased and, when the sub hit the bottom, sediment clouds rose. Some areas above the nepheloid layer looked as if they had been cleared or bulldozed. The depressions in this area had interspersed whiter sediment lying on the top of the regular sediment. Fairly coarse calcium carbonate sediment was found in some of the ravines in the 66 to 70 m depth region.

Over the outcrops and patchy areas, there were some fish that appeared out of burrows or depressions. The burrows or depressions were usually semi-protected excavations with a bit of hard substrate on the top."

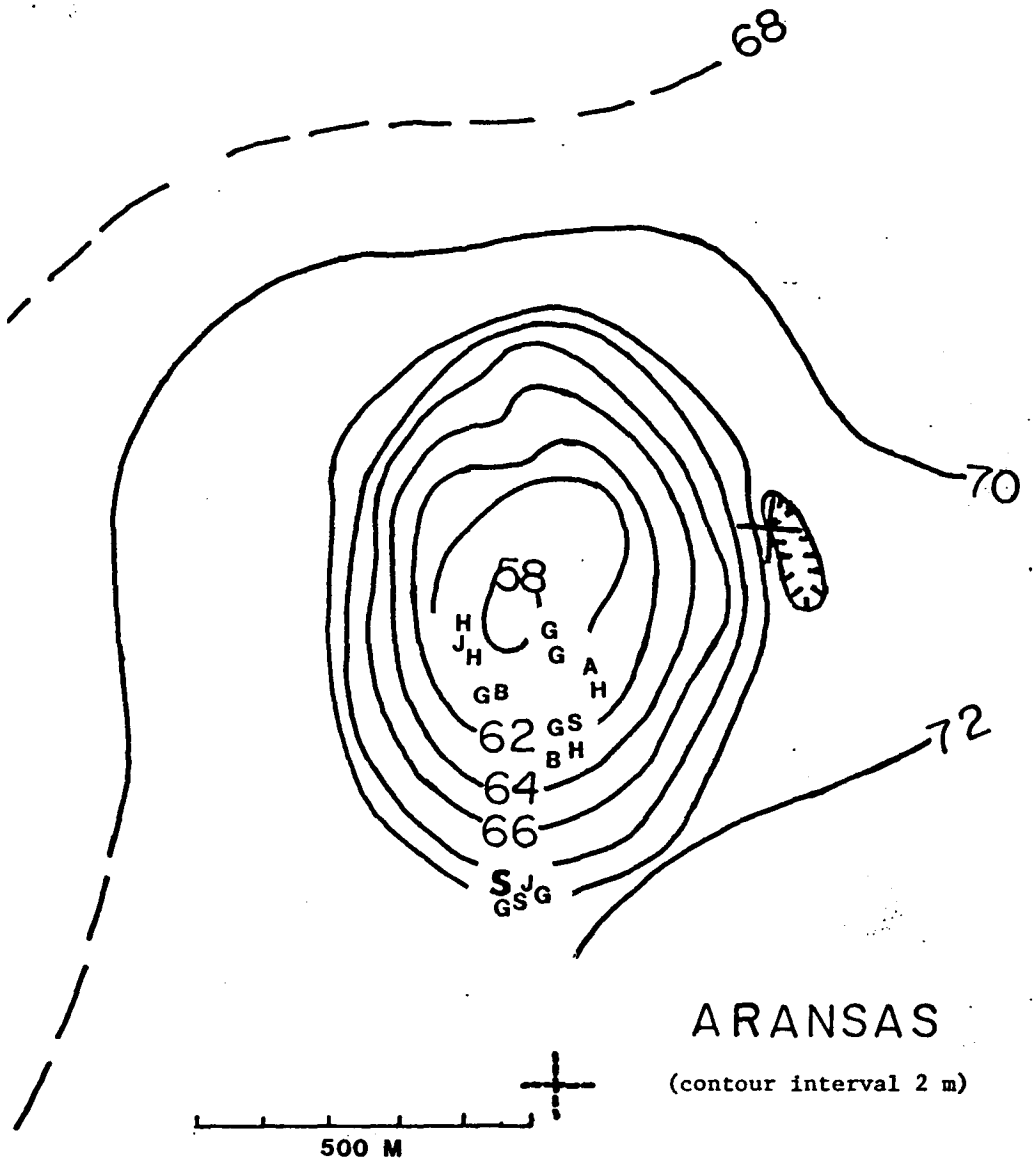


Figure VII-41. Sightings of fishes at Aransas Bank.

A. Reef fish A
B. Reef butterflyfish (Chaetodon sedentarius)
C. Burrowing fish C
G. Groupers (Mycteroperca spp.)
H. Spotfin hogfish (Bodianus pulchellus)
S. school of Red snapper
s. Red snapper (Lutjanus campechanus)
J. Amberjack (Seriola spp.)

The biotic community of Aransas Bank is distinctly similar to that described for all of the other high-relief South Texas banks and should be considered in the same category from the standpoint of environmental concern.

BLACKFISH RIDGE AND MYSTERIOUS BANK

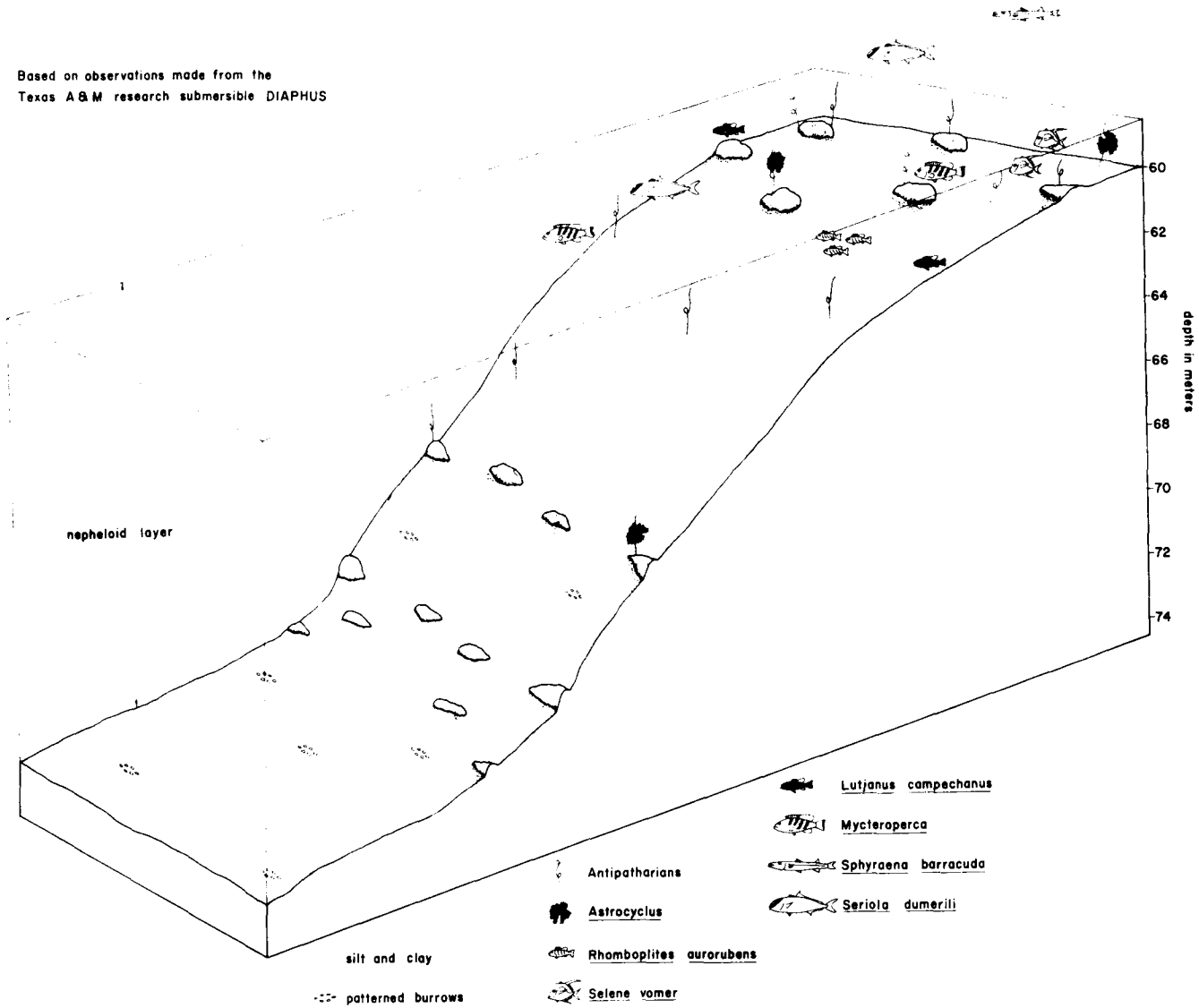
Although topographically these two banks differ considerably, they both appear to suffer the same basic environmental affliction as that reported last year for Big Adam Bank, namely, low relief above the surrounding level bottom in an area of chronically thick nepheloid layers (Fig. VII-42). This has seemingly resulted in the establishment of epibenthic communities of very limited diversity.

The conspicuous organisms, however, are those which are also predominant on the more northerly South Texas banks of greater relief (Dream, Southern, South Baker, etc.). *Cirripathes* is fairly abundant and gorgonocephalid basket stars were frequently seen clinging to the upper extremities of the *Cirripathes* whips (Table VII-5).

Such fishes as Red snapper, *Lutjanus campechanus*; Vermilion snapper, *Rhombophites aurorubens*; Lookdown, *Selene vomer*; and Greater amberjack, *Seriola dumerili* were seen in schools. Solitary *Mycteroperca* and Great barracuda, *Sphyraena barracuda*, were also observed.

The epibenthic biota may be somewhat better developed on the tops of old reef patches which occur at certain levels on the banks.

Figure VII-42. BLACKFISH RIDGE



Even so, such rocks are heavily laden with fine sediment which serves to inhibit epifaunal community development in the same fashion as described for the deeper turbid water parts of Southern Bank and Hospital Rock.

TABLE VII - IA

28 FATHOM BANK

LIST OF SPECIES COLLECTED

	Observed Depth Range (m)	No. of Specimens
Algae		
Valonia ventricosa	52 - 76	3
Dictyota bartayresii	55	1
Galauxaura (*obtusata* v. *major*)	55	1
Cladophora sp.	79	3
Goniotrichum alsidii	76	1
Lobophora variegata	64	1
Pterocladia sp. (?)	64	1
Erythrocladia subintegra	64	1
pink, green encrusting sp.	64	1
Sponges		
Keratosid specimens	56	8
Ircinia fasciculata	56	1
Ircinia strobilina	56	1
Ircinia sp. "a"	56	1
Halisarca sp.	56	1
Gelliodes sp.	56	1
Adocid specimen	56	1
Siphonodictyon coralliphagum	56	1
Callyspongia armigera	56	1
Microciona sp.	56	1
Merriamium tortugasensis	56	1
Anthoarcuata sp.	56	1
Agelas dispar	56	1
Mycale angulosa	56	1
Mycale sp.	56	1
Axinella sp.	56	1
Spirogastrella coccinee	56	1
Cliona lampa	56	1
Thoosa sp.	56	1
Epipolasid specimen	56	2
Cinachyra sp.	56	1
Plakinid specimen	56	1
Chondrosid specimen	56	1

TABLE VII-1A, con't.

Corals		
Madracis mirabilis	56	5
Madracis asperula	56	7
Madracis myriaster (?)	100	
Oculina varicosa (?)	100	12
Madrepora carolina	100	
Carophylia n. sp.	100	
Sp. "A"	100	3
Paracyathus pulchellus	100	19
Coenocyathus n. sp.	100	3
Alyconarians		
Nicella sp.	69 - 70	4
Elisellid specimen	69 - 70	3
Nidalia occidentalis	30	1
Bebryce sp.	30	1
Neospongodes sp.	30	1
Antipatharians	30	1
Antipathes sp.	30	1
Polychaetes		
Eunicidae specimen	56,77	2
Eunice antennata	56.	2
Eunice aphroditois	56	2
Eunice vittata	56	1
Opisthosyllis cf *ankylochaeta*	56	1
Ceratonereis mirabilis	56	2
Syllis (*Typosyllis*) *hyalina*	56	1
S. (T.) *prolifera*	56	2
S. (T.) *alternata*	56	1
S. (*Haplosyllis*) *spongicola*	56	21
S. (*Langerhansia*) *cornuta*	56	3
Trypanosyllis zebra	56	2
Nereidae specimen	56	4
Lysidice ninetta ninetta	56	1
Sabellidae specimen	56	1
Polynoidae specimen	56	2
Terebellidae specimen	56	1
Ampharetidae specimen	56	1
Hydroides norvegica	56	1
Dorvillea sociabilis	56	2
Hermodice carunculata	56	1
Harmothoe sp.	56	1
H. aculeata	56	1
Paleanotus heteroseta	56	1
Vermiliopsis cf. *bermudensis*	56	1

TABLE VII-1A, con't.

Mollusks		
Chlamys bendicti	56	1
Barbatia cancellaria	56	2
Barbatia domingensis	56	2
Gregariella opifex	56	7
Lithophaga bisulcata	56	1
Emarginula pumila	56	1
Botula fusca	79	1
Chiton - species "B"	56	1
Chiton - species "C"	56	1
Crustaceans		
Ampithoe sp. A	56	2
Anomixidae ?	56	2
Colomastix sp.	56	1
Leucothoe spinicarpa	56	5
Melita appendiculata	56	1
? (Damaged)	56	1
Isopoda specimen	56	5
Tanaidacea specimen	56	6
?*Synalpheus* n. sp.	56	1
Thor sp.	56	1
Periclimenes americanus	56	1
Caridean - unidentifiable (damaged)	56	2
Munida simplex	56	1
Melybia ?*thalamita*	79	2
Pilumnus ?*floridana*	56	1
Pilumnus sayi	56	2
Pagurus pygamaeus	56	1
Ophiuroids		
Chaetaster nodosus	56	1
Ophiactis sp.	56	2
Ophiactis savignyi	56	17
Ophioderma sp.	79	1
Ophiothrix sp.	56	1
Amphiuridae specimens	56	2
Echinoids		
Clypeaster sp.	56	1
Chordates		
Didemnidae specimen	56	2

TABLE VII - IB

28 FATHOM BANK

LIST OF ORGANISMS OBSERVED

	Observed Depth Range (meters)	No. of Observations
Algae		
Filamentous	73	1
Leafy	52 - 91	6
Coralline	66 - 91	7
Halimeda sp.	72 - 78	2
Valonia sp.	52 - 76	3
Sponges		
Ircinia sp.	81	2
Neofibularia sp.	52 - 64	2
Agelas sp.	52 - 61	2
orange	67	1
sponge - general	31 - 79	7
Stony Corals		
Madracis sp.	52 - 76	7
Agaricia sp.	52 - 72	10
Millepora sp.	53	1
Antipatharia		
Cirripathes sp.	56 - 93	17
Antipathes sp.	67	1
Alcyonarians	58 - 91	5
Anemones		
Condylactus sp.	52 - 69	3
Stichodactyline anemone	69 - 78	5
Mollusks		
Spondylus americanus	52 - 79	10

TABLE VII-1B, con't.

Crustaceans		
Stenorynchus seticornis	56	1
Mantis shrimp	78	1
Echinoderms		
Comatulid crinoids	56 - 91	12
Isostichopus sp.	69 - 79	8
Starfish	78 - 91	3
Basket star	79	1
Fishes		
Balistes vetula (Queen triggerfish)	52 - 67	5
Xanthichthys ringens (Sargassum triggerfish)	52 - 55	3
Malacanthus plumieri (Sand tilefish)	61 - 67	2
Seriola dumerili (Greater amberjack)	52 - 73	4
Centropyge argi (Cherubfish)	52 - 73	6
Holacanthus tricolor (Rock beauty)	52 - 67	4
Chaetodon ocellatus (Spotfin butterflyfish)	52	1
Chaetodon sedentarius (Reef butterflyfish)	52 - 81	8
Pomacanthus paru (French angelfish)	52 - 61	2
Prognathodes aculeatus (Longsnout butterflyfish)	52 - 91	2
Amblycirrhitus pinos (Red spotted hawkfish)	52	1
Gobiosoma sp. (gobies)	52	1
Synodus intermedius (Lizardfish)	76 - 79	4
Paranthias furcifer (Creolefish)	52 - 73	2
Holocentrus sp. (Squirrelfish)	52 - 76	6
Bodianus pulchellus (Spotfin hogfish)	52 - 91	6
Halichoeres sp. (Wrasses)	58	1
Lutjanus campechanus (Red snapper)	79 - 91	4

TABLE VII-1B, con't.

Rhomboplites aurorubens (Vermilion snapper)	76 - 91	4
Pseudupeneus maculatus (Spotted goatfish)	52	1
Gymnothorax sp. (Moray eel)	73	1
Acanthostracion sp. (Cowfish)	55 - 67	2
Chromis enchrysurus (Yellowtail poetfish)	52 - 91	8
Eupomacentrus partitus (Bicolor Damselfish)	52	1
Priacanthus arenatus (Bigeye)	76	2
Sparisoma sp. (Parrotfish)	52 - 76	4
Liopropoma sp. (Basslets)	52 - 81	5
Mycteroperca sp. (Groupers)	76 - 91	4
Serranus annularis (Orangeback bass)	52 - 73	3
Serranus phoebe	79 - 93	3
Calamus sp. (Porgy)	52	1
Canthigaster rostrata (Sharpnosed putter)	58 - 79	3
Reef fish A	76 - 81	4

TABLE VII - 2A

28 FATHOM BANK, SOUTHWEST PEAK

LIST OF SPECIES COLLECTED

	Observed Depth Range (m)	No. of Specimens
Algae		
Halimeda tuna	76	1
Cladophora sp.	76	1
Padina sp.	76	1
Lobophora variegata	76	1
Agardhinula? #1005	76	1
Rhodymenia pseudopalmata	76	1
Dictyopteris delicatula		
Halymenia rosea (?)		
Microdictyon boergesenii		
Sp. #1001	74	1
Sp. #1004	74	1
Sp. #1006	74	1
Sponges		
Keratose specimens	73 - 88	3
Haplosclerid specimens	73 - 88	1
Gelliodes sp.	76	1
Alcyospongia sp.	76	1
Rhizochalina sp.	73 - 88	1
Agelas dispar	76	1
Auletta sp.	73 - 88	1
Prianos sp.	76	1
Epipolasid specimens	73 - 88	2
Geodia gibberosa	103 - 112	1
Corallistes sp.	76	2
Scleritodermid specimen	73 - 88	1
Stony corals		
Oxsmilia rotundifolia	91	6
Guynia annulata	91	4
Agaricia fragilis fragilis	75	1
Agaricia agaricites purpurea	76	1
Madracis ?*formosa*	72	1
Siderastrea?*siderea*	72	1
?*Madrepora* sp.	72	1
Alcyonarians		
Nicella sp.	73	2
Swifta sp.	73	3

TABLE VII-2A, con't.

Polychaetes		
Trypanosyllis zebra	152	3
Eunice vittata	76	1
Ceratonereis mirabilis	- 88	2
Dorvillea rubrovittata	76	1
Phyllodoce (Anaitides) madeirensis	74 - 88	1
Sabellidae specimen	61	1
Hydroides norvegica	61	1
Potamilla reniformis	74 - 88	1
Ophiodromus obscurus	74 - 88	1
Polynoidae specimen	74 - 88	1
Platynereis dumerilii	74 - 88	1
Opisthosyllis sp.	74 - 88	1
Nereidae specimen	74 - 88	1
Mollusks		
Chlamys benedicti	76	1
Gregariella opifex	73 - 88	2
?*Lima scabra*	76	1
Haliotis pourtalesi	76	1
Botula fusca	76	1
Barbatia candida	76	1
B. domingensis	73 - 88	4
Limpet sp. "B"	61	1
Chiton sp. "D"	56	1
Chiton sp. "A"	56	1
Crustaceans		
Anomixidae	73 - 88	1
Leucothoe spinicarpa	73 - 88	1
Melita dentata	73 - 88	1
Isopoda specimen	76	6
Gonodactylus torus	76	1
Galathea rostrata	76	1
Munida simplex	76	1
Alpheus n. sp.	1	1
Synalpheus pandionis	76	1
Synalpheus tanneri	73 - 88	3
Synalpheus n. sp.	73 - 88	3
Thor sp.	61 - 76	4
Mithrax acuticornis	76	2
Xanthidae sp. "B"	73 - 88	1
Asteroids		
Narcissia trigonaria	76	1

TABLE VII-2A, con't.

Ophiuroids		
Ophidiaster sp.	73 - 88	2
Ophiactis sp.	73 - 88	1
Ophiactis savignyi	73 - 88	11
Ophiactidae specimen	73 - 88	1
Ophiodermatidae specimen	76	1
Ophiothrix angulata	73 - 88	3
Ophiuridae specimen	73 - 88	1
Ophiacanthidae	56	1
Euryalae	76	1
Gorgonocephalidae specimen	76	1
Echinoids	76	1
Crinoids	112	1

TABLE VII - 2B

28 FATHOM BANK, SOUTHWEST PEAK

LIST OF ORGANISMS OBSERVED

	Observed Depth Range (m)	No. of Observations
Algae		
Filamentous	77	1
Leafy	64 - 77	5
Padina sp.	77	1
Halimeda sp.	76	1
Coralline	76 - 108	7
Sponges		
Neofibularia sp.	64 - 75	7
Geodia sp.	113	1
Corallistes sp.	122-125	2
Hydroids	64 - 76	7
Stony Corals		
Agaricia sp.	72 - 76	3
Madracis sp.	64 - 73	4
Solitary type	101 - 146	12
Antipatharia		
Cirripathes sp.	66 - 129	14
Anemones		
Condylactus sp.	72	1
anemones	73 - 75	2
Alcyonarians		
Scleracis sp.	73	1
White branching	96 - 146	3
alcyonarians	105 - 146	7
Orange	98	1

TABLE VII-2B, con't.

Mollusks		
Spondylus sp.	75 - 122	3
Slit shell	98	1
Crustacean		
Hippolysmata grabhami	72	1
Stenorynchus sp.	73 - 134	2
Asteroids	77 - 129	4
Ophiuroids		
Basket star	69 - 134	6
ophiuroids	146	1
Crinoids		
Comatulid	64 - 146	14
Echinoids		
Diademid specimen	99	1
Holothuroids		
Isostichopus sp.	76 - 85	2
Sea cucumbers	64 - 101	4
Fishes		
Balistes capriscus (Gray triggerfish)	77	1
Canthidermis sufflamen (Ocean triggerfish)	75	1
Xanthichthus ringens (Sargassum triggerfish)	72	1
Seriola dumerili (Greater amberjack)	76 - 110	4
Centropyge argi (Cherubfish)	64 - 77	4
Chaetodon aya (Bank butterflyfish)	105 - 108	2
Chaetodon sedentarius (Reef butterflyfish)	72 - 96	4
Holacanthus bermudensis (Blue angelfish)	77	1
Holacanthus tricolor (Rock beauty)	76	1

TABLE VII-2B, con't.

Prognathodes aculeatus (Longsnout butterflyfish)	66 - 76	3
Synodus intermedius (Lizardfish)	76	1
Paranthias furcifer (Creolefish)	75 - 77	3
Holocentrus sp. (Squirrelfish)	72	2
Bodianus pulchellus (Spotfin hogfish)	75 - 96	7
Halichoeres sp. (wrasses)	77	1
Lutjanus campechanus (Red snapper)	75 - 104	9
Rhomboplites aurorubens (Vermilion snapper)	75 - 104	6
Pseudupeneus maculatus (Spotted goatfish)	76	1
Gymnothorax moringa (Spotted moray)	72	1
Ogcocephalus sp. (Batfish)	146	1
Chromis enchrysurus (Yellowtail reeffish)	64 - 77	10
Priacanthus arenatus (Bigeye)	76 - 99	8
Equetus lanceolatus (Jackknife-fish)	95 - 88	2
Scorpaena sp. (Scorpionfish)	137	1
Epinephelus sp. (Groupers)	101 - 122	4
Liopropoma sp. (Basslet)	76 - 96	5
Mycteroperca spp. (Groupers)	76 - 85	7
Serranus annularis (Orangeback bass)	66 - 75	3
Calamus sp. (Porgy)	75	1
Canthigaster rostrata (Sharpnose puffer)	64	1
Triglidae specimen (Sea robins)	101	1
Reef fish A	66 - 116	8

TABLE VII-3A

CLAYPILE BANK

LIST OF SPECIES COLLECTED

	Observed Depth Range (m)	No. of Specimens
Algae		
Lobophora variegata	43 - 46	1
Sponges		
Adociidae	43 - 46	1
Agelas dispar	43 - 46	1
Axinella reticulata	43 - 46	1
Callyspongia armigera	43 - 46	1
Ircinia sp. "b"	43 - 46	1
Placospongia melobesioides	43 - 46	1
Stony corals		
Madracis mirabilis	43 - 46	1
Paracyathus pulchellus	43 - 46	1
Polychaetes		
Syllis (Haplosyllis) spongicola	43 - 46	1
Crustaceans		
Acasta cyathus	43 - 46	1
Leucothoe spinicarpa	43 - 46	9
Paranebalia sp.	43 - 46	1
Gonodactylus bredini	43 - 46	1
Galathea rostrata	43 - 46	1
Synalpheus townsendi	43 - 46	4
Pilummus ? sayi	43 - 46	1
Sp. "A"	43 - 46	1
Bryozoa		
Holoporella albirostris	43 - 46	1
Diaperoecia floridana	43 - 46	4
Idmonea atlantica	43 - 46	2
Beania mirabilis	43 - 46	2
Crisia sp.	43 - 46	2
Aeta truncata	43 - 46	3
Hippothoa distans	43 - 46	1
Parasmittina spathulata	43 - 46	5

TABLE VII-3A, con't.

Chordates		
Didemnidae specimen	43 - 46	3

TABLE VII 3B

CLAYPILE BANK

LIST OF ORGANISMS OBSERVED

	Observed Depth Range (m)	No. of Observations
Algae		
Filamentous	38 - 40	3
Leafy	38	1
Coralline	40	1
Sponges		
Black	38 - 44	2
Neofibularia sp.	38 - 46	10
Callyspongia sp.	38 - 44	3
Barrel	38 - 46	2
Branching	40	1
Ircinia sp.	40 - 46	6
Placospongia sp.	40 - 46	4
Red	46	1
Agelas sp.	46	1
Encrusting specimens	40 - 44	2
Hydroid		
Plume-like	38 - 46	4
Stony corals		
Millepora sp.	38	1
Madracis sp.	41	1
Siderastrea sp.	40 - 44	2
Branching specimen	46	1
Alcyonarians	40	1
Polychaetes		
Spirobranchus sp.	44	1

TABLE VII-3B, con't.

Mollusks		
Lyropecten nodosus	38	1
Conus sp.	46	1
Crustacean		
Stenorynchus sp.	38	1
Echinoderms		
Narcissia sp.	40	1
Clypeaster sp.	43	1
Bryozoans		
Branching specimen	40 - 46	12
Fishes		
Acanthurus bahianius (Ocean surgeon)	38	1
A. chirurgus (Doctorfish)	40	1
Balistes vetula (Queen trigger)	40 - 44	2
Canthidermis sufflamen (Ocean trigger)	18 - 40	4
Canthigaster rostrata (Charpnose puffer)	40	1
Seriola dumerili (Greater amberjack)	40 - 46	3
Holacanthus bermudensis (Blue angelfish)	38 - 46	7
Holacanthus ciliaris (Queen angelfish)	44	1
Pomacanthus paru (French angelfish)	38 - 44	5
Chaetodon ocellatus (Spotfin butterflyfish)	38 - 40	4
C. sedentarius (Reef butterflyfish)	38 - 40	4
Holocentrus sp.	38 - 44	3
Halichoeres sp.	38 - 41	8
Bodianus pulchellus (Spotfin hogfish)	44	3
Rhomboplites aurorubens (Vermillion snapper)	38 - 40	3
Lutjanus campechanus (Red snapper)	40 - 44	6

TABLE VII-3B, con't.

Pseudupeneus maculatus (Spotted goatfish)	44	2
Chromis enchrysurus (Yellowtail reeffish)	38 - 44	school
Eupomacentrus variabilis (Cocoa damselfish)	40 - 44	2
Haemulon melanurum (Cottonwick)	38 - 44	3, plus 6 schools
Orthopristis chrysopterus (Pigfish)	44	4
Pricanthus arenatus (Bigeye)	38 - 40	4
Equetus umbrosus (Cubbyu)	38 - 40	3
Epinephelus adscensionis (Rock hind)	38 - 44	6
Serranus phoebe	38 - 46	5
Mycteroperca sp. (grouper)	44	2
Calamus sp. (orgy)	40 - 44	2
Burrowing fish C	38 - 43	8

TABLE VII 4A

ARANSAS BANK

LIST OF SPECIES COLLECTED

	Observed Depth Range (meters)	No. of Specimens
Sponges		
Ircinia campana	59	1
I. fasciculata	59	1
I. sp. "a"	59	1
I. sp.	59	1
Siphonodictyon coralliphagum	59	1
Alyconarians		
Hypnogorgia sp.	59	1
Polychaetes		
Subadyte pellucida	59	1
Crustaceans		
Erichthonius brasiliensis	59	96
Leucothoe ?	59	3
Melita appendiculata	59	3
Synalpheus townsendi	59	1
? *Periclimenaeus* sp.	59	1
Petrochirus diogenes	59	1
Ophiuroids		
Astroporpa sp.	59	1
Bryozoa		
Holoporella albirostris	59	1

TABLE VII 4B

ARANSAS BANK

LIST OF ORGANISMS OBSERVED

	Observed Depth Range (m)	No. of Observations
Algae		
Coralline Algae	61 - 73	4
Sponge		
Purple	58 - 61	2
Verongia sp.	58	1
Yellow	58	1
Orange encrusting	61 - 73	4
Yellow encrusting	61 - 73	4
Neofibularia sp.	61	2
Red encrusting	61	2
Tube	61	2
Spongia barbara	61	2
Ircinia sp.	57 - 61	3
Ircinia campana	58	2
Ircinia sp."A"	61	2
Stony corals		
Agaricia sp.	58 - 61	4
Madracis sp.	58 - 61	3
Alcyonarians		
Sea fan	58 - 61	10
White Sea fan	58 - 59	3
Gorgonians	68	1
Antipatharia		
Cirripathes sp.	68	1
Antipathes sp.	58 - 73	11

TABLE VII-4B, con't.

Mollusks		
Spondylus sp.	60 - 62	7
Crustaceans		
Hermit	61	2
Ophiuroids		
Unknown type	61	1
Basket Star	58 - 61	7
Crinoids	59 - 73	18
Bryozoans		
Holoporella sp.	61 - 73	6
Fishes		
Seriola dumerili (Greater amberjack)	58 - 69	4
Holacanthus ciliaris (Queen angelfish)	58	1
H. bermudensis (Blue angelfish)	61	1
Chaetodon sedentarius (Reef butterflyfish)	58 - 73	4
Holocentrus sp. (Squirrelfish)	58	2
Bodianus pulchellus (Spotfin hogfish)	58 - 73	4
Lutjanus campechanus (Red snapper)	68	2
Chromis enchrysurus (Yellowtail reeffish)	58 - 61	5
Priacanthus arenatus (Bigeye)	58 - 62	7
Equetus acuminatus (Cubbyu)	58	1
Mycteroperca phenax (Scamp)	61	1
M. sp.	58 - 68	4
Serranus phoebe	61	4
Calamus sp. (Porgy)	58	1
Reef fish A	61	1

TABLE VII 5

BLACKFISH RIDGE

LIST OF ORGANISMS OBSERVED

	Observed Depth Range (m)	No. of Observations
Antipatharians		
Cirripathes sp.	56 - 62	7
Ophiuroids		
Basket star	60	1
Fish		
Seriola dumerili (Greater amberjack)	40 - 59	7
Seriola sp.	55	1
Selene vomer (Lookdown)	58	1
Lutjanus sp.	55 - 56	2
L. campechanus (Red snapper)	59	1
Rhomboplites aurorubens (Vermilion snapper)	55 - 62	5
Mycteroperca phenax (Scamp)	59	1
Sphyraena barracuda (Barracuda)	20	1

CHAPTER VIII

POST-DRILLING

AND

MONITORING STUDIES

POST-DRILLING
AND
MONITORING STUDIES

Principal Investigator

Thomas J. Bright

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INTRODUCTION

Post-drilling assessments of epibenthic and groundfish communities were required in 1976 for Stetson Bank, South Baker Bank, Southern Bank and the East Flower Garden Bank. All of the assessments added new information to what had previously been gathered concerning biotic communities occupying the banks in question, but no "effects" due to drilling were apparent.

Environmental monitoring of reef communities at the Flower Garden Banks revealed numerous examples of natural pathological conditions of hermatypic corals. Knowledge of the extent, causes and effects of these conditions are of profound importance from the standpoint of management of coral reef resources in the northwestern Gulf of Mexico, particularly insofar as it is suspected that under certain circumstances man's activities on or near such reefs can accelerate the processes by which infectious coral pathogens destroy living coral tissue.

Part of the monitoring effort was accomplished as required by the 1976 BLM contract and part was done in conjunction with a Union Oil Company study before, during and after drilling at the West Flower Garden.

STETSON BANK

In the spring of 1974, our group performed a pre-drilling baseline survey of Stetson Bank for Signal Oil & Gas Company. We were asked by BLM to revisit Stetson in 1976 to make a comparative assessment of the condition of the communities there in an attempt

to determine to what extent nearby drilling may have affected the biota of the bank. We found no evidence of deterioration of biotic communities between 1974 and 1976 and could demonstrate no effects due to drilling. The biota found in 1976 were in virtually the same condition as seen in 1974. The following description of Stetson Bank epibenthic and groundfish communities is a modification of a part of the 1974 report, taking into account new findings made during 1976 and using photographic figures from 1976 only.

Stetson bank occupies about 10 acres of sea bottom, rising from a base depth of 50 m or so to a crest of 20 m on its northwest side (Figs. VIII-1 and 2). The substratum of the bank is primarily soft siltstone and claystone (Neumann, 1958), the surface of which is extensively perforated with what are interpreted as boring pelecypod holes.

The morphology of the bank consists of a relatively level top penetrated in places by thin, nearly vertical beds of more highly indurated rock and often broken by abrupt upward outcropping siltstone structures of approximately 0.3 to 3 m horizontal and vertical dimensions.

The bank's margins are characterized by areas of high relief with outcropping structures standing 4 to 5 m above the surrounding bottom. These structures are sometimes separated by small canyon-like passages. The slope of the bank's margin varies from low angles to near vertical drops of 12 m or more.

Debris and sediment (clay to boulder size) derived from bedrock are found in varying degrees everywhere on the bank, in holes

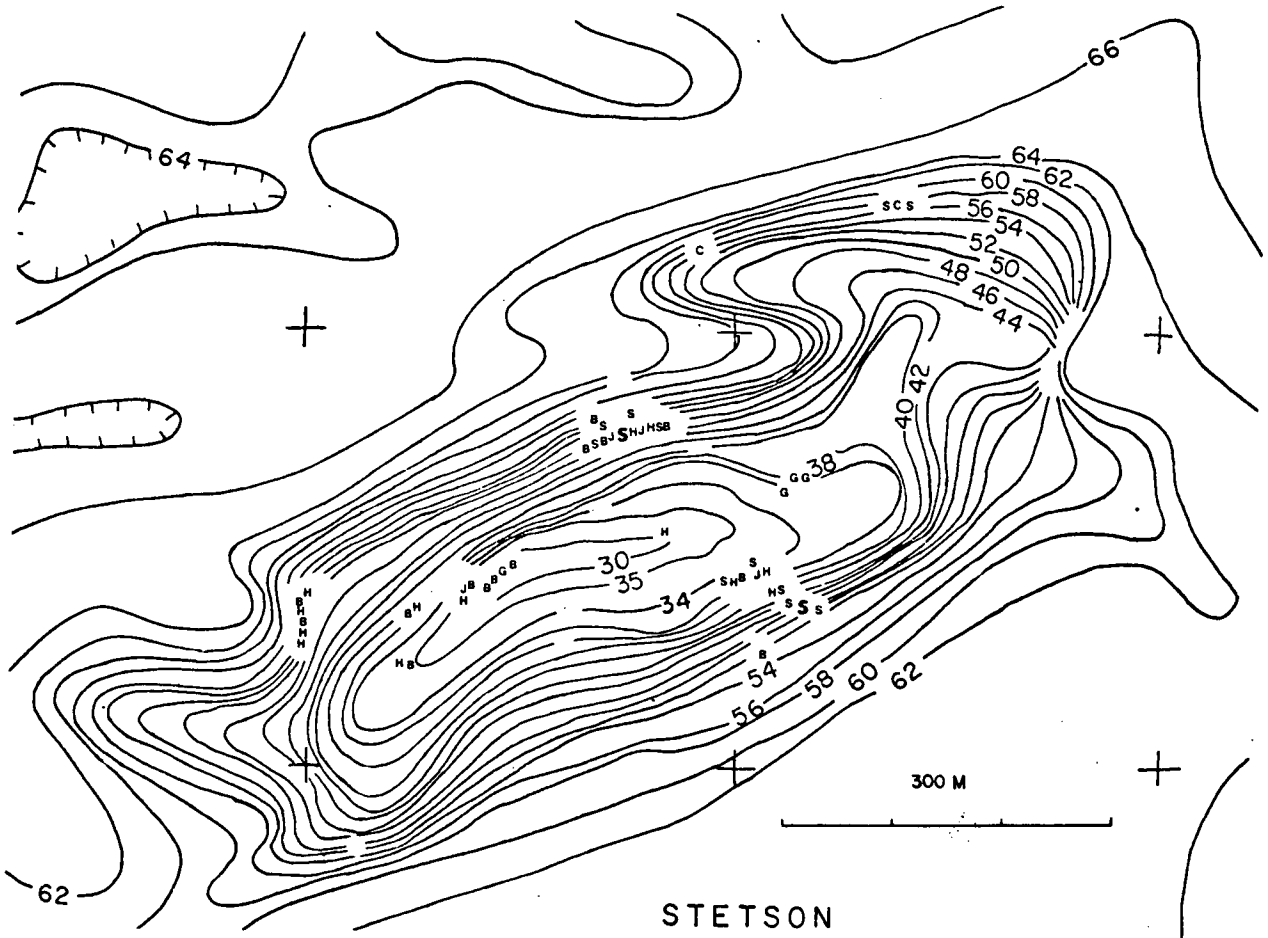
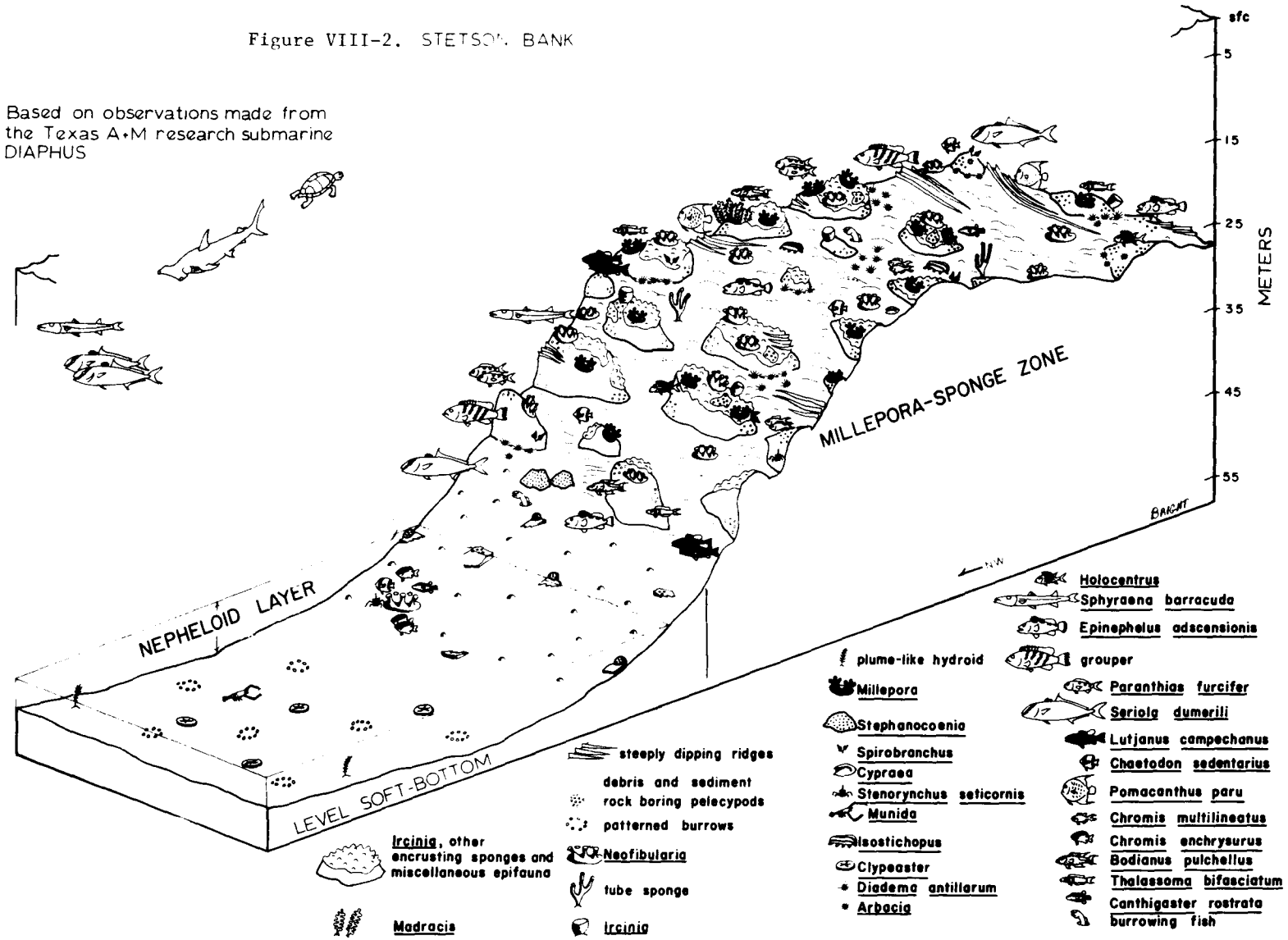


Figure VIII-1. Sightings of fish at Stetson Bank. (contour interval 2 m)

A. Reef fish A
B. Reef butterflyfish (Chaetodon sedentarius)
C. Burrowing fish C
G. Groupers (Mycteroperca spp.)
H. Spotfin hogfish (Bodianus pulchellus)
S. school of Red snapper
s. Red snapper (Lutjanus campechanus)
J. Amberjack (Seriola spp.)

Figure VIII-2. STETSON BANK



and depressions and overlying level hard-bottom areas. On the level soft-bottom near the base of the bank, various sized pieces of bedrock are mixed with extremely fine sediment. In general, the level bottom away from the bank consists of soft, fine mud which is easily stirred up and stays in suspension for a long while.

The hard substratum and high relief of the bank have attracted and provided habitats for a moderately diverse assemblage of epifauna, mobile invertebrates and groundfishes (Table VIII-1). The surrounding level soft-bottom at the base of the bank supports a community of infauna, mobile benthos and, where isolated rocks or sponges occur, epifauna and groundfishes.

The most conspicuous faunal elements of the soft mud bottom surrounding Stetson Bank are the sand dollar Clypeaster sp. (Fig. VIII-3), small burrows of unknown origin occurring in characteristic circular patterns (patterned burrows) and plume-like hydroids, probably of the families Plumularidae and Sertulariidae. Although few live organisms are visible in or on the mud, we have captured certain polychaete worms, mollusks, echinoderms and crustaceans on the soft-bottom (Table VIII-1).

On the level bottom near the base of the bank, isolated exposures and fragments of bedrock fallen down from above provide a substratum for attachment of some of the epifaunal organisms typically found on the bank itself (Fig. VIII-4). The most conspicuous organism occurring in this transition zone between the level soft-bottom below and hard-bank above is the sponge Neofibularia sp. (Fig VIII-5). Here and on the bank proper,

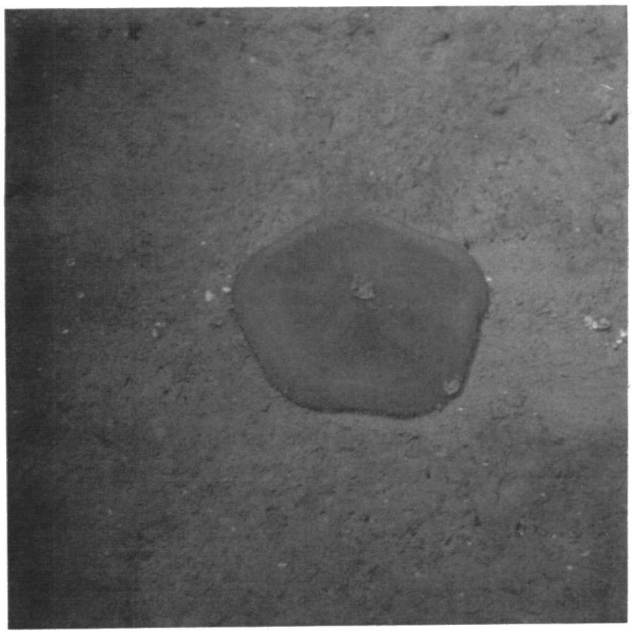


Figure VIII-3. Clypeaster on soft sediment adjacent to Stetson Bank. Note the distinctive trail to the right of the organism.

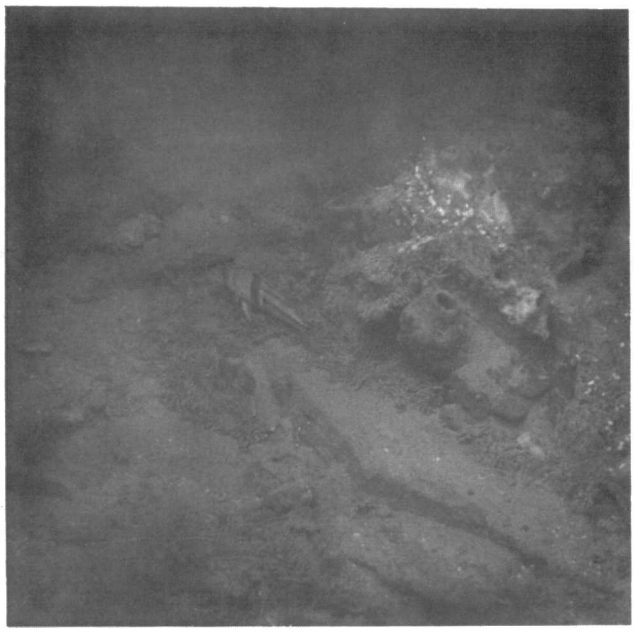


Figure VIII-4. Serranus phoebe at a small outlying outcrop near the base of Stetson Bank.

Figure VIII-5. Neofibularia near the top of Stetson Bank. The base of the sponge is typically covered the sediment.

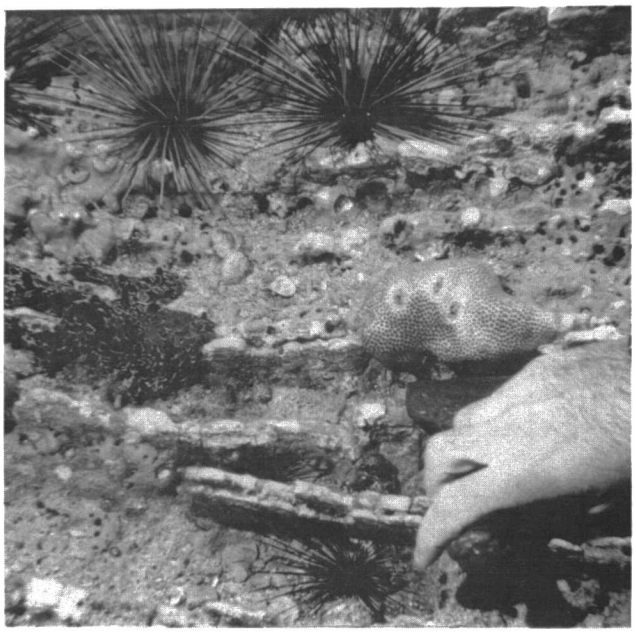


Figure VIII-6. Outcrop at 27 m depth on Stetson Bank showing bedding, boring pelecypod holes, Diadema, sponges and a small head of hermatypic coral (probably Stephanocoenia above diver's hand).

Neofibularia grows in roughly circular encrusting masses with numerous vertically standing "chimneys". Where they occur on the level soft-bottom, they serve as points of congregation for a number of mobile benthic invertebrates and groundfishes (particularly juveniles or certain fish species which occur as adults in the shallower Hard-Bank Zone). For example, at a depth of 53 m south of the bank, the following species were observed on or hovering above a Neofibularia sponge:

Stenorynchus seticornis, Arrow crab

Chaetodon sedentarius, Reef butterflyfish

Holacanthus bermudensis, juvenile, Blue angelfish

Pomacanthus paru, juvenile, French angelfish

Chromis enchrysurus, Yellowtail reeffish

Equetus umbrosus, Cubbyu

Canthigaster rostrata, Sharpnose puffer

Almost every square meter of the soft-bottom below the base of the bank contained a number of burrows, generally in the typical circular patterns described previously. The organisms which produced these burrows must be currently active, possibly nocturnal, because the holes would not persist long unoccupied at these depths.

Visual observations from the research submersible indicated that below 46 m depth, water clarity observations were rather variable. Above 30 m depth, water clarity was consistently good. Probably, therefore, the benthic biota inhabiting the level Soft-Bottom Zone below 49 m depth adjacent to Stetson Bank are subjected to chronically high turbidity and sedimentation. Indeed, the bases of growths of Neofibularia there and in the Hard Bank Zone

were repeatedly observed to be covered to some extent with sediment, a condition to which they are obviously adjusted.

The predominant biotic feature of the Hard-Bank Zone (20-50 m depth) is the extensive riddling of the substratum, apparently by rock boring pelecypods such as *Jouannetia quillingi* and *Lithophaga bisulcata* (Fig. VIII-6). Neumann, 1958, was not sure that rock boring molluscs, particularly *Jouannetia quillingi*, were alive on the bank. All of the specimens he collected consisted only of hard parts with no evidence of living tissue. He did not, however, obtain specimens from depths less than 44 m, which is very near the base of the Hard-Bank Zone. Living representatives of both species mentioned above were collected by us in June, 1974 at 24 and 27 m depth respectively.

The percentage of bore holes occupied by living pelecypods is unknown. We have found up to 350 holes per square meter of bottom in places, although the average is considerably less. If one assumes that an average of 30 of these holes per square meter harbour living pelecypods, it would mean that a population of nearly 1.5 million rock boring pelecypods may be active on Stetson Bank at the present time. While this is numerical speculation, it would be interesting to engage in a quantitative study of the population, relating its density and destructive capacity to erosional processes on the bank.

The encrusting epifauna of the Hard-Bank Zone are overwhelmingly sponges and hydrozoan fire coral, *Millepora* (Fig. VIII-7). Of the sponges, *Ircinia* and *Neofibularia* seem most important (Fig. VIII-8). The percentage of epifaunal cover is highly

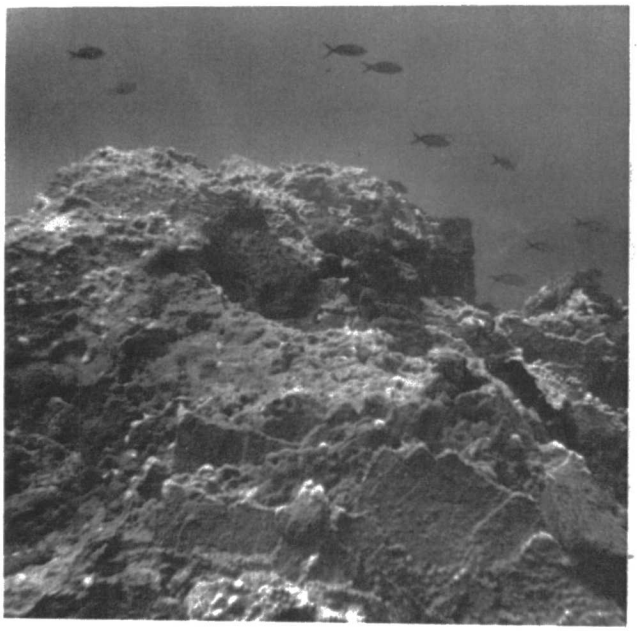


Figure VIII-7. Top of typical outcrop near crest of Stetson Bank, encrusted heavily with Millepora, right foreground, and sponges.

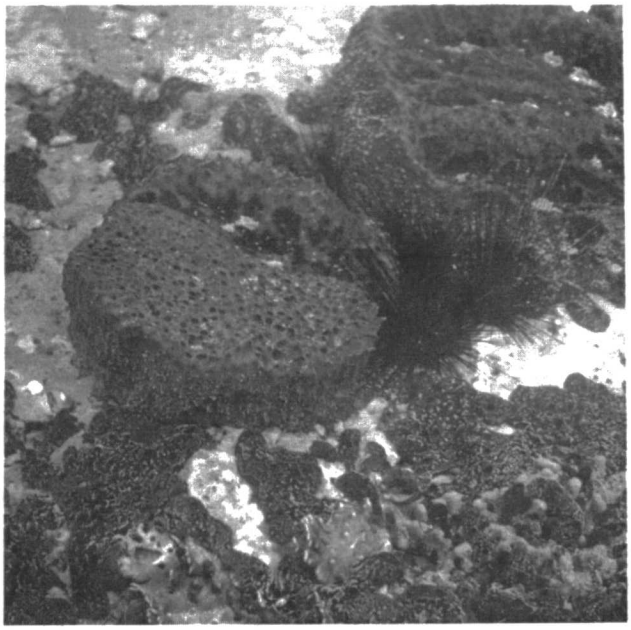


Figure VIII-8. One of the predominant epifaunal sponges, Ircinia sp., possibly I. strobilina, in encrusting and massive phases. Diadema in right center. Near top of Stetson Bank.

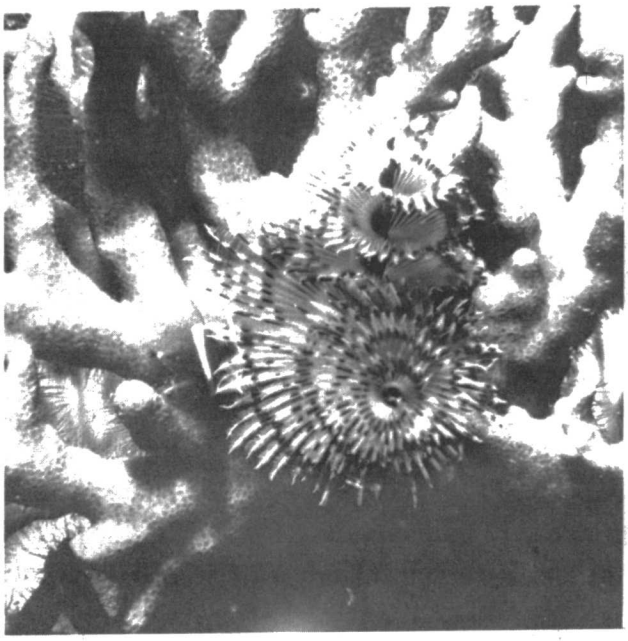


Figure VIII-9. Closeup of Spirobranchus growing in mass of Madracis at 27 m depth at Stetson Bank.

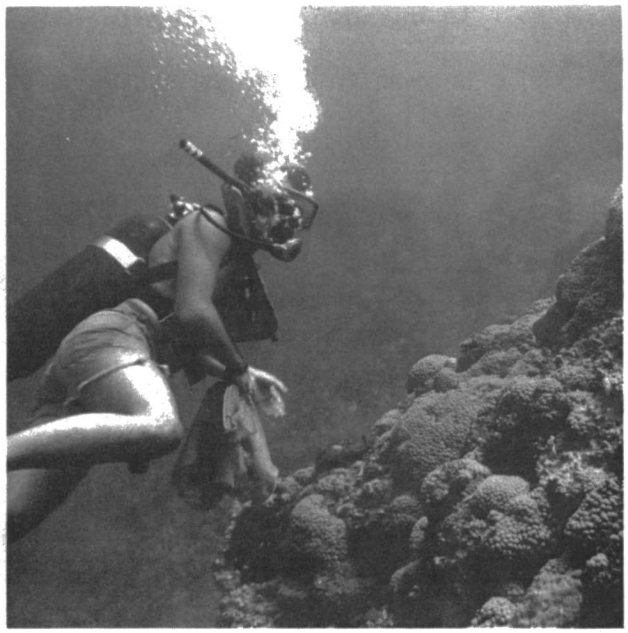


Figure VIII-10. Small field of Madracis decactis at 27 m depth at Stetson Bank.

variable from place to place in the Hard-Bank Zone. As indicated in Fig. VIII-2, much of the Hard-Bank Zone is occupied by a bottom which, though not level, has outcrops only 0.3 m or so high and is frequently penetrated by thin, nearly vertical beds of harder rock usually standing only a few centimeters high. This very low relief bottom is conspicuously strewn with encrusting Neofibularia growths from 1 to 1.5 m or so in diameter and generally less than 0.5 m high (Fig. VIII-5). The population density and spacing of these Neofibularia growths varies considerably from place to place. Generally, they are more abundant near the edges of the bank than on its interior. Almost everywhere in the Hard-Bank Zone, however, at least one or two of these growths could be seen at any time from the submarine. In certain places near the north and south bank edges at 27 to 30 m depth, Neofibularia growths were found in aggregations, being separated from one another by only 3 to 5 m. Generally, where Neofibularia occurred on level-bottoms, or hard-bottoms of low relief, the bases of the growths were covered to some extent by sediment, as mentioned previously. On the higher outcrops, a species of the sponge Ircinia (possibly Ircinia strobilina) shares predominance with Neofibularia and Millepora (Figs. VIII-7 and 8).

The high dip bedding described above is frequently topped by encrustations of Millepora which, consequently, often appear on the low relief hard-bottom in linear growth with low upward directed branches. Millepora is certainly not restricted to the high dip bedding; it occurs also as small patches on somewhat elevated parts of the hard-bottom. The Millepora population, however,

approaches in magnitude that of the sponges only on the outcropping siltstone structures of high relief (Fig. VIII-7).

The high relief outcrops, which are larger and more numerous near the bank edges than on its interior, bear varying amounts of epifauna composed primarily of sponges and Millepora in a ratio approximating 60:40% respectively. Total epifaunal cover on the middle and upper parts of the high relief outcrops varies from sparse to nearly 90%. The bases of these outcrops, though normally bored by pelecypods, are usually devoid of other epifauna or have only a very limited cover. The feather duster worm, Spirobranchus, deserves mention as a conspicuously visible element of the epifauna in the Hard-Bank Zone, with its tubes penetrating Millepora as well as bare rock (Fig. VIII-9).

There are important deficiencies in Stetson Bank's moderately diverse epibenthic community. We saw no leafy algae and no alcyonarian corals (sea whips and sea fans). Encrusting calcareous algae, though present, are apparently insignificant as constructional agents. Only two occurrences of the algae have been recorded. Neumann, 1958, reports Lithothamnium from a claystone rock in 44 m depth and we found traces collected at 43 m depth. We saw no calcareous algae from the submarine or during SCUBA dives.

Corals other than Millepora are not generally abundant at Stetson. We saw and collected Stephanocoenia sp. between 27 and 50 m depth on the north and south margins of the bank and near the top (Figs. VIII-2 and 6). Two coral heads seen at 43 m depth on the north margin were about 1.5 m in diameter, all others were

less than 0.3 m. Interestingly, as we descended the north slope of the bank after collecting a piece of Stephanocoenia sp. in relatively clear water at 43 m depth, we continued seeing small heads growing atop large fallen slabs of claystone down to 48 m depth and well into the nepheloid layer. On the underside of a piece of Stepanocoenia collected at 43 m depth in 1974, we discovered encrustations of another coral, Madracis decactis. In 1976, we found a small field of Madracis decactis at about 24 m depth near the top of the bank (Fig. VIII-10). Edwards (1971) reported isolated heads of four species of scleractinian corals from Stetson Bank (Siderastrea sp., Montastrea annularis, Madracis asperula and the brain coral, Diploria strigosa); of these, we have encountered only Siderastrea. A sponge, Placospongia, encrusting rocks at Stetson, mimics the brain corals to some extent (Fig. VIII-11). The large branching bryozoan, Holoporella, was observed near the bank edge. It resembles to some extent the branching growth form of Madracis.

Of the mobile macroinvertebrates in the Hard-Bank Zone, the sea urchins, Diadema antillarum, are most conspicuous and quite abundant above 46 m depth (Fig. VIII-8). They were seen singly or, more often, in close aggregations of up to 50 individuals (average about 15) on the low-relief hard-bottom and at the bases of high-relief outcrops. A smaller sea urchin, possibly Arbacia punctulata, was seen at 24 to 27 m depth on the top interior of the bank. Not as abundant as Diadema, this species occurred in similar aggregations. It is more likely to be found in cracks and holes or under small ledges than is Diadema.

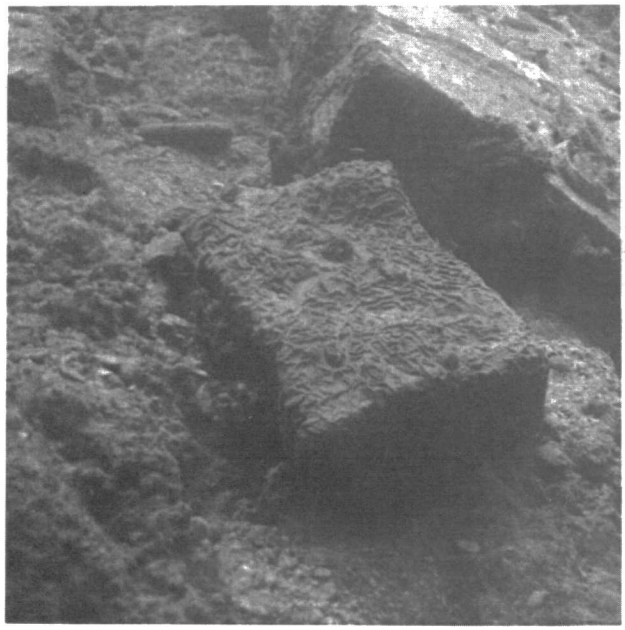


Figure VIII-11. Placospongia, in situ, near the base of Stetson Bank.

Figure VIII-12. Specimen of Scyllarides aequinoctialis taken from 27 m depth at Stetson Bank.

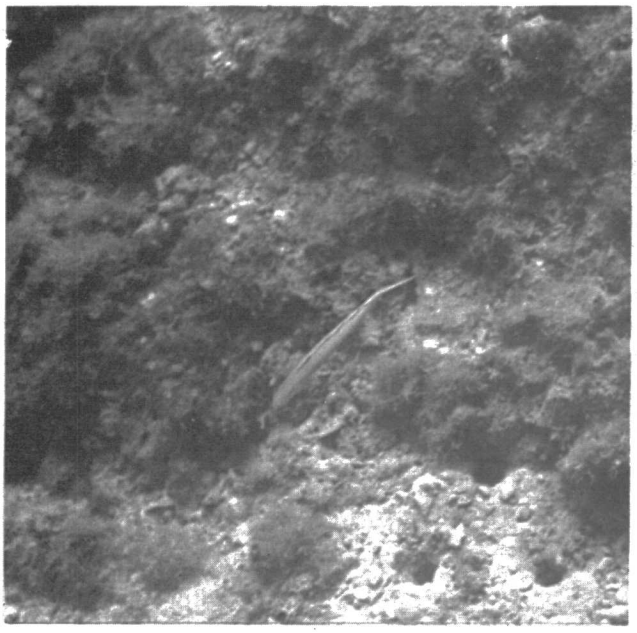


Figure VIII-13. Burrowing fish C at bank edge on Stetson Bank.

Figure VIII-14. Red snappers in nepheloid layer near base of Stetson Bank.

The large sea cucumber, Isostichopus badionotus, was sighted frequently between 24 and 27 m depth on unconsolidated sediment and bare rock. Fecal castings were observed in sediment adjacent to, and presumably produced by, Isostichopus, indicating that these organisms rework to some extent the thin veneer of sediment on the low-relief bottom of the Hard-Bank Zone.

The asteroid Narcissia trigonaria was encountered in the Hard-Bank Zone at 56 m depth and Astropecten was captured in the level Soft-Bottom Zone off the bank (Table VIII-1). Brittle stars, especially Ophiothrix angulata and Ophiactis savignyi, which were frequently found inside sponges collected in the Hard-Bank Zone, are fairly well represented in both zones.

Of the crustaceans listed in Table VIII-1, only the Arrow crab, Stenorynchus seticornis, was seen from the submarine. Its distinctive shape and rather non-secretive habits make it easily recognized. Stenorynchus is generally associated with Neofibularia sponges, rocks, coral heads and other objects on the bottom. SCUBA divers captured a fine specimen of Scyllarides aequinoctialis near the top of the bank (Fig. VIII-12).

The groundfishes inhabiting Stetson's Hard-Bank Zone are tropical Atlantic reef fish (Table VIII-1) and occur abundantly on coral reefs in the Caribbean, Bahamas and Gulf of Mexico (Florida, Yucatan shelf, off Veracruz, off Tampico, East and West Flower Gardens and other banks on the Texas-Louisiana continental shelf). The most frequently encountered fish was the Bluehead, Thalassoma bifasciatum, as is generally the case at comparable depths on other banks studied by the author in the Western Gulf of

Mexico and Caribbean. Fishes most often seen by us at Stetson are illustrated in Fig. VIII-2. The Rock hind, Epinephelus adscensionis; Reef butterflyfish, Chaetodon sedentarius; French angelfish, Pomacanthus paru; squirrelfish, Holocentrus sp. (rufus or ascensionis) and large groupers, Mycteroperca spp. are particularly characteristic of the entire Hard-Bank Zone.

Though most of the species (42 or 43) were typically solitary, many (16) occurred in twos, threes or groups of several or more. Other species (8 to 10) formed schools of usually 10 or more fish. The surgeonfishes, Acanthurus spp., are often seen in schools in the Caribbean, but were observed only singly or in pairs at Stetson during our survey.

A fish cleaning station was found on Stetson at 27 m depth near the base of a high relief outcrop. Two Rock hinds, Epinephelus adscensionis, were cleaned by two small gobies, Gobiosoma sp. These gobies are abundant in the Hard-Bank Zone and were often seen to swim up toward the submarine when it stopped near them. The as yet unidentified Burrowing fish C (Fig. VIII-13) occurs in considerable numbers over the bank.

At least 23 species of fish frequenting Stetson Bank could be considered sport and/or commercial varieties (Table VIII-2). Although some are rarely, if ever, eaten, they have frequently been caught at night on Texas snapper banks by anglers during cruises in which the author has participated. Of particular sport or commercial importance due to their size or edibility are sharks; Great barracuda, Sphyraena barracuda; Rock hind, Epinephelus adscensionis; groupers, Mycteroperca spp.; Greater

amberjack, Seriola dumerili; jacks, Caranx spp.; mackerels, Scomberomorus spp.; Red snapper, Lutjanus campechanus; and Vermilion snapper, Rhomoboplites aurorubens. Red snappers (Fig. VIII-14), as at other banks, prefer large ledges and do not seem concerned with turbidity of the water (Fig. VIII-1).

At the surface during the Stetson survey, we sighted a 2.5 to 3 m long hammerhead shark; Sphyrna sp.; small schools of Great barracuda and Greater amberjack; a sea turtle, Cheloniidae; and large feeding schools of mackerel-like fish, individuals of which were seen to leap 5 m or so into the air on several occasions (Fig. VIII-2).

SOUTH BAKER BANK

We were asked by BLM to return to South Baker Bank and assess the "health" and condition of epibenthic communities in comparison to observations made by us in 1975. Essentially, we were to make a cursory post-drilling biotic survey because one or more wells had been drilled nearby in the interim.

We saw no visual evidence of effects on bank associated biota due to drilling. The list of viable species noted in 1976 compares well with that generated in 1975; differences are probably due to sampling error (Table VIII-3). It was the author's impression that the epibenthic community at the crest of South Baker is, if anything, more profuse than those viewed on some of the other South Texas Banks, such as Southern and Hospital Rock. We now recognize large populations of branching antipatharians, Antipathes, in addition to the

whip-like Cirripathes, on the high-relief South Texas Banks. These organisms are well developed at South Baker above the nepheloid layer (Fig. VIII-15). Comatulid crinoids are abundant, coralline algae is moderately so, and there is a sizeable Spondylus population. Medium-sized yellow sponges, possibly Spongia barbara, are especially conspicuous here.

The northern flank of South Baker is a stepped scarp which drops sharply from approximately 64 m to 70 m. The vertical cliff, presumably an old coralline algal reef, is cut by canyon-like channels similar to the surge channels one would find on living shallow water reefs. A considerable number of ship anchors have been lost on this ledge, along with some cables and one scientific rock dredge which was recognized as R.V. GYRE equipment (Fig. VIII-16). A pair of Trumpetfish, Aulostomus maculatus, had apparently taken residence inside the dredge.

At 70 m a platform about 50 m wide extends from the base of the cliff to the top of another cliff which drops vertically to 78 m or so. The platform bears components of the bank-top epibenthic community, but the population levels are lower. Cirripathes and the branching antipatharian are quite conspicuous, with gorgonocephalid basket stars frequently clinging to Cirripathes (Fig. VIII-17). The cliff-platform-cliff structure of the bank edge here has seemingly made this a preferred "hang-out" for Red snapper, Vermilion snapper, groupers and amberjack, all choice game fish (Figs. VIII-18 & 19).

The top of the nepheloid layer at this point coincided almost exactly with the top of the lowermost cliff, but did not extend

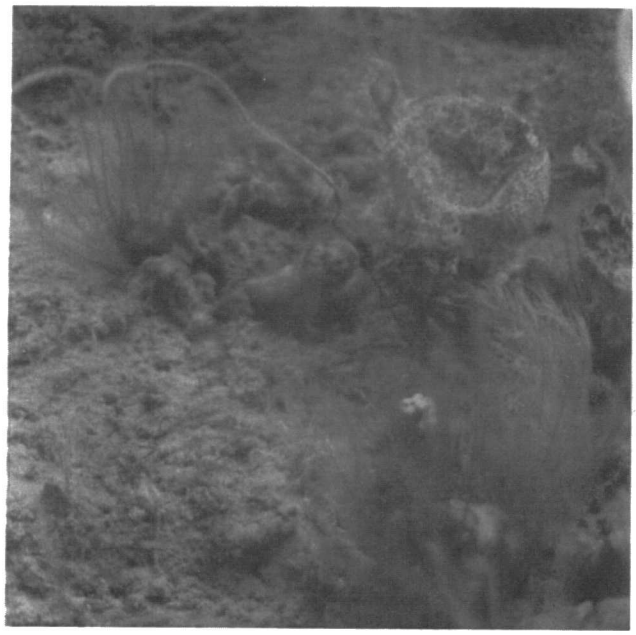


Figure VIII-15. Typical epifauna at top of South Baker Bank. Crinoids, Ircinia, Cirripathes, Antipathes, hydroids, etc.

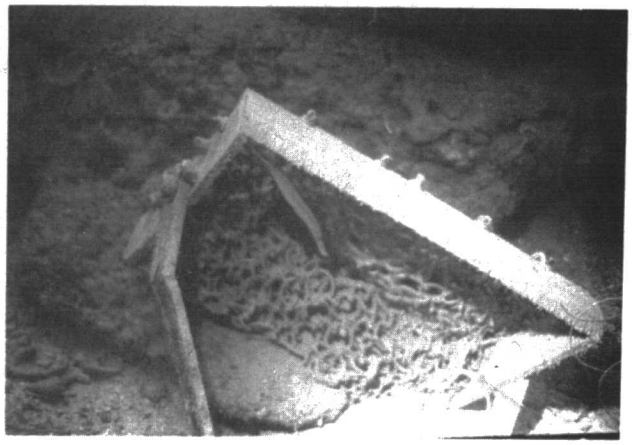
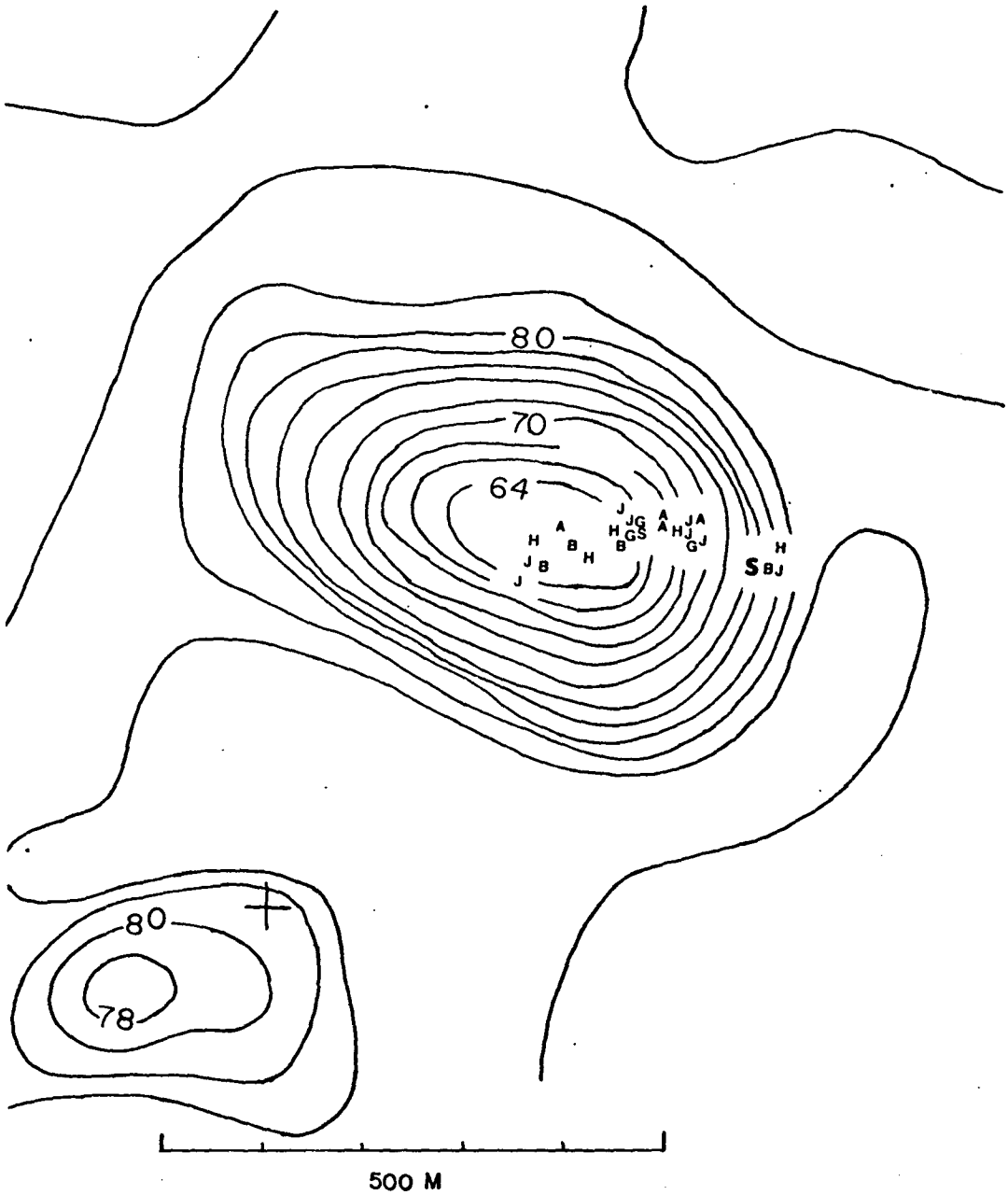


Figure VIII-16. Trumpetfish in rock dredge lost by us in 1975. 70 m depth, South Baker Bank.

Figure VIII-17. Basket star clinging to Cirripathes whip. 70 m depth, South Baker Bank.

Figure VIII-18. Top of nepheloid layer, upper left, intersecting bank edge, 70 m depth, South Baker Bank.



SOUTH BAKER
(contour interval 2m)

Figure VIII-19. Sightings of fishes at South Baker Bank.

A. Reef fish A
B. Reef butterflyfish (Chaetodon sedentarius)
C. Burrowing fish C
G. Groupers (Mycteroperca spp.)
H. Spotfin hogfish (Bodianus pulchellus)
s. school of Red snapper
s. Red snapper (Lutjanus campechanus)
J. Amberjack (Seriola spp.)

over onto the adjacent platform at 70 m (Fig. VIII-18). Red snappers and other fish were seen lurking in the nepheloid layer with no apparent dislike of the turbidity.

SOUTHERN BANK

At Southern Bank, we were asked to draw a comparison between conditions of "community health" with those observed in 1975 in an attempt to assess the effects, if any, of nearby drilling operations carried out in the interim.

There was no visual evidence of effects due to drilling on the biota. The list of living species in Table VIII-4 compares well with that presented in our report last year. Moreover, the 1976 list includes a number of leafy algae which we did not detect in 1975, as well as an interesting and colorful species of shrimp, *Hippolysmata grabhami* (Scarlet lady), which is typical of shallow reefs in Florida and the Caribbean. These shrimps were observed cleaning Spotfin hogfish, *Bodianus pulchellus*, as well as *Chromis enchrysurus*, which is the most abundant of the conspicuous resident fishes. The relatively rare Bank butterflyfish, *Chaetodon aya*, was seen for the first time on the South Texas banks at 61 m on Southern Bank.

A significant observation was made concerning the relationship, trophically, between mobile benthic biota and certain larger planktonic organisms of the water column. Hundreds of pyrosomes (colonial planktonic urochordates) were seen lying gently on the bottom, wedged into holes, or hung on rocks or sea whips (Fig. VIII-20). Numerous pyrosomes were also seen floating above

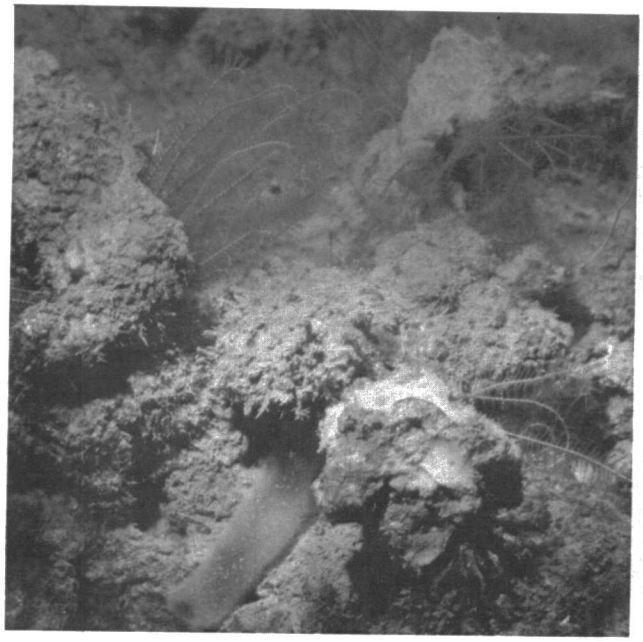


Figure VIII-20. Pyrosome, bottom center, lying on substratum at 60 m depth on Southern Bank.

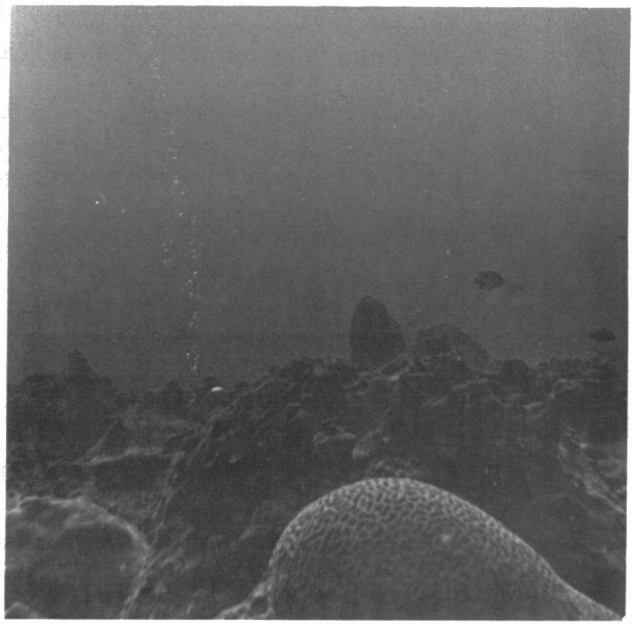


Figure VIII-21. Gas seep on coral reef at East Flower Garden, 25 m depth.

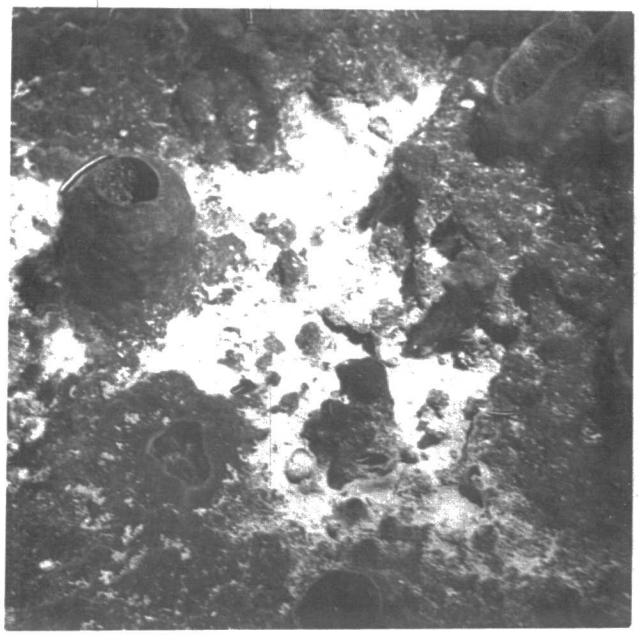


Figure VIII-22. Fine gray sediment on Neofibularia within Algal-Sponge Zone on southeast transect at East Flower Garden Bank, 60 m depth.

Figure VIII-23. "Scoop" hole made by submersible in sediment at 80 m depth at base of East Flower Garden Bank showing coarse carbonate sand with very fine gray "flowing" sediment in bottom of hole.

the bank, moving slowly with the current. Reef fish were feeding on the floating pyrosomes and a hermit crab was feeding on one of the pyrosomes trapped on the bottom. This is probably only one obvious example of a significant link in the trophic structure of the fishing bank communities. Certainly a majority of the food necessary to support the banks' moderately substantial epibenthic and groundfish communities must be derived from the plankton. There is certainly no evidence of a population of benthic primary producers which could contribute enough food matter to sustain the consumer populations.

More detailed comments on the condition of Southern Bank biotic communities can be found in Chapter IX of this report.

EAST FLOWER GARDEN

We were required to repeat a survey of the southeast transect run by us in 1974 and 1975 for comparative purposes, and as a post-drilling assessment of community condition in the *Diploria-Montastrea-Porites* Zone, *Algal-Sponge* Zone and *Antipatharian* Zone.

In general, we found conditions and biota (Table VIII-5) along the southeast transect to be essentially the same as described by us previously (Bright et al., 1976). Natural gas seeps were seen on the living coral reef as well as in the Algal-Sponge Zone and Antipatharian Zone deeper on the bank (Fig. VIII-21). Brooks et al., 1976, have determined that the gas issuing from the coral reef at the East Flower Garden is biogenic in origin (bacterially produced in near surface organic deposits), whereas seeps from deeper portions of the bank are petrogenic (produced

in deep-lying strata under the influence of high temperature and pressure). In December 1976, our group collected gas from a seep on the West Flower Garden reef at a depth of 25 m. Chemical analyses indicated biogenic origin. Gas seeps, whether biogenic or petrogenic, occur pervasively over the East and West Flower Garden Banks. Because both types of gas are 98 to 99% methane with small amounts of ethane and propane, environmental effects of the gas seeps should be similar in both cases (see Chapter X).

Insofar as we were required to search for evidences of effects due to drilling, we made note of any sediment which in any way resembled drill mud. Fine, olive colored material was observed on Neofibularia on the southeast transect (Fig. VIII-22). Subsequently, however, we observed similar conditions at other banks where drilling has not occurred and in photographs taken at the East Flower Garden before drilling occurred in 1974.

It was felt that if sediment and effluents produced during drilling had reached the bank at all, residues would most likely be apparent at the base of the bank. Therefore, some attention was devoted to observing conditions on the level, soft bottom adjacent to the bank on the southeast transect. Very fine, apparently heavier (but not necessarily drill related), sediment was observed to run into and collect in holes scooped out of the basically coarse sand by the submersible manipulator arm (Fig. VIII-23). Though these fine sediments were superficially similar in appearance to certain components of drill mud, analysis for barium was not attempted. Further "scooping" experiments in areas where drill-related sediments were not expected revealed a similar

"flowing" behavior of water saturated fine sediments. We cannot say, therefore, that we have found any drill-related sedimentary residues on the southeast transect at the East Flower Garden.

The larger epibenthic and infaunal organisms of the level, soft bottom show no obvious signs of ill effects due to recent drilling activities (Figs. VIII 24-27). We saw numerous burrows as in past years (Fig. VIII-25), in some of which were fishes (Fig. VIII-26) and crustaceans (Fig. VIII-27). The asteroid and sea urchin populations typical of this zone (Bright et al., 1976) were in evidence and apparently healthy.

Gamefish populations were substantial as in past years, the fishes tending to be associated with zones of high vertical relief, such as ledges or old drowned reefs (Fig. VIII-28).

During one "weather day" at the East Flower Garden, the underwater television system was used in combination with LORAC navigation to gather information concerning the locations, laterally, of components of several clear-water biotic zones on the upper portion of the bank. The results are shown in Figure VIII-29. Some very interesting, but tentative patterns are indicated for the reefal cap of the bank above the Algal-Sponge Zone. Coral reefs (*Diploria-Montastrea-Porites* Zone) appear to predominate in the central, shallowest portions of the transects. Significant fields of leafy algae (*Leafy Algae Zone*) occur adjacent to the coral reefs on their western and southern sides, and beds of *Madracis* (*Madracis* Zone) are present on their eastern side. In 1972, *Madracis* beds were seen due north of the living reef. The distribution of biota in these shallowest zones appears to be

Figure VIII-24. Serranus phoebe at 80 m depth on sand at base of East Flower Garden Bank, southeast transect.

Figure VIII-25. Patterned burrows at 80 m depth at base of East Flower Garden Bank, southeast transect.

Figure VIII-26. Jawfish? in burrow at 80 m depth at base of East Flower Garden Bank, southeast transect.

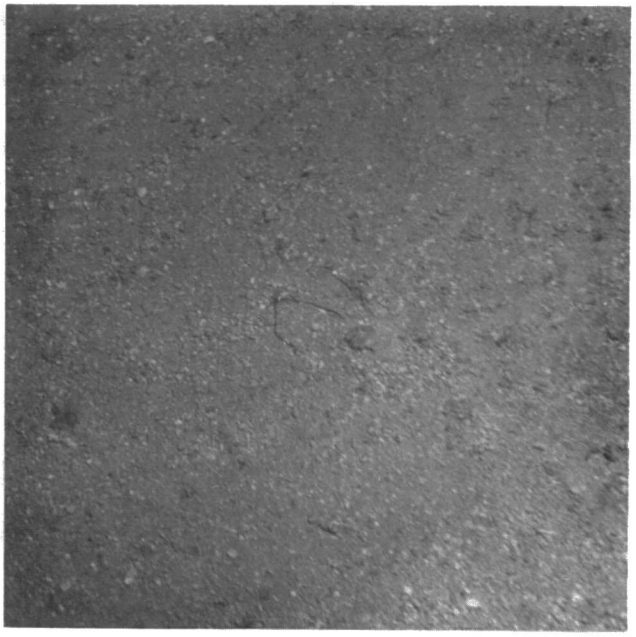


Figure VIII-27. One of a sizeable population of Munida-like crustaceans occupying burrows at 80 m at base of East Flower Garden Bank, southeast transect.

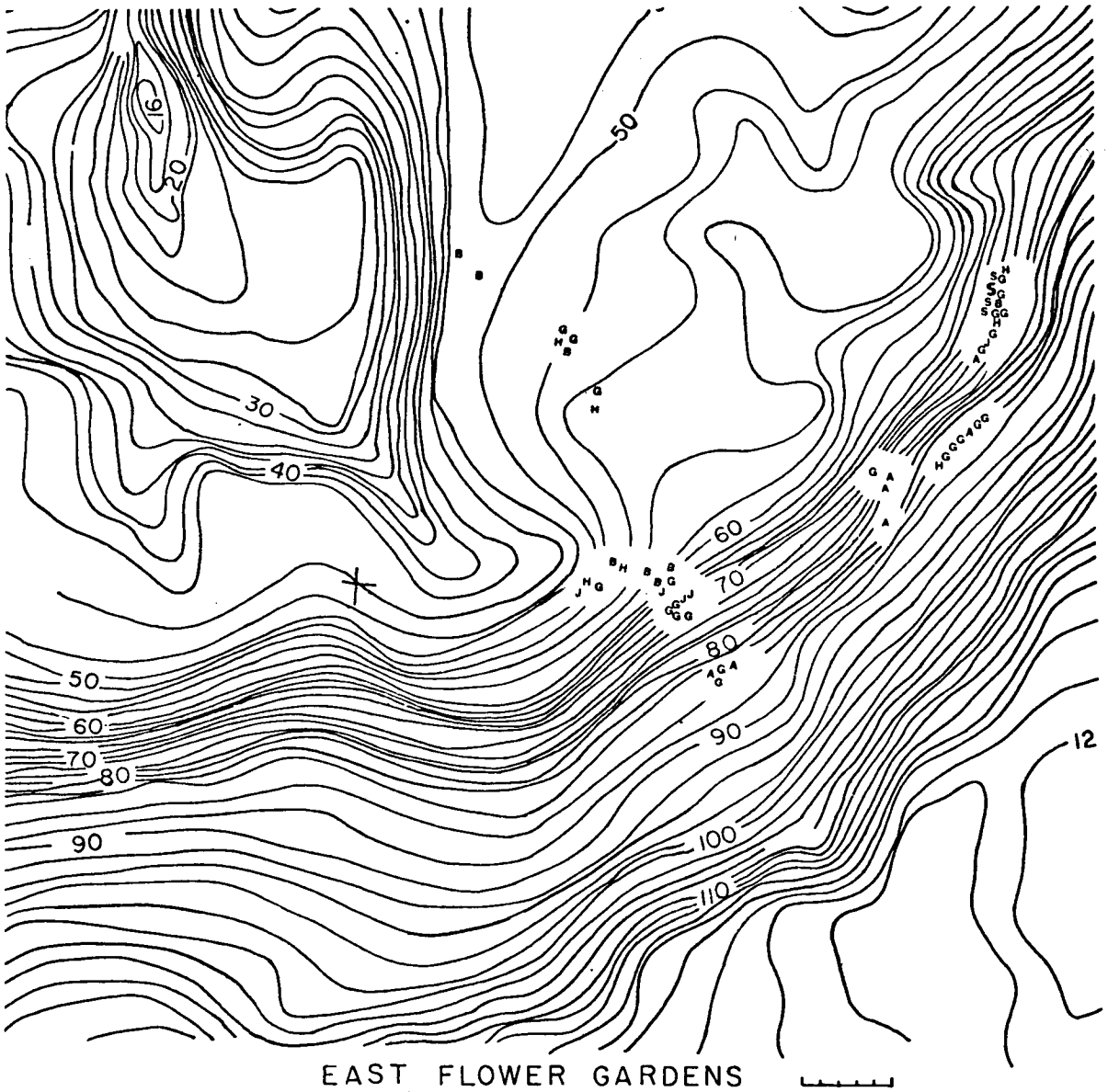


Figure VIII-28. Fish sightings on the southeast transect at the East Flower Garden.

A. Reef fish A
B. Reef butterflyfish (Chaetodon sedentarius)
C. Burrowing fish C
G. Groupers (Mycteroperca spp.)
H. Spotfin hogfish (Bodianus pulchellus)
S. school of Red snapper
s. Red snapper (Lutjanus campechanus)
J. Amberjack (Seriola spp.)

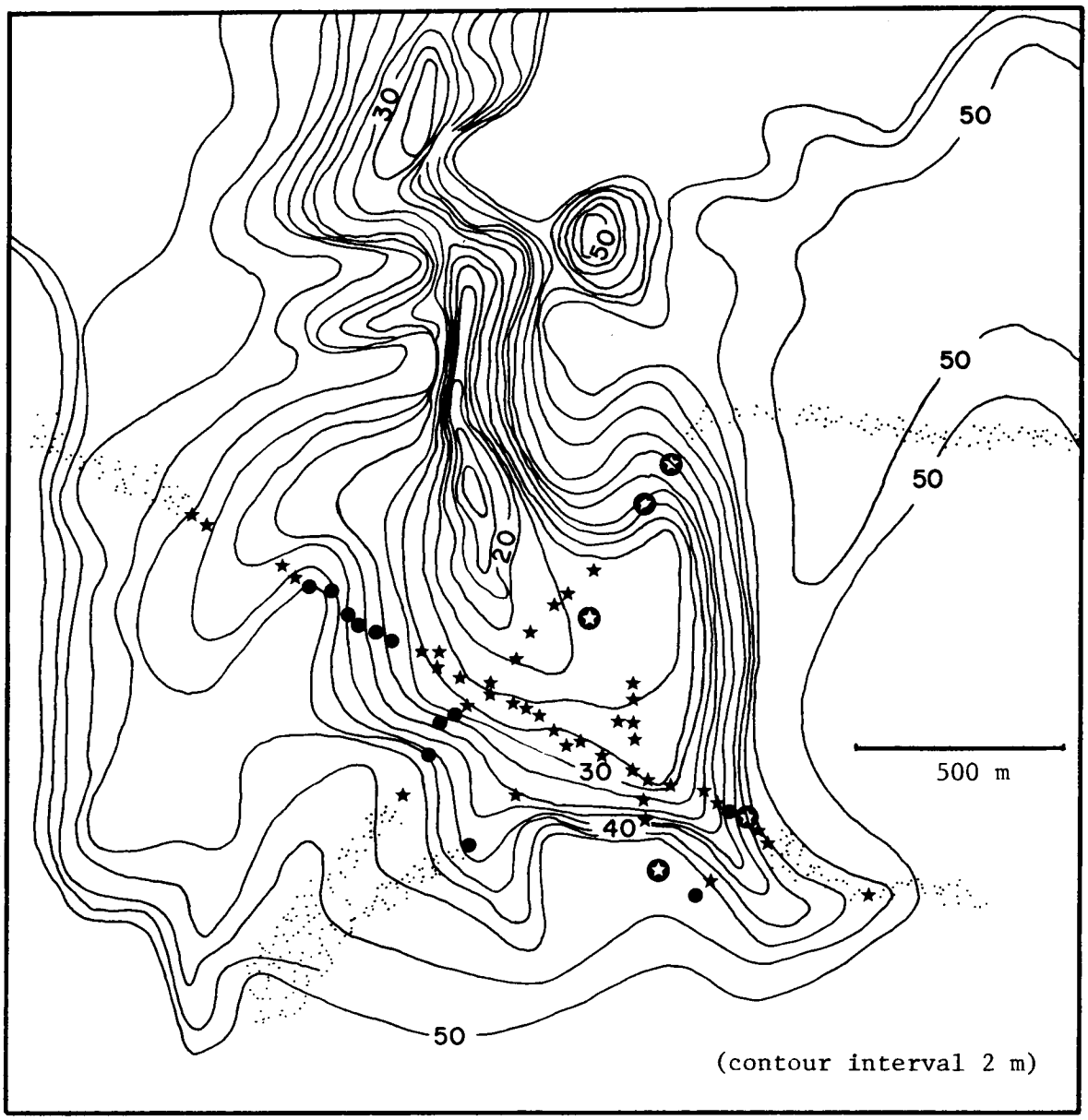


Figure VIII-29. Distribution of clear-water communities along precision underwater television transects at East Flower Garden Bank.

★ Coral reef (Diploria-Montastrea-Porites Zone)

✪ Madracis Zone

● Leafy Algae Zone

Algal-Sponge Zone. Based on underwater television transects which followed tracks shown. Absence of symbols on other parts of map does not imply absence of communities.

related more to topographical factors and a possible upstream-downstream effect than strictly to depth. Because of the importance of Madracis as a contributor to the sediments of the reef and upper Algal Sponge Zone, and because of the importance of the leafy algae as primary producers, it is felt that more of these accurate determinations of community distribution should be made.

We found no obvious "effects" of drilling on biotic communities of the East Flower Garden. Details of certain non-drilling-related "unhealthy" and pathological conditions observed by us on the coral reef are included in the following pages.

HEALTH OF HERMATYPIC CORALS

Much of our work at the East Flower Garden in 1976 was directed toward assessment of the health of hermatypic corals and the coral reef community at the crest of the bank. Particularly, we were to attempt to determine the nature and significance of a material causing a white discoloration of the outer surface of a number of the predominant hermatypic corals. Material for the coral "health" portion of our study was gathered during the Summer, 1976 submersible cruise in the northwestern Gulf of Mexico, during a Spring, 1976 field trip to the Cayman Islands and during a Winter, 1976 monitoring study at the West Flower Garden.

It is felt that the types of observations described below are most pertinent to the design and implementation of long-term and real-time monitoring plans for coral reefs in the northwestern Gulf of Mexico and elsewhere. In order to determine whether or

not the well-being of a marine benthic community has been affected by an episode such as drilling, it is necessary to assess the apparent "health" of at least the predominant biotic components of that community. In the current instance, of course, the predominant, and dominant, organisms are hermatypic corals, without which the coral reef and attendant habitats and ecological "niches" would not exist.

MECHANICAL DAMAGE

Mechanical damage to corals continues to be the only clearly demonstrable effect of man on the Flower Garden reefs. During our studies we have seen a number of overturned coral heads. These and smaller abrasions are presumably the results of anchoring on the reef. Accidental abrasions are also often caused by divers.

An obvious instance of mechanical damage is depicted in Fig. VIII-30. Some time ago, divers had tied a nylon line around the juncture between two brain coral heads. Over the months, or years, the periodic lateral movement of the line has abraded the coral, killing all polyps within 0.3 m or so of the juncture. We did not observe the line being moved by surge or any other water motion while we were on site, but the fact that the dead reefrock was not greatly encrusted with epibenthos indicates at least periodic scouring. There appears to be a band just to the right of the nylon line which is somewhat more eroded than the rest and this may represent a zone of most frequent abrasion. Outside the abraded area, the corals appear to be fairly healthy, even along the edges bordering the damaged reefrock. This, and the fact that

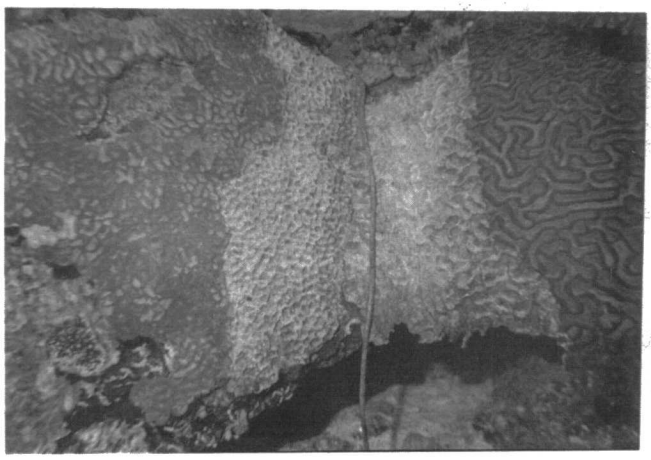


Figure VIII-30. Two heads of brain coral (two different species of Colpophyllia), formerly growing in competition for space at juncture in center of picture. Months or years previously, a nylon line was tied around the heads at that point. The result has been coral mortality due to abrasion. West Flower Garden, 25 m depth.

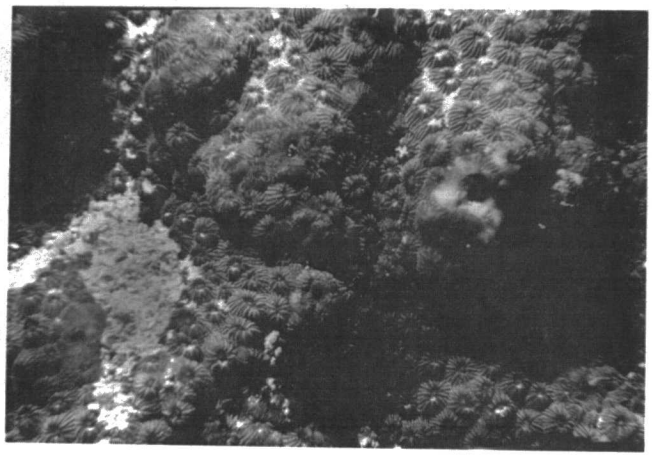


Figure VIII-31. Natural carbonate sediment on top of Montastrea annularis colony. West Flower Garden, 25 m depth.

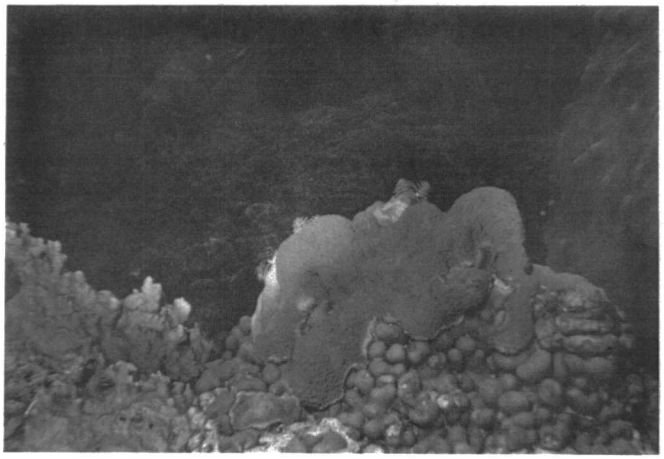


Figure VIII-32. Cluster of Madracis decactis being overgrown by sponge (top) in competition for living space. Millepora in lower left. West Flower Garden, 25 m depth.

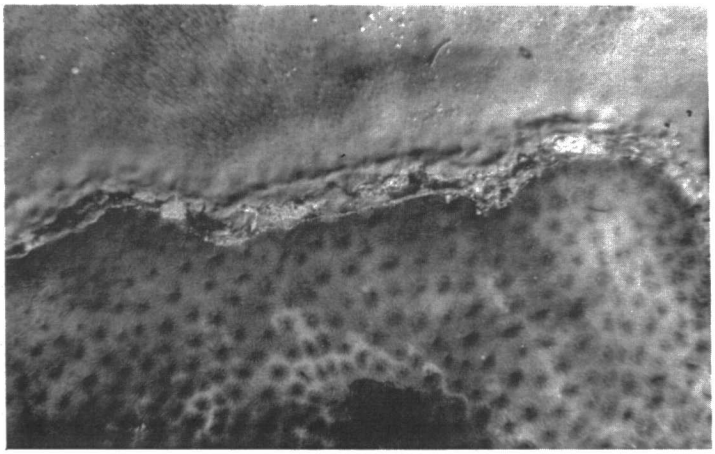


Figure VIII-33. Closeup of Siderastrea losing ground to encrusting Millepora in competition for space. West Flower Garden, 25 m depth.

these living edges have some slight relief, may indicate that the corals are now growing back toward the line in an attempt to reoccupy the denuded area. Placement of lines and markers on a reef, unless done carefully, is probably not advisable; modern materials (nylon, polypropylene) do not rot and may remain on the reef for years, moving with surge and currents, causing abrasion.

Although no anchoring of drill related vessels and equipment is permitted on or near the Flower Gardens, offshore drilling activities may indirectly result in mechanical damage to the reefs. During a monitoring study for an oil company, our group collected two derelict drill rig anchor buoys from an unknown source and hauled them to the drill rig for pickup. One of the buoys had become snagged at the edge of the West Flower Garden reef by its 60 m or so mooring cable. If it had been blown across the reef, it would have caused a considerable amount of mechanical damage.

Sport divers, fishermen and scientific parties typically anchor directly on the reef. Now that a number of drill rigs and platforms are emplaced within radar range of the Flower Gardens, such traffic and attendant anchoring may increase because navigation has been made easier.

The extent to which mechanical damage is a threat to the Flower Gardens in comparison to "natural" mortality and pathological organisms is not known. There is reason to believe, however, that wounds created by even slight mechanical damage to coral tissues may create openings for infection by pernicious coral pathogens and ultimately result in larger scale mortality on the affected head.

NATURAL SEDIMENTATION

Figure VIII-31 shows coarse carbonate sediment on top of living coral colonies. This is common and normal in reefal environments where water movements and organisms (particularly fishes) feeding on the bottom dislodge and cause suspension of carbonate grains which then settle on corals. Hermatypic corals are adapted to removal of such particulate matter through the actions of ciliary currents, mucus layers and polyp movements; all of these actions are aided by wave surge and, on non-horizontal surfaces away from depressions in the colony, by gravity.

NATURAL MORTALITY AND COMPETITION

Mortality and regrowth of corals are natural and common on all reefs. The East and West Flower Gardens everywhere bear examples of natural mortality in all stages, from ancient to incipient. Following or during a mortal episode, there is generally a sequence of colonization of the newly dead reefrock by non-coral epibenthic organisms. Later, and at a slower pace, the affected area may be recolonized by other corals, or by expanding remnants of the original coral colony. Generally, after a short while, encrusting coralline algae become established on a good part of the dead reefrock which is exposed to light and exclude most other forms of epibenthos. Mechanical or biologically induced erosion of dead reefrock typically occurs where the rock does not have a protective cover of suitable living epibenthic organisms.

The biological cycle of coral growth, death and recolonization

almost always results in competition for growing space between attached benthonic organisms which have become established in proximity to one another. The Flower Gardens are replete with examples of such competition. The competition itself is often a significant factor in coral mortality. Where certain fast-growing massive sponges are involved, corals may simply be overgrown (Fig. VIII-32). Millepora, a relatively fast-growing hydrozoan coral, may overgrow anthozoan corals where it comes in contact with them (Fig. VIII-33).

A more complex relationship exists between competing species within the anthozoan stony corals, involving a hierarchy of aggression wherein certain species are actually capable of killing polyps of a colony of another species growing in direct proximity (Lang, 1973). Dead bands of brain coral adjacent to the edge of an advancing colony of Montastrea annularis, which is a more "aggressive" species (Fig. VIII-34), are typical. In other instances, particularly where the competitors are of one species, the two colonies may grow together, meeting at a very neat juncture without mortality on either side. In some of these cases, the most obvious indications that there are two colonies present are differences in colony coloration and deformation of polyps at the juncture (Fig. VIII-35). Interestingly, however, it is apparently not uncommon for one coral colony to overgrow another of the same species.

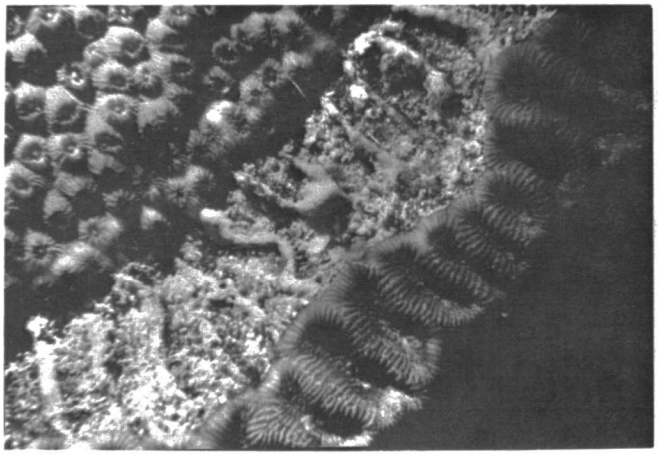


Figure VIII-34. Montastrea annularis seemingly advancing downward to cover dead Colopophyllia skeletal rock which has been encrusted partly with coralline algae. Carbonate sand particles have collected in valleys in dead band of coral. Live Colpophyllia, lower right, appears to be "giving up ground" to the Montastrea, leaving a band of dead reefrock in between; a frequently observed occurrence on this reef. West Flower Garden, 25 m depth.

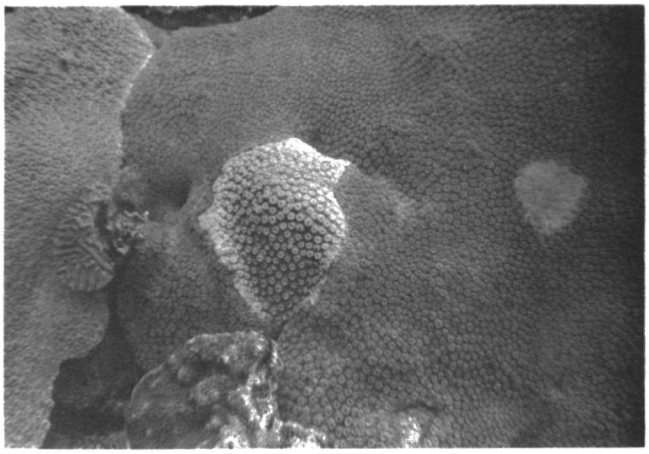


Figure VIII-35. Three contiguous colonies of Montastrea cavernosa. The left hand colony and the one nearly surrounded by the third are substantially infested with "white gop". The third colony is only mildly infested but exhibits a pale spot where zooanthellae have been expelled by a group of polyps (right). West Flower Garden, 25 m depth.

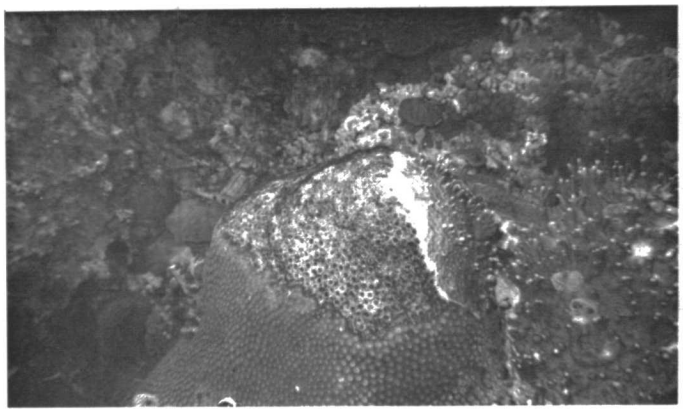


Figure VIII-36. Apparently diseased Montastrea cavernosa head which has experienced serious mortality on its upper half. The dead area has been moderately colonized by attached epibenthos on the left and encrusted heavily on the right by Millepora. The broad white peripheral band of Millepora indicates rapid growth. It appears that the Millepora crust may be entering into competition for space with the still living Montastrea polyps in the lower right. West Flower Garden, 25 m depth.

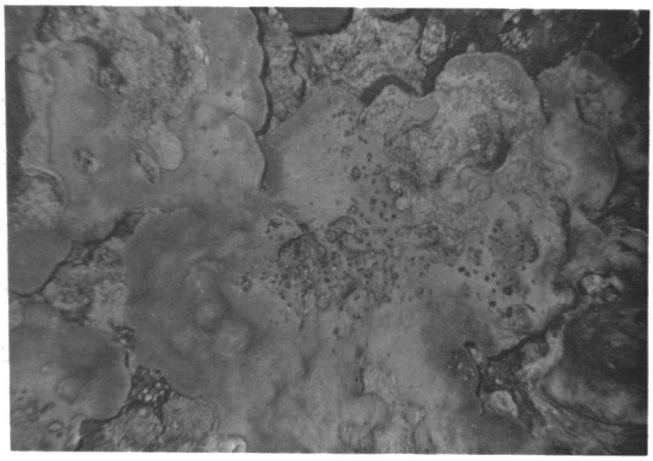


Figure VIII-37. Large Montastrea annularis head adjacent to gas seep, exhibiting various stages of health and mortality. The pale coloration is indicative of loss of zooxanthellae, an apparent stress reaction. The small dark spots are tufts of filamentous algae growing on dead coral rock. This algae also occurs as a ring bordering larger areas of dead coral such as that in the lower center. West Flower Garden, 25 m depth.

PATHOLOGICAL CONDITIONS

In addition to coral mortality caused by mechanical damage and direct competition between species for space upon which to live, we observed numerous instances of apparent disease to corals. It may be that disease pathogens are the most important causes of coral mortality on the Flower Garden reefs. Once certain pathogens gain a "foothold" within the tissue of a coral colony, mortality may devastate the head leaving a bare, dead surface which is soon recolonized by other epibenthic organisms which are often not as "desirable" as the original coral colony (Fig. VIII-36). It is felt by some reef ecologists that many pathological infections enter corals by way of wounds left following anchor damage, abrasions caused by fish, or other means of mechanical disruption (Bright and Jaap, in press). It is possible, therefore, that a minor incidence of mechanical damage could develop into a catastrophe for one particular coral head. Some of the worst coral pathogens are algae (Antonius, 1974), whose growth may be facilitated by local enrichment of sea water. It is the author's impression that the Flower Gardens are on the whole more heavily infested with coral pathogens than other reefs he has visited in Florida, the Bahamas, U.S. Virgin Islands and Mexico.

From the standpoint of the effects of petroleum production on the reefs, it is worth noting the poor condition of some coral heads adjacent to a natural gas seep at 25 m depth on the West Flower Garden. A large head of Montastrea annularis near the gas seep appeared generally unhealthy and exhibited recent and apparently progressive signs of zooxanthellae loss, mortality and

infestation with filamentous algae, which may themselves be pathogenic (Fig. VIII-37). A Diploria head near the gas seep exhibited an interesting pattern of temporal succession wherein coral death appears to be followed by establishment of a band of filamentous algae and epifauna which is later supplanted by coralline algae (Fig. VIII-38).

Loss of Zooxanthellae

Zooxathellae are endosymbiotic, photosynthetic dinoflagellates living within the tissues of hermatypic corals. They give the corals color, facilitate the secretion and deposition of calcium carbonate skeletal material, and produce photosynthetic products which are thought to be used by the corals for nutriment. Loss or expulsion of zooxanthellae by corals occurs during periods of environmental stress. A coral which has lost zooxanthellae is seemingly at a disadvantage from the standpoints of nutrition and growth, and can therefore be said to be relatively "unhealthy" until it has obtained a new population of the useful dinoflagellates.

We have observed several instances of apparent zooxanthellae loss at the East and West Flower Gardens (Figs. VIII-35, 37 and 39). The most serious and extensive case involved the large Montastrea annularis head near the gas seep at 25 m depth (Fig. VIII-37). Such widespread loss of zooxanthellae over most of a head may reduce the coral colony's ability to resist infection by possibly serious pathogens, such as filamentous algae (Figs. VIII-37 and 39). On the other hand, temporary localized

Figure VIII-38. Diploria head adjacent to gas seep showing recent and apparently progressing mortality (broad median light band) followed by a dark band of filamentous algae which in turn is followed by encroachment of coralline algae (bottom center). Healthy coral tissue is represented by dark coloration on upper right quarter of the head. West Flower Garden, 25 m depth.

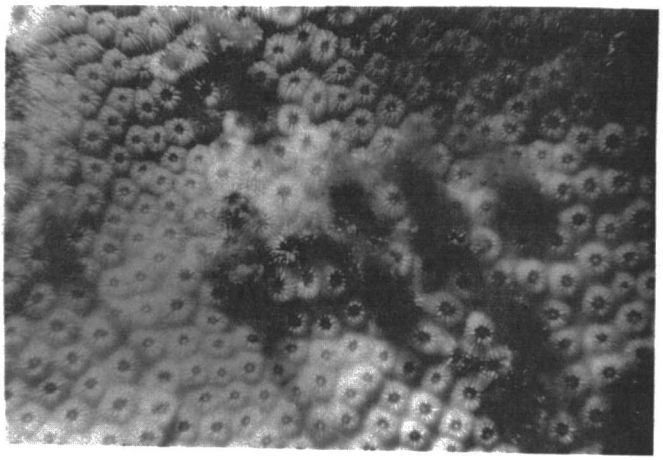


Figure VIII-39. Closeup of Montastrea annularis exhibiting apparent paucity of zooxanthellae (pale coloration) and ulcer-like dead spots occupied now by epibenthic organisms and algae. West Flower Garden, 25 m depth.

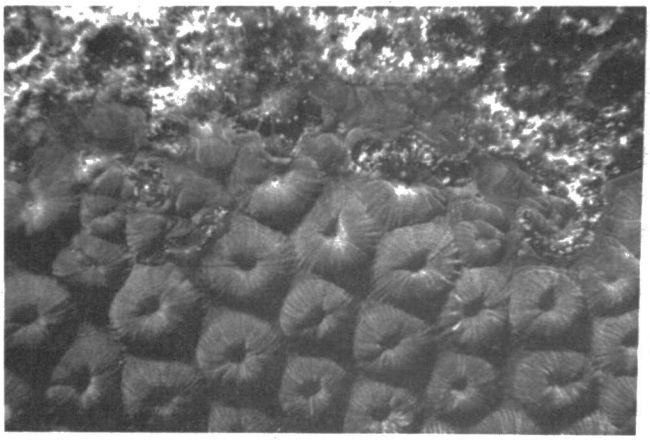


Figure VIII-40. Closeup of Montastrea cavernosa showing the type of "disease" associated with mortality described in Figure VIII-36 above. We call this condition "leprosy" because of the apparent nature of disintegration of coral tissue at the edge of the colony. West Flower Garden, 25 m depth.

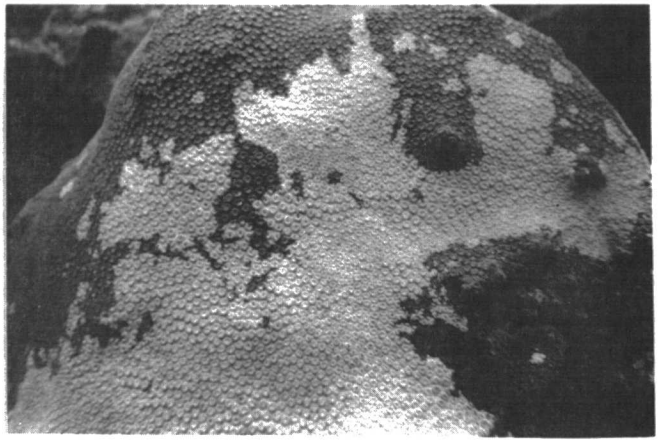


Figure VIII-41. Montastrea cavernosa head with coating of "white flake".

loss of zooxanthellae in a small part of a coral colony may have little, if any, effect on its overall well-being insofar as food and nutrients can be transferred laterally from one part of a colony to another through polyp-to-polyp gastrovascular connetions (Fig. VIII-35).

Filamentous Algae

Whether they are actually causative pathogens or not, filamentous algae are often associated with death of coral tissue (Figs. VIII-37, 38 and 39). The ring-like nature of its growth, bordering dead patches of coral, is typical and suggests a cause-and-effect relationship. The filamentous alga *Oscillatoria submembranacea* is known to be a serious coral pathogen in Florida, especially in areas where the water has been "fertilized" by sewage outfalls. We found the algae-coral mortality relationship best developed near the gas seep.

"Leprosy" of *Montastrea cavernosa*

Montastrea cavernosa is affected by a disease which apparently causes disintegration of tissue at the borders of patches of dead coral (Figs. VIII-36 and 40). This seems to be the major problem relating to mortality in this species at the West Flower Garden. The nature of the pathogen is not known.

Discoloration of *Siderastrea siderea*

Siderastrea siderea heads often exhibit a "moldy" coloration (pink-brown-pink) which may or may not be pathological (Fig. VIII-33). Quite possibly, this condition is only one of lateral variation in zooxanthellae populations within the *Siderastrea* colony.

"White Flake"

We have observed a substance, "white flake", which forms a severe coating on the colony surfaces of some Montastrea cavernosa heads (Fig. VIII-41). We have not determined the nature of "white flake" and do not know if it is similar or related to "white gop" (below). Nor do we know if the material's presence on a coral head is highly detrimental. "White flake" may be of rather transitory nature insofar as the photographs appear to show scattered remnants of previously more widespread covers of the material.

"White Gop"

All coral colonies cover themselves with a thin coating of mucus for protective purposes. This coating prevents direct contact of live coral tissue with surrounding water and often serves to entangle particulate matter landing on the coral surface. Such entangled matter can be wafted away by water movements as the coral secretes more mucus. Deep in the surficial mucus layers or the upper epithelial cell layers of some colonies, an embedded, granular white material ("white gop") occurs which may remain for long periods of time. During the present study we attempted to determine the nature and significance of "white gop".

Observations from the research submersible, D/RV DIAPHUS, at the East Flower Garden in 1975 revealed the white material on several specimens of Montastrea cavernosa. This "white gop" appeared to accumulate in the depressions and rifts on the coral's surface (Fig. VIII-42). It was described as appearing to have a a semi-solid, mucoid consistancy. Collections were not made in

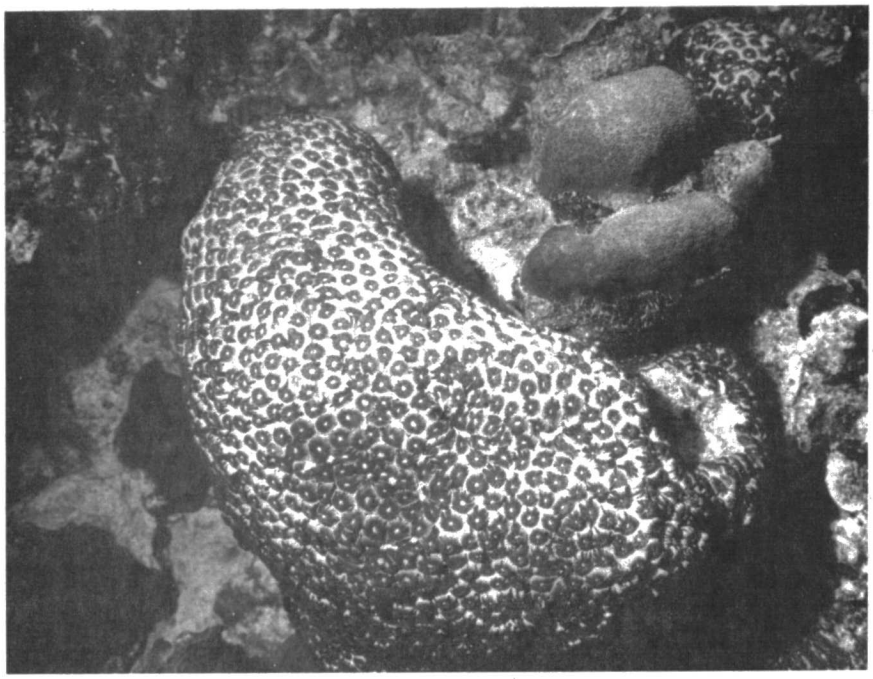


Figure VIII-42. "White gop" accumulated in mouth areas and between polyps on Montastrea cavernosa.

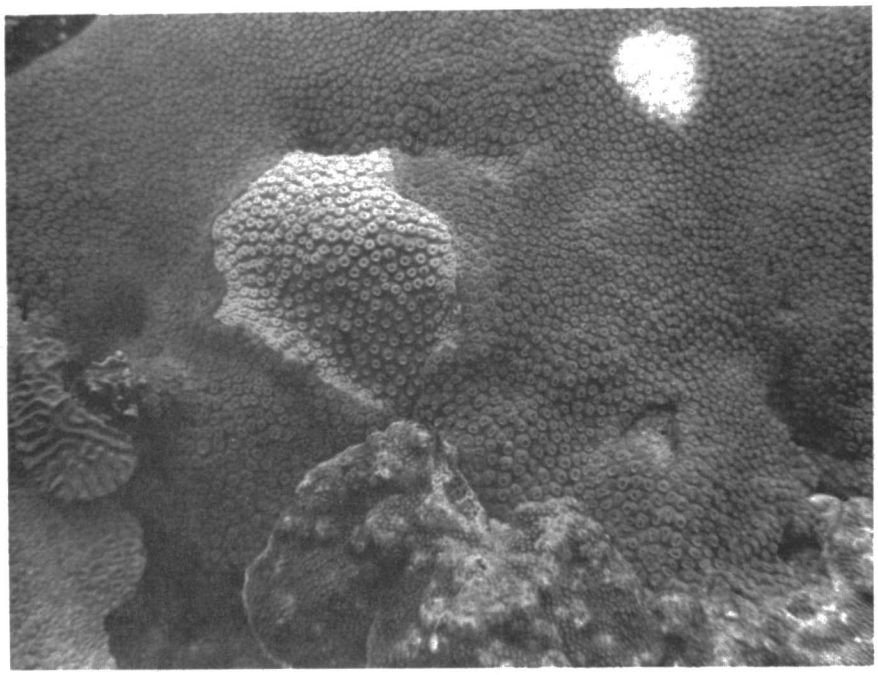


Figure VIII-43. Small area of "white gop" on a small head of Montastrea cavernosa (center) which is surrounded by an unaffected head of the same species. Small white area in upper right is apparently a condition of zooxanthellae expulsion.

1975. In 1976, samples of infested Montastrea cavernosa were obtained from the Cayman Islands and the East Flower Garden.

The "white gop" has been observed on Montastrea cavernosa, M. annularis, Colpophyllia sp. and Diploria sp. It can completely cover the coral's surface or be restricted to either mouth areas or areas between the polyps. Often an infested head can be seen in contact with an apparently uninfested head (Fig. VIII-43). This would seem to indicate that the causative agent is not infectious. Moreover, "infections" would not likely be restricted to the mouth areas of one coral head and outside the polyp areas of another.

Time lapse photography revealed no significant differences in feeding behavior between normal and "white gop" heads of Montastrea cavernosa in Grand Cayman (Minolta XL-400 Super 8 movie cameras and Vivitar Model 50 strobe units, both in Ikelight underwater housing, were used to take one exposure every 25 seconds for 24 hour periods). Repeated trips to a study site on the West Flower Garden Bank for 6 weeks in November and December, 1976 failed to show any noticeable changes in the condition of several "white gop" heads observed. Laboratory specimens of "white gop" coral have thus far appeared to fare as well as the normal heads. These observations suggest that the "white gop" is not highly pathogenic, if at all.

Several of our colleagues suggested that "white gop" may be calcium carbonate. Samples were analyzed on an energy dispersive x-ray spectrophotometer (EDAX) unit to determine their elemental composition. Small amounts were placed on a glass cover slip and

rinsed carefully with distilled water to remove as much seawater from the sample as possible. The cover slip and sample were then immersed in liquid nitrogen, removed and placed in a freeze dryer for 25 hours at -50°C.

The EDAX unit at Texas A&M cannot recognize elements with an atomic number smaller than 11 (sodium); consequently, organic matter, composed of mainly C, O, H and N, is not detected by the unit. Silicon was the most abundant element detected. This was presumably due to the glass cover slip on which the sample was placed. Chromium and aluminum were also present. These probably came from the conductive paint which must be used to prevent the sample from electrically charging under the electron beam. Sodium, chlorine and potassium all appeared in very small quantities. This can be attributed to the residual salts which were undoubtedly present in the water and mucus. None of the inorganic elements were detected in high concentrations, and there were plausible non-"white gop" origins for those that were detected. Furthermore, commercial hyperchlorite (Clorox) dissolved an entire sample of "white gop" and mucus within minutes, a reaction typical of organic materials. Immersion in a 10 percent solution of HCl failed to produce any effervescence, indicating that there was no calcium carbonate present. The results of these tests indicate that the "white gop" is organic.

Preliminary scanning of wet samples of mucus and "white gop" were made on a WILD M-11 light microscope with phase contrast objectives and condenser. For scanning electron microscopy, small amounts of the material were placed on glass cover slips and then

fixed in FAA solution (70 percent methyl alchol, 10 percent formalin, 15 percent distilled and 5 percent glacial acetic acid). After having been taken through a series of acetone-distilled water solutions to a final bath of pure acetone, the samples were treated in a critical point dryer to replace any liquid in the sample with CO_2 gas. This is done to prevent cracking by dessication when the sample is subjected to the electron beam. Gold-paladium was used to coat the specimens before viewing on a JEOL JSMU3 scanning electron microscope.

For observing the internal structure of the spherical bodies by transmission electron micrography, a small sample of the "white gop" was placed in epoxy resin and centrifuged to form a pellet. The resin was then allowed to dry and thin sections were cut from the resin block with a microtome. The sections were mounted on glass slides and viewed on a Hitachi HULLE transmission electron microscope.

Close examination of samples of the "white gop" shows that it is not itself mucoid, but a multitude of small white inclusions suspended in the coral's mucus or upper epithelium (Fig. VIII-44). Viewed through the phase contrast light microscope, scanning electron microscope and transmission electron microscope, the "white gop" appears as irregular grape-like clusters of small spherical bodies; each body approximately 10 microns (μm) in diameter (Figs. VIII-45 and 46). We feel that these clusters are the white inclusions responsible for the white coloration in the mucus or epithelium. These small spheres are imbedded in an organic matrix. Within the spherical bodies are smaller spheres

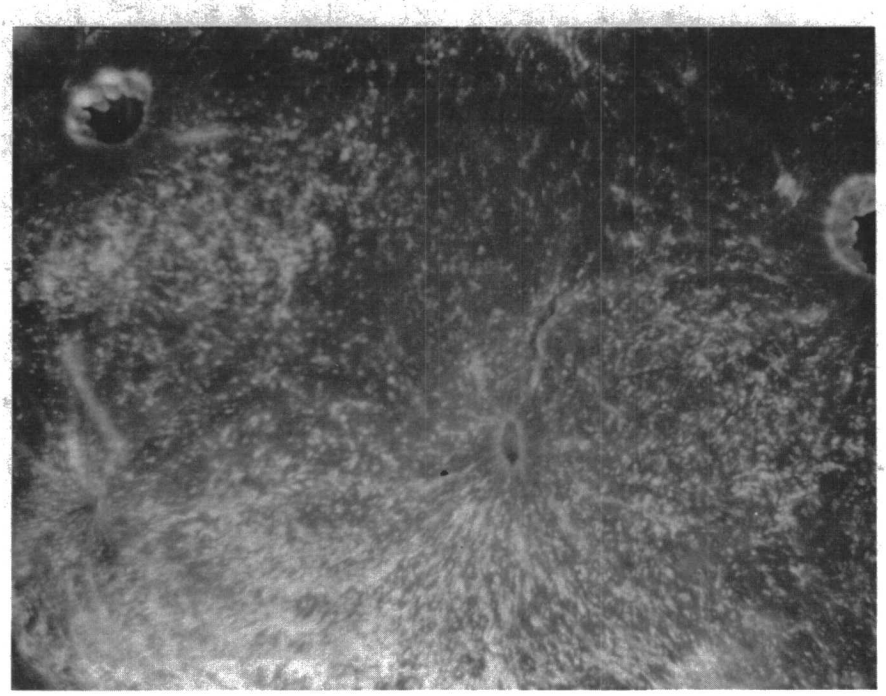


Figure VIII-44. Small inclusions of "white gop" suspended in the mucus or epithelium of Montastrea cavernosa.

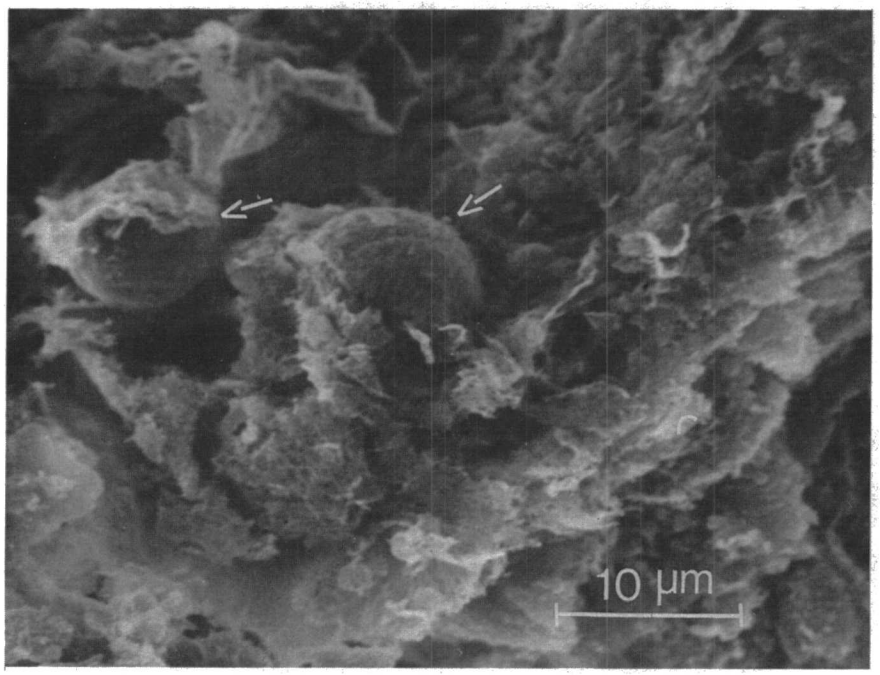


Figure VIII-45. Scanning electron micrograph showing individual spherical bodies (approximately 10 µm diameter) imbedded in an organic matrix.

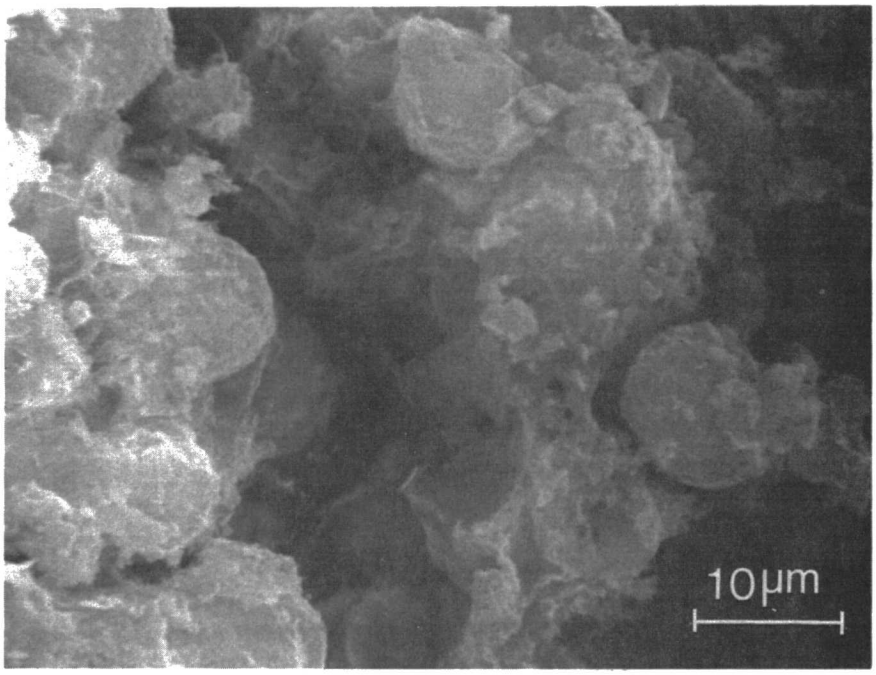


Figure VIII-46. Same as Figure VIII-45 showing spherical bodies comprising the "white gop."

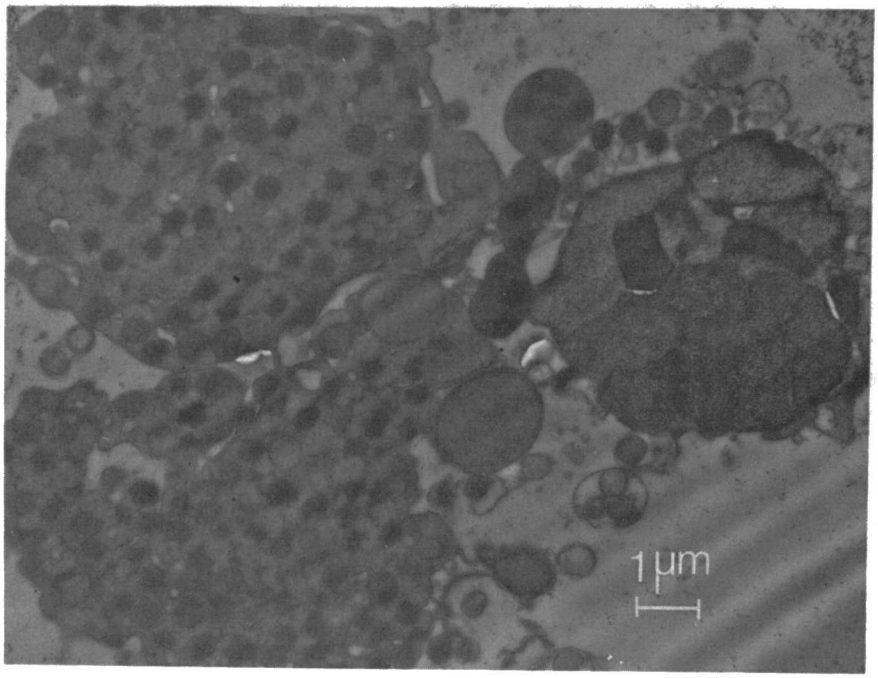


Figure VIII-47. Transmission electron micrograph showing cross-sections of what are apparently the same spherical bodies shown in Figures VIII-45 and 46.

approximately 0.5-2.0 μm in diameter. Still smaller "dots" were observed within the smaller spheres (Fig. VIII-47).

Figure VIII-47 shows three roughly spherical sections approximately 5-6 μm in diameter. One should note that thin sectioning distorts the original shape of certain entities, such as cells. Also, a spherical body may be sectioned through any plane, therefore one may or may not observe the sphere at its maximum diameter. The diameter of the orbs in Figure VIII-47 are comparable to those in Figures VIII-45 and 46. Careful examination of the three large spheres in Figure VIII-47 reveals numerous smaller spheres (approximately 0.5 μm) within them. Still smaller, dark spheres (less than 0.5 μm) are apparent in the leftmost two bodies in Figure VIII-47. These are presumably the "dots" mentioned earlier. The absence of these "dots" in the rightmost sphere is believed to be a result of the sectioning of this particular sample.

Interpretations of the nature of these scanning and transmission electron micrographs are inconclusive. Mr. Randy Scott of the Texas A&M Electron Microscopy Center, has stated that the large spheres in the 10 μm range appear very much like secretory cells, with smaller secretory granules within them. Definite identifications of these spheres are pending.

"White Gop" Microbial Investigations

During a trip to Grand Cayman, British West Indies, divers collected mucus and "white gop" samples from corals, using plastic syringes and a scraping tool. The syringes were returned

to the field lab, and respective portions of each sample were frozen, preserved in formalin, innoculated onto DIFCO Marine Agar plates or into DIFCO Marine Broth tubes (bacterial media) and Erdschreiber algal media preparations. Only one small head of Montastrea cavernosa was returned to the lab at Texas A&M. This coral was designated as gc-22.

Samples were taken in a different fashion at the East Flower Garden Bank. Divers collected small heads of both normal and afflicted corals and placed them in plastic bags. Immediately on their return to the ship's lab, mucus samples were taken from the heads and innoculated into marine agar or broth. The coral heads were then placed in aquaria located in the ship's wet lab. Care was taken to keep the normal heads segregated in aquaria separate from those which harbored the "white gop".

The collected heads were returned to a specially designed aquarium system located at our lab (Fig. VIII-48). A large 100 gallon holding tank (A) serves as a mechanical and biological filter as well as a water reservoir for the system. Water is pumped via an air-lift tube (B) to a small holding receptacle (C). From here, water is siphoned through Ultra Violet (UVO filters (D) and into another holding receptacle (E). Ten plastic hoses feed water from this tank into ten individual 5 gallon aquaria arranged in two rows of five each (F). Water overflows from these aquaria into a trough (G) and is carried back to the main reservoir (A). This design was used to "sterilize" the sea water within the system, and thereby prevent or minimize undesired cross "infection" between coral heads in different aquaria. This is necessary to

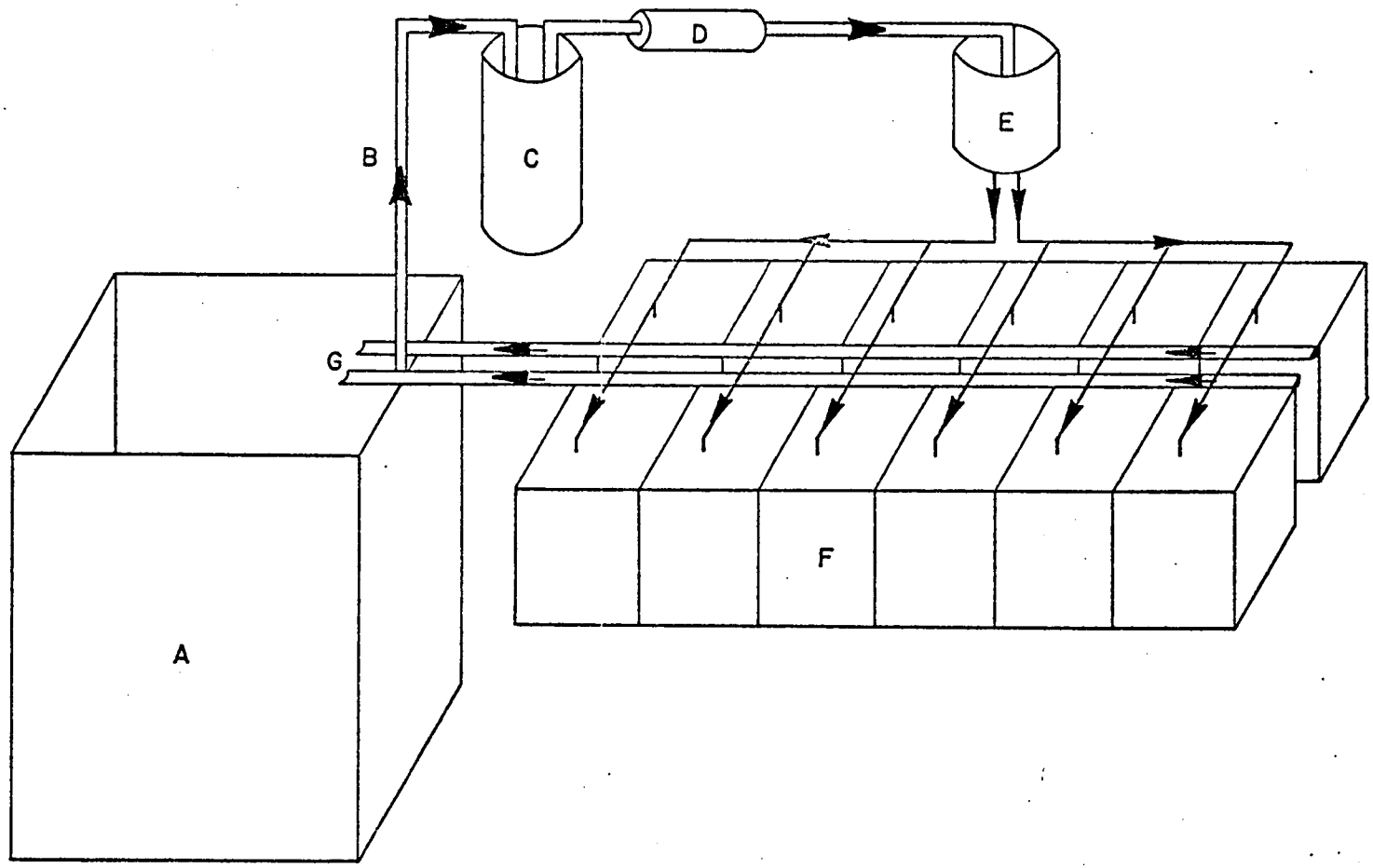


Figure VIII-48. Aquarium system for maintaining isolated coral heads in laboratory - A, 100 gallon holding tank; B, air-lift tube; C, holding receptacle; D, ultra-violet filter, E, holding receptacle; F, 5 gallon aquaria in which corals are maintained.

prevent large fluctuations in the natural bacterial populations of the individual coral heads. One bacterium, Aeromonas formicans, appeared to survive the UV radiation (see Table VIII-6).

We examined only the aerobic heterotrophic bacteria present in the coral mucus. Autotrophic and anaerobic varieties are probably also present in small populations on the corals, however, these groups are very difficult to culture and identify.

As mentioned above, all mucus samples were streaked onto plates of DIFCO Marine Agar. Bacterial colonies were allowed to grow for 24 to 48 hours at room temperature before they were isolated in pure culture. Individual colonies were initially selected according to their morphological characteristics. These pure cultures were grown on marine agar slants and then covered with mineral oil for storage.

Identification procedures for these bacteria followed those given by Lewis (1973). These consist of a series of biochemical tests on each bacterial type and they are identified according to the specific reactions elicited. All bacterial isolates from Grand Cayman Island were identified and are included in Table VIII-6. Due to the large numbers of isolates from the East Flower Garden collections (79 bacterial colonies from 16 heads), bacteria from only two normal (EFG-H & EFG-L) and two "white gop" heads (EFG-J & EFG-O) were identified (Table VIII-6). It had originally been expected that the "white gop" was either bacterial, or the product of some bacteriological process. By identifying bacterial populations from normal and "white gop" heads, as well as water borne populations, it was hoped that a

bacterium could be isolated that would be present in the "white gop" and not in normal mucus. This was not the case. The data in the tables indicate no definite relationships between bacterial species and coral heads or water samples.

The "white gop" was tested for contagiousness. A small, unaffected head of M. cavernosa which had been maintained in the lab for one month was placed in direct contact with a "white gop" head. After 8 months, the unaffected coral showed no sign of the white material in its mucus. It did eventually show signs of tissue regression and zooxanthellae expulsion, and is at present, quite unhealthy. However, several corals have experienced such a decline in the aquaria, and it is felt that this cannot be attributed to any effect of the "white gop".

Ray (1966) describes a technique for culturing the fungus, Dermocystidium marinum, which infests oysters. These fungi appear as small spheres less than 50 μm in diameter. The possibility that the "white gop" was a similar fungus was tested. Stock salt was added to the thioglycolate medium to bring the salt concentration to 3 percent. Mycostatin (2500 units/10 ml) was added to the medium to retard bacterial and yeast growth. A small volume of sample containing the "white gop" was added to three tubes of the treated thioglycolate. Foil was wrapped around the tubes to occlude the light. They were incubated at room temperature for one week. The tubes were then centrifuged, and the material was collected and stained with Lugol's solution. The results were negative, no fungal culture developed and no fungal cells were observed.

Innoculations of the Erdschreiber media with mucus samples from the Grand Cayman corals produced no algal growth. Duplicate efforts were not made on the East Flower Garden specimens.

Conclusions Concerning "White Gop"

From the data obtained using both light and electron microscopy, we conclude that the small white inclusions in the coral mucus and/or outer epithelial cell layer are aggregates of grape-like clusters. Each cluster is composed of spheres approximately 10 μm in diameter. The white spheres are organic in nature, not calcium carbonate. Repeated tests suggest, however, that they are neither bacterial, nor fungal, nor algal. The "white gop" does not appear to be highly infectious, if at all.

It is possible that the spheres comprising "white gop" are a type of secretory or pigment cell associated with the outer epithelial layer of the coral tissue.

Observations on corals in the field and those maintained in the laboratory indicate that the "white gop" does not alter the behavior of the coral and probably is not pathogenic.

TABLE VIII - 1A

STETSON BANK

LIST OF SPECIES COLLECTED (1976)

	Observed Depth Range (m)	No. of Specimens
Sponges		
Ircinia campana	27.3	1
I. strobilina	27.3	1
I. sp.	21 - 24	1
Spongia barbara	27.3	1
Halisarca sp.	21- 27	1
Gelliodes ramosa	27.3	1
Adociidae specimen	23 - 26	1
Prianos sp.	21 - 24	1
Pseudosuberites sp.	21 - 24	1
Stony corals		
Siderastrea radians	24	1
Agaricia fragilis fragilis	24	1
Oculina sp.	24	1
Madracis decactis	24	1
Millepora alcicornis	24	3
Polychaetes		
Hermodice carunculata	21 - 24	1
Syllis gracilis	21 - 24	1
Syllis sp.	21 - 24	1
Mollusks		
Pinctada radiata	21 - 24	1
Astrea tecta sp.	23 - 26	2
Gregariella opifex	21 - 24	1
Lyropecten nodosus	27	2
Cypraea zebra	-	1
Bursa granularis cubaniana	-	1
Latinus infundibulum	-	1
Strombus raninus	-	1
Cymatium pileare	-	1
Cassis flammea	-	1

TABLE VIII - 1A, con't.

Crustaceans		
Corophiidae	24	1
Synalpheus fritzmuelleri	24	1
S. minus	27	1
S. pandionis	24	1
Galathea rostrata	27	3
Scyllarides nodifer	24	1
Lobopilumnus agassizii	24	1
Xanthidae sp. C	24	1
Asteroids		
Narcissia trigonaria	48	1
Ophiuroids		
Ophiactis sp.	21 - 24	2
Ophioderma guttatum	21.2	1
Echinoids		
Clypeaster sp.	23 - 26	1

TABLE VIII - 1B

STETSON BANK

LIST OF ORGANISMS OBSERVED

	Observed Depth Range (m)	No. of Observations
Algae		
Brown	37	1
Sponges		
Purple	21	1
White	56	1
Neofibularia sp.	21 - 56	16
Orange and Yellow	56 - 58	2
Barrel	27 - 34	2
Hydroids	46 - 55	2
Stony corals		
Madracis sp.	52	1
Stephanocoenia sp.	27	1
Millepora sp.	21 - 40	9
Siderastrea sp.	34	1
Antipatharians		
Cirripathes sp.	58	1
Anemone	55 - 58	2
Polychaetes		
Spirobranchus sp.	37 - 56	7
Mollusks		
Lyropecten nodosus	48	1
Spondylus sp.	56 - 58	2
Squid	57	1
Octopus sp.	58	1

TABLE VIII -1B, con't.

Crustacean		
Shrimp	48	1
Hermit crab	46 - 58	6
Asteroids		
Narcissia sp.	56	4
Starfish	49 - 58	3
Echinoids		
Clypeaster sp.	56 - 58	2
Diadema sp.	21 - 52	10
Crinoids	53 - 55	2
Holothuroids	22 - 41	3
Fishes		
Acanthurus sp.	37	1
A. coeruleus (Blue tang)	34	1
Apogon sp.	58	1
Balistes vetula (Queen triggerfish)	34 - 41	5
Ophioblennius atlanticus (Redlip blenny)	27 - 40	2
Canthigaster rostrata (Sharpnose puffer)	37	1
Seriola dumerili (Greater amberjack)	26 - 52	4
Chaetodon sedentarius (Reef butterflyfish)	21 - 56	13
C. ocellatus (Spotfin butterflyfish)	27 - 41	2
Holacanthus ciliaris (Queen angelfish)	26 - 50	7
H. bermudensis (Blue angelfish)	22 - 52	18
Pomacanthus paru (French angelfish)	26 - 56	22
Gobiosoma sp.	27 - 40	2
Rypticus saponaceus (Soapfish)	56	1
Holocentrus sp.	21 - 50	7
Bodianus pulchellus (Spotfin hogfish)	27 - 52	13
B. rufus (Spanish hogfish)	21 - 27	2

TABLE VIII - 1B, con't.

Thalassoma bifasciatum (Bluehead)	22 - 50	3
Lutjanus campechanus (Red snapper)	27 - 55	12
L. apodus (Schoolmaster snapper)	30	1
Pseudupeneus maculatus (Spotted goatfish)	21 - 37	4
Chromis enchrysurus	40 - 58	9
Eupomacentrus variabilis (Cocoa damselfish)	40 - 46	2
E. partitus (Bicolor damselfish)	37 - 50	2
Opichthidae specimen	58	1
Priacanthus arenatus (Bigeye)	44 - 55	3
Equetus punctatus (Spotted drum)	46	1
Mycteroperca tigris (Tiger grouper)	27	1
M. sp.	22 - 46	4
Serranus phoebe	40 - 56	7
Epinephelus adscensionis (Rock hind)	21 - 55	13
Paranthias furcifer (Creolefish)	23 - 34	4
Liopropoma sp.	37 - 52	3
Calamus sp.	30 - 40	4

TABLE VIII - 1C

Organisms seen or captured at the surface and in the major benthic zones in the vicinity of Stetson bank in 1974.

M, Several per sighting or sample; SM, one to several per sighting or sample; Sc, schooling fishes or large aggregations of invertebrates per sighting; Sc?, Sc expected but not observed; ?, identification in doubt; * from inside sponges.

	Depth (m)	No. of observations and/or samples
Ocean surface		
Siphonophores		
Physalia pelagica	sfc.	1
Amphipods		
Hyperiidae	sfc.	1(Sc)
Crabs		
Megalops larvae	sfc.-53	1(M)
Portunus spinicarpus	sfc.-175	1
Callinectes ornatus	sfc.	
Mantis shrimps		
larvae	sfc.	1(M)
Fishes		
Ophichthus sp.	sfc.	1
Exocoetidae	sfc.	2(M)
Sphyraena sp.	sfc.-	1
Sphyraena barracuda	sfc.- 31	1
Seriola dumerili	sfc.- 46	1(M)
Caranx sp. (juvenile)	sfc.- 23	1
Mullidae (juvenile)	sfc.	1
Turtles		
Cheloniidae	sfc.	1
Level Soft-Bottom Zone		
Hydroids (plume-like)		
Sertulariidae	50	1
Plumularidae	50-55	2
Polychaete worms		
Chloea viridis	50	1
Nephtys (*Aglaophamus*) *verrilli*	55	1

TABLE VIII - 1C, con't.

Pelecypods		
Jouannetia quillingi	26 - 56	see text
Arca zebra	52	2
Americardia media	50	1
Cephalopods		
Octopus sp. (juvenile)	53	1
Starfishes		
Astropecten antillensis (juvenile)	56	1
Sea urchins		
Clypeaster ravenelii	49 - 56	5
Brittle Stars		
Ophioderma brevispinum	43 - 58	2
Ophiostigma isacanthum	53	2 *
Ophiura sp.	50	1
Ophiolepis paucispina	53	1
Ophiolepis elegans	?	1
Ophiophragmus brachyactis	55	1
Ophiotrix angulata	24 -55	2
Anomuran crustaceans		
Munida sp.	53	1
Crabs		
Callidactylus asper	53	1
Portunus spinicarpus	53	2
Cryptopodia concava	53	1
Unknown organism producing patterned burrows	53 -55	6(Sc)

Hard-Bank Zone

Algae		
encrusting calcareous algae	43 - 44	2
Sponges		
Neofibularia sp.	24 - 53	26
?*Agelas* sp.	43	1
Hydrozoan corals		
Millepora alcicornis	20 - 40	36
Scleractinian corals		
Madracis decactis	43	1
Stephanocoenia intersepta	40 - 49	3
Polychaete worms		
Eunice (*Palola*) *siciliensis*	24	1
Spirobranchus giganteus	26	1
Spirobranchus sp. (probably *giganteus*)	20 - 49	15(M)
Pelecypods		
Lithophaga bisulcata	26	1
Jouannetia quillingi	20 - 56	9(Sc)
Lyropecten nodosus	24	1
Pseudochama radians	24	1

TABLE VIII - 1C, con't.

Gastropods		
Diodora sp.	24	1
Strombus cf. *raninus*	24	1
Cypraea cf. *cervus*	24	2
Sea cucumbers		
Isostichopus badionotus	24 - 29	10
Sea urchins		
Diadema antillarum	20 - 46	25(SM, Sc)
Arbacia punctulata	24 - 29	6(M, Sc)
Lytechinus variegatus	44	2
Brittle stars		
Ophioderma squamosissimum	24	1
Ophiactis savignyi	24	3(M,*)
Ophioneries reticulata	27	1
Ophiocoma sp.	46	1
Ophiothrix angulata	24 - 55	5*
Hermit crabs		
?*Paguristes grayi*	24.	1
Crabs		
Actaea rufopuntata nodosa	37	1
Stenorynchus seticornis	37 - 53	2
Mantis shrimps		
Gonodactylus bredini	37	1
Fish		
Muraenidae	53	1
Holocentrus rufus	24	2
Holocentrus sp.	24 - 32	10
Holocentridae	43	1
Myripristis jacobus	34 - 43	3(SM)
Sphyraena barracuda	sfc.- 31	4
Epinephelus adscensionis	21 - 46	18
groupers	24 - 40	10(SM)
Paranthias furcifer	24 - 37	5(Sc)
?*Liopropoma* sp.	31 - 53	3
Rypticus sp.	31 - 43	3
Priacanthus arenatus	46	1
?*Apogon maculatus*	24 - 43	3(M)
Seriola dumerili	sfc.- 46	4(SM, Sc)
Caranx sp.	24	1(Sc)
Scomberomorus sp.	23	1
Lutjanus campechanus	24 - 43	3(M, Sc)
?*Lutjanus apodus*	37 - 43	1(Sc)
Rhomboplites aurorubens	24	1(Sc?)
Haemulon melanurum	24	1(Sc?)
Calamus calamus	21 - 24	3
Calamus sp.	43	1
Equetus umbrosus	53	1
Equetus sp.	31	1
Mulliodichthys martinicus	37	1(Sc)
Pseudupeneus maculatus	24 - 43	5

TABLE VIII - 1C, con't.

Chaetodon ocellatus	23.8 - 30.5	5(SM)
Chaetodon sedentarius	21.3 - 53.3	10(SM)
Pomacanthus arcuatus	27.4 - 29.0	4(SM)
Pomacanthus paru	23.8 - 53.3	10(SM)
Holacanthus ciliaris	24.4 - 53.3	5(SM)
Holacanthus isabelita	30.5	5(SM)
?Eupomacentrus variabilis	23.8 - 45.7	4
Chromis multilineatus	32.0	7(Sc)
?Chromis cyaneus (juvenile)	23.8	1(M)
Chromis enchrysurus	45.7 - 54.9	7(SM, Sc)
Bodianus rufus	24.4 - 27.4	5
Bodianus pulchellus	24.4 - 42.7	5
Thalassoma bifasciatum	23.8 - 45.7	12(SM)
?Ophioblennius atlanticus	24.4 - 29.0	4
Gobiosoma sp.	23.8 - 32.0	5
Acanthurus coeruleus	24.4	1(SM)
Acanthurus sp.	21.3 - 36.6	3(SM)
Balistes vetula	23.8 - 27.4	3
Balistes capriscus	45.7	1
?Acanthostracion sp.	24.4	1
Canthigaster rostrata	23.8 - 53.3	6
Burrowing fish C	27.4 - 45.7	5

TABLE VIII - 2

Game fishes seen or caught on Stetson Bank in June, 1974 (adult fish only).

	Depths (m)
Holocentrus sp. (Squirrelfish)	23.8 - 32.0
Sphyraena barracuda (Great Barracuda)	0 - 30.5
Epinephelus adscensionis (Rock Hind)	21.3 - 45.7
Mycteroperca and Epinephelus spp. (groupers)*	23.8 - 39.6
Paranthias furcifer (Creolefish) (Schools)	24.4 - 36.6
Priacanthus arenatus (Bigeye)	45.7
Seriola dumerili (Greater amberjack) (solitary and schools)	0 - 45.7
Caranx spp. (jacks) (schools)	23.8
Scomberomorus spp. (mackerels)	22.9
Lutjanus campechanus* (Red snapper) (schools)	23.8 - 42.7
?Lutjanus apodus (Schoolmaster snapper) (schools)	36.6 - 42.7
Rhomboplites aurorubens (Vermilion snapper) (schools)	23.8
Haemulon melanurum (Cottonwick) (schools ?)	23.8
Calamus calamus (Saucereye porgy)	21.3 - 24.4
Pomacanthus arcuatus (Gray angelfish)	27.4 - 29.0
Pomacanthus paru (French angelfish)	23.8 - 24.4
Holacanthus ciliaris (Queen angelfish)	24.4 - 42.7
Holacanthus isabelita (Blue angelfish)	27.4 - 30.5
Bodianus rufus (Spanish hogfish)	24.4 - 27.4

TABLE VIII - 2, con't.

Acanthurus coeruleus (Blue tang)	24.4
Acanthurus spp. (surgeonfishes)	21.3 - 36.6
Balistes vetula (Queen triggerfish)	23.8 - 27.4
Balistes capriscus (Gray triggerfish)	45.7

TABLE VIII - 3A

SOUTH BAKER BANK

LIST OF SPECIES COLLECTED

	Observed Depth Range (m)	No. of Specimens
Algae		
Botryocladia occidentalis	64 - 70	1
Gymnothamnion sp.	64 - 70	1
Sponges		
Spongia barbara	64 - 70	1
Desmacidon sp.	64 - 70	1
Siphonodictyon coralliphagum	64 - 70	1
Rhizochalina sp.	64 - 70	1
Cliona schmidti	64 - 70	1
Polychaetes		
Syllis (Haplosyllis) spongicola	64 - 70	1
Syllis (Typosyllis) hyalina	64 - 70	1
Vermiliopsis annulata	64 - 70	1
Subadyle pellucida	64 - 70	1
Megalomma lobiferum	64 - 70	1
Mollusks		
Barbatia candida	64 - 70	1
Crustaceans		
Mithrax acuticornis	64 - 70	1

TABLE VIII - 3B

SOUTH BAKER BANK

LIST OF ORGANISMS OBSERVED

	Observed Depth Range (m)	No. of Observations
Algae		
Coralline	64 - 70	4
Sponges		
Yellow	63	1
Yellow tube	64	1
White	64	1
Ircinia sp	64 - 70	3
Pink encrusting	64	1
Neofibularia sp.	63	1
Spongia sp.	63	1
Spongia barbara	63	2
Purple	64	1
Agelas sp.	64	1
Hydroid		
Plume-like	70	2
Antipatharians		
Cirripathes sp.	63 - 78	15
Antipathes sp.	63 - 70	8
Mollusks		
Spondylus sp.	64 - 70	5
Ophiuroids		
Basket Star	64 - 70	6
Crinoids		
Comatulids	64 - 70	8
Crustaceans		
Hippolysmata grabhami	76	1

TABLE VIII - 3B, con't.

Fishes

Aulostomus maculatus (Trumpetfish)	70	1
Seriola dumerili (Greater amberjack)	63 - 74	9
Holacanthus bermudensis (Blue angelfish)	63	2
Chaetodon sedentarius (Reef butterflyfish)	63 - 78	4
Gobiosoma sp.	70	1
Holocentrus sp.	63 - 64	3
Bodianus pulchellus (Spotfin hogfish)	63 - 78	5
Halichoeres sp. (Slippery dick)	63 - 64	2
Lutjanus campechanus (Red snapper)	63 - 74	2
Chromis enchrysurus (Yellowtail reeffish)	63 - 70	9
Priacanthus arenatus (Bigeye)	64 - 71	2
Scorpaena sp.	78	1
Mycteroperca spp.	63 - 70	3
M. phenax (Scamp)	63 - 70	5
Serranus phoebe	63 - 64	4
Liopropoma sp.	64	1
Sphyraena barracuda (Barracuda)	63 - 64	2
Reef Fish A	64 - 70	4

TABLE VIII - 4A

SOUTHERN BANK

LIST OF SPECIES COLLECTED

	Observed Depth Range (m)	No. of Specimens
Sponges		
Ircinia sp. "a"	61 - 71	?
I. sp. "b"	61	1
Spongia barbara	61 - 71	?
Gelliodes sp.	61 - 71	1
Xytopsene sigmatum	61	1
Adocia sp.	61	1
Siphonodictyon coralliphagum	61 - 71	1
Strongylophora sp.	61	1
Adocid specimens	61 - 71	2
Rhizochalina sp.	61	1
Phorbasid specimen	61	1
Tedania ignis	61	1
Lissodendoryx sp.	61	1
Tricheurypon viridis	61	1
Microcionid specimen	61 - 71	1
Ectoforcepia sp.	61 - 71	1
Agelas dispar	61 - 71	2
Agelas sp.	61	1
Agelasid specimen	61	1
Poecilosclerid specimen	61 - 71	1
Axinella sp.	61 - 71	1
Axinellid specimen	61 - 71	2
Halichoudrid specimen	61 - 71	2
Cliona delitrix	61 - 71	1
Cliona sp.	61 - 71	1
Suberitid specimen	61 - 71	2
Terpios pugax	61	1
Epipoasis sp.	61	1
Epallax sp.	61 - 71	1
Trachygellius sp.	61 - 71	1
Tethya sp.	61 - 71	1
Epipolasid specimen	61	5
Carnosid specimen	61	1
Stony corals		
Madracis asperula	61	?
Antipatharia		
Cirripathes sp.	61	1

TABLE VIII - 4A, con't.

Polychaetes		
Syllis (*Haplosyllis*) *spongicola*	61	1
S. (*Typosyllis*) *hyalina*	61	1
Nereidae specimen	61	6
Phyllodoce (*Anaitides*) *madierensis*	61	1
Mollusks		
Lima scabra	61 - 71	1
Barbatia domingensis	61 - 71	3
B. candida	61 - 71	2
Chlamys benedicti	61 - 71	1
Limpet - species "A"	61 - 71	1
Crustacean		
Ampelisca sp. (near pacificia)	61 - 71	1
Anomixidae ?	61 - 71	1
Anomixis sp.	61 - 71	5
Chevalia aviculae	61 - 71	3
Colomastix sp.	61 - 71	2
Corophiidae	61 - 71	23
Lembos sp.	61 - 71	3
Leucothoe spinicarpa	61	12
Luconacia incerta	61 - 71	12
Melita appendiculata	61 - 71	9
Melita sp.	61 - 71	4
Megalropus	61 - 71	4
Photis sp.	61 - 71	8
Stenothoe sp.	61 - 71	4
Luconacia incerta	61	2
Isopoda specimen	61 - 71	8
Tanaidacea specimen	61 - 71	19
Cumacea specimen	61 - 71	1
Paranebalia sp.	61 - 71	8
Synalpheus tanneri	61	1
S. townsendi	61 - 71	10
? *Coutierea* n. sp.	61 - 71	1
Periclimenes americanus	61 - 71	2
Galathea rostrata	61 - 71	1
Periclimenes sp. A	61	3
Dardanus venosus	61 - 71	1
Pagurus sp.	61 - 71	1
Porcellana sayana	61 - 71	1
Axiidae specimen	61 - 71	1
Melybia thalmita	61 - 71	3
Xanthidae sp. C	61 - 71	2
Asteroids	61	1
Ophiuroids		
Ophiactis savignyi	61 - 71	2
Crinoids		
comatulids	61 - 71	3

TABLE VIII - 4 B

SOUTHERN BANK

LIST OF ORGANISMS OBSERVED

	Observed Depth Range (m)	No. of Observations
Algae		
Coralline	61 - 72	12
Leafy	61	2
Sponges		
Ircinia sp.	72	1
Agelas sp.	61	2
Neofibularia sp.	69	1
Yellow	61 - 72	12
Pink encrusting	61 - 72	7
Spongia barbara	69 - 72	2
Orange encrusting	69	2
Orange	61 - 72	7
Purple	72	1
Hydroids		
Plume-like	72	1
Stony corals		
Saucer agariciid	61 - 69	9
Stephanocoenia sp.	61	1
Antipatharia		
Cirripathes sp.	61 - 72	26
Antipathes sp.	61 - 68	5
Anemones	61	1
Polychaetes		
Hermodice sp.	64 - 68	2
Serpulid specimen	72	1
Spirobranchus sp.	61	1

TABLE VIII - 4B, con't.

Mollusks		
Spondylus sp.	61 - 72	12
Cypraea sp.	61	1
Conus sp.	68 - 69	2
Crustaceans		
Shrimp	61 - 72	6
Hermit crab	61	1
Crinoid		
comatulid	61 - 72	11
Bryozoan		
Holoporella sp.	61	1
Pyrosomes (Planktonic)	61 - 72	15
Fishes		
Apogon sp. (Flame ish)	61 - 69	4
Canthigaster rostrata (Sharpnose puffer)	61	1
Caranx sp.	30	1
Seriola dumerilii (Greater amberjack)	61 - 69	8
Chaetodon aya (Bank butterflyfish)	61	3
C. sedentarius (Reef butterflyfish)	61 - 69	12
Holacanthus bermudensis (Blue angelfish)	61	5
Gobiosoma sp.	69	1
Holocentrus sp.	61 - 72	
Halichoeres sp.	61 - 69	7
Bodianus pulchellus (Spotfin hogfish)	61 - 72	11 11
Lutjanus campechanus (Red snapper)	61 - 72	3
Rhomboplites aurorubens (Vermilion snapper)	sfc & 61	2
Chromis enchrysurus (Yellowtail reeffish)	61 - 72	18
Priacanthus arenatus (Bigeye)	61 - 68	5
Equetus acuminatus (High hat)	61	1
Scomberomorus cavalla (King mackerel)	30	1
Mycteroperca sp.	61	3
M. phenax	61	3

TABLE VIII - 4B, con't.

Serranus phoebe	61 - 72	6
S. annularis (Orangeback bass)	61	1
Paranthias furcifer (Creolefish)	61	2
Liopropoma sp.	69 - 72	5
synodus intermedias (Lizardfish)	61	1
Reef fish A	61 - 69	11

TABLE VIII - 5A

EAST FLOWER GARDENS

LIST OF SPECIES COLLECTED

	Observed Depth Range (m)	No. of Specimens
Algae		
Nemalion (schrammi ?)		1
Galaxaura (obtusata v. major)	50	1
?Amphiroa tribulas	30	1
Tolypothrix tenuis	30	1
Dictyota bartayresii	33 - 50	2
Rhodymenia pseudopalmata	33 - 50	2
Fauchea peltata	33 - 50	2
Halimeda tuna f. platydisca	48 - 61	2
Codium isthmocladum	47	1
Cladophora sp. (repens?)	47	1
Valonia ventricosa	55	1
Caulerpa racemosa v. macrophysa	33 - 55	3
Chondria cnicophylla	33 - 55	3
Gelidium (floridanum or corneum)	33 - 55	3
Caulerpa microphysa	33 - 55	3
Lobophora variegata	54	1
Fragonema sp. (?)	54	1
Acrochaetium sp. (?)	54	1
Ulothrix flacca	54	1
Jania capillacea	54	1
Hypoglossum involvens	54	1
Nitophyllum punctatum	54	1
Acetabularia sp.	54	1
Pterocladia sp.	54	1
Erythrocladia subintegra	54	1
Goniotrichum alsidii	54	1
Ectocarpales sp.	54	1
Derbesia sp.	54	1
Chaetomorpha sp.	54	1
Ulva sp.	54	1
Anadyomene stellata	54	1
Spatoglossum (?) #1002	54	1
Sp. #1007	54	1
Chondris floridana	54	1
Sp. # 1008	54	1
Sp. #1009	54	1
Sp. $1010	54	1

TABLE VIII - 5A, con't.

Sponges		
Ircinia sp. "a"	18 - 52	4
I. sp. "b"	18 - 52	1
Spongia barbara	18 - 52	4
Verongia cauliformis rufa	18 - 52	4
Haplosclerid specimen	81	1
Haliclona palmata	81	1
Mycale angulosa	18 - 52	1
Agelas dispar	18 - 52	1
Spirastrella sp.	81	1
Stony corals		
Helioseris cuculatta		1
Agaricia undata		1
Madracis formosa ?		1
M. mirabilis	32	1
Diploria strigosa	24	1
Montastrea annularis	24	1
M. cavernosa	24	1
Porites astreoides	24	1
Polychaetes		
Serpula vermicularis	81	1
Mollusks		
Arca zebra	88	2
Gregariella opifex	88	1
Coralliophila abbreviata	?	1
Conus testudinarius	?	1
Crustaceans		
Isopoda specimen	88	1
Pilumnus ? *floridanus*	59	1
Pilumnus ? *sayi*	18 - 52	1
Munida simplex	58	1
Sp. "B"	59	1
Ophiuroids		
Ophidiaster sp.	88	1
Amphiodia sp.	88	1
Ophiactis savignyi	18 - 52	3
Ophiactis sp.	18 - 52	3
Echinoids		
Clypeaster sp.	88	1
Crinoids		
comatulids	88	1

TABLE VIII - 5B

EAST FLOWER GARDENS

LIST OF ORGANISMS OBSERVED

	Observed Depth Range (m)	No. of Observations
Algae		
Coralline algae	49 - 67	10
Filamentous algae	61 - 76	2
Leafy	55 - 58	2
Sponges		
Neofibularia sp.	24 - 61	18
Branching	53 - 58	5
Purple	52	5
White - veined	55	1
Ircinia sp.	55	1
Hydroids	58	1
Corals		
Millepora sp.	20 - 54	3
Eusmilia sp. ?	24	1
Madracis sp.	22 - 58	11
Stephanocoenia sp.	49	1
Saucer agariciids	47 - 61	10
Montastrea cavernosa	49	1
M. sp.	37	1
Brain coral	22 - 24	2
Antipatharia		
Cirripathes sp.	48 - 87	11
Anemones	55 - 82	4
Polychaetes		
Hermodice sp.	90 - 93	3

TABLE VIII - 5B, con't.

Mollusks		
Spondylus sp.	49 - 79	4
Lyropecten nodosus	90	1
Octopus macropus ?	55	1
Crustaceans		
Stenorynchus sp. (arrow crab)	58 - 83	5
Red spotted crab	93	1
Shrimp	58 - 82	3
Asteroids		
Narcissia sp.	75 - 84	3
N. trigonaria	82	1
Starfish	82 - 88	9
Echinoids		
Sand dollars	73 - 90	3
Diadema sp.	48	1
Crinoids		
comatulids	80 - 96	7
Holothuroid		
Isostichopus sp.	55	1
Fishes		
Acanthurus bahianus (Ocean surgeon)	49 - 70	2
A. chirurgus (Doctorfish)	29	1
Apogonidae specimen	82	1
Balistes vetula (Queen triggerfish)	49 - 70	2
Melichthys niger (Black surgon)	18 - 29	4
Malacanthus plumieri (Sand Tilefish)	37 - 55	3
Caranx ruber (Bar jack)	25	1
C. latus (Horse-eye jack)	21	3
Seriola dumerili (Greater amberjack)	37 - 67	6
Chaetodon sedentarius (Reef butterflyfish)	47 - 87	10
C. ocellatus (Spotfin butterflyfish)	18	1
Holacanthus bermudensis (Blue angelfish)	33	1
H. tricolor (Rock beauty)	24	1

TABLE VIII - 5B, con't.

H. ciliaris (Queen angelfish)	33 - 52	3
Pomacanthus paru (French angelfish)	33 - 70	4
Centropyge argi (Cherubfish)	79	2
Gobiosoma sp.	52 - 58	3
Holocentrus sp.	56 - 75	3
Bodianus pulchellus (Spotfin hogfish)	52 - 81	5
B. rufus (Spanish hogfish)	37 - 49	3
Clepticus panae (Creole wrasse)	18 - 49	12
Lutjanus campechanus (Red snapper)	64 - 87	3
Pseudupeneus maculatus (Spotted goatfish)	37 - 49	3
Chromis multilineata (Yellow-edge chromis)	22	1
C. enchrysurus (yellowtail)	52 - 79	12
Pomacentridae specimen	47	1
Haemulon melanurum (Cottonwick)	82 - 87	4
Priacanthus arenatus (Bigeye)	61 - 87	4
Scaridae specimen	37 - 58	3
Equetus lanceolatus (Jacknife fish)	53 - 58	3
Scorpaena sp. (Scorpionfish)	79	1
Mycteroperca sp.	74 - 81	4
Serranus phoebe	79 - 90	4
S. annularis (Orangeback bass)	47 - 79	5
Liopropoma sp.	52 - 79	4
Petrometopon cruentatum (Graysby)	52 - 87	2
Dermatolepis inermis (Marbled grouper)	82	1
Paranthias furcifer (Creolefish)	17 - 42.5	15
Calamus sp. (Porgy)	55 - 64	2
Sphyraena barracuda (Barracuda)	18 - 49	7
Triglidae specimen (Sea robin)	82	2
Synodus intermedius (Lizardfish)	82 - 88	4
Reef fish A	75 - 87	5

TABLE VIII - 6A

BACTERIA FROM EAST FLOWER GARDEN (EFG) AND GRAND CAYMAN (GC)

NORMAL HEADS

Specimen No.	Species	*Aeromonas formicans*	*Aeromonas* sp.	*Pseudomonas alcaligenes*	*Pseudomonas atlantica?*	*Pseudomonas croaker*	*Pseudomonas diminuta*	*Pseudomonas piscicida*	*Pseudomonas* sp. (purple)	*Vibrio algosus*	*Vibrio algynolyticus*	*Vibrio anguillarum*
GC-1	*Montastrea cavernosa*	X										
GC-2	*Montastrea cavernosa* (same head as GC-1)											
GC-3	*Colpophylia*		X					X				X
GC-6	*Montastrea cavernosa*					X					X	X
GC-17	*Montastrea cavernosa*	X										
GC-18	*Montastrea annularis*	X					X	X				
EFG-H (in vitro)	Sample taken from *Montastrea cavernosa* immediately after collection	X			X			X				X
EFG-H (in vitro)	Sample taken from coral after it had been in aquarium in lab	X			X			X	X			
EFG-L	*Montastrea cavernosa*	X		X			X	X				

TABLE VIII - 6B

"WHITE GOP" INFESTED HEADS

Specimen No.	Species	*Aeromonas formicans*	*Aeromonas* sp.	*Pseudomonas alcaligenes*	*Pseudomonas atlantica?*	*Pseudomonas croaker*	*Pseudomonas diminuta*	*Pseudomonas piscicida*	*Pseudomonas* sp. (purple)	*Vibrio algosus*	*Vibrio algynolyticus*	*Vibrio anguillarum*
GC-7	*Montastrea cavernosa*					X				X		
GC-8	*Montastrea cavernosa*	X				X	X					
GC-9	*Montastrea cavernosa*	X				X				X		
GC-10	*Montastrea cavernosa*	X				X						
GC-11	*Montastrea cavernosa*	X				X					X	
GC-12	*Montastrea cavernosa*	X					X					
GC-15	*Montastrea cavernosa*	X								X		
GC-19	*Montastrea cavernosa*					X	X			X		
GC-20	*Montastrea cavernosa*	X										
GC-22	*Montastrea cavernosa* small head returned to lab	X										
EFG-0 (in vitro)	Sample taken from *Montastrea cavernosa* immediately after collection									X		
EFG-0 (in vitro)	Sample taken from coral after it had been in aquarium in lab	X					X				X	
EFG-J	*Montastrea cavernosa*					X	X				X	

TABLE VIII - 6C

Sample No. or type	Comments	*Aeromonas formicans*	*Aeromonas* sp.	*Pseudomonas alcaligenes*	*Pseudomonas atlantica?*	*Pseudomonas croaker*	*Pseudomonas diminuta*	*Pseudomonas piscicida*	*Pseudomonas* sp. (purple)	*Vibrio algosus*	*Vibrio algynolyticus*	*Vibrio anguillarum*
WATER SAMPLES												
GC-13	Heavy effluent from mariculture farm	X										
GC-14	300 yd. upcurrent from effluent	X								X		X
GC-21	Aquarium water from lab where *Montastrea cavernosa* was kept	X										
Aquarium water	Sample of aquarium water before corals were added to system				X			X				
Aquarium water	Sample of aquarium water after it had passed through ultraviolet filter	X										
MISCELLANEOUS SAMPLES												
GC-5	White corrosion on camera housing			X		X						X
GC-16	"Marine snow" from 100 ft. depth	X										X

CHAPTER IX

EFFECTS OF THE NEPHELOID LAYER ON DISTRIBUTION OF EPIBENTHIC COMMUNITIES AT SOUTHERN BANK AND HOSPITAL ROCK

EFFECTS OF THE NEPHELOID LAYER ON DISTRIBUTION OF EPIBENTHIC COMMUNITIES AT SOUTHERN BANK AND HOSPITAL ROCK

Principal Investigator
Thomas J. Bright

INTRODUCTION

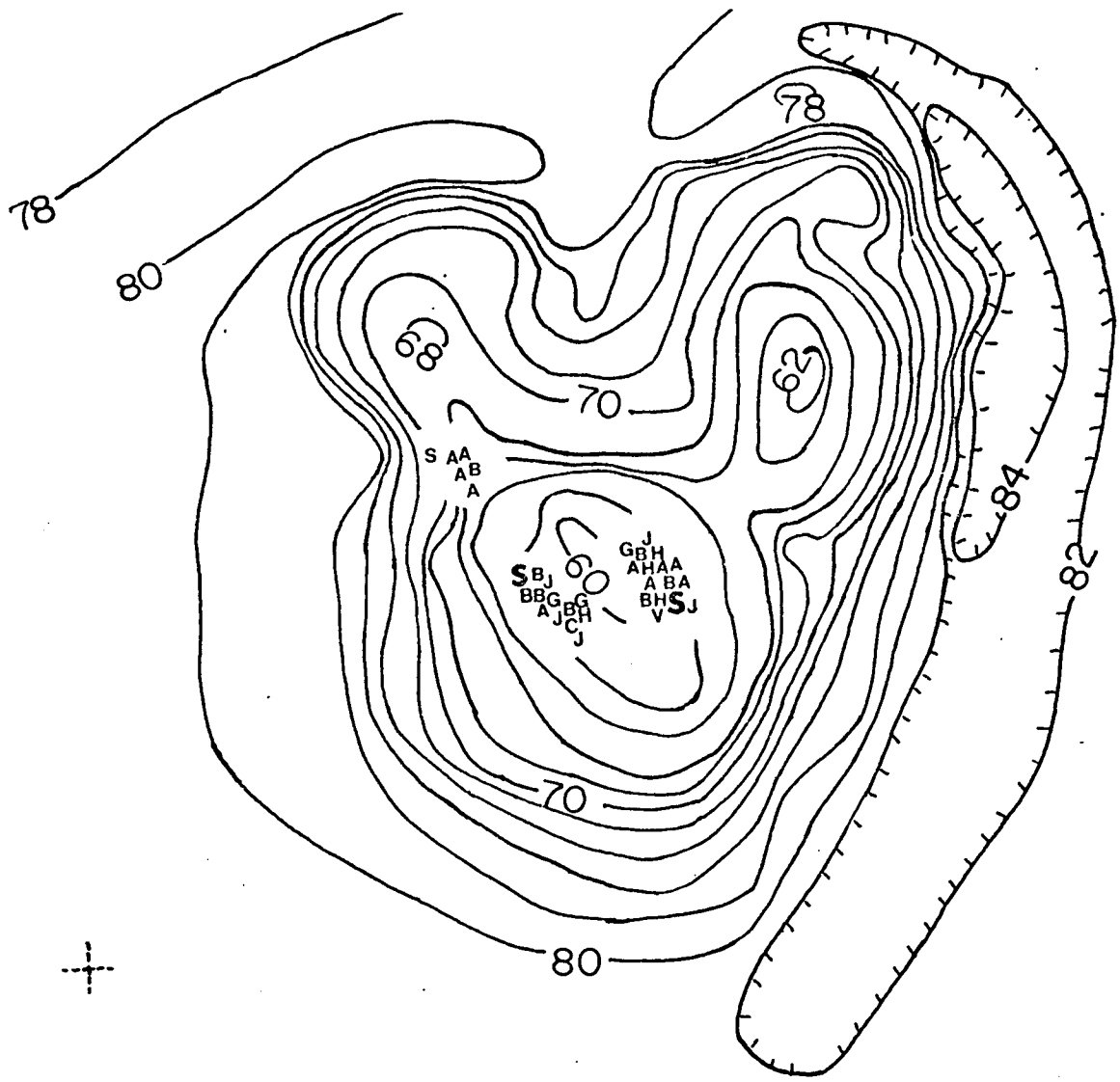
The primary objective in examining Southern Bank and Hospital Rock (Figs. IX-1 and 2) in 1976 was to attempt to confirm, through non-destructive quantitative sampling, an impression gained in 1975 that epibenthic populations occupying the high-relief South Texas fishing banks exhibit a substantial decrease in diversity and abundance with increasing depth; presumably due to environmental stress imposed by the chronic presence of nepheloid layers on the lower flanks of the banks.

RESULTS

The biotic communities of Hospital Rock are basically the same as those occupying Southern Bank (Table VIII-4 and IX-1). To demonstrate numerical relationships between depth, turbidity, species composition and species abundance, counts were made at both banks. Twelve stations were occupied at Southern Bank (4 at 59 m, 4 from 66 to 67 m, 4 at 72 m) and 12 at Hospital Rock (4 at 61m, 4 from 68 to 69 m, 4 from 71 to 72 m). Results of the counts are presented in Tables IX-2 and 3 and compared in Table IX-4.

The general conditions of water clarity and sediment cover at these stations were as follows:

59 - 61 m; water visibility greater than 15 m, thin veneer of sediment on rocks.

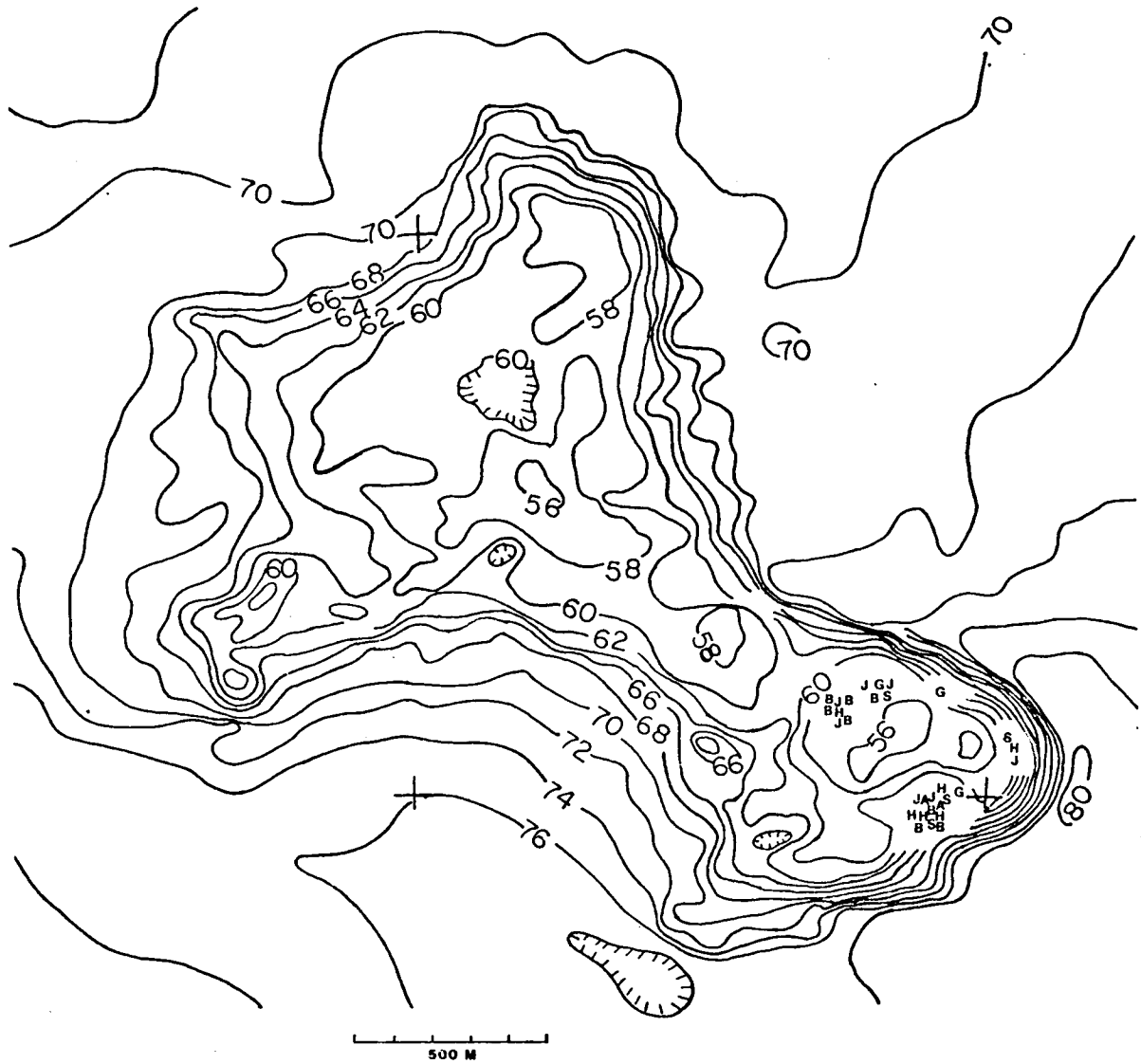


SOUTHERN
(contour interval 2 m)

500 M

Figure IX-1. Fish Sightings at Southern Bank

A. Reef fish A
B. Reef butterflyfish (Chaetodon sedentarius)
C. Burrowing fish C
G. Groupers (Mycteroperca spp.)
H. Spotfin hogfish (Bodianus pulchellus)
S. school of Red snapper
s. Red snapper (Lutjanus campechanus)
J. Amberjack (Seriola spp.)



HOSPITAL
(contour interval 2 m)

Figure IX-2. Fish sightings at Hospital Rock.

A. Reef fish A
B. Reef butterflyfish (Chaetodon sedentarius)
C. Burrowing fish C
G. Groupers (Mycteroperca spp.)
H. Spotfin hogfish (Bodianus pulchellus)
S. school of red snapper
s. Red snapper (Lutjanus campechanus)
J. Amberjack (Seriola spp.)

(66-69 m) compared to those found above 61 m. Below 71 m however, where rocks are heavily laden with thick layers of very fine sediment and water turbidity is generally high most of the time, there appears to be a substantial reduction in the number of organisms present. Certain types of encrusting sponges may "thrive" in the turbid water and, therefore, exhibit little, if any, decrease in abundance with increasing depth down to 72 m. One of these sponges was collected with a Spondylus taken at South Baker Bank. Dr. Teerling noticed that underneath the pinkish layer of sponge tissue was a rather thick layer of mud (Fig. IX-6). Apparently, the sponge had in some way either overgrown the sediment layer or caused the sediment to be entrapped between its tissue and the Spondylus shell. Whichever the case, the implication is that these sponges, which are the most conspicuous encrusting organisms within the nepheloid layer, are somehow adapted to an existence on the rocks bearing the heavy sediment layers which apparently tend to discourage development of other components of the epibenthic bank community.

The visually and numerically apparent reduction in percent cover of coralline algae with increasing depth was expected due to the algae's dependence on favorable light conditions for proper growth. Algal populations are not very extensive anywhere on the South Texas banks, although 20 to 25 percent cover on drowned reef patches at the very tops of the banks is not uncommon. As turbidity and depth increase, light conditions must, on the average, become less and less favorable. At around 67 m depth, which is often near the top of the nepheloid layer, the coralline

algal populations observed during our counts had decreased to 10 percent or less cover on the elevated rocks. Within the nepheloid layer at 71 to 72 m the average algal cover on the rocks was approximately 3 percent. Insofar as the rocks protruding above the general substratum occupy probably less than 50 percent of the bank, the coralline algal population is generally sparse overall.

CONCLUSIONS

Based on a combination of qualitative and quantitative observations made from the research submersible, there seems little doubt that a correlation exists between a sharp decrease in abundance of the coralline algae-invertebrate-fish populations and the presence of persistently very turbid water and thick sediment layers on rocks on the lower flanks of Southern and Hospital Banks. Undoubtedly, the same relationship exists on other South Texas banks. Seemingly, the environmental factors most significant in restricting epibenthic populations within the "permanent" nepheloid layer are reduced light and increased sediment cover and sedimentation on elevated rocks. The inadequate light levels alone could explain the severe reduction in algal populations below 72 m. It is felt, however, that the effect of increased sedimentation and encroaching sediment cover may act to "smother" incipient patches of coralline algae. Indeed, at one station within the nepheloid layer (Table IX-2), a substantial (15 percent) cover of coralline algae was observed

on the vertical face of a very prominent, overhanging ledge which was relatively sediment free.

The vertical face and underside of this same ledge supported a somewhat larger population of epifaunal organisms than was common elsewhere at that depth. Such observations indicate that the abundant presence of suspended matter in the water of the nepheloid layer (turbidity) may not be the most important direct cause of reduced epibenthic populations. They may be limited more by the low light levels, sedimentation associated with the high turbidity and the chronic presence of substantial veneers of sediment on the hard-bottom which may inhibit settling and attachment of pelagic stages of sessile organisms.

TABLE IX - 1A

HOSPITAL ROCK

LIST OF SPECIES COLLECTED

	Observed Depth Range (m)	No. of Specimens
Sponges		
Ircinia campana	67 - 70	?
I. sp. "a"	59	?
I. Sp. "b"	59	1
Spongia barbara	67 - 70	?
Spongia sp.	59	1
Keratose specimen	67 - 70	1
Haliclonid specimen	59	1
Gelliodes ramosa	59	1
Iotrochota birotulata	67 - 70	1
Adocia albifragilis	67 - 70	1
Siphonodictyon coralliphagum	59	1
Rhizochalina sp.	59	1
Callyspongia armigera	59	1
Microciona rarispinosa	59	1
Tedania sp.	67 - 70	1
Lissodendoryx isodictyalis	59	1
Ectoforcepia sp.	59	1
Anthoarcuata sp.	59	1
Mycale sp.	59	1
Agelas dispar	59	?
Axinella sp.	67 - 70	1
Auletta sp.	59	1
Spirastrella coccinea	59	1
Cliona vastifica	59	1
Cliona sp.	59	1
Epipolasis sp.	59	1
Sollasellid specimen	59	1
Leuconia aspera	67 - 70	1
Stony corals		
Madracis bruegemanni	67 - 70	?
Paracyathus pulchellus	60 - 70	3
Antipatharia		
Cirripathes sp.	59, 67 - 70	2

TABLE IX-1A, con't.

Polychaetes		
Nereidae specimen	59	5
Harmothoe sp.	59	2
Eunice filamentosa	59	2
Ceratonereis mirabilis	59	4
Chloeia viridis	67 - 70	1
Syllis gracilis	67 - 70	1
Syllis (*Haplosyllis*) *spongicola*	59	4
S. (*Typosyllis*) *hyalina*	59	1
Tryponosyllis zebra	67 - 70	1
Mollusks		
Lima scabra	59	1
Arca imbricata	67 - 70	1
Chiton - sp. "D"	54 - 70	2
Crustaceans		
Ampelisca sp. (near *pacifica*)	59 - 70	1
Corophiidae	59 - 70	5
Leucothoe spinicarpa	59 - 70	7
Stenothoe sp.	59 - 70	1
Isopoda specimen	67 - 70	3
Tanaidacea specimen	67 - 70	6
Paranebalia sp.	67 - 70	3
Synalpheus bousfieldi	67 - 70	12
S. townsendi	67 - 70	4
S. n. sp.	67 - 70	4
Alpheidae specimen	67 - 70	1
**Periclimenaeus caraibicus*	67 - 70	1
Axiidae specimen	67 - 70	2
Xanthidae specimen	59 - 70	2
Ophiuroids		
Ophiothrix angulata	59	2
Ophiactis sp.	59	3
Ophiactis savignyi	59	6
Ophiactidae specimen	59	2
Amphiuridae	59	1
Crinoids		
comatulids	59	1

TABLE IX - 1B

HOSPITAL ROCK

LIST OF ORGANISMS OBSERVED

	Observed Depth Range (m)	No. of Observations
Algae		
Coralline	60 - 72	19
Sponges		
Neofibularia sp.	60 - 64	7
Ircinia sp.	60 - 67	20
Agelas sp.	60	8
Orange specimen	72	1
White encrusting	60	4
Pink encrusting	66 - 72	9
Yellow encrusting	61 - 72	4
Yellow Branching	64	2
Yellow "ball type"	66 - 72	6
Orange encrusting	60 - 66	3
Spongia barbara	67 - 71	2
Grey stalked	66	1
Hydroids		
Plume - like	67 - 71	4
Stony corals		
Madracis sp.	60 - 64	6
Saucer agariciids	64	1
Branching specimen	64 - 72	2
Alcyonarians		
fans	60 - 64	5
Antipatharians		
Cirripathes sp.	60 - 72	47

TABLE IX-1B, con't.

Polychaete		
Hermodice sp.	67	1
Mollusks		
Spondylus sp.	60 - 72	22
Crustacean		
Stenorynchus sp.	60	1
Ophiuroids		
Diadema sp.	60 - 66	2
Crinoids		
comatulids	60 - 71	18
Bryozoan		
Holoporella sp.	60 - 66	5
Fishes		
Aulostomus maculatus (Trumpetfish)	61	1
Balistes vetula (Ocean triggerfish)	52 - 61	2
Caranx sp. (Jack)	49	1
Seriola dumerili (Greater amberjack)	61 - 67	11
Chaetodon sedentarius (Reef butterflyfish)	60 - 67	12
C. ocellatus (Spotfin butterflyfish)	60	1
Centropyge argi (Cherubfish)	60	3
Holacanthus bermudensis (Blue angelfish)	61 - 64	2
Holocentrus sp.	60 - 64	5
Halichoeres sp.	60 - 64	5
Bodianus pulchellus (Spotfin hogfish)	60 - 67	8
Lutjanus campechanus (Red snapper)	67	2
L. apodus (Schoolmaster snapper)	61	1
Chromis sp.	67	1
C. enchrysurus (Yellowtail reeffish)	60 - 67	15
Priacanthus arenatus (Bigeye)	60 - 64	4
Sparisoma sp.	60	1
Scomberomorus sp.	46	1

TABLE IX-1B, con't.

Liopropoma sp.	60 - 67	4
Serranus phoebe	60 - 64	7
A. annularis (Orangeback bass)	60	2
Paranthias furcifer (Creolefish)	61	1
Mycteroperca sp.	55 - 64	3
M. phenax (Scamp)	61 - 67	6
Sphyraena barracuda (Barracuda)	46 - 67	9
Reef fish A	60 - 62	4

TABLE IX - 2

SOUTHERN BANK

FISH and EPIFAUNA STATIONS

Numbers of Organisms (or % cover where indicated)

DEPTH:	61	61	61	61	69	69	69	68	72	72	72	72
ORGANISM STATION:	1	2	3	4	5	6	7	8	9	10	11	12
Coralline algae %cover	30-40		25	35-40	15	10-15	5	15	1	1	1	15
Agelas sp.			1									
Spongia barbara						2						
Neofibularia sp.							1					
Yellow sponge balls and spires			8			1		1	4	1	1	1
Yellow encrusting sponge						2						
Pink encrusting sponge % cover				2			trace	trace		trace		trace
other sponges	3		1			1		6	6	1	2	1
Plume-like hydroid										2		3
Cirripathes sp.	2		9	1	1	1	2	1	1	1		
Antipathes sp.	1											
Stephanocoenia sp.			1									
Agaricia sp.		1	2	5			1					
Spondylus americanus	2			4		3	2	1			4	
Comatulid crinoids	2		9		12	10	7	9	5	4	3	2
Holocentrus sp.		1		1								
Mycteroperca sp.	1											
Paranthias furcifer			5									
Liopropoma sp.			1	1	1			1				
Serranus phoebe			1								1	1
Seriola dumerili	4			2		1						
Equetus acuminatus			3									
Chaetodon sedentarius				1		1		1				
Chromis enchrysurus			7	13			1	15				
Bodianus pulchellus		1	1	1		1	1					
Halichoeres sp.			2	1		1		1				
Gobiosoma sp.						2						
Reef fish A			2									

TABLE IX - 3

HOSPITAL ROCK

FISH and EPIFAUNA STATIONS

Number of Organisms (or % cover where indicated)

DEPTH:	59	59	59	59	67	66	66	67	72	71	71	71
ORGANISM STATION:	1	2	3	4	5	6	7	8	9	10	11	12
Coralline algae % cover	30	30-40	25	20	5-10	5	3	5	Trace	Trace	Trace	Trace
Callyspongia sp.				2								
Agelas sp.	7	4	1	1								
Ircinia sp.		3	1		2							
Spongia barbara					1							1
Neofibularia sp.	1											
Yellow sponge balls and spires						4	4		4	1	7	4
Yellow encrusting sponge % cover									Trace	Trace	Trace	Trace
Pink encrusting sponge % cover					Trace	1	1	5	Trace	Trace	Trace	Trace
Other sponges	4		2	4	1	1	2		1			
Plume-like hydroid					2						3	
Scleracis sp.	1											
Cirripathes sp.	1	2	5	3	7	3	3	2	1	1		
Antipathes sp.	2	7		1								
Madracis sp.	2	2	3									
Spondylus americanus	5	5	6	3	3			1	2	1		1
Stenorhynchus seticornis		1										
Comatulid crinoids	4	3	1	9	14	14	12	3			1	7
Holoporella sp.	1						1					
Sphyraena barracuda				1								
Liopropoma sp.	2				1							
Serranus annularis	1			1								
Serranus phoebe	2		1									
Seriola dumerili			1	1								
Chaetodon sedentarius	2	1	4	2	1							
Centropyge argi	1	1										
Chromis enchrysurus	24	16	9	12								
Bodianus pulchellus	1		1	1								
Scarus spp.	1											
Halichoeres sp.												
Reef fish A	1	1	4									

TABLE IX - 4

AVERAGE OCCURENCES OF OBSERVED ORGANISMS

PER QUADRANT PER DEPTH INTERVAL PER BANK

BANK	SOUTHERN	HOSPITAL	SOUTHERN	HOSPITAL	SOUTHERN	HOSPITAL
ORGANISM DEPTH INTERVAL (meters)	61	59	66-67	68-69	72	71-72
Coralline algae - % cover	24.25	27.50	11.86	5.0	4.5	Trace
Ircinia sp.	0	1.00	0	.50	0	0
Agelas sp.	.25	3.25	0	0	0	0
Neofibularia sp.	0	.25	.25	0	0	0
Spongia barbara	0	0	,50	.25	0	.25
Yellow sponge balls and spires	2.00	0	.50	2.00	1.75	4.00
Yellow encrusting sponge % cover	0	0	.25	0	0	Trace
Pink encrusting sponge % cover	.25	0	.25	2.00	.25	Trace
Plume-like hydroid	0	0	0	.50	1.25	.75
Cirripathes sp.	3.00	2.75	3.75	1.25	.50	.50
Antipathes sp.	.25	2.70	0	0	0	0
Scleracis sp.	0	.25	0	0	0	0
Madracis sp.	0	1.75	0	0	0	0
Stephanocoenia sp.	.25	0	0	0	0	0
Agaricia sp.	2.00	0	.25	0	0	0
Spondylus americanus	1.50	4.75	1.50	1.00	1.00	1.00
Stenorynchus seticornis	0	.25	0	0	0	0
Comatulid crinoids	2.75	4.25	9.50	10.75	3.50	2.00
Holoporella sp.	0	.25	0	.25	0	0
Serranus annularis	0	.50	0	0	0	0
Serranus phoebe	0	.50	0	0	0	0
Chaetodon sedentarius	.25	2.25	.50	.25	0	0
Chromis enchrysurus	5.00	15.00	4.00	0	0	0
Centropyge argi	0	.50	0	0	0	0
Bodianus pulchellus	.75	.75	.50	0	0	0
Halichoeres sp.	.75	.75	.50	0	0	0

CUMULATIVE TOTALS:		A. Per depth per bank			B. per depth					
Average Coralline algae % cover	A	24.24		27.50		11.86		5.00		4.50		Trace
	B		25.87				8.43				2.75	
All Invertebrates	A	12.5		21.15		18.25		18.50		7.75		9.00
	B		33.65				36.75				16.75	
All Fish	A	8.00		22.50		6.00		.50		.50		0
	B		30.50				6.50				.50	

CHAPTER X

HYDROCARBONS AND HEAVY METALS IN MACRONEKTON AND *SPONDYLUS*

HEAVY MOLECULAR WEIGHT HYDROCARBONS IN MACRONEKTON AND *SPONDYLUS* SAMPLES

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Technician: Mrs. Darlene Garey
Secretary/Technical: Mrs. Kathy Gage

INTRODUCTION

The purpose of this project has been to analyze macronekton and *Spondylus* samples from selected banks on the South Texas Outer Continental Shelf (OCS) for heavy molecular weight hydrocarbons. The results of these analyses are to be used to provide baseline and monitoring data for the South Texas OCS.

Although petroleum hydrocarbons are known to be taken up relatively rapidly by marine organisms (Anderson *et al.*, 1974) and have been detected at parts per million levels in animals from highly polluted areas (Farrington and Quinn, 1973; Scarrett and Zitko, 1972), little is known about detecting trace or parts per billion levels of petroleum hydrocarbons. One obstacle to low level detection of petroleum hydrocarbons is interference from biogenic hydrocarbons. This interference may be minimized by obtaining profiles of biogenic hydrocarbons from different species. These biogenic profiles can then be subtracted from the profiles obtained from organisms to be monitored to better detect trace levels of petroleum hydrocarbons. Thus, our major effort has been directed to defining biogenic profiles and to determining which organisms are most consistent and most suitable for monitoring purposes.

Samples for these studies consisted of macronekton and *Spondylus* that were obtained from stations at the East Flower Garden, 28 Fathom Bank, Stetson Bank and the 28 Fathom Bank, southwest peak. The macronekton were mainly red and vermilion

snappers. The analyses performed in our laboratories were based on the hydrocarbons methodology as outlined by BLM. Our methods are detailed in the following section. Interpretation of the data was based on our previous experience (Giam et al., 1976; Farrington et al., 1972; Farrington et al., 1976), on the report of Clark (1974) and on gas chromatography-mass spectral data.

METHODS AND MATERIALS

MATERIALS[a]

Solvents used in the procedure were Mallinckrodt Nanograde[R] and were used as received or re-distilled when required. Silica gel (Woelm, 70-230 mesh) and Aluminum Oxide Woelm Neutral (Activity Grade 1) were activated at 200°C for at least 24 h before use. Hydrocarbon standards were obtained from Analabs and Polyscience Co.

INSTRUMENTATION

A Hewlett-Packard 5830 gas chromatograph (GC) equipped with dual flame ionization detectors and a programmable integrator was used for analyses. It was equipped with 1.83 m x 3.2 mm (6' x 1/8") stainless steel columns of 5% FFAP on Gas Chrom Q 100/120. The injector was at 280°C and the detector at 350°C. The column oven was temperature programmed from 100°C to 250°C at 5°C/min.

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[a] Trade names of reagents, solvents and equipment, and addresses for sellers are included to facilitate recognition by interested users of what we happen to use; there is no implication that these are solely recommended.

PROCEDURE

Background Reduction

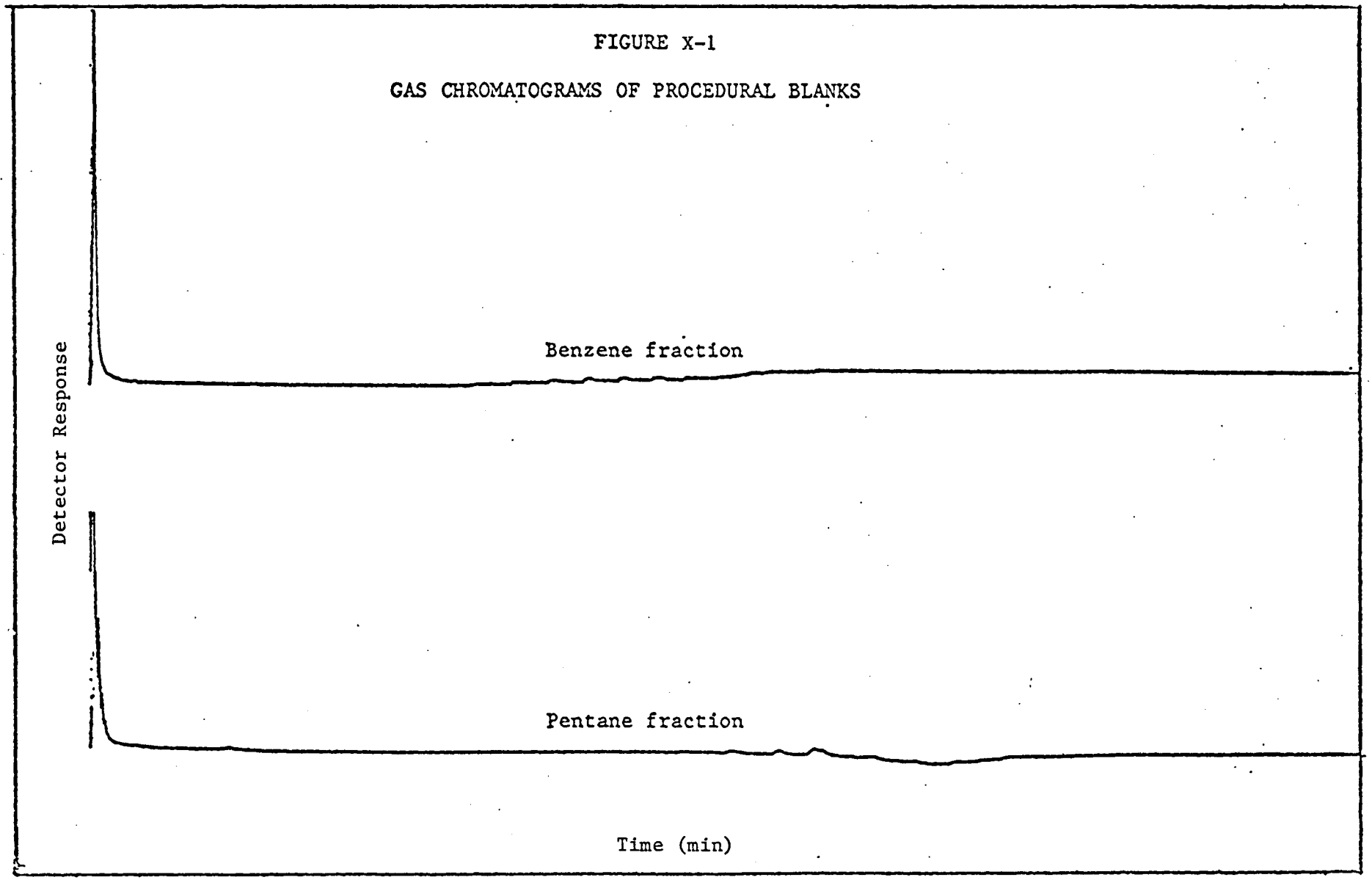
Prior to actual sample analyses, procedure blanks and recovery studies were performed. All solvents to be used in the procedure were concentrated to the extent required by the procedure and analyzed by gas chromatography. Any solvent exhibiting any impurities in the hydrocarbon region of the spectrum was rejected or redistilled in an all glass system. Solid reagents were purified by heating in a 325°C oven for at least 24 hours; concentrates of solvent rinses of these materials were inspected by gas chromatography as for solvents. Glassware and equipment were washed with Micro cleaning solution (International Products Corp.) and distilled water, rinsed with acetone, methanol and hexane and heated overnight at 325°C. After heating, they were rinsed with two portions of benzene and two of hexane. The final hexane rinse was concentrated and checked by gas chromatography. If any impurities were present, rinsing was repeated as needed to obtain an acceptable blank. (See Figure X-1.) Glassware checks accompanied each sample run and procedure blanks were performed at frequent intervals.

Extraction of Macrofauna

Approximately 100 g of tissue were used for all analyses. When possible, a minimum of five organisms or portions thereof were used for an analysis to minimize the natural variability of hydrocarbon content in conspecifics. The weighed sample was cut into smaller pieces along with any water present and an aliquot

FIGURE X-1

GAS CHROMATOGRAMS OF PROCEDURAL BLANKS



of the sample was removed and placed in a tared beaker and dried at 60°C until a constant weight was obtained. In this manner, the wet weight and dry weight of the sample were obtained. The remainder of the sample was saponified.

Saponification

Saponification was carried out by refluxing the sample with 0.05 g KOH/g tissue in approximately 50 ml methanol. The saponification was continued until the tissues were digested. After the completion of digestion, an equal volume of purified water was added to the mixture. The mixture was then refluxed overnight. Upon completion of the hydrolysis, the mixture was diluted with an equal volume of a saturated NaCl solution. The mixture was then extracted three times with n-pentane. The volume of n-pentane used for each extraction was equivalent to the volume of methanol initially used in the saponification. The n-pentane fractions are then combined and washed with an equal volume of water. The solvent was removed from the pentane extract (for weight determination) prior to column chromatographic separation.

Column Chromatography

Column material weight ratios of about one-hundred (100) parts alumina to one (1) part lipid sample and 200 parts silica gel to one (1) part lipid sample were used. The column had a length to i.d. ratio of approximately 20:1. Both the silica gel and the neutral alumina were Activity I. The column was packed in hexane and rinsed with one column volume of n-pentane. At no time was the column allowed to run dry. The extract taken up in

a small volume of n-pentane was then applied to the column and the aliphatic fraction eluted with two column volumes of n-pentane. This was followed by elution of aromatics with two column volumes of benzene. The eluates from the two fractions were then taken to near dryness. They were then transferred to screw cap vials with teflon lined caps, and the remainder of the solvent was removed with a stream of purified nitrogen. Following column chromatography, all eluates were analyzed by gas chromatography.

Gas Chromatography Separations

Each eluted fraction obtained from the column chromatographic separation was quantitatively dissolved in a small volume of carbon disulfide for injection into the GC. A stainless steel column (3.2 mm x 1.83 m (1/8" x 6')) packed with 5% FFAP on Gas Chrom Q (100-120 mesh) was used for the analysis. The column resolved n-C_{17} from pristane and n-C_{18} from phytane with a resolution (R) of approximately unity, where

$R = 2d/w_1 + w_2$ and,

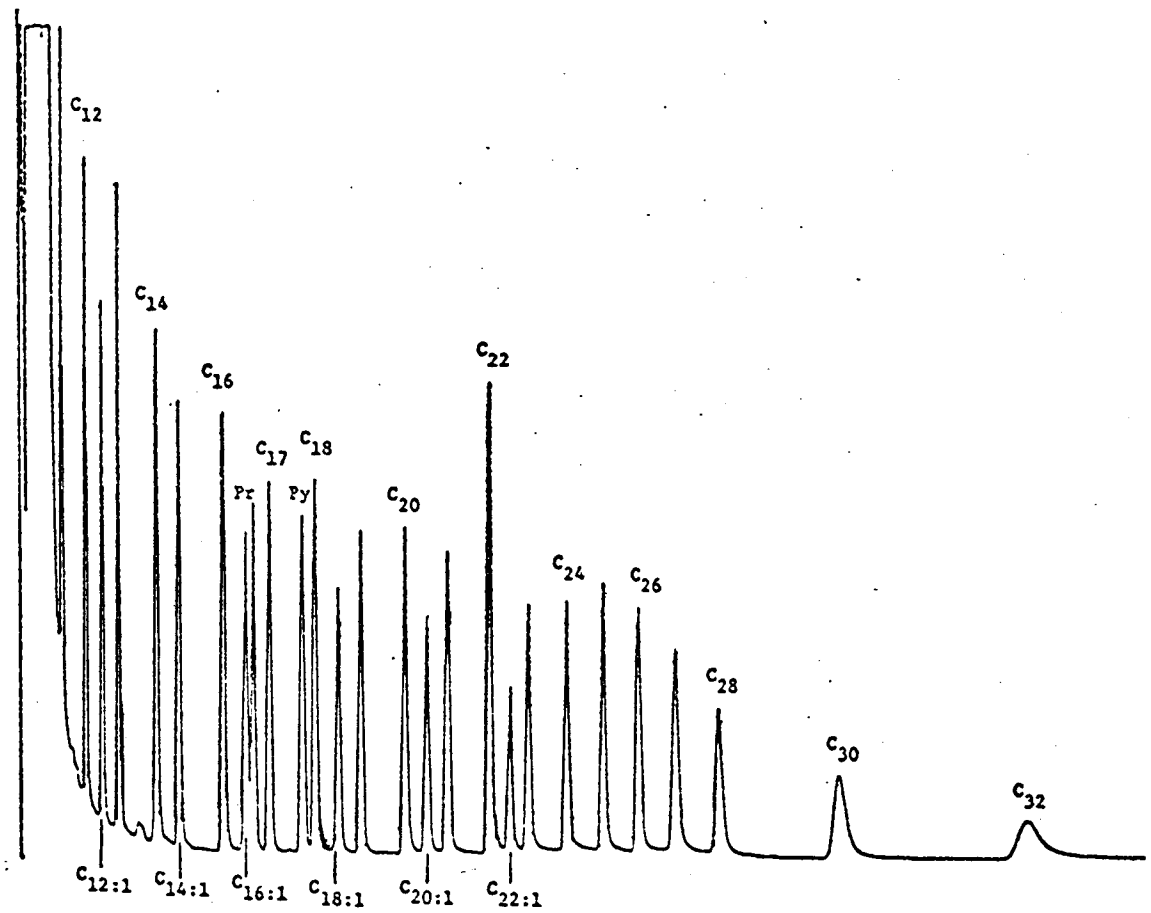
w is the width of each peak at the base on one phase for both pairs of components, and

d is the distance between apices.

The column was also capable of resolution of hydrocarbons from n-C_{14} through n-C_{36} (Figure X-2). To assist identification, the following compounds were used as standards to match the retention times of peaks in the gas chromatogram: aliphatic hydrocarbons C_{15}-C_{32}, trimethylbenzene, 1,2,3,5-tetramethylbenzene, 1,2,3,4-

FIGURE X-2

GAS CHROMATOGRAM OF ALIPHATIC STANDARDS ON A 10' x 1/8" 5% FFAP COLUMN. GLC CONDITIONS: CARRIER GAS, N_2 at 20 cc/min, COLUMN TEMPERATURE 100-240°C at 5°/min.



tetramethylbenzene, naphthalene, 2-methylnaphthalene, 1-methylnaphthalene, 1,5-dimethylnaphthalene, 2,3-dimethylnaphthalene, 4-phenyltoluene, 3,3'-dimethylbiphenyl, 4,4'-dimethylbiphenyl, fluorene, 1-methylfluorene, phenanthrene, anthracene, 9-methylanthracene, fluoranthene, and chrysene (Figure X-3).

Gas Chromatography-Mass Spectrometry

Aliquots of extracts from 12% of the GC samples were analyzed by GC-MS; runs were made by Dr. R. Spraggins (of the Center for Trace Characterization) in cooperation with Dr. H. S. Chan. Since the concentrations of components were very low (often near the limit of detection of GC-MS) only major components found in gas chromatograms were identified.

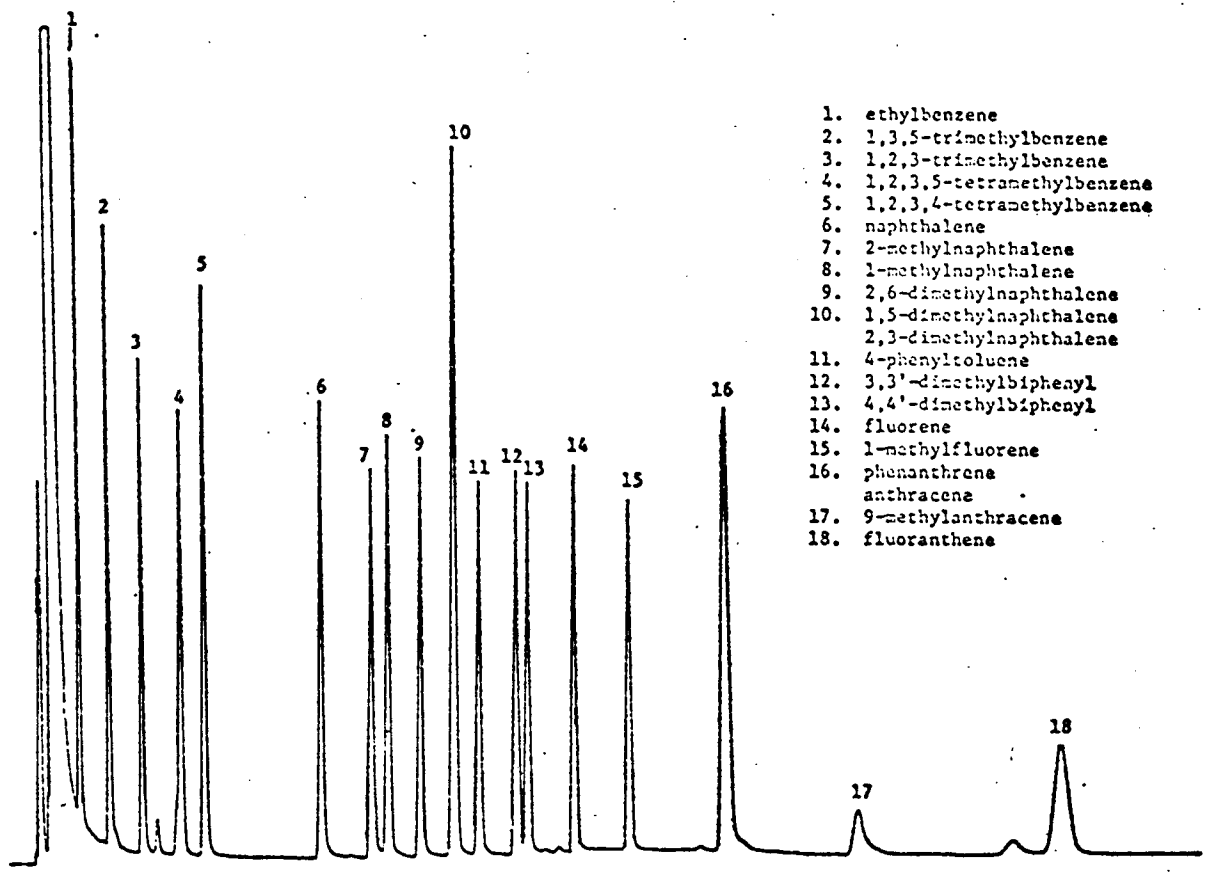
(a) Equipment. The analyses were run on a Hewlett-Packard 5980A dodecapole mass spectrometer interfaced to a 5710A gas chromatograph. This GC-MS system is supported with a 5933A Data System, a Tektronix 4012 CRT terminal, a Tektronix 4631 Hard Copy Unit, and a 15,000 spectra reference library stored on a single disc (Aldermaston).

(b) Gas Chromatography Conditions. The BLM samples for GC-MS analysis were carried out in four groups (quarterly). The first group of 10 samples was analyzed using a 1.83 m (6'), 3% apiezon GC column for separation, with temperature programming from 150-270°C at a rate of 16°C/min and a helium flow rate of 60 ml/min.

The second group containing 21 samples and all subsequent samples were analyzed on 30 m glass capillary GC columns (G 50,

FIGURE X-3

GAS CHROMATOGRAM OF AROMATIC STANDARDS ON A
10' x 1/8" 5% FFAP COLUMN. (SAME GLC CONDITIONS AS IN FIG. X-2)



1. ethylbenzene
2. 1,3,5-trimethylbenzene
3. 1,2,3-trimethylbenzene
4. 1,2,3,5-tetramethylbenzene
5. 1,2,3,4-tetramethylbenzene
6. naphthalene
7. 2-methylnaphthalene
8. 1-methylnaphthalene
9. 2,6-dimethylnaphthalene
10. 1,5-dimethylnaphthalene
    2,3-dimethylnaphthalene
11. 4-phenyltoluene
12. 3,3'-dimethylbiphenyl
13. 4,4'-dimethylbiphenyl
14. fluorene
15. 1-methylfluorene
16. phenanthrene
    anthracene
17. 9-methylanthracene
18. fluoranthene

#1176B and #1176F) coated with OV 101 purchased from J&W Scientific, Inc. These columns provide baseline separation of n-heptadecane and n-octadecane from pristane and phytane respectively. Hewlett-Packard's variable injection splitter was incorporated into the GC-MS system for capillary column analyses. A split ratio (10:1) was found to give optimum peak shapes while still retaining good detection limits using column #1176B. The capillary column was temperature programmed from 150-250°C at a rate of 2°C/min. Column #1176F was found to give optimum results using a 20:1 split ratio and a temperature program rate of 4°C/min.

(c) Mass Spectrometer Conditions. The mass spectrometer was operated with an ion source temperature of 180°C and an analyzer temperature of 110°C. The maximum detector gain remained at 2×10^{-6} torr during sample groups 1 and 2. Maximum detector gain for sample group 3 was 1×10^{-7} torr.

The mass spectrometer was tuned on perfluorotributyl amine (PFTBA) prior to analysis. Optimum source potentials for each set of analyses are shown below:

Sample Group #	1	2	3
Date	5/76	9/76	12/76
Drawout len	4	6	3
Repeller	15	16	16
Ion focus len	23	18	12
Electron energy (ev)	70	70	70
Emission	20	22	20
Target	20	21	15
X-ray	1	1	1

(d) Compounds Confirmed by GC-MS. The total ion chromatogram for each sample has been permanently stored on auxillary discs. Major sample components which appear in both GC and GC-MS have to date been identified. Some minor sample components have not been identified due to poor signal-to-background spectra. The electron-impact spectra of individual components were permanently stored on disc for comparison with library spectra or for other uses. Individual spectra from data files were: (1) compared by computer with spectra included in the Aldermaston Library on disc using the "search" routine; (2) with reference spectra run on our instrument; and (3) with the "eight Peak Index of Mass Spectra" (Mass Spectrometry Data Center). Table X-1 shows the compounds that were confirmed by GC-MS for each BLM sample.

RESULTS

ANALYTICAL PROCEDURES

Procedure blanks and recoveries of spikes were carried out prior to sample analyses. Excellent procedure blanks (Figure X-1) were routinely obtained; for a detailed discussion on decontamination procedures, see Giam and Wong, 1972, and Giam *et al.*, 1975.

The analytical method described in this report was essentially that required by the BLM. The procedure which included two evaporative concentration steps gave very good recoveries for the higher molecular weight but the expected lower recovery in low molecular weight and the more volatile hydrocarbons, as shown

in Table X-2. However, this lower recovery did not affect the characteristic (odd-even) distribution pattern of petroleum; thus, if a biota sample was contaminated with petroleum, the analytical procedure would be capable of detecting the contamination.

ANALYSES OF SAMPLES FROM THE TOPOGRAPHIC HIGH STUDY

The results of the analyses of 15 Spondylus and 30 samples of muscle, liver and gill of macronekton from four banks are reported in Tables X-3 to X-8 as the total concentration of alkanes, percent distribution of n-paraffins, the levels of pristane and phytane, the ratios of pristane/phytane, pristane/C_{17}, phytane/C_{18}, and the Carbon Preference Index (CPI) ratios.

The Spondylus samples had very low hydrocarbon concentrations ranging from below the limits of detection (<0.001 ppm) to 0.13 ppm. The only hydrocarbons detected were the C_{15} and C_{17} alkanes; the C_{15} hydrocarbon was dominant and often the only hydrocarbon noted.

The macronekton were mainly red and vermilion snappers; a graysby, rock hind and squirrel fish were also analyzed. Total n-paraffin concentrations varied from 0.002 to 12.36 ppm in gill, from <0.001 to 30.52 ppm in liver and from 0.09 to 6.06 ppm in muscles. Pristane was present in all but one sample at 0.002 to 13.98 ppm. Phytane was present in 8 samples at 0.03 to 0.54 ppm. The pristane/phytane ratio varied from 4.5 to 40. The pristane/C_{17} ratio ranged from 0.02 to 29.2 while phytane/C_{18} was from 0.5

to 3.2. The CPI_{14-20} ranged from 1.2 to 47.3 and the CPI_{20-32} had values from 0.2 to 1.7.

DISCUSSION

GENERAL COMMENTS

The analytical method was adequate for the main purpose of the project, namely to provide baseline data for hydrocarbons in biota and to evaluate whether the hydrocarbons are of petroleum or biogenic origin. Because of the very low levels of hydrocarbons in biota (generally ≤ 2 ppm), contamination during sampling and analyses must be scrupulously avoided. For most species, C_{15} and C_{17} n-alkanes constituted the major component of the hydrocarbons (Tables X-3 to X-8). There were little or no phytane, no aromatics, or distribution patterns to indicate that the hydrocarbons were of petroleum origin.

TOPOGRAPHIC HIGH STUDY

Only 15 samples of *Spondylus* were received rather than the contracted 18. Thirty macronekton samples were analyzed, 6 more than the contracted 24 and thus, the total number of samples analyzed was greater than the contracted number.

The *Spondylus* samples contained only C_{15} and C_{17} n-alkanes and no indication of petroleum contamination.

The macronekton samples were mainly red and vermilion snappers and the C_{15} and C_{17} n-alkanes and pristane were the dominant hydrocarbons. This is probably due to the diet of the organisms

as pristane is the major hydrocarbon in zooplankton (Blumer et al., 1964) and the C_{15} and C_{17} n-alkanes are the dominant hydrocarbons in unpolluted algae (Clark and Blumer, 1967). The hydrocarbons present in more than 10% of the samples were confirmed by GC-MS; squalene was the only compound confirmed in the aromatic fraction. Phytane was found in 8 or 25% of the samples. It was present in red snapper from East Flower Garden Bank, 28 Fathom Bank and 28 Fathom Bank, southwest peak (6 samples) and in vermilion snapper from Stetson Bank (2 samples). The red snappers also had higher hydrocarbon levels at the East Flower Garden and 28 Fathom banks, while the vermilion snapper had its highest levels at Stetson Bank. As phytane is generally considered to be from petroleum rather than from biogenesis (Farrington et al., 1972), these findings suggest that there could be sources of petroleum pollution at those stations.

There was also an absence of correlation between and within banks of the pristane/phytane, pristane/C_{17} and phytane/C_{18} ratios. These parameters are often used to identify sources of oil pollution and would be expected to be similar in organisms exposed to a single petroleum source, although there is some indication that biogenic hydrocarbons can affect the ratios (Farrington and Medeiros, 1975). In any case, the lack of correlation of the ratios further implies the absence of significant petroleum sources in the topographic high study area.

Other indices of the presence of petroleum are odd-even ratios. In this study, carbon preference indices (CPI) have been

used as a measure of odd-carbon dominance. They are calculated as follows:

$$CPI_{20-32} = 1/2 \left[\frac{\sum_{n=21}^{n=31} \text{HC odd}}{\sum_{n=22}^{n=32} \text{HC even}} + \frac{\sum_{n=21}^{n=31} \text{HC odd}}{\sum_{n=20}^{n=30} \text{HC even}} \right]$$

$$CPI_{14-20} = 1/2 \left[\frac{\sum_{n=15}^{n=19} \text{HC odd}}{\sum_{n=16}^{n=20} \text{HC even}} + \frac{\sum_{n=15}^{n=19} \text{HC odd}}{\sum_{n=14}^{n=18} \text{HC even}} \right]$$

The CPI_{20-32} is generally of the same order of magnitude for petroleum (mean 1.2) and for biological organisms (mean 1.0-1.5), but the CPI_{14-20} more accurately reflects the odd-carbon dominance of biological samples that are free of petroleum. The CPI_{14-20} is almost always >2 for organisms, while it averages <1.0 for petroleum (Clark, 1974). In this study, most of the CPI_{14-20} values were between 10 and 30, with a range of 1.9 to 70. The few values that were found to be close to 1 were for samples with a small number of hydrocarbons whose distribution patterns did not resemble petroleum. Thus, this parameter also supports the other findings in indicating very low levels of petroleum in the Texas OCS Topographic High study area.

CONCLUSIONS

The distribution patterns of *n*-alkanes and the absence of aromatic hydrocarbons in the macronekton and *Spondylus* samples from the Topographic High study area imply that very little or no heavy hydrocarbons of anthropogenic origins are present in organisms of the study area.

TRACE METALS IN MACRONEKTON AND *SPONDYLUS* SAMPLES FROM THE TEXAS OUTER CONTINENTAL SHELF TOPOGRAPHICAL HIGH STUDY (1976)

Principal Investigator

B.J. Presley

Co-Principal Investigator

Paul N. Boothe

INTRODUCTION

As part of the Topographical High Study, macronekton and spiny oysters were collected from selected topographical highs (i.e., fishing banks) on the Texas Outer Contential Shelf and analyzed for trace metal content. The resultant baseline data set of trace metal levels in organisms from these bank stations is the subject of this report.

Macronekton (primarily 2 species of fish: Lutjanus campechanus and Rhomboplites aurorubens) were collected from four stations on a series of cruises during September - October 1976. East Flower Garden (EFG), Stetson Bank (STB) 28 Fathom Bank (TFB), and 28 Fathom Bank southwest peak (TFBSWP) were sampled. Spiny Oysters (Spondylus americanus) were also collected from the same banks (except TFBSWP) during these cruises as well as from Southern Bank (SB) and Hospital Rock (HR). As part of the South Texas Outer Continental Shelf (STOCS) Monitoring Study, the same macronekton species were collected from SB and HR nine times during 1976, including three seasonal samplings (viz. January-February, May-June, September-October) and five monthly samples (viz. March, April, July, August, November). The trace metal data from all macronekton samples from both studies will be discussed.

A total of 103 sample analyses, each for ten trace metals (Al, Ca, Cd, Cr, Cu, Fe, Ni, Pb, V, Zn), were conducted on material from 30 macronekton samples and 15 Spondylus samples. Three types of tissue were analyzed from each macronekton sample. These types were muscle (30 analyses), liver (28 analyses) and gills (30 analyses). An aliquot from each of the whole Spondylus collected was analyzed.

This baseline trace metal data set is characterized in two ways. First the average concentrations of trace metals in each species analyzed are compared. Second the ways in which trace metal levels vary over space and time within the same species and between similar species are described.

METHODS

All macronekton samples were caught by hook and line. Spondylus samples from EFG and STB were collected by divers. Spondylus from the other banks were collected using the submersible DR/V DIAPHUS. Every reasonable precaution was taken to avoid contamination during sampling. All samples were placed in polyethylene bags. When potentially contaminating sediment or other foreign material was adhering to the exterior surfaces of the organisms collected, they were rinsed prior to being put into the polyethylene bags. Each individual Spondylus was strapped shut with plastic straps before being placed in the sample bag. This was done to minimize the potential contamination of samples resulting from the exchange of materials between the inside and outside of the mantle cavity during sample storage. To avoid any release of metals from organisms caused by microbial activity, all samples were immediately frozen on board ship and remained frozen during transportation and storage until prepared for analysis.

Three Spondylus samples each consisting of a single individual were collected from five bank stations as detailed above. Optimally five individuals of two macronekton species (L. campechanus,

R. aurorubens) were collected from each bank during each sampling period. Due to the varying success of collecting fish by hook and line, limited on station time, etc., this sampling goal frequently could not be achieved. Thirty macronekton samples were collected out of a total of 44 samples desired. Two macronekton samples were collected at each of the four secondary bank stations (i.e., EFG, STB, TFB, TFBSWP) sampled once in September-October 1976. Nine samples were collected from HR and 13 samples from SB.

SAMPLE PREPARATION

Non-contaminating procedures used to prepare each of the major sample types (fish flesh, liver, gills, and oysters) are detailed below. Macronekton and Spondylus samples were thawed just prior to being prepared for freeze drying. They were rinsed with deionized water as necessary to remove any mud or other foreign material adhering to the exterior surfaces of the organims. The deionized water used for all work in this study was prepared by passing distilled water through an ultrapure, mixed-bed demineralizer column (BARNSTEAD D0809). All dissections were done in a clean room on acrylic plastic cutting boards using stainless steel scalpels, scissors and nylon or teflon tweezers as required. At no point during the dissection were the preparer's fingers allowed to touch the tissue to be analyzed. All dissecting equipment was thoroughly rinsed with 1 N HNO_3 and deionized water between each sample. At the end of each preparation session, all equipment was thoroughly cleaned in a Na_2CO_3 solution and rinsed with 1 N HNO_3 and deionized water. The equipment was stored in polyethylene bags until the

next use. The acrylic boards were soaked in 0.5 N HNO_3 between each use.

Muscle, liver and gill tissues from each individual fish were prepared for analysis. A maximum amount of the appropriate tissue from each individual was prepared for freeze drying as described below. This action was taken to insure that extra freeze-dried material would be available for repeat analyses when necessary and to avoid having material from the same sample stored in two different ways for long periods. An equivalent wet weight tissue aliquot was taken from up to seven individuals in the sample (if available) and pooled in a tared plastic, snap-cap vial to give a total wet weight of 6-12 g. After dehydration this pooled sample yielded a dry weight of 1-3 g, all of which was analyzed for trace metals. Pooled samples were prepared in this manner to insure that the trace metal concentrations in the pooled sample represented a true average of the concentrations existing in each of the individual organisms included in the sample, and also to avoid having to homogenize a large, pooled sample with a ball mill or mortar and pestle and risk contamination. If sufficient tissue remained, reserve pooled samples identical to the first were prepared in separate vials. If there was insufficient tissue remaining to prepare a second replicate pooled sample, or if there was still tissue left over after the preparation of the additional replicates, the remaining tissue from each individual was placed in separate vials for possible future use.

The standard length and sex (whenever possible) of each individual fish was determined. In dissecting out the lateral trunk

musculature, an effort was made to avoid contamination of the muscle sample which would occur if the sample came into contact with the exterior surface of the skin. On each side of the fish, a dorso-ventral incision was made along the anterior margin of the lateral trunk musculature. This incision was continued posteriorly just lateral to the mid-dorsal and mid-ventral planes. The skin was flayed off and discarded. The muscle was cut away from the axial skeleton. When sufficient tissue was available, the margins, where possible contact with the exterior skin could occur, were trimmed off and discarded. If there was insufficient tissue available, these margins were rinsed sparingly with deionized water and retained. Gill and liver tissues were also sampled. The gills (including gill rakers) were removed by cutting the dorsal and ventral attachments and were rinsed sparingly with deionized water to remove any foreign material. As the last step, the body cavity was opened and the liver excised. All tissues once removed were handled as described below.

The shell length and width of each spiny oyster were measured. The whole organism was then removed and placed in an acid-cleaned 140 mm plastic petri dish. Mucus, particulates and other foreign material were washed off with filtered seawater. Portions of the gut containing ingested material were also removed. The whole oyster was then placed in a tared, snap-cap vial and handled as described below.

To check possible sources of contamination during sample preparation, the following experiment was conducted. Eight replicate aliquots of flesh from a single red snapper (*Lutjanus campechanus*)

were prepared as described above. Two replicates were frozen immediately. Four aliquots were refrigerated for 18 h and then frozen. During refrigeration, one replicate received no further treatment, one was exposed to a scalpel which had been used in numerous previous dissections, one was exposed to a similar scalpel which had never been used, and the final refrigerated aliquot was exposed to a pair of dissecting scissors. The remaining two aliquots were exposed to an acrylic cutting board or WHATMAN Number 1 filter paper for 20 min at room temperature and then frozen. All samples were then handled as described below. The only significant contamination observed was a $\geq$ 30-fold increase in the Cr concentration of the aliquot exposed to the scissors. The use of dissecting scissors in sample preparation throughout this study was minimized. However, the time of contact between tissue and dissecting instruments during this experiment was much longer than would ever occur during actual sample preparation. This experiment suggests that the preparation techniques were not a source of sample contamination for the eight metals (not Al or Ca) measured.

At the end of each sample dissection, the tissue was placed immediately in a tared snap-cap vial and weighed immediately to determine wet weight. The samples were covered with parafilm and placed in a freezer. When a sufficient number of samples had accumulated, all samples were freeze-dried for 24 to 96 h to a constant weight. After removal from the freeze dryer, the samples were reweighed to determine dry weight and the percentage of moisture lost by each sample was calculated. Samples were then stored in a desiccator until analyzed.

DIGESTION (WET OXIDATION) OF SAMPLES

Freeze-dried samples were prepared for atomic absorption spectrophotometric (AAS) analysis using the HNO_3-$HCLO_4$ digestion procedure described in Method 3 of Attachment B to the 1976 BLM STOCS contract (AA550-CT6-17). Unacceptably high procedural blanks for Cd, Cr and Pb were observed in preliminary sample digestions using this method.

The primary sources of contamination were $HCLO_4$ (double redistilled) and, to a much lesser extent, HNO_3 (double redistilled) since up to 25 ml HNO_3 were being used per sample digested. To minimize this blank problem, a new lot of $HCLO_4$ containing considerably lower concentrations of Cd, Cr and Pb was obtained and the amount of HNO_3 and $HCLO_4$ used to digest each sample was significantly reduced. This reduction was realized by changing to an essentially closed refluxing system. A 1-3 g dry weight sample was placed in a spoutless, electrolytic style Pyrex beaker and 4-5 ml of 70% HNO_3 per gram of sample and 1 ml total of $HCLO_4$ were added. The beaker was covered with a 75 mm, non-ribbed Pyrex watchglass and allowed to sit overnight at room temperature. The mixture was then refluxed at low heat on a hotplate for 6-24 h. A bent glass rod was placed between the beaker lip and the watchglass and the heat increased to permit HNO_3 evaporation. At the first sign of white $HCLO_4$ fumes (i.e., when most of the HNO_3 was gone), the glass rod was removed allowing the watchglass to again rest flush on top of the beaker. The sample was allowed to reflux until the solution cleared completely. If the sample did not clear, an additional 1 ml HNO_3 and 0.5 $HCLO_4$ were added and the refluxing continued until clearing occurred.

This step was repeated once if necessary. Finally, the watchglass was removed and the mixture was allowed to evaporate to near dryness.

Each digested sample was transferred to a tared 30 ml Oak Ridge type, screw-top polypropylene centrifuge tube by washing the beaker several times with 0.1 N HNO_3 (BAKER ULTREX grade) and pouring the resultant solutions into the centrifuge tube. Each sample was brought to approximately 25 ml, thereby diluting the original dry weight sample 10-20 times. The volume of each sample was determined by reweighing the filled sample tube and making a small correction (e.g. 1.01-1.04, pH $\sim$ 0.5-1) for the specific gravity of the sample solution which was determined for each digestion. Insoluble residue which occurred in significant amounts in several gill samples was allowed to settle in the tubes. Further dilutions from the original solution were made on a weight/weight basis in 5 dram snap-cap vials using 0.1 N HNO_3.

All digestion glassware were soaked immediately after use in a solution of "Micro" detergent and distilled water in covered polyethylene pans for up to several days. The glassware were then rinsed thoroughly with deionized water and soaked in 3 N reagent grade HNO_3 in covered polyethylene or polypropylene pans until the next use. The centrifuge tubes were prepared for use by cleaning in a "Micro" solution. They were then filled with 5 N reagent grade HNO_3, heated for several days at 50°C and stored at room temperature until used. Prior to use, the tubes were emptied, rinsed thoroughly with deionized water and tared. The 5 dram snap-cap vials used for further dilutions were filled with 1 N reagent grade HNO_3 and allowed to sit at room temperature for several days.

Prior to use they were emptied, rinsed with deionized water and tared.

Three to five procedural blanks were included with each group of samples digested to determine the amount of each metal contributed to the samples by the digestion glassware and reagents. These blanks received the same reagents and treatment as the tissue samples. An aliquot of the 0.1 N HNO_3 used to transfer and dilute the samples was placed in a centrifuge tube and analyzed with each digestion as a diluent/tube blank. Reagent blanks were analyzed for all bottles of acid prior to their used in sample digestion. These blanks were prepared by taking $\geq$ 10 ml of acid, evaporating it to near dryness in digestion glassware and transferring the residue to a centrifuge tube in the same manner described above. For each series of dilutions made using 5 dram vials, one or more vial blanks were prepared and analyzed.

To determine if any of the metals of interest were being lost from samples during digestion, spike recovery experiments were conducted during four different digestions. Three experiments used aliquots of fish flesh and one used shrimp flesh. In each experiment two replicate aliquots of tissue were placed in separate beakers and digested as described above. One aliquot was spiked during initial heating with the following amounts of metals: Cd (.025 μg), Cr (0.25 μg), Cu (50 μg), Fe (50 μg), Ni (2 μg), Pb (0.5 μg) and Zn (50 μg). Replicate aliquots of the spike were placed in two separate tared centrifuge tubes and brought to 25 ml with 0.1 N HNO_3 diluent. These two samples were analyzed to determine the actual amount of each metal in the spike. The unspiked tissue sample was

analyzed to determine the actual amount of each metal in the sample itself. The total amount of each metal expected in the spiked sample was calculated using these two values. Percent recovery was determined by comparing the expected amount of each metal with the actual amount measured in the spiked sample. The average percent recovery was as follows: Cd 93%, Cr 94%, Cu 107%, Fe 93%, Ni 95%, Pb 103% and Zn 107%. Considering the low levels of metals used in the spikes and the precision of the analyses, these results were quite acceptable. They indicate that there was no significant loss of any of the metals studied during the digestion procedure.

ATOMIC ABSORPTION SPECTROSCOPY (AAS) PROCEDURES

The concentrations of eight elements (Cd, Cr, Cu, Fe, Ni, Pb, V and Zn) were determined in the macronekton and oyster samples from the 1976 Topographical High Study. Flameless AAS was used to measure Cd, Cr, Ni and Pb, which occurred at low levels. These analyses were made using a PERKIN-ELMER Model 306 atomic absorption spectrophotometer equipped with an HGA-2100 graphite furnace atomizer. A summary of the instrumental operating conditions and the average procedural blanks for all eight digestions are given in Table X-9. External and internal furnace purge gas flow rates were verified at specified levels of 0.9 and 0.3, l/min respectively at 40 psi delivery pressure. The injection volume was 25 µl. The furnace temperature gauge was calibrated using a clamp-on (inductive) ammeter and an optical pyrometer. Dry, char and atomization temperatures and times were optimized for each metal using selected representative samples according to the manufacturer's recommendations (Anon., 1974). Nonresonance lines used for this optimization to estimate the magnitude

of broad band molecular absorption for various sample types were 226.5 (Cd), 231.6 (Ni), 282.0 (Pb) and 352.0 (Cr) nm. Corrections for non-specific or broad band molecular absorption were made by a deuterium arc background corrector. For Cd and Pb, sample dilutions $\geqq$ 1/50 were used for quantitation, and for Cr and Ni, dilutions of $\geqq$ 1/50. Chemical interference was evaluated and corrected as necessary by frequent use of the standard additions technique and check dilutions. Mixed standard metal solutions were prepared in dilute HNO_3 (BAKER ULTREX grade) by diluting concentrated commercial atomic absorption standards. Samples were quantitated by peak height comparison with bracketing standards injected before and after the sample. Consideration was given to temporal variations in instrumental sensitivity, non-linearity between bracketing standards and gross differences in peak shape.

Copper, Fe and Zn were analyzed by flame AAS using a JARRELL-ASH Model 810 atomic absorption spectrophotometer. Analyses were carried out following the manufacturer's recommended procedure (Anon., 1971; 1972). A summary of the operating parameters for these analyses is given in Table X-10. Non-specific absorption was monitored by measuring simultaneously the absorbance of a non-resonance line and the analytical line of the element of interest. A fairly lean air-acetylene flame with flow rates of circa 7 and 2.5 l/min, respectively, were used for all three elements. Aspiration rate was generally 5 to 6 ml/min. Chemical interference was checked by use of the standard additions technique. Mixed standards used were prepared as described above.

The accuracy and precision of AAS analysis was evaluated by analyzing two NBS standard biological reference materials (i.e., #1571 orchard leaves and #1577 bovine liver) with each digestion. The results of these analyses compared to NBS values are given in Table X-11. These results indicate the AAS techniques used were acceptable. The only significant deviation occurred with Fe in orchard leaves. We were consistently below this NBS value using a variety of different batches of AA standards. We feel that this plant material may be resistant to complete dissolution by HNO_3: $HCLO_4$ and are trying other digestion procedures.

DETERMINATION OF VANADIUM IN ORGANISMS

Vanadium determination by AAS has a low sensitivity with a minimum detectable quantity of $\geq$ 100 ng. Neutron activation analysis (NAA) was prescribed by BLM in Attachment B to the 1976 STOCS Study Contract in an effort to improve the sensitivity of V analysis. The primary difficulty that must be overcome when using NAA for the determination of V in marine organisms is interference from Na-24 and Cl-38 background levels produced during irradiation. BLM prescribed the use of H_2SO_4 and hydrated antimony pentoxide (HAP) as pre-irradiation chemistry reagents for the removal of Cl and Na, respectively, from acid digests of organism samples.

These pre-irradiation chemical separations required considerable effort to implement in the laboratory. A method had to be developed for the synthesis of HAP ($Sb_2O_5 \cdot 4H_2O$). The sole commercial source of HAP is in Italy, delivery is slow and the product variable in Na affinity. Also large amounts of Cl, which are very difficult to

remove, are introduced into the samples by using $HCLO_4$ as the oxidizing agent. To keep Cl below the interference level in the samples, it was necessary to do separate, duplicate digestions of each sample for V analysis using H_2O_2 as an oxidizing agent (i.e. Method 2, Attachment B, Contract AA550-CT6-17). Chlorine concentrations after this digestion procedure were at acceptable levels and no further treatment was required. The HAP procedure was modified from Girardi and Sabbioni (1968). A batch method was used to remove Na from the sample digests. The HNO_3:H_2O_2 digest of a 0.5-1 g dry weight sample was added to a 50 ml screw-top, polyethylene centrifuge tube containing from 0.1-0.5 g of HAP. Enough 70% HNO_3 was added to provide a final acid concentration of about 10 N. After shaking for 5 min the samples were centrifuged and the supernatant poured into a 50 ml teflon beaker. This step was repeated using 10 ml of 70% HNO_3. The contents of the teflon beaker were then evaporated to a volume which could conveniently be poured into a 1.5 ml irradiation polyethlene vial used by the Texas A&M University Nuclear Science Center. The vial was heat-sealed to prevent sample loss during analysis.

Each sample was irradiated separately for 2 min by a 1 MW TRIGA REACTOR. This process was facilitated by a pneumatic transport system which can rapidly transfer samples in and out of the reactor core. The sample was first placed in a secondary polyethylene vial, together with an aluminum flux monitor, before being transported to the core for irradiation. Standards prepared from commercial AAS standards of pure metals were used.

After return of the sample and a 1 min delay, the aluminum flux

monitor was counted by a multi-channel pulse height analyzer. After an appropriate delay period (usually 3-5 min so that the dead time was < 30%), the irradiated sample was placed on an ORTEC Ge(Li) detector and counted using a separate GEOS Quanta 4096 channel pulse height analyzer. After 5 min counting period, the spectrum was stored on magnetic tape.

Data reduction was done using the program HEVESY (Schlueter, 1972). This program calculated peak intensities and converted them to concentration by comparison with standards. Corrections were made for varying delay times, dead times and neutron fluxes.

In spite of achieving acceptable levels of Na and Cl in the sample digests, the average minimum detectable quantity (MDQ) for V by NAA was about 60 ng. Many samples were below the limit of detection. This relatively poor sensitivity was apparently due to interference from the considerable remaining sample matrix. This problem was exacerbated by the fact that the concentration in many samples was low (i.e., 0.3 ppm), and relatively large samples were required to get a sufficient amount of V for analysis. Another problem on a small percentage of samples was Sb carry-over to the treated samples. Although Sb lends no direct interference to NAA determination of V, its neutron cross-section is large enough to render the sample sufficiently "hot", after even 2 min irradiation, to increase the dead time to a prohibitive level. Sometimes this situation can be compensated for by altering the counting geometry. In either case, the sensitivity for detecting V-52 is severely reduced and most often no useable data derived.

One characteristic of NAA is its capability for analyzing

several elements from a single irradiation. Concurrent with V analysis, the concentrations of Al, Ca and Cu were determined. However, the analytical conditions could not be optimized for all four elements during a single irradiation. The sensitivity for Al was good and the Al concentration data satisfactory. However, the sensitivity for Ca was marginal and many of the samples were below the detection limit which was quite variable and often very high. The sensitivity for Cu was very poor and almost all the samples were below the elevated detection limit. These "less-than" values were consistent with Cu concentrations for the same samples determined by AAS analysis, but are of no practical use.

RESULTS AND DISCUSSION

Table X-12 compares the annual mean concentrations of ten elements in the four major sample types as well as comparing inter-specific differences within each of the major macronekton sample types. The averages were determined using all "less-than" values at the calculated limits of detection to avoid excluding too much data from consideration. Fish muscle had the most frequently un-detectable values for Cr, Ni and V, and less frequently for Cd and Pb. Because "less-than" values were used in these calculations, the true means for the above elements are lower than the indicated values. However, since the detection limits for Cd, Cr, Ni and Pb are quite low (i.e., < 0.01 to 0.1 ppm dry weight), the over-estimation of these means should not be excessive and should not affect the relationships in these general comparisons.

Two approaches were used to characterize systematically the relative levels of trace metals among the four major sample types in Table X-12. The first approach was to rank types from 1 to 4 using the overall average for each type (not shown) for each of eight metals (except Al, Ca). The average ranking for each group was then calculated (i.e., sum of ranks for each type/8). Spondylus has generally the highest trace metals concentrations. The order of the remaining groups is liver, gill and muscle.

The second approach was to order the four types according to the sum total of the eight metals in each one. Again the overall average for each type (not shown) was used in this determination. The relative position of the first two groups changes using this second criteria. Liver tissue has the highest average total metal content (1.2 mg/g) with Spondylus second (0.42 mgm). Gill tissue has a total of 0.23 mgm with muscle tissue having < 0.1 mgm. Liver tissue was first because of the higher concentrations of the important metabolites, Fe and Zn, in this metabolically active tissue. Spondylus has relatively high concentrations of all metals, but none match the high levels that occur in liver tissue. Gill and muscle tissue have generally lower levels of most metals with expected higher concentrations for only the metabolically active ones, Cu, Fe and Zn.

Variability in this data set is one of the key factors in determining how small a change in the concentration of one of these trace metals could be detected during some future monitoring program. Relative variability in trace metals content among the four types (Table X-12) was quantitatively characterized by calculating the

mean percent coefficient of variation for eight metals for each type [i.e., % C.V. = (std. dev./mean) x 100] and then ranking these values. Liver samples had the greatest variability in trace metal concentrations (% C.V. = 128). Fish muscle and gill tissue samples had similar variability (% C.V. = 85 and 84 respectively). Spondylus samples had the lowest variability (% C.V. = 74).

The variability in this data set is generally high. Some variability could have arisen from differences in sample preparation techniques such as taking tissue from different areas of the body, liver or gills of various individuals for a pooled sample, or from individuals of very different sizes, etc. The contribution from this factor should be small because an effort was made during sample preparation to minimize these differences. Much of the variability may be simply that naturally found among similar individuals of the same species from any one place and time. The amount of variability in this data set would permit the detection of only large scale concentration changes (on the order of $\geq$ 100%).

Interspecific and intraspecific comparisons of trace metals within each major sample type will be discussed in separate sections below. These comparisons will be based on annual mean trace metal concentrations (Table X-12) as well as mean concentrations organized by season or month of sample collection and by bank station sampled (Tables X-12 to 19). These comparisons, however, are often based on only one or a few samples per season or bank station and cannot be considered statistically valid in most cases. Hospital Rock and Southern Bank were the only stations sampled more than once in 1976.

FISH MUSCLE TISSUE

There are no significant differences in annual mean trace metal concentrations among the three species analyzed (Table X-12). Tables X-13 and X-14 give the mean concentration data ordered by time or station sampled for the two predominant macronekton species analyzed (i.e., Lutjanus campechanus, red snapper; Rhomboplites aurorubens, vermilion snapper). No differences between any of the bank stations or time periods for either species are apparent. The trace metals levels in fish muscle appear to be generally quite low and uniform during the year among widely separated fishing banks on the Texas Outer Continental Shelf.

FISH LIVER AND GILL TISSUE

Table X-12 shows that Cu and Fe concentrations were higher in livers than in gill tissue, as would expected for this metabolically active tissue. Cadmium was significantly higher in liver tissue from both species than in gills.

Tables X-15, X-16, X-17 and X-18 give trace metals data for liver and gill tissue from both species organized according to season or month, or stations sampled. Trace metal levels in both tissues of Rhomboplites were generally not significantly different from levels in the same tissues from Lutjanus. At Hospital Rock, Rhomboplites gill and liver tissue had significantly greater Cd concentrations than did Lutjanus gills and livers. However, in almost all cases (31/36 comparisons), the metal levels in Rhomboplites gill and liver tissues at each station were higher than those in similar tissues from Lutjanus from the same station. Both

species were collected at the same time from the same station. One possible reason for this consistent difference is differential exposure of the two species to metals caused by differences in habits or diets. Within each species, the concentrations of all metals studied in each tissue were similar for both Hospital Rock and Southern Bank, as well as generally similar to the levels among the other four bank stations sampled.

No seasonal trends in trace metal concentrations in gill and liver tissue from either species were observed. The data were quite variable making small trends difficult to see.

SPONDYLUS AMERICANUS (SPINY OYSTER)

Spondylus samples were collected over a two to three week period during September-October 1976. Compared to sediment trace metals levels (Berryhill, 1977), Spondylus was enriched in Cd, Cu, Ni and Zn. The enrichment in Ni was especially noteworthy since Ni was generally very low in the other organisms analyzed. The concentrations of Al and Fe were generally low, showing that incorporation of aluminosilicate detritus was not a significant source of trace metals. The levels observed were similar to concentrations reported in other studies (Sims and Presley, 1976) although the reported trace metals concentrations in oysters were quite variable.

Table X-19 shows the mean trace metals concentrations in Spondylus samples from each of the five bank stations sampled. The concentrations of Cr, Ni and V were similar among the five stations. The levels of Cd, Cu, Fe, Pb and Zn were quite variable among these stations. Spondylus from East Flower Garden had the highest levels

of Cd, Cu, Pb and Zn. This mean Cd concentration was significantly greater than the levels at Southern Bank and Stetson Bank. The Cu concentration was significantly greater than those at all other stations. The Pb and Zn levels were probably not significantly different from any of the other stations. Oysters from Hospital Rock had the highest concentrations of Fe, which was significantly different from the lower levels at the East Flower Garden and 28 Fathom Banks. The variability in most trace metal levels among Spondylus from a single bank station was generally quite low.

CONCLUSIONS

1. No indication of substantial trace metal pollution was observed at any of the Topographic High stations sampled.

2. The major sample types analyzed in order of decreasing total trace metal content (except Al, Ca) were fish liver, Spondylus, fish gill and fish muscle (Table X-12).

3. Considerable variability in trace metal levels was observed within each major sample type. Sample types in order of decreasing variability were fish livers, fish muscle, fish gills and Spondylus. With this level of variability, small differences in trace metal levels (e.g., $\leq$ 50%) could not be detected statistically.

4. Muscle tissue from fish has generally low, uniform trace metal concentrations with few apparent geographical, seasonal or interspecific differences.

5. Gill and liver tissue from Rhomboplites aurorubens had generally higher concentrations of trace metals than similar tissues from L. campechanus. Cadmium levels were higher in livers than gills for both species. Cadmium levels were higher in samples from Hospital Rock than in those from Southern Bank.

6. Spondylus had generally higher levels of all trace metals analyzed. Levels of Cd, Cu, Pb and Zn were significantly higher in East Flower Garden samples than in those from the other four banks.

TABLE X-1

GC-MS ANALYSIS OF MAJOR COMPONENTS IN AROMATIC FRACTIONS OF SAMPLES FROM THE SOUTH TEXAS OCS STUDY (1976)

Sample Identification	Date	File Reference Number	Cartridge Reference Number	Compounds Identified
BLM-TPC-G	01/02/77	16070, 16087	14	Squalene
BLM-TPM-M	01/02/77	16058	14	Squalene
BLM-TPM-L	01/03/77	16076, 16094	15	Squalene
BLM-TPM-G	01/02/77	16071, 16089	14	Squalene
BLM-TPS-M[a]	01/02/77	16073, 16092	15	Squalene
BLM-TPS-L	01/03/77	16061, 16100	16	Squalene
BLM-TPS-G	01/02/77	16057, 16082	14	No Peaks
BLM-TQK-M	12/21/76	16052, 16066	13	Squalene
BLM-TQK-L	01/03/77	16078, 16097	15	Squalene
BLM-TQS-M	12/21/76	16054, 16068	13	Squalene
BLM-TQS-L	01/04/77	16060, 16099	13	Squalene

[a] A 1.83 m, 3% Apiezon Column was used for this analysis; all other analyses were performed using a 30 m capillary column coated with OV 101 (#1176F).

TABLE X-2

PROCEDURAL RECOVERY[1] OF ALIPHATICS AND AROMATICS

	PERCENT RECOVERY AVERAGE OF 14 DETERMINATIONS
C_{17}	75 ± 15
C_{18}	75 ± 10
C_{19}	93 ± 6
C_{20}	93 ± 3
C_{21}	97 ± 3
C_{22}	86 ± 5
C_{23}	96 ± 3
C_{24}	91 ± 5
C_{25}	89 ± 7
C_{26}	86 ± 9
1-methylnaphthalene	62 ± 19
2,6-dimethylnaphthalene	77 ± 14
1,5-dimethylnaphthalene	76 ± 16
4-phenyltoluene	88 ± 11
3,3'-dimethylbiphenyl	81 ± 10
4,4'-dimethylbiphenyl	88 ± 11
fluorene	93 ± 10
1-methylfluorene	76 ± 15
anthracene	66 ± 16

[1] Recovery of hydrocarbons (approximately 20 μg added) that were subjected to all steps in the analytical procedure in the absence of biota.

TABLE X-3

CONCENTRATION OF ALKANES[1] IN MACRONEKTON FROM SOUTH TEXAS TOPOGRAPHIC FEATURES STUDY (1976)

Station/ Transect	Code[a]	Species	Sample Wt. (g)	Conc. in ppm (μg/g dry wt.)
East Flower Garden	TPC→L-M	Red snapper *Lutjanus campechanus*	106.0	0.11
	TPC→L-L		34.6	15.41
	TPC→L-G		59.8	3.98
28 Fathom Bank	TPM→R-M	Red snapper *Lutjanus campechanus*	120.3	0.65
	TPM→R-L		52.5	14.06
	TPM→R-G		77.0	7.23
28 Fathom Bank, southwest peak	TPS→TPV-M	Red snapper *Lutjanus campechanus*	96.7	0.26
	TPS→TPV-L		31.4	5.22
	TPS→TPV-G		69.3	5.90
Stetson Bank	TQA→TQE-M	Red snapper *Lutjanus campechanus*	110.5	0.17
	TQA→TQE-L		15.8	0.36
	TQA→TQE-G		52.0	0.77
28 Fathom Bank	TQF→TQJ-M	Vermilion snapper *Rhomboplites aurorubens*	69.3	0.12
	TQF→TQJ-L		5.1	0.50
	TQF→TQJ-G		22.9	0.14
28 Fathom Bank, southwest peak	TQK→TQR-M	Vermilion snapper *Rhomboplites aurorubens*	95.3	0.60
	TQK→TQR-L		13.0	0.01
	TQK→TQR-G		24.2	0.00
Stetson Bank	TQS-M	Vermilion snapper *Rhomboplites aurorubens*	91.2	7.39
	TQS-L		1.5	44.85
	TQS-G		6.2	18.25
East Flower Garden	TQT-M	Graysby	29.2	0.06
	TQT-L		1.6	1.02
	TQT-G		3.5	0.69
Stetson Bank	TQU→TQW-M	Rock Hind *Epinephelus adscensionis*	97.2	0.09
	TQU→TQW-L		5.1	0.39
	TQU→TQW-G		14.9	1.98
28 Fathom Bank	TQX-M	Squirrel Fish *Holocentrus rufus*	9.6	0.80
	TQX-L		0.5	3.97
	TQX-G		1.6	0.60

[1] Total alkanes includes total paraffins, pristane, and phytane.

[a] TAMU

TABLE X-4

ORGANS AND INDIVIDUALS ANALYZED FROM THE SOUTH TEXAS TOPOGRAPHIC FEATURES STUDY (1976)

Station/ Transect	Code	Species	Organ Used[a]	# of Individuals
East Flower Garden	TPC→L-M	Red snapper *Lutjanus campechanus*	M	10
	TPC→L-L		L	10
	TPC→L-G		G	20
28 Fathom Bank	TPM→R-M	Red snapper *Lutjanus campechanus*	M	6
	TPM→R-L		L	6
	TPM→R-G		G	12
28 Fathom Bank, southwest peak	TPS→TPV-M	Red snapper *Lutjanus campechanus*	M	4
	TPS→TPV-L		L	4
	TPS→TPV-G		G	8
Stetson Bank	TQA→TQE-M	Red snapper *Lutjanus campechanus*	M	5
	TQA→TQE-L		L	5
	TQA→TQE-G		G	10
28 Fathom Bank	TQF→TQJ-M	Vermilion snapper *Rhomboplites aurorubens*	M	5
	TQF→TQJ-L		L	5
	TQF→TQJ-G		G	10
28 Fathom Bank, southwest peak	TQK→TQR-M	Vermilion snapper *Rhomboplites aurorubens*	M	8
	TQK→TQR-L		L	8
	TQK→TQR-G		G	16
Stetson Bank	TQS-M	Vermilion snapper *Rhomboplites aurorubens*	M	1
	TQS-L		L	1
	TQS-G		G	2
East Flower Garden	TQT-M	Graysby	M	1
	TQT-L		L	1
	TQT-G		G	2
Stetson Bank	TQU→TQW-M	Rock Hind *Epinephelus adscensionis*	M	3
	TQU→TQW-L		L	3
	TQU→TQW-G		G	6
28 Fathom Bank	TQX-M	Squirrel Fish *Holocentrus rufus*	M	1
	TQX-L		L	1
	TQX-G		G	2

[a] M = muscle only; L = liver; G = gill.

TABLE X-5

PERCENT DISTRIBUTION OF n-PARAFFINS IN MACRONEKTON FROM SOUTH TEXAS TOPOGRAPHIC FEATURES STUDY (1976)

STATION	East Flower Garden	East Flower Garden	East Flower Garden	28 Fathom Bank
SAMPLE CODE[a]	TPC→L-M	TPC→L-L	TPC→L-G	TPM→R-M
CARBON NO.				
14	-	-	-	-
15	79.1	55.9	80.5	64.0
16	4.4	7.2	3.0	2.2
17	12.1	13.5	15.3	33.8
18	-	7.8	1.1	-
19	-	4.1	0.1	-
20	-	3.6	-	-
21	3.3	4.7	-	-
22	-	2.3	-	-
23	1.1	0.9	-	-
24	-	-	-	-
25	-	-	-	-
26	-	-	-	-
27	-	-	-	-
28	-	-	-	-
29	-	-	-	-
30	-	-	-	-
31	-	-	-	-
32	-	-	-	-
n-paraffins (ppm)	0.09	12.45	3.15	0.51
Pristane (ppm)	0.02	2.42	0.79	0.14
Phytane (ppm)	-	0.54	0.04	-
Pr/Py	-	4.5	19.8	-
Pr/C_{17}	2.0	1.4	1.7	0.8
Py/C_{18}	-	0.6	1.3	-
CPI_{14-20}	20.7	4.4	23.4	44.5
CPI_{20-32}	-	1.7	-	-
Total alkanes	0.11	15.41	3.98	0.65

STATION	28 Fathom Bank	28 Fathom Bank	28 Fathom Bank southwest peak	28 Fathom Bank southwest peak
SAMPLE CODE	TPM→R-L	TPM→R-G	TPS→TPV-M	TPS→TPV-L
CARBON NO.				
14	-	-	-	2.5
15	49.6	67.1	48.5	73.1
16	4.4	4.7	5.5	3.0
17	25.0	18.3	44.8	20.2
18	7.9	7.5	1.2	0.7
19	3.4	2.4	-	0.3
20	3.3	-	-	0.2
21	4.4	-	-	-
22	2.0	-	-	-
23	-	-	-	-
24	-	-	-	-
25	-	-	-	-
26	-	-	-	-
27	-	-	-	-
28	-	-	-	-
29	-	-	-	-
30	-	-	-	-
31	-	-	-	-
32	-	-	-	-
n-paraffins (ppm)	10.10	5.31	0.16	4.01
Pristane (ppm)	3.54	1.69	0.10	1.18
Phytane (ppm)	0.42	0.23	-	0.03
Pr/Py	8.4	7.4	-	39.3
Pr/C_{17}	1.4	1.7	1.4	1.5
Py/C_{18}	0.5	0.6	-	1.0
CPI_{14-20}	5.7	7.2	13.9	19.6
CPI_{20-32}	1.5	-	-	-
Total alkanes	14.06	7.23	0.26	5.22

TABLE X-5 CONT'D

STATION	28 Fathom Bank southwest peak	Stetson Bank	Stetson Bank	Stetson Bank
SAMPLE CODE	TPS→TPV-G	TQA→TQE-M	TQA→TQE-L	TQA→TQE-G
CARBON NO.				
14	3.3	2.4	-	1.1
15	72.4	84.9	68.8	77.1
16	2.9	3.2	7.9	2.0
17	17.8	9.5	22.4	19.8
18	1.8	-	0.9	-
19	0.9	-	-	-
20	0.2	-	-	-
21	0.1	-	-	-
22	0.6	-	-	-
23	-	-	-	-
24	-	-	-	-
25	-	-	-	-
26	-	-	-	-
27	-	-	-	-
28	-	-	-	-
29	-	-	-	-
30	-	-	-	-
31	-	-	-	-
32	-	-	-	-
n-paraffins (ppm)	4.43	0.13	0.21	0.46
Pristane (ppm)	1.41	0.04	0.15	0.31
Phytane (ppm)	0.06	-	-	-
Pr/Py	23.5	-	-	-
Pr/C_{17}	1.8	4.0	3.0	3.4
Py/C_{18}	0.8	-	-	-
CPI_{14-20}	15.0	23.2	10.4	39.9
CPI_{20-32}	0.2	-	-	-
Total alkanes	5.90	0.17	0.36	0.77

STATION	28 Fathom Bank	28 Fathom Bank	28 Fathom Bank	28 Fathom Bank southwest peak
SAMPLE CODE	TQF→TQJ-M	TQF→TQJ-L	TQF→TQJ-G	TQK→TQR-M
CARBON NO.				
14	-	-	-	-
15	67.5	65.1	95.2	86.1
16	6.8	8.7	4.8	2.1
17	25.7	26.2	-	11.8
18	-	-	-	-
19	-	-	-	-
20	-	-	-	-
21	-	-	-	-
22	-	-	-	-
23	-	-	-	-
24	-	-	-	-
25	-	-	-	-
26	-	-	-	-
27	-	-	-	-
28	-	-	-	-
29	-	-	-	-
30	-	-	-	-
31	-	-	-	-
32	-	-	-	-
n-paraffins (ppm)	0.07	0.28	0.06	0.34
Pristane (ppm)	0.05	0.22	0.08	0.26
Phytane (ppm)	-	-	-	-
Pr/Py	-	-	-	-
Pr/C_{17}	2.5	3.1	-	6.5
Py/C_{18}	-	-	-	-
CPI_{14-20}	13.7	10.5	19.8	46.6
CPI_{20-32}	-	-	-	-
Total alkanes	0.12	0.50	0.14	0.60

TABLE X-5 CONT'D

STATION	28 Fathom Bank southwest peak	28 Fathom Bank southwest peak	Stetson	Stetson	Stetson
SAMPLE CODE	TQK→TQR-L	TQK→TQR-G	TQS-M	TQS-L	TQS-G
CARBON NO.					
14	-	-	5.0	3.9	2.1
15	-	-	90.0	86.8	85.7
16	-	-	3.5	2.7	2.8
17	-	-	0.7	6.2	8.5
18	-	-	0.8	0.4	0.6
19	-	-	-	-	0.2
20	-	-	-	-	-
21	-	-	-	-	-
22	-	-	-	-	0.1
23	-	-	-	-	-
24	-	-	-	-	-
25	-	-	-	-	-
26	-	-	-	-	-
27	-	-	-	-	-
28	-	-	-	-	-
29	-	-	-	-	-
30	-	-	-	-	-
31	-	-	-	-	-
32	-	-	-	-	-
n-paraffins (ppm)	-	-	6.06	30.52	12.36
Pristane (ppm)	0.01	-	1.26	13.98	5.89
Phytane (ppm)	-	-	0.07	0.35	-
Pr/Py	-	-	18.0	39.9	-
Pr/C_{17}	-	-	31.5	7.4	5.6
Py/C_{18}	-	-	1.4	2.9	-
CPI_{14-20}	-	-	15.4	21.6	22.5
CPI_{20-32}	-	-	-	-	-
Total alkanes	0.01	-	7.39	44.85	18.25

STATION	East Flower Garden	East Flower Garden	East Flower Garden	Stetson	Stetson
SAMPLE CODE	TQT-M	TQT-L	TQT-G	TQU→TQW-M	TQU→TQW-L
CARBON NO.					
14	-	29.2	21.6	-	1.3
15	14.6	24.1	53.5	37.5	30.1
16	25.0	18.5	10.4	12.5	36.4
17	41.7	18.8	10.0	50.0	23.5
18	18.7	9.4	4.5	-	2.7
19	-	-	-	-	6.0
20	-	-	-	-	-
21	-	-	-	-	-
22	-	-	-	-	-
23	-	-	-	-	-
24	-	-	-	-	-
25	-	-	-	-	-
26	-	-	-	-	-
27	-	-	-	-	-
28	-	-	-	-	-
29	-	-	-	-	-
30	-	-	-	-	-
31	-	-	-	-	-
32	-	-	-	-	-
n-paraffins (ppm)	0.05	0.97	0.69	0.02	0.30
Pristane (ppm)	0.01	0.05	-	0.07	0.09
Phytane (ppm)	-	-	-	-	-
Pr/Py	-	-	-	-	-
Pr/C_{17}	0.5	0.3	-	7.0	1.3
Py/C_{18}	-	-	-	-	-
CPI_{14-20}	1.3	1.1	3.0	7.0	1.5
CPI_{20-32}	-	-	-	-	-
Total alkanes	0.06	1.02	0.69	0.09	0.39

TABLE X-5 CONT'D

STATION	Stetson	28 Fathom Bank	28 Fathom Bank	28 Fathom Bank
SAMPLE CODE	TQU+TQW-G	TQX-M	TQX-L	TQX-G
CARBON NO.				
14	0.9	2.0	9.3	-
15	50.1	7.6	34.8	8.4
16	9.5	13.7	16.6	16.9
17	36.7	73.1	33.2	65.3
18	2.2	3.9	6.1	9.4
19	0.6	0.6	-	-
20	-	-	-	-
21	-	-	-	-
22	-	-	-	-
23	-	-	-	-
24	-	-	-	-
25	-	-	-	-
26	-	-	-	-
27	-	-	-	-
28	-	-	-	-
29	-	-	-	-
30	-	-	-	-
31	-	-	-	-
32	-	-	-	-
n-paraffins (ppm)	0.69	0.79	3.77	0.59
Pristane (ppm)	1.29	0.01	0.20	0.01
Phytane (ppm)	-	-	-	-
Pr/Py	-	-	-	-
Pr/C_{17}	5.2	0.02	0.2	0.03
Py/C_{18}	-	-	-	-
CPI_{14-20}	7.2	4.3	2.6	2.8
CPI_{20-32}	-	-	-	-
Total alkanes	1.98	0.80	3.97	0.60

[a] The code and order of samples correspond to X-3.

TABLE X-6

CONCENTRATION OF ALKANES[1] IN SPONDYLUS
FROM THE SOUTH TEXAS TOPOGRAPHIC FEATURE STUDY (1976)

Station/ Transect	Code	Species	Sample Wt. (g)	Conc. in ppm (μg/g dry wt.)
28 Fathom Bank	SPA	*Spondylus americanus*	65.0	0.001
28 Fathom Bank	SPB	*Spondylus americanus*	110.0	0.001
28 Fathom Bank	SPC	*Spondylus americanus*	19.8	0.13
Stetson Bank	SPD	*Spondylus americanus*	93.1	0.001
Stetson Bank	SPE	*Spondylus americanus*	118.3	-[a]
Stetson Bank	SPF	*Spondylus americanus*	7.4	0.04
East Flower Garden	SPG	*Spondylus americanus*	11.9	0.01
East Flower Garden	SPH	*Spondylus americanus*	39.6	0.002
East Flower Garden	SPI	*Spondylus americanus*	10.3	0.01
Hospital Rock	SPJ	*Spondylus americanus*	40.5	-
Hospital Rock	SPK	*Spondylus americanus*	29.2	-
Hospital Rock	SPL	*Spondylus americanus*	20.2	-
Southern Bank	SPM	*Spondylus americanus*	22.5	-
Southern Bank	SPN	*Spondylus americanus*	18.1	-
Southern Bank	SPO	*Spondylus americanus*	39.8	0.02

[1] Total Alkanes include total paraffins, pristane and phytane.

[a] - = below detection limit of 0.001 μg/g.

TABLE X-7

ORGANS AND INDIVIDUALS ANALYZED IN SPONDYLUS FROM THE SOUTH TEXAS TOPOGRAPHIC FEATURE STUDY (1976)

Station/ Transect	Code	Species	Organ Used[a]	# of Individuals
28 Fathom Bank	SPA	*Spondylus americanus*	W-s	1
28 Fathom Bank	SPB	*Spondylus americanus*	W-s	1
28 Fathom Bank	SPC	*Spondylus americanus*	W-s	1
Stetson Bank	SPD	*Spondylus americanus*	W-s	1
Stetson Bank	SPE	*Spondylus americanus*	W-s	1
Stetson Bank	SPF	*Spondylus americanus*	W-s	1
East Flower Garden	SPG	*Spondylus americanus*	W-s	1
East Flower Garden	SPH	*Spondylus americanus*	W-s	1
East Flower Garden	SPI	*Spondylus americanus*	W-s	1
Hospital Rock	SPJ	*Spondylus americanus*	W-s	1
Hospital Rock	SPK	*Spondylus americanus*	W-s	1
Hospital Rock	SPL	*Spondylus americanus*	W-s	1
Southern Bank	SPM	*Spondylus americanus*	W-s	1
Southern Bank	SPN	*Spondylus americanus*	W-s	1
Southern Bank	SPO	*Spondylus americanus*	W-s	1

[a] W-s = Whole less shell.

TABLE X-8

PERCENT DISTRIBUTION OF n-PARAFFINS IN SPONDYLUS FROM SOUTH TEXAS TOPOGRAPHIC FEATURES STUDY (1976)

STATION	28 Fathom Bank	28 Fathom Bank	28 Fathom Bank	Stetson Bank	Stetson Bank
SAMPLE CODE[a]	SPA	SPB	SPC	SPD	SPE
CARBON NO.					
14	-	-	-	-	-
15	100	100	67.9	100	-
16	-	-	-	-	-
17	-	-	32.1	-	-
18	-	-	-	-	-
19	-	-	-	-	-
20	-	-	-	-	-
21	-	-	-	-	-
22	-	-	-	-	-
23	-	-	-	-	-
24	-	-	-	-	-
25	-	-	-	-	-
26	-	-	-	-	-
27	-	-	-	-	-
28	-	-	-	-	-
29	-	-	-	-	-
30	-	-	-	-	-
31	-	-	-	-	-
32	-	-	-	-	-
n-paraffins (ppm)	0.001	0.001	0.13	0.001	-
Pristane (ppm)	-	-	-	-	-
Phytane (ppm)	-	-	-	-	-
Pr/Py	-	-	-	-	-
Pr/C_{17}	-	-	-	-	-
Py/C_{18}	-	-	-	-	-
CPI_{14-20}	-	-	-	-	-
CPI_{20-32}	-	-	-	-	-
Total alkanes	0.001	0.001	0.13	0.001	-

STATION	Stetson Bank	East Flower Garden	East Flower Garden	East Flower Garden
SAMPLE CODE	SPF	SPG	SPH	SPI
CARBON NO.				
14	-	-	-	-
15	51.4	100	100	100
16	-	-	-	-
17	48.6	-	-	-
18	-	-	-	-
19	-	-	-	-
20	-	-	-	-
21	-	-	-	-
22	-	-	-	-
23	-	-	-	-
24	-	-	-	-
25	-	-	-	-
26	-	-	-	-
27	-	-	-	-
28	-	-	-	-
29	-	-	-	-
30	-	-	-	-
31	-	-	-	-
32	-	-	-	-
n-paraffins (ppm)	0.04	0.01	0.002	0.01
Pristane (ppm)	-	-	-	-
Phytane (ppm)	-	-	-	-
Pr/Py	-	-	-	-
Pr/C_{17}	-	-	-	-
Py/C_{18}	-	-	-	-
CPI_{14-20}	-	-	-	-
CPI_{20-32}	-	-	-	-
Total alkanes	0.04	0.01	0.002	0.01

TABLE X-8 CONT'D

STATION	Hospital Rock	Hospital Rock	Hospital Rock	Southern Bank	Southern Bank	Southern Bank
SAMPLE CODE	SPJ	SPK	SPL	SPM	SPN	SPO
CARBON NO.						
14	-	-	-	-	-	-
15	-	-	-	-	-	100.0
16	-	-	-	-	-	-
17	-	-	-	-	-	-
18	-	-	-	-	-	-
19	-	-	-	-	-	-
20	-	-	-	-	-	-
21	-	-	-	-	-	-
22	-	-	-	-	-	-
23	-	-	-	-	-	-
24	-	-	-	-	-	-
25	-	-	-	-	-	-
26	-	-	-	-	-	-
27	-	-	-	-	-	-
28	-	-	-	-	-	-
29	-	-	-	-	-	-
30	-	-	-	-	-	-
31	-	-	-	-	-	-
32	-	-	-	-	-	-
n-paraffins (ppm)	-	-	-	-	-	0.02
Pristane (ppm)	-	-	-	-	-	-
Phytane (ppm)	-	-	-	-	-	-
Pr/Py	-	-	-	-	-	-
Pr/C_{17}	-	-	-	-	-	-
Py/C_{18}	-	-	-	-	-	-
CPI_{14-20}	-	-	-	-	-	-
CPI_{20-32}	-	-	-	-	-	-
Total alkanes	-	-	-	-	-	0.02

[a] The code and order of samples correspond to Table X-6.

TABLE X-9

SUMMARY OF OPERATING CONDITIONS FOR FLAMELESS ATOMIC ABSORPTION ANALYSIS

Element	Wavelength (nm)	Source[1]	Temperature (°C) Time (seconds)			Minimum Detectable Concentration[3] (ppb)	Sensitivity[2] (pg)	Average Procedural Blank (ng)
			dry	char	atomize			
Cd	228.8	EDL (5)	85°	300°	1800°	0.025	9	6
		HCL (8)	60 sec	60 sec	8 sec			
Cr	357.9	HCL (10)	85°	800°	2600°	1	25	<27
			60 sec	30 sec	8 sec			
Ni	232.0	HCL (20)	85°	1200°	2500°	4	100	<107
			60 sec	30 sec	8 sec			
Pb	283.3	EDL (9)	85°	500°	2000°	0.3	25	39
			60 sec	60 sec	8 sec			

[1] Electrodeless discharge lamp (EDL). Numbers in parentheses are source energy in watts. Hollow Cathode Lamp (HCL). Numbers in parentheses are source current in milliamps.

[2] Average amount of metal injected giving a signal of .0044 absorbance units.

[3] At 10x scale expansion and approximately 1 chart unit; except Ni at 3x and 2 chart units.

TABLE X-10

SUMMARY OF OPERATING CONDITIONS FOR FLAME ATOMIZATION ATOMIC ABSORPTION ANALYSIS

Element	Analytical Wavelength (nm)	Non-resonance Wavelength (nm)	Sensitivity[1] (ppm)	Average Procedural Blank (ng)
Cu	324.7	322.9	0.05	< 75
Fe	248.3	247.3	0.07	<100
Zn	213.9	220.2	0.02	< 75

[1] Average concentration giving a signal of .0044 absorbance units. Minimum detectable concentration was generally about one half of the sensitivity.

TABLE X-11

ACCURACY AND PRECISION OF ATOMIC ABSORPTION ANALYSIS

Standard Reference Material	Concentration (ppm dry weight ± 1 standard deviation)						
	Cd	Cr	Cu	Fe	Ni	Pb	Zn
Bovine liver (NBS No. 1577)							
This study (8)	0.31 ± .03	0.08 ± .01	198 ± 22	257 ± 68	0.09 ± .03	0.39 ± .09	130 ± 13
NBS values	0.27 ± .04	<0.2[2]	193 ± 10	270 ± 20	<0.2[2]	0.34 ± .08	130 ± 10
Precision[1]							
This study	10	13	11	26	33	23	10
NBS values	15	NA	5	7	NA	24	8
Orchard Leaves (NBS No. 1571)							
This study (8)	0.11 ± .02	2.2 ± 0.4	12 ± 1	220 ± 40	1.1 ± 0.1	43 ± 3	24 ± 6
NBS values	0.11 ± .02	2.6 ± 0.2	12 ± 1	300 ± 20	1.3 ± 0.2	45 ± 3	25 ± 3
Precision[1]							
This study	18	18	8	18	9	7	25
NBS values	18	8	8	7	15	7	12

[1] Precision expressed as percent coefficient of variation *i.e.* std. dev./mean x 100.

[2] Not certified values.

TABLE X-12

Annual mean concentration of trace metals in fish and oysters collected from selected topographical highs in the Texas Outer Continental Shelf

Sample Type	Species	Total No. of Samples	No. of Topo-highs Sampled	No. of Periods Sampled	Concentration (p.p.m. dry weight ± 1 standard deviation)									
					Cd	Cr	Cu	Fe	Ni	Pb	V	Zn	Al	Ca
Fish Muscle	Lutjanus campechanus	17	6	8	0.01±0.00	0.03±0.01	0.8±0.3	5.4±2.8	0.06±0.01	0.03±0.01	0.2±0.1	12±9.6	31±25	4300±7000
	Rhomboplites aurorubens	14	6	9	0.01±0.01	0.03±0.03	1.0±0.2	6.9±2.7	0.05±0.02	0.03±0.02	0.2±0.1	11±6.3	21± 7	6600±13000
	Holocentrus rufus	1	1	1	0.01	0.01	0.8	8.0	0.07	0.01	0.1	13	17	1000
Fish Liver	Lutjanus campechanus	16	6	8	1.9±0.80	0.05±0.02	20 ± 15	530±290	0.13±0.07	0.20±0.10	3 ± 8	120±37	110±150	53000±55000
	Rhomboplites aurorubens	12	6	8	14.4±9.3	0.10±0.06	31 ± 32	1290±750	0.36±0.28	0.62±0.45	3.5±2.5	560±430	39±20	75000±87000
	Holocentrus rufus	1	1	1	5.3	0.02	28	600	0.43	0.47	-	650		-
Fish Gills	Lutjanus campechanus	16	6	8	0.28±0.32	0.11±0.07	2.4±2.2	100±34	0.48±0.17	0.92±1.1	0.5±0.2	70±24	80±73	9700±25000
	Rhomboplites aurorubens	14	6	9	1.5±1.5	0.13±0.08	3.4±2.8	180±77	0.49±0.11	1.9±2.0	3.6±2.7	95±65	140±190	54000±38000
	Holocentrus rufus	1	1	1	0.29	0.05	3.2	92	0.47	0.45	-	84	-	-
Oyster Whole Orgamisms	Spondylus americanus	15	5	1	28 ± 18	2.6 ± 1.7	26 ± 35	140±92	41 ± 17	3.3 ± 2.9	9 ± 7	170±99	500±1500	3300±2100

TABLE X-13

Mean concentrations of selected trace metals in muscle tissue of *Lutjanus campechanus* according to time or station sampled during 1976

	No. of Samples	Concentration (p.p.m. dry weight ± 1 standard deviation)									
		Cd	Cr	Cu	Fe	Ni	Pb	V	Zn	Al	Ca
Season/Month Sampled											
Winter	3	0.01 ± 0.005	0.02 ± 0.01	0.7 ± 0.2	7.0 ± 2.6	0.07 ± 0.03	0.04 ± 0.01	0.2 ± 0.1	11 ± 0.0	30 ± 8	370 ± 410
March	2	0.02 ± 0.01	0.02 ± 0.01	0.6 ± 0.1	5.5 ± 0.7	0.06 ± 0.01	0.04 ± 0.00	0.1 ± 0.0	11 ± 1.4	19 ± 6	520 ± 130
April	2	0.01 ± 0.00	0.04 ± 0.01	0.6 ± 0.00	9.5 ± 6.4	0.5 ± 0.01	0.03 ± 0.01	0.1 ± 0.0	30 ± 25	24 ± 4	430 ± 110
July	2	0.01 ± 0.00	0.03 ± 0.01	0.4 ± 0.2	5.0 ± 1.4	0.04 ± 0.01	0.03 ± 0.01	0.1 ± 0.0	11 ± 0.0	20 ± 0	13000 ± 18000
August	1	0.01 ± -	0.01 ± -	0.8 ± -	4.0 ± -	0.07 ± -	0.03 ± -	0.5 ± -	10 ± -	26 ± -	860 ± -
Summer	2	0.01 ± 0.00	0.04 ± 0.01	1.2 ± 0.1	4.0 ± 0.0	0.06 ± 0.01	0.02 ± 0.01	0.2 ± 0.0	7.5 ± 2.1	72 ± 69	5200 ± 6700
October	4	0.01 ± 0.00	0.03 ± 0.01	1.0 ± 0.3	3.8 ± 1.0	0.06 ± 0.01	0.03 ± 0.02	0.3 ± 0.05	9.8 ± 2.1	27 ± 8	9300 ± 470
November	1	0.01 ± -	0.04 ± -	0.7 ± -	3.0 ± -	0.08 ± -	0.01 ± -	0.1 ± -	2.0 ± -	34 ± -	560 -
Bank Sampled											
HR	6	0.01 ± 0.00	0.02 ± 0.02	0.7 ± 0.3	5.0 ± 0.9	0.06 ± 0.02	0.03 ± 0.01	0.2 ± 0.2	10 ± 2.1	39 ± 40	2100 ± 3900
SB	6	0.01 ± 0.005	0.03 ± 0.005	0.7 ± 0.3	6.0 ± 4.0	0.06 ± 0.01	0.03 ± 0.02	0.1 ± 0.05	16 ± 16	24 ± 6	4700 ± 10000
EFG	1	0.01 ± -	0.02 ± -	0.9 ± -	3.0 ± -	0.08 ± -	0.05 ± -	0.3 ± -	10 ± -	27 ± -	8800 ± -
STB	1	0.01 ± -	0.05 ± -	0.6 ± -	5.0 ± -	0.05 ± -	0.03 ± -	- ± -	10 ± -	- ± -	- ± -
TFB	1	0.01 ± -	0.02 ± -	0.9 ± -	3.0 ± -	0.06 ± -	0.04 ± -	0.2 ± -	12 ± -	27 ± -	9500 ± -
UB	1	0.01 ± -	0.03 ± -	1.4 ± -	4.0 ± -	0.06 ± -	0.01 ± -	0.3 ± -	7.0 ± -	26 ± -	9700 ± -

TABLE X-14

Mean concentrations of selected trace metals in muscle tissue of *Rhomboplites aurorubens* according to time or station sampled during 1976

	No. of Samples	Concentration (p.p.m. dry weight ± 1 standard deviation)									
		Cd	Cr	Cu	Fe	Ni	Pb	V	Zn	Al	Ca
Season/Month Sampled											
Winter	1	0.03 ± -	0.02 ± -	1.0 ± -	7.0 ± -	0.06 ± -	0.06 ± -	- ± -	13 ± -	- ± -	- ± -
March	2	0.02 ± 0.00	0.08 ± 0.01	1.1 ± 0.4	8.5 ± 0.7	0.05 ± 0.01	0.02 ± 0.02	0.1 ± 0.0	12 ± 0.7	14 ± 4	460 ± 170
April	1	0.01 ± -	0.01 ± -	1.0 ± -	12 ± -	0.06 ± -	0.03 ± -	0.1 ± -	12 ± -	15 ± -	320 ± -
Spring	1	0.01 ± -	0.01 ± -	0.8 ± -	6.0 ± -	0.05 ± -	0.01 ± -	0.1 ± -	11 ± -	19 ± -	330 ± -
July	2	0.01 ± 0.00	0.01 ± 0.00	1.0 ± 0.1	7.0 ± 4.2	0.04 ± 0.01	0.04 ± 0.04	0.2 ± 0.0	11 ± 0.0	18 ± 1	26000 ± 34000
August	1	0.01 ± -	0.02 ± -	0.9 ± -	5.0 ± -	0.06 ± -	0.03 ± -	0.1 ± -	9.0 ± -	18 ± -	170 ± -
Summer	1	0.02 ± -	0.03 ± -	1.3 ± -	5.0 ± -	0.07 ± -	0.01 ± -	0.3 ± -	4.0 ± -	27 ± -	10000 ± -
October	4	0.01 ± 0.005	0.04 ± 0.02	1.0 ± 0.1	6.5 ± 3.1	0.04 ± 0.02	0.03 ± 0.005	0.1 ± 0.0	16 ± 9.5	27 ± 7	2900 ± 4100
November	1	0.01 ± -	0.02 ± -	0.8 -	4.0 ± -	0.07 ± -	0.01 ± -	0.4 ± -	1.0 ± -	27 ± -	11000 ± -
Bank Sampled											
HR	3	0.02 ± 0.005	0.04 ± 0.04	1.0 ± 0.2	7.7 ± 2.5	0.05 ± 0.02	0.03 ± 0.03	0.2 ± 0.1	9.0 ± 4.4	21 ± 6	4300 ± 5000
SB	7	0.01 ± 0.01	0.02 ± 0.02	1.0 ± 0.2	6.7 ± 2.9	0.06 ± 0.01	0.03 ± 0.02	0.2 ± 0.1	10 ± 4.2	18 ± 5	10000 ± 20000
EFG	1	0.01 ± -	0.06 ± -	0.9 ± -	6.0 ± -	0.03 ± -	0.03 ± -	0.1 ± -	10 ± -	22 ± -	840 ± -
STB	1	0.02 ± -	0.02 ± -	0.9 ± -	5.0 ± -	0.03 ± -	0.03 ± -	0.1 ± -	12 ± -	21 ± -	1500 ± -
TFB	1	0.01 ± -	0.03 ± -	1.1 ± -	11 ± -	0.04 ± -	0.04 ± -	0.1 ± -	30 ± -	28 ± -	110 ± -
UB	1	0.01 ± -	0.04 ± -	0.9 ± -	4.0 ± -	0.07 ± -	0.03 ± -	0.1 ± -	11 ± -	36 ± -	9000 ± -

TABLE X-15

Mean concentrations of selected trace metals in liver tissue of *Lutjanus campechanus* according to time or station sampled during 1976

	No. of Samples	Concentration (p.p.m. dry weight ± 1 standard deviation)									
		Cd	Cr	Cu	Fe	Ni	Pb	V	Zn	Al	Ca
Season/Month Sampled											
Winter	2	1.4 ± 0.42	0.04 ± 0.00	45 ± 35	455 ± 21	0.19 ± 0.01	0.34 ± 0.14	- ± -	120 ± 3.5	- ± -	- ± -
March	2	0.91 ± 0.27	0.06 ± 0.01	7.7 ± 4.7	390 ± 410	0.15 ± 0.14	0.15 ± 0.18	0.5 ± -	81 ± 22	20 ± -	55000 ±
April	2	1.8 ± 0.49	0.06 ± 0.00	13 ± 4.2	750 ± 420	0.13 ± 0.06	0.25 ± 0.04	- ± -	110 ± 18	- ± -	- ± -
Spring											
July	2	1.4 ± 0.00	0.04 ± 0.00	17 ± 0.7	420 ± 230	0.08 ± 0.01	0.19 ± 0.11	1.1 ± 0.8	130 ± 21	160 ± 180	1800 ± 210
August	1	0.92 ± -	0.04 ± -	7.7 ± -	280 ± -	0.08 ± -	0.08 ± -	0.2 ± -	76 ± -	21 ± -	420 ± -
Summer	2	2.1 ± 0.42	0.08 ± 0.02	13 ± 3.5	760 ± 370	0.19 ± 0.11	0.27 ± 0.04	0.8 ± 0.6	190 ± 59	98 ± 88	58000 ± 24000
October	4	2.8 ± 0.67	0.04 ± 0.01	27 ± 6	590 ± 320	0.1 ± 0.01	0.15 ± 0.05	7 ± 13	130 ± 7.9	150 ± 230	76000 ± 75000
November	1	2.2 ± -	0.04 ± -	17 ± -	350 ± -	0.15 ± -	0.21 ± -	0.3 ± -	140 ± -	26 ± -	98000 ± -
Bank Sampled											
HR	6	1.5 ± 0.63	0.05 ± 0.01	22 ± 23	680 ± 300	0.14 ± 0.08	0.24 ± 0.08	0.9 ± 0.7	130 ± 54	120 ± 130	25000 ± 28000
SB	6	1.6 ± 0.49	0.06 ± 0.02	13 ± 5.9	350 ± 150	0.14 ± 0.07	0.21 ± 0.14	0.4 ± 0.1	113 ± 30	32 ± 5	58000 ± 50000
EFG	1	0.35 ± -	0.04 ± -	35 ± -	1100 ± -	0.08 ± -	0.19 ± -	1.2 ± -	120 ± -	62 ± -	58000 ± -
STB	1	3.2 ± -	0.03 ± -	21 ± -	400 ± -	0.11 ± -	0.19 ± -	0.4 ± -	130 ± -	20 ± -	340 ± -
TFB	1	2.0 ± -	0.04 ± -	27 ± -	520 ± -	0.1 ± -	0.13 ± -	0.3 ± -	120 ± -	31 ± -	67000 ± -
UB	1	2.6 ± -	0.04 ± -	26 ± -	380 ± -	0.09 ± -	0.1 ± -	26 ± -	136 ± -	490 ± -	180000 ± -

TABLE X-16

Mean concentrations of selected trace metals in liver tissue of *Rhomboplites aurorubens* according to time or station sampled during 1976

	No. of Samples	Concentration (p.p.m. dry weight ± 1 standard deviation)									
		Cd	Cr	Cu	Fe	Ni	Pb	V	Zn	Al	Ca
Season/Month Sampled											
Winter	1	3.8 ± -	0.09 ± -	8.0 ± -	290 ± -	0.16 ± -	0.24± -	- ± -	99 ± -	- ± -	- ± -
March	2	11.0 ±5.7	0.14 ±0.04	15 ± 8.2	980 ± 610	0.59 ±0.54	0.38± 0.22	0.7± -	180 ± 41	17 ± -	770 ± -
April	1	2.1 ± -	0.03 ± -	10 ± -	1400 ± -	0.17 ± -	0.25± -	- ± -	170 ± -	- ± -	- ± -
Spring											
July	1	11. ± -	0.04 ± -	14 ± -	1140 ± -	0.22 ± -	0.43± -	4.9± -	460 ± -	46 ± -	780 ± -
August	1	16. ± -	0.08 ± -	16 ± -	1800 ± -	0.16 ± -	0.31± -	- ± -	180 ± -	- ± -	- ± -
Summer	1	18. ± -	0.20 ± -	18 ± -	3200 ± -	0.81 ± -	1.30± -	3.5± -	850 ± -	80 ± -	26000 ± -
October	4	21. ± 12.	0.09 ±0.09	39 ± 20	1100 ± 320	0.34 ±0.21	0.84± 0.58	4.3± 3.1	880 ± 420	30 ± 10	60000 ± 47000
November	1	15. ± -	0.08 ± -	116 ± -	1400 ± -	0.29 ± -	0.75± -	1.5± -	1000 ± -	44 ± -	99000 ± -
Bank Sampled											
HR	3	15. ± 3.5	0.13 ±0.08	14 ± 4.3	1900± 1100	0.67± 0.40	0.76± 0.47	4.2±1.0	490± 350	63 ± 24	130000± 180000
SB	5	8.8± 6.4	0.08 ±0.03	34 ± 46	1100± 640	0.20± 0.06	0.36± 0.22	1.1±0.5	340 ± 390	30 ± 19	50000± 69000
EFG	1	27. ± -	0.07 ± -	64 ± -	790± -	0.48± -	0.66± -	4.8± -	1300 ± -	27 ± -	720± -
STB	1	13. ± -	0.22 ± -	25 ± -	860± -	0.08± -	0.45± -	0.9± -	1000 ± -	20 ± -	46000± -
TFB	1	35. ± -	0.03 ± -	45 ± -	1500± -	0.53± -	1.70± -	8.2± -	770 ± -	30 ± -	89000± -
UB	1	9.8± -	0.05 ± -	21 ± -	1100± -	0.25± -	0.55± -	3.2± -	360 ± -	44 ± -	110000± -

TABLE X-17

Mean concentrations of selected trace metals in gill tissue of *Lutjanus campechanus* according to time or station sampled during 1976

	No. of Samples	Concentration (p.p.m. dry weight ± 1 standard deviation)									
		Cd	Cr	Cu	Fe	Ni	Pb	V	Zn	Al	Ca
Season/Month Sampled											
Winter	2	0.64±0.80	0.14±0.04	1.8± 0.6	74 ± 37	0.25± 0.10	0.34± 0.00	- ± -	62 ± 9.2	- ± -	- ± -
March	2	0.42±0.40	0.08±0.00	1.3± 0.6	99 ± 44	0.48± 0.18	0.27± 0.04	0.3± -	56 ± 16	38 ± -	70000± -
April	2	0.33±0.37	0.16±0.10	2.1± 1.3	110 ± 70	0.44± 0.13	0.30± 0.11	0.6± 0.1	62 ± 3.5	220 ± 49	130000±140000
Spring											
July	2	0.24±0.08	0.06±0.01	1.6± 0.5	100 ± 37	0.36± 0.06	0.68± 0.36	0.4± 0.1	66 ± 4.2	42 ± 1	74000± 27000
August	1	0.05± -	0.04± -	2.5± -	140 ± -	0.56± -	0.46± -	0.7± -	68 ± -	40 ± -	100000 ± -
Summer	2	0.26±0.23	0.12±0.09	1.3± 1.1	140 ± 21	0.76± 0.06	2.69± 2.59	- ± -	130 ± 18	- ± -	- ± -
October	4	0.16±0.18	0.13±0.09	4.4± 3.8	89 ± 16	0.51± 0.16	1.33± 0.58	0.4± 0.1	60 ± 4.2	53 ± 9	98000 ±16000
November	1	0.07± -	0.04± -	1.5± -	100 ± -	0.49± -	0.39± -	- ± -	61 ± -	- ± -	- ± -
Bank Sampled											
HR	6	0.16±0.14	0.10±0.06	1.8 ±0.8	100 ± 44	0.50 ±0.18	1.03 ± 1.70	0.5 ± 0.2	72 ± 23	93 ± 100	91000 ± 38000
SB	6	0.49±0.43	0.10±0.07	1.5 ±0.6	110 ± 32	0.44 ±0.20	0.54 ± 0.29	0.6± 0.2	74 ± 32	110 ± 98	110000 ±19000
EFG	1	0.07± -	0.09 ±-	2.6 ± -	72 ± -	0.72 ± -	1.30 ± -	0.4 ± -	56 ± -	57 ± -	100000 ± -
STB	1	0.08± -	0.12 ±-	1.5 ± -	110 ± -	0.33 ± -	1.20 ± -	0.5 ± -	65 ± -	62 ± -	120000 ± -
TFB	1	0.07± -	0.26 ±-	3.5 ± -	85 ± -	0.51 ± -	0.71 ± -	0.3 ± -	58 ± -	42 ± -	78000 ± -
UB	1	0.43 ± -	0.06 ±-	10 ± -	90 ± -	0.47 ± -	2.10 ± -	0.3 ± -	63 ± -	50 ± -	98000 ± -

TABLE X-18

Mean concentrations of selected trace metals in gill tissue of *Rhomboplites aurorubens* according to time or station sampled during 1976

	No. of Samples	Concentration (p.p.m. dry weight ± 1 standard deviation)									
		Cd	Cr	Cu	Fe	Ni	Pb	V	Zn	Al	Ca
Season/Month Sampled											
Winter	1	4.00 ± -	0.24 ± -	1.8 ± -	53 ± -	0.55 ± -	4.80 ± -	- ± -	89 ± -	- ± -	- ± -
March	2	2.76 ±3.17	0.13±0.04	2.2 ± 0.6	240 ± 53	0.44 ± 0.10	0.80 ± 0.14	0.7 ± -	76 ± 0.00	17 ± -	770 ± -
April	1	0.72 ± -	0.11 ± -	1.3 ± -	240 ± -	0.33 ± -	0.90 ± -	1.2 ± -	73 ± -	67 ± -	65000 ± -
Spring	1	2.70 ± -	0.16 ± -	3.7 ± -	150 ± -	0.30 ± -	0.80 ± -	4.3 ± -	75 ± -	170 ± -	110000 ± -
July	2	0.76±0.05	0.16±0.16	5.4 ± 2.2	160 ± 21	0.50 ± 0.06	1.25 ± 0.21	4.2 ± 2.5	74 ± 7.8	160 ± 92	55000 ± 60000
August	1	0.18 ± -	0.08 ± -	1.7 ± -	120 ± -	0.53 ± -	1.50 ± -	- ± -	79 ± -	- ± -	- ± -
Summer	1	0.62 ± -	0.26 ± -	2.5 ± -	360 ± -	0.75 ± -	7.70 ± -	- ± -	320 ± -	- ± -	- ± -
October	4	0.97±1.19	0.10±0.06	2.3 ± 0.8	160 ± 29	0.51 ± 0.04	1.60 ± 0.67	4.9 ± 3.4	84 ± 13	200 ± 300	49000 ± 31000
November	1	1.60 ± -	0.04 ± -	12 ± -	130 ± -	0.42 ± -	0.90 ± -	1.4 ± -	65 ± -	34 ± -	55000 ± -
Bank Sampled											
HR	3	0.62±0.10	0.21±0.10	2.7 ± 1.0	240 ± 110	0.60 ± 0.13	3.27 ± 3.86	5.9 ± -	160 ± 140	220 ± -	12700 ± -
SB	7	2.14±1.82	0.12±0.07	4.3 ± 3.9	160 ± 76	0.42 ± 0.10	1.56 ± 1.45	2.0 ± 1.4	75 ± 7.7	76 ± 60	66000 ± 43000
EFG	1	1.10± -	0.18± -	3.3 ± -	190 ± -	0.57 ± -	2.60 ± -	8.7 ± -	97 ± -	44 ± -	28000 ± -
STB	1	0.90± -	0.11± -	2.2 ± -	160 ± -	0.48 ± -	1.20 ± -	6.5 ± -	79 ± -	650 ± -	24000 ± -
TFB	1	0.08 ± -	0.04 ± -	2.4 ± -	120 ± -	0.52 ± -	1.40 ± -	3.3 ± -	68 ± -	57 ± -	92000 ± -
UB	1	2.60 ± -	0.05 ± -	1.4 ± -	150 ± -	0.48 ± -	1.20 ± -	1.1 ± -	90 ± -	34 ± -	52000 ± -

TABLE X-19

Mean trace metal concentrations in whole *Spondylus americanus* from 5 bank stations in September - October 1976

Bank Station	No. of Samples	Concentration (p.p.m. dry weight ± 1 standard deviation)									
		Cd	Cr	Cu	Fe	Ni	Pb	V	Zn	Al	Ca
HR	3	24 ± 8.5	3.5 ± 1.9	9.1 ± 5.1	240 ± 95	31 ± 3.8	1.2 ± 0.12	11 ± 4.9	110 ± 32	48 ± 3.5	2400 ± 400
SB	3	16 ± 5	3.5 ± 2.8	3.1 ± 1.0	150 ± 33	33 ± 2.6	1.1 ± 0.54	8.2 ± 0.8	85 ± 68	94 ± 82	1900 ± 750
EFG	3	50 ± 26	3.0 ± 1.5	87 ± 34	47 ± 11	47 ± 3.1	6.7 ± 4.0	6.3 ± 2.2	258 ± 84	78 ± 28	2900 ± 560
STB	3	17 ± 4.0	1.2 ± 0.3	19 ± 6.7	160 ±120	31 ± 9.8	2.3 ± 0.76	13 ± 16	207 ± 55	2000 ± 3300	5200 ± 3200
TFB	3	33 ± 17	1.9 ± 0.45	12 ± 2.3	77 ± 14	63 ± 25	5.1 ± 2.2	9.4 ± 2.6	181 ± 150	300 ± 230	4300 ± 3000

CHAPTER XI

A BRINE FLOW AT THE EAST FLOWER GARDEN BANK

A BRINE FLOW AT THE EAST FLOWER GARDEN BANK

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GENERAL DESCRIPTION, BIOTA AND CHEMISTRY

Using the D/RV DIAPHUS in September, 1976 the authors found and sampled a brine pool in a depression on the East Flower Garden Bank at a depth of 72 m (Figs. XI-1 to 3). Apparently seeping from a diapiric structure underlying the bank (salt domes are common off Texas and Louisiana, accounting for many of the topographical features found there), the 188 ppt brine flows over the margin of the pool (Figs. XI-2 and 4). down the axis of a canyon cut into the bank's hard carbonate substratum, and out onto surrounding level, sandy bottom at 80 m depth. By the time the brine reaches the level bottom, it has become diluted to 39.6 ppt due to turbulent flow and mixing in the axis of the canyon (Table XI-1, Fig. XI-5). There is evidence that the substained flow of dense water (observed also by the author in 1974) through the 7 to 15 m deep canyon contributes locally to sediment transport and erosional porcesses, resulting in movement of sand-to-cobble-sized particles off the hard-bank (Fig. XI-6). Disintegration and dissolution of the old reef, which seemingly at this depth is a coralline algal bioherm, also may be facilitated by the downhill flow (Fig. XI-2).

Within the brine pool there is apparently little, if any, mixing between the brine and overlying marine water. The interface between the two is sharp and totally invisible except for flat, white, spittle-like masses floating on the brine (Figs. XI-7 and 8). At times, objects floating in the marine water were seen to be moving in a direction opposite from those floating in

TABLE XI - 1

CHEMICAL ANALYSES OF EAST FLOWER GARDEN BRINE

Parameter	Station* A	B	C
Salinity†	39.6 g/kg	48.4 g/kg	188 g/kg
Salinosity†	39.7 g/L	48.5 g/L	211 g/L
Potassium	0.421 g/kg	0.426 g/kg	0.375 g/kg
Calcium	0.466 g/kg	0.513 g/kg	1.309 g/kg
Sodium	13.3 g/kg	12.7 g/kg	61.1 g/kg
Magnesium	1.421 g/kg	1.387 g/kg	1.133 g/kg
Chloride	22.2 g/kg	28.2 g/kg	122.8 g/kg
	2.82 g/kg	2.81 g/kg	4.70 g/kg
Sulfate	29.4 mmoles/L	29.4 mmoles/L	54.9 mmoles?
ΣCO_2	20.6 mgC/L	22.3 mgC/L	33.5 mgC/L
Methane	42 µl/L	140 µl/L	2.0 ml/L
Ethane	2.8 µl/L	9.5 µl/L	0.24 ml/L
Propane	<10 nl/L	<10 nl/L	1.21 µl/L
$C_1/(C_2+C_3)$	15	15	8.3
$\delta^{13}C[CH_4]$	-	-	-42.5°/oo
$\delta D_{smow}[H_2O]$	+4.6±2°/oo	+2.9±2°/oo	+3.2±2°/oo
Phosphate	1.89 µM	3.13 µM	7.5 µM
Nitrate	8.1 µM	7.9 µM	3.6 µM
Silicate	3.8 µM	5.3 µM	16.3 µM
Dissolved Organic Carbon	1.62 mgC/L	1.37 mgC/L	4.56 mgC/L
Salinity (sum of ionic species)	40.6 g/kg	46.0 g/kg	191.4 g/kg

* Station A is at the base of the canyon, Station B is in the overflow canyon and Station C is in the brine lake.

†Refractometer

Figure XI-1.

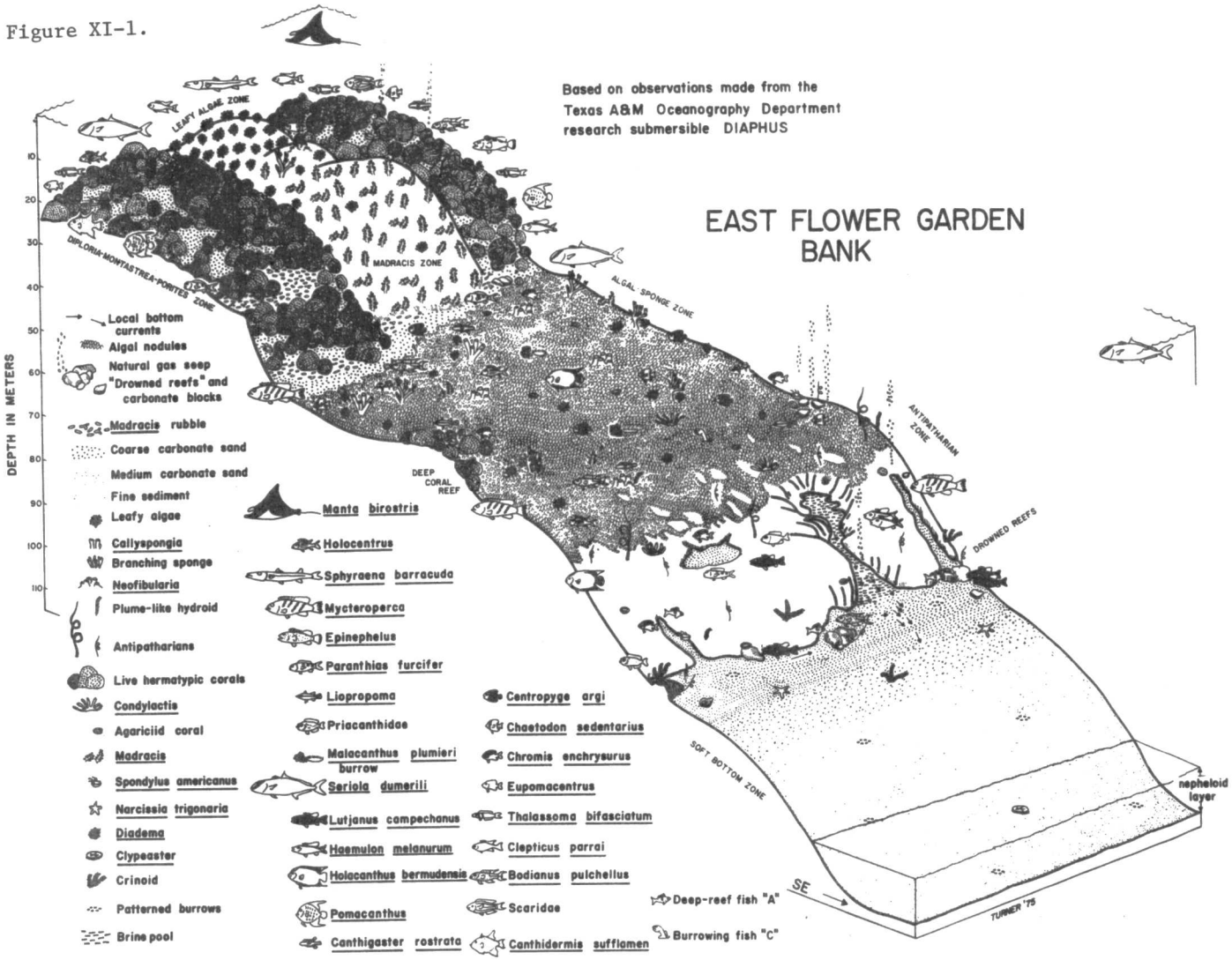
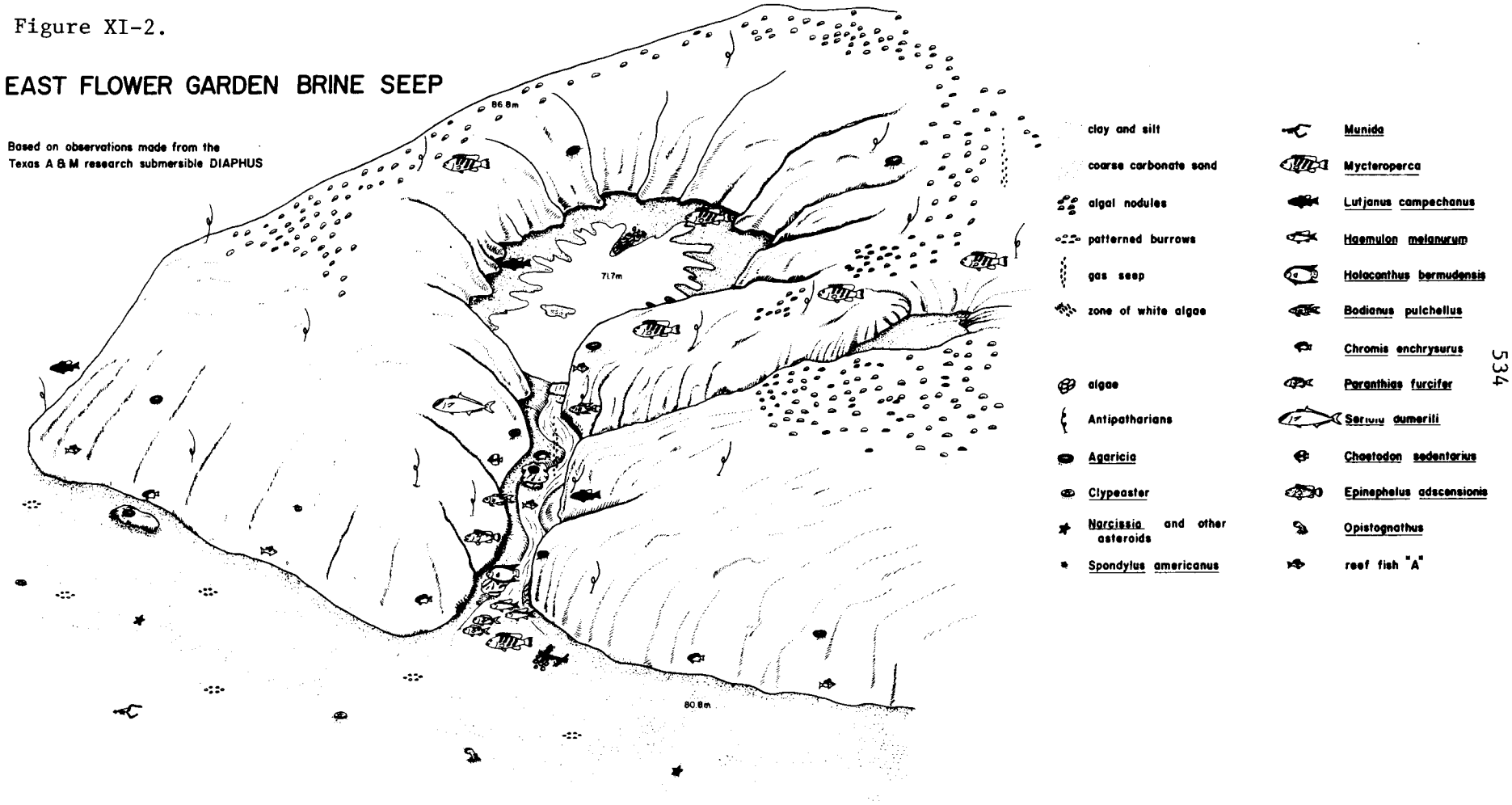

Based on observations made from the Texas A&M Oceanography Department research submersible DIAPHUS
EAST FLOWER GARDEN BANK
DEPTH IN METERS
10
20
30
40
50
60
70
80
90
100
110
LEAFY ALGAE ZONE
DIPLORIA-MONTASTREA-PORITES ZONE
MADRACIS ZONE
ALGAL SPONGE ZONE
ANTIPATHARIAN ZONE
DEEP CORAL REEF
DROWNED REEFS
SOFT BOTTOM ZONE
nepheloid layer
SE
TURNER '75
Local bottom currents
Algal nodules
Natural gas seep
"Drowned reefs" and carbonate blocks
Madracis rubble
Coarse carbonate sand
Medium carbonate sand
Fine sediment
Leafy algae
Callyspongia
Branching sponge
Neofibularia
Plume-like hydroid
Antipatharians
Live hermatypic corals
Condylactis
Agariciid coral
Madracis
Spondylus americanus
Narcissia trigonaria
Diadema
Clypeaster
Crinoid
Patterned burrows
Brine pool
Manta birostris
Holocentrus
Sphyraena barracuda
Mycteroperca
Epinephelus
Paranthias furcifer
Liopropoma
Priacanthidae
Malacanthus plumieri burrow
Seriola dumerili
Lutjanus campechanus
Haemulon melanurum
Holacanthus bermudensis
Pomacanthus
Canthigaster rostrata
Centropyge argi
Chaetodon sedentarius
Chromis enchrysurus
Eupomacentrus
Thalassoma bifasciatum
Clepticus parrai
Bodianus pulchellus
Scaridae
Canthidermis sufflamen
Deep-reef fish "A"
Burrowing fish "C"

Figure XI-2.


EAST FLOWER GARDEN BRINE SEEP
Based on observations made from the
Texas A & M research submersible DIAPHUS
86.8m
71.7m
80.8m
clay and silt
coarse carbonate sand
algal nodules
patterned burrows
gas seep
zone of white algae
algae
Antipatharians
Agaricia
Clypeaster
Narcissia and other asteroids
Spondylus americanus
Munida
Mycteroperca
Lutjanus campechanus
Haemulon melanurum
Holacanthus bermudensis
Bodianus pulchellus
Chromis enchrysurus
Paranthias furcifer
Seriola dumerili
Chaetodon sedentarius
Epinephelus adscensionis
Opistognathus
reef fish "A"

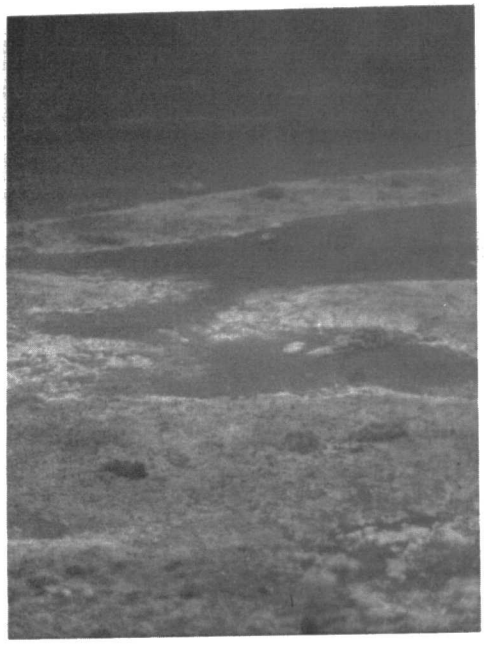


Figure XI-3. Substratum of brine pool, dark coloration; "shoreline," white; and carbonate sand in regular marine water. Brine is crystal clear and colorless.

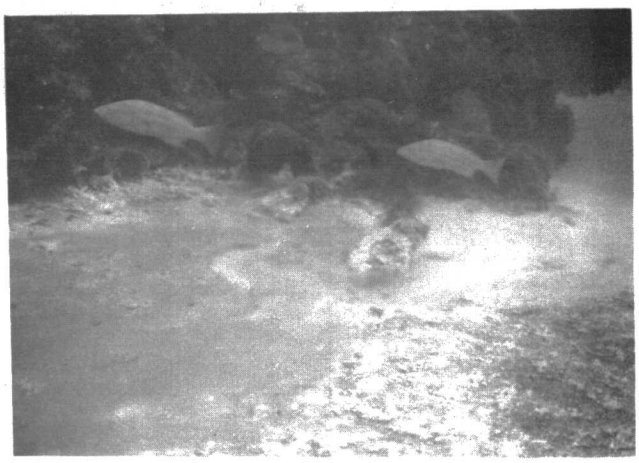


Figure XI-4. Overflow of heavy brine from "pool", left, into "stream" which flows down the axis of "canyon". Two Mycteroperca swim in regular marine water above brine.

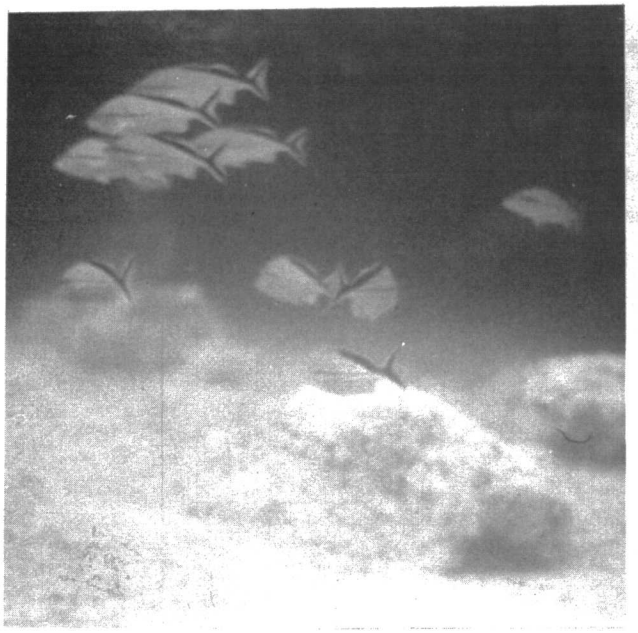


Figure XI-5. School of Cottonwick swimming in and out of mixed brine and sea water, 39.6 ppt., at the mouth of the canyon.

Figure XI-6. Chaetomorpha growing attached to buried anchor and cobble-sized sediment which apparently has been transported down the canyon and collected around the anchor at the mouth of the canyon.

Figure XI-7. "Donut" shaped deposit and growth on rock within brine pool. Spittle-like masses floating at invisible interface between brine and marine water. Top of deposit, white, marks the interface. Dark band below white may be sulfur-bacteria. Gray band below dark may be mineral deposit (possibly gypsum).

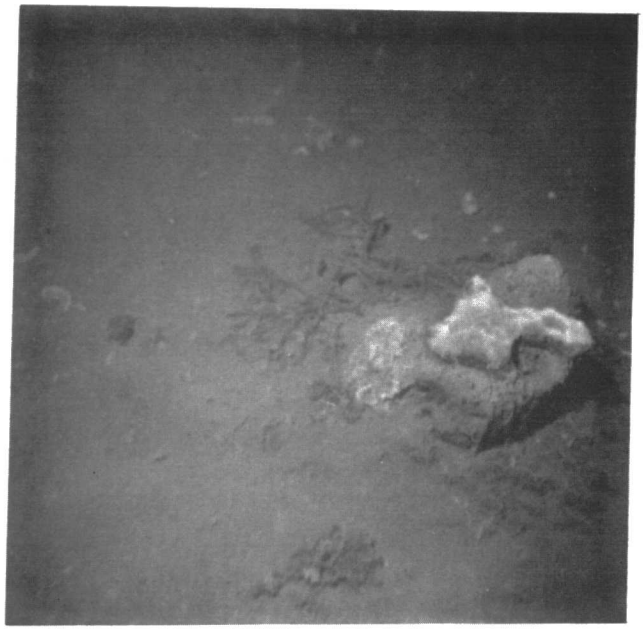


Figure XI-8. Living or "pickled" alga, center, next to rock in brine pool. White growth on rock and spittle-like masses mark interface.

Figure XI-9. "Shoreline" of brine pool and the brine-marine water interface are marked by the whitest band. Thin band of unoccupied carbonate sand directly above brine (possibly a zone of "tidal" fluctuation where neither deposits nor organisms are favored). Above bare sand, in marine water, is a population of the alga Microdictyon, top center. Progressing downward in the pool the color bands are white, dark olive, light olive with patches of purple, all suggesting a sulfur bacterial system (sulfuretum).

the brine, indicating differential water movement in a vertical space of millimeters. The submersible's movement set up "standing" or "internal" waves at the interface, which could be seen by following the oscillatory movement of the floating masses.

Dr. Rezak and Mr. Bob Tomkins performed powder X-Ray diffraction analyses on two rock samples taken from beneath the interface in the brine pool (Fig. XI-8). The resulting bulk mineralogical determinations indicated the presence in both rocks of high magnesium calcite, aragonite and small amounts of gypsum. One of the rocks contained low magnesium calcite. According to Dr. Rezak, the presence of gypsum on the substratum within the brine pool is indicative of contact between the brine and the gypsum caprock commonly associated with salt domes in the northwestern Gulf of Mexico.

Filamentous and leafy algae are associated with the East Flower Garden Brine. One large species of reddish-brown alga was collected from the brine pool, which is one-third meter or so deep at its center (Fig. XI-8). It is not known whether this alga was alive or "pickled" in the brine. A substantial population of Microdictyon and other low-growing algae occurs on the sandy bottom directly adjacent to the brine pool (Fig. XI-9). Chaetomorpha, a filamentous green alga which turns white under adverse conditions, occurs in the lower reaches of the canyon (Fig. XI-6). A significant bacterial population on the bottom of the brine pool is indicated by vertical color variation on the sediment or rocks near the brine interface (Figs. XI-7 to 9). The thin white layer at the interface suggests elemental sulfur.

The broader olive band and purple patches below the white resemble bacterial populations. These bands, and the fact that a significant amount of hydrogen sulfide is present in the water, imply that a sulfur bacterial system (sulfuretum) may exist in the brine pool.

It spite of its rather potent nature, the East Flower Garden Brine does not appear to have affected epibenthic populations outside of a ring extending a meter or so above the interface between the brine and overlying average marine water. Fishes were not observed to enter the highly saline brine in the pool, but groupers, Mycteroperca spp., and Cottonwick, Haemulon melanurum, swam freely in and out of the mixing brine stream within the canyon (Fig. XI-5). Large Red snappers, Lutjanus campechanus, swam very close to the brine interface.

The East Flower Garden Brine is chemically comparable to that described from the Orca Basin off Louisiana. This basin is located at 26° 55' N, 91° 20' W, has a 2400 m bottom depth, and contains an anoxic brine lake 200 m deep and 1,000 sq km in extent (Shokes et al., 1977). The Orca Brine (Table XI-2) is very similar to brines found in the Red Sea, except that the Red Sea Brines are hot. The East Flower Garden and Orca Brines are only slightly higher in temperature, 0.5°C or so, than surrounding sea water. Chemically, the East Flower Garden Brine differs from the others in that it is less salty, has much less dissolved silicate and contains dissolved petrogenic natural gas and hydrogen sulfide.

There may be other brine seeps at the East Flower Garden and

TABLE XI - 2

CHEMICAL COMPOSITION OF REPRESENTATIVE NATURAL GASES AND BRINE

biogenic, from seep on coral reef: * from 1900 meters depth at Orca Basin site: ** % of hydrocarbon gas present: ## Petrogenic, from gas which effervesced out of brine sample.

	West Flower Garden Natural Gas#	East Flower Garden Brine	Orca Brine +	Red Sea Brine +	Average Sea Water +
Salinity, g/Kg		188.0	258.1	256.4	35.4
Potassium g/Kg		0.375	0.63	2.16	0.40
Calcium g/Kg		1.309	1.09	4.71	0.41
Sodium, g/Kg		61.1	91.5	92.9	10.8
Magnesium, g/Kg		1.133	1.05	0.81	1.29
Chloride, g/Kg		122.8	149.5	155.3	19.4
Sulfate, g/Kg		4.70	3.66	0.75	2.72
Phosphate, μ Moles		>7.5	81.5		2.5*
Nitrate, μ Moles		3.6	0	0.8	23.0*
Silicate, μ Moles		16.3	235.0	235.0	25.0*
Methane, %**	99.95	89.24##			
Ethane, %**	.05	10.71##			
Propane, %**	nil	.05##			

+ from Shokes et. al., 1977

elsewhere around salt-dome induced structures off Texas and Louisiana, but unless they are very large, they probably will not be found except through the use of research submersibles. The East Flower Garden Brine and the Orca Brine are undoubtedly manifestations of a hitherto unrecognized and unique biogeochemical phenomenon of major proportion in the northwestern Gulf of Mexico.

HYDRODYNAMIC PROBLEMS

(Takashi Ichiye)

Hot brine pools were discovered at places in the Red Sea in the sixties (Degans and Ross, 1969). These are much larger in horizontal dimensions and thickness, and were located at much deeper depths than the Flower Garden pool. However, the hydrodynamic features of those pools are less known because all the measurements have been made indirectly, that is, with water sampling techniques and with echo-sounders. On the other hand, the observation of the pool in the Gulf was carried out directly from the submersible and thus, more details are known about its physical features. Further, in the future it will be possible to deploy more appropriate instruments and sensors from the submersible and mother ship. Then we shall be able to monitor motion of different time and space scales in or near the pool, and determine the distributions of water properties and their fluctuations in time. Therefore, in the future we can expect to obtain data which are useful to understand the dynamics of a stratified fluid in geophysical contexts, as well as to study effects and

causes of the brine pool itself.

The highlights of the hydrodynamics of the brine pool so far observed are an effluent from the pool and seiches of the pool caused by the submersible. The salinity of the brine in the pool was 191 ppt at temperature 20.5^{o}C (Sta. C in Fig. XI-10). The brine overflowed along a canyon which started from an end of the pool. It terminated at the base of the canyon, which was at a depth of 81 m and about 50 m of horizontal distance from the end of the pool (Fig. XI-10). The salinity of the brine was already reduced to 46 ppt at the head of the canyon (Sta. B in Fig. XI-10) and further to 41 ppt at its base (Sta. A in Fig. XI-10). Then it seemed to completely disappear at a short distance from there.

The video tape taken by Bright from the submersible indicated the oscillating motion of the brine interface, apparently caused by the movement of the submersible. Although the interface oscillation was not recorded with any instrument, its period can be estimated as 1.5 minutes from the video tape.

Stability of a stratified fluid and mixing of fluids with different diffusivities in temperature and salinity will be discussed below. Further internal seiches are treated particularly by use of the classical model, and also, the bottom and coastal friction is determined by considering the boundary layer for the oscillatory motion.

MIXING OF STRATIFIED FLOWS

As Ellison and Turner (1959) pointed out, flows in different

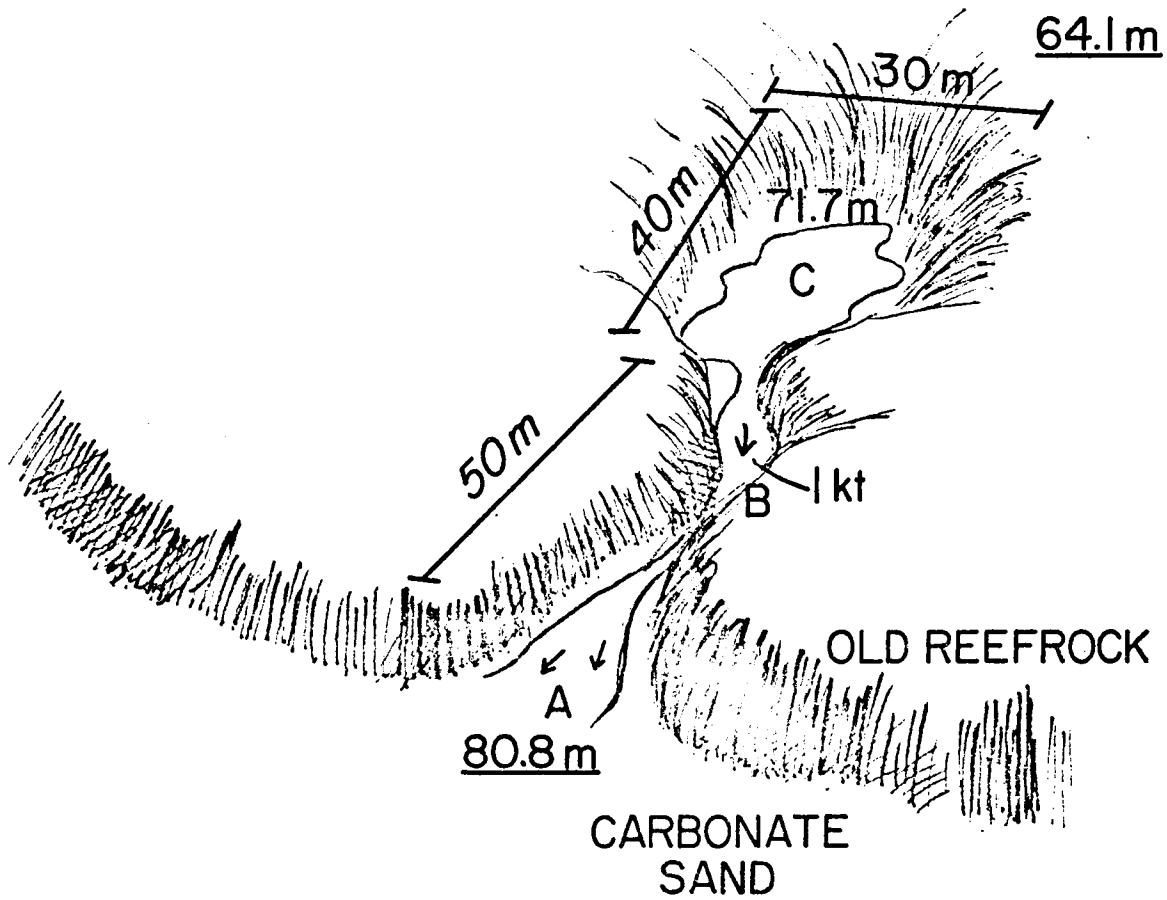


Figure XI-10. Estimated dimensions, depths, direction of flow and station locations (A, B and C) for the brine seep at the East Flower Garden. Constructed with the aid of side-scan sonar records provided and interpreted by Dr. Rezak.

geophysical contexts (for example, katabatic winds flowing downhill, cold bottom water from the Arctic Ocean over a submarine ridge, the fresh upper water in the estuary, turbidity currents at the ocean bottom slope and methane gas under the sloping roof of a mine) have more or less common fundamental hydrodynamical properties; these are that a thin layer of different density is moving over or under the ambient fluid and that the layer flow is mainly caused by gravity.

There are two distinct regimes of motion in the thin layer. One is laminar flow, including the case of slow fluctuating vertical motions or internal waves. The other is turbulent flow. For the latter regime, Ellison and Turner (1959, 1960) carried out a series of experimental and theoretical work with an heuristic approach, based on the entrainment function $E(R_i)$, where R_i is the overall Richardson number of the layer depending on the density difference across the interface of the layer and the characteristic layer velocity.

For the laminar flow, excluding internal waves which are discussed later, the complexity arises for salt water, because of differences of molecular diffusivity for salt and heat. The problem of double diffusivity in relation to oceanic microstructures of temperature and salinity distributions has been studied since 1960, both theoretically and experimentally (in water tanks and in seas) by several authors, and is summarized in the monograph of Turner (1973).

Stability and perturbation problems of the stratified flow

were extensively discussed in a monograph by Yih (1965). This monograph also includes a gravity current in which a wedge of heavy fluid intrudes into an expanse of light fluid. Benjamin (1965) discussed this problem in extending the classical theory of hydraulic jumps.

The salinity decreased rapidly from 191 ppt at one end of the pool (Sta. C) to 46 ppt at the outflow of the pool (Sta. B). This decrease may be attributed to the entrainment mechanism of Ellison and Turner (1959). The main body of the pool has an almost flat bottom and no measurable velocity. Actually, the video tape indicates that the entrainment was most intense near the narrow outlet, where the depth was merely about 7 cm and the current was estimated about 50 cm/sec (1 kt) from movement of particles at the interface of the brine. The sigma-t value for the water of salinity 191 ppt and 20.5^{o}C is calculated from extrapolation of Knudsen's table to be 155.6. Neev and Emery (1967) determined the density of the high saline Dead Sea water by use of a pycnometer, and obtained the density-salinity relationship for the range of salinity higher than about 200 ppt. A sigma-t value of 150.5 for the same water (191 ppt and 20.5^{o}C) was extrapolated from their table and figure. Both are extrapolated values and thus the mean of them, 153, is taken as the representative sigma-t of the brine pool. The sigma-t of the outlet and the end of the effluent are 33.06 and 28.92, respectively, for salinity 46.0 ppt and 40.6 ppt at 20.5^{o}C from Knudsen's table.

The <u>overall</u> Richardson number R_i was introduced by Ellison and Turner (1959) for determining the entrainment function E of a plume of different density flowing over a sloped floor. It is defined by

$$R_i = g(\rho-\rho_a)\rho_a^{-1} h \cos\theta V^{-2} \tag{1}$$

where ρ and ρ_a are density of the plume and the ambient fluid, respectively, h and V are the characteristic depth and velocity of the plume, respectively, and θ is the slope of the floor. This number is not the same as the local Richardson number which generally can be used as a criterion for stability of a stratified shear flow. With the sigma-t of the ambient water of about 26, equation (1) leads to R_i=0.34 for h=7 cm, V=50 cm/sec for the main pool salinity. The entrainment constant E is about 0.015 from the experiment of Ellison and Turner (1959) and θ=0. In fact, the slope was not zero. However, even if the slope is taken as 7°, the mean slope of the canyon, the value of R_i does not change except in the third decimal. If the sigma-t of the canyon outlet 33.06 is used for ρ, then R_i=0.027. The corresponding E ranges from about 0.06 to 0.096 from Ellison and Turner's (1959) experiment.

However, in a later paper Ellison and Turner (1960) cautioned that their experimental results may not be applicable quantatively to other fluid motion of different geophysical contexts. On the other hand, their experiments (Ellison and Turner, 1960) indicated very rapid mixing near the source of an inclined plume, though the

velocity was smaller and the density difference was larger than downstream, leading to the higher overall Richardson number near the source. There was no explanation in their paper on processes or causes of such apparent deviation from their theoretical reasoning.

The flow in the canyon can be treated as a gravity flow on a sloping bottom. Following Ellison and Turner (1959), the equation for continuity of mass deficiency can be written as

$$\int_0^\infty u g \rho_a^{-1} (\rho - \rho_a) dy = Vh\Delta = A(\text{const.}) \tag{2}$$

where y is in the vertical direction and u is the velocity in the downward direction of the slope. The characteristic values of velocity, depth and mass deficiency are expressed with V, h and Δ, respectively. Ellison and Turner (1959) did not include the integral part of the continuity equation. Since vertical distributions of u and ρ are to be determined as solutions of the conservation of mass and momentum, V, h and Δ are unknown. Only the total deficiency A can be determined from the observed vertical distributions (at one point) of u and ρ.

In order to determine three unknowns u, h and Δ, two more equations are necessary. Ellison and Turner (1959) introduced the equations for entrainment and for conservation of momentum

$$V^{-1} d(Vh)/dx = E \tag{3}$$

and

$$d(V^2h)/dx = -CV^2 - \tfrac{1}{2}d(S_1\Delta h^2 \cos\theta)/dx + S_2\Delta h \sin\theta \tag{4}$$

where S_1 and S_2 are defined from

$$S_1 h^2\Delta = \int_0^\infty 2g\rho_a^{-1}(\rho_a - \rho)y\,dy \tag{5}$$

$$S_2 h\Delta = \int_0^\infty g\rho_a^{-1}(\rho_a - \rho)\,dy \tag{6}$$

On the right hand side of the momentum equation (4), the first term is the frictional drag of the bottom, the second term expressed the pressure force due to the difference of the integrated hydrostatic pressure at x and $x + dx$, and the last term represents the gravity acceleration due to the slope.

Equation (3) does not specify conservation of any quantity, but rather defines the entrainment function E, which should be determined experimentally. Ellison and Turner (1959) postulated that E is function of R_i only as defined by

$$R_i = \Delta h \cos\theta\, V^{-2} = A \cos\theta\, V^{-3} \tag{7}$$

Then in equation (4), Δ can also be eliminated by use of (2), when S_1 and S_2 are assumed constant (similarity assumption) and can be determined from observed vertical distributions of density. Then equations (3), with known E, and (4) become a closed system to two unknown functions, h and V.

It is possible that change in the flux of the mass deficit $dV\Delta/dx$ is related to the mixing process, and that the entrainment (or mixing) coefficient is introducted as $-E_dV$, though the experimental procedure is less straightforward for

determining E_d than for E. Another alternative is to use the transfer equation of salt as done by Ellison and Turner (1960), though this again requires another parameter, eddy diffusivity of salt, which should be determined experimentally. Solution of V and h from (3) and (4), or from other alternatives, needs vertical distributions of u and ρ, at least one section, and the roughness parameter of the bottom. When these data become available, more details on mixing, entrainment and flow characteristics of the pool and the canyon can be determined.

INSTABILITY IN THERMOHALINE CONVECTION

In the Red Sea brines, temperature reached 56.6°C from about 20°C above the brine, the salinity of which was 321 ppt, for instance, at Atlantis II station, where the depth was 2100 m and the thickness of the brine with salinity above 151 ppt was more than 80 m (Brewer et al., 1969). In such conditions, it is certain that double diffusivity processes were very intense, as discussed by Turner (1969). However, in the case of the brine pool of the Gulf, temperature difference between the ambient water and the brine was estimated in the order of 0.5°K in the pool and 1.5°K in the canyon.

Stability of a fluid with double diffusivities was analyzed by Baines and Gill (1969) for infinitesimal disturbances in a fluid with linear vertical gradients of temperature and salinity. In describing the convection regimes with a dimensionless formulation, four parameters are required, the thermal and salinity Rayleigh numbers, R and R_s, the Prandtl number $\sigma = \nu/K_T$ and

$\tau = K_s/K_T$, where ν, K_T and K_s are the kinematic viscosity and diffusivities of heat and salt, respectively. Since σ and τ are almost constant for the water, the result of stability analysis can be represented in the domains of the plane $R - R_s$, where these parameters are defined as

$$R = g\alpha\Delta T d^3/\nu K_T, \quad R_s = g\beta\Delta S d^3/\nu K_T \tag{8}$$

In equation (8), α and β are coefficients of expansion for temperature increase and salinity decrease, respectively, d is the thickness of the fluid, and ΔT and ΔS are differences in temperature and salinity between the bottom and the top, respectively. It should be noted that R_s does not contain K_T, because this parameter is implicitely represented by τ which equals 0.01 for the water. Also the Prandtl number σ is about 10.

Baines and Gill (1969) obtained the stability criterion in terms of the frequency equation for the non-dimensional perturbation stream function ψ with the free upper and lower horizontal boundaries. This function is expressed as

$$\psi = \psi_o \, e^{pt} \sin \pi a x \sin n\pi z \tag{9}$$

where x and z are horizontal and vertical coordinates, a and n are the horizontal and vertical wave number (n , integer) and the vertical distance is scaled with d. The frequency equation is a cubic equation of p and is given by

$$p^3 + (\sigma + \tau + 1)k^{-2}p^2 + \{(\sigma + \sigma\tau + \tau)k^4 - (R - R_s)\sigma\pi^2\gamma^2k^2\}p$$
$$+ \sigma\tau k^6 + (R_s - \tau R)\sigma\pi^2 a^2 = 0 \qquad (10)$$

where

$$k^2 = \pi^2 (a^2 + \eta^2) \qquad (11)$$

For $\sigma = 10$ and $\tau = 0.01$, three roots of equation (10) have different characteristics for different regions of the R-R_s plane.

There are four different regions of instability as sketched in Fig. XI-11. The region I is stable, since no root of (10) has a positive real part. In the region II, the two complex roots of (10) have a positive real part, and thus the perturbations in this region grow in their amplitudes while they oscillate, that is, they are subject to oscillating instability. In regions III or IV, there are two or one positive roots of (10), respectively, therefore perturbations become always unstable.

Since positive roots or positive part of the complex roots of p indicate the growth rate of the perturbations, the maximum values of the $p\pi^{-2}$ or $p_r\pi^{-2}$ (real part of p) are sketched in Fig. XI-12 with corresponding values of a^2 (in the original paper) in the regions III and IV for n=1. In region III, the larger positive root corresponds to the extension of the positive root from the region IV. In this figure, four sub-regions in regions III and IV are also indicated according to the vorticity change. The vorticity change arises from the inertia (instability) and diffusion effects and the generation by buoyancy due to temperature and salinity effects.

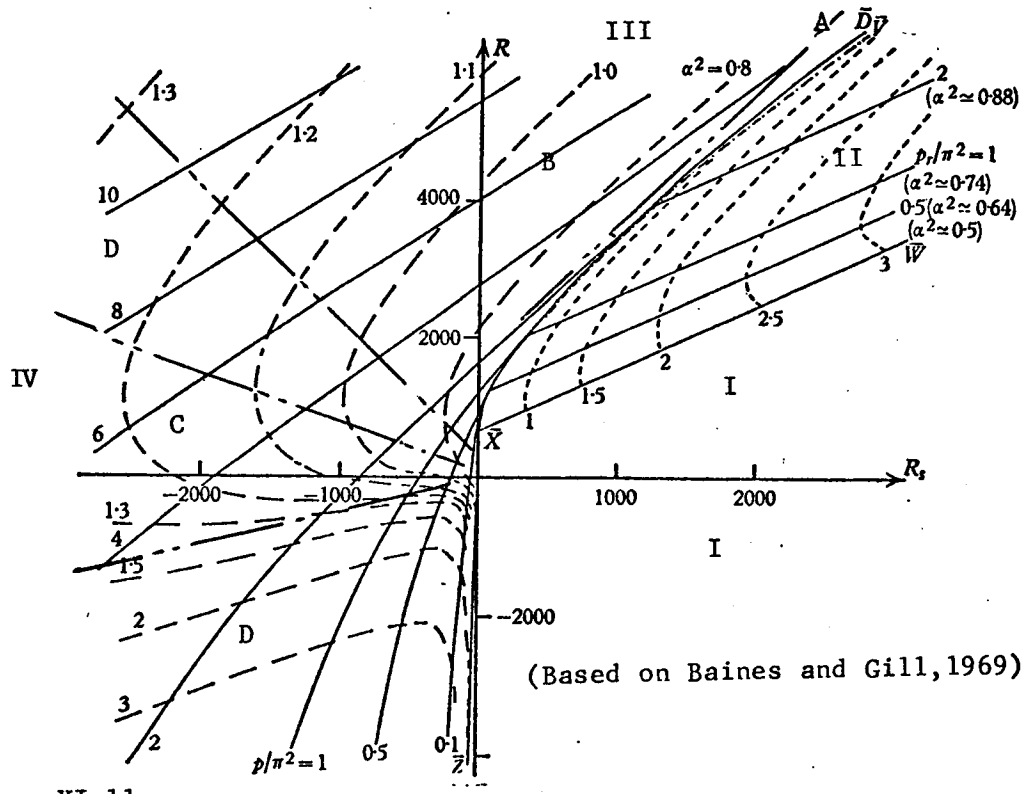


Figure XI-11. Curves showing the nature of the most unstable mode. ——, lines of constant growth rate showing values of p/π^2; – – –, lines of constant wave-number with values of α^2 indicated (with $n = 1$); - - - - -, lines of constant frequency with numbers giving values of p_i/π^2; –·–·–, the line $\bar{X}\bar{V}$, which is almost indistinguishable from the line $\bar{X}\bar{D}$.

(α^2 is referred a^2 in the text)

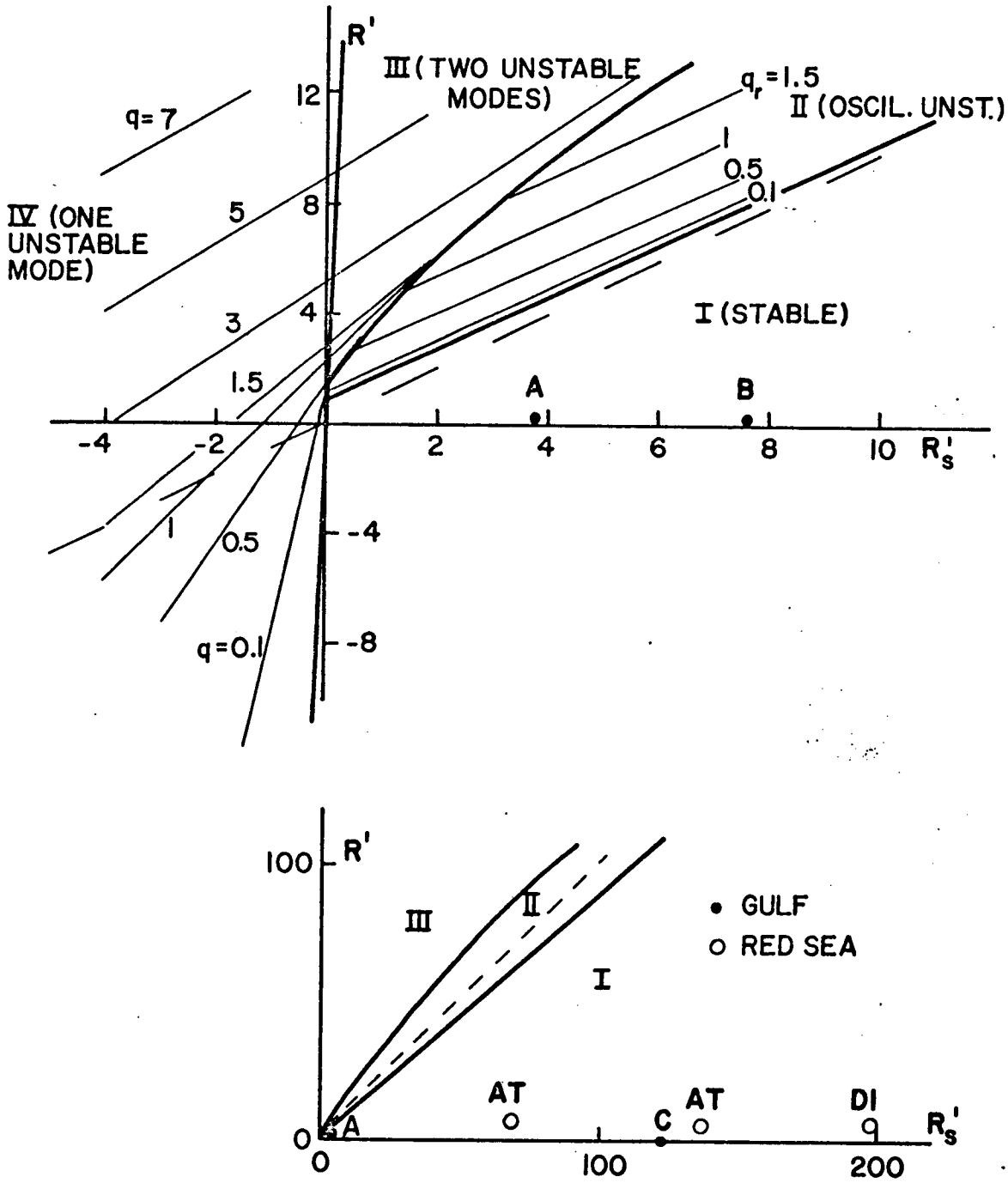


Figure XI-12. Stability modes dependent on scaled Rayleigh number R' and scaled salinity Rayleigh number R's. The upper figure indicates the domain for small R and R's, whereas the lower figure indicates the domain for larger R and R's together with observed data in the Gulf brine pool and the Red Sea.

In the sub-region A, the buoyancy effect due to both temperature and salinity dominates. In sub-regions B or C (Fig. XI-11), the buoyancy due to temperature or salinity, respectively dominates. In sub-region D (Fig. XI-11), all three effects are comparable.

In applying the criterion by Baines and Gill (1969), one of the difficulties is how to determine d, thickness of the layer, where temperature and salinity change linearly with the vertical distance. Since R and R_s have a factor d^3, both increase rapidly with an increasing value of d. Further, R and R_s have large values for relatively small values of d. For example, since the sea water of 15^oC and $35\ ^o/_{oo}$, α and β are $2.2 \times 10^{-4}/\ ^oC$ and 7.7×10^{-4}/ppt, respectively, R and R_s are 2.2×10^4 and 7.7×10^4, respectively, for $d = 1$ cm and $\Delta T = 1^oC$, $\Delta S = 1$ ppt. Therefore, it is necessary to explore the stability problem for much larger values of R and R_s in the R-R_s plane than shown in Figs. XI-11 and 12. For this purpose, q, R' and R_s' are introduced in place of p, R and R_s. These parameters are defined by

$$q + k^{-2}p,\ R_1' = \pi^2 a^2 R k^{-6},\ R_s' = \pi^2 a^2 R_s k^{-6} \tag{12}$$

Then after some manipulation, equation (10) can be written as

$$q + \sigma = \left(\frac{\sigma R'}{q+1} - \frac{\sigma R_s'}{q+\tau}\right) \tag{13}$$

This can be compared with the Boussinesq pertubation equation for the stream function

$$(\sigma^{-1}\ \partial/\partial t - \nabla^2)\nabla^2\psi = -R\partial T/\partial x + R_s\partial S/\partial x \tag{14}$$

where ∇^2 is the Laplacian in the $x - z$ plane

$$(u, w) = (-\partial\psi/\partial Z, \partial\psi/\partial x) \tag{15}$$

and T and S are temperature and salinity perturbations. The latter are related to ψ by

$$(\partial/\partial t - \nabla^2)T = (\partial/\partial t - \tau\nabla^2)S = -\partial\psi/\partial x \tag{16}$$

Comparison of equation (13) with equation (14) leads to the following interpretation. The first and second term of the l.h.s. of (13) corresponds to the inertia and dissipational change of the vorticity, respectively. The first and second term of the r.h.s. of (13) corresponds to vorticity change due to the buoyancy caused by temperature and salinity perturbation, respectively.

The boundary between the regions I and II (line XW) corresponds to $q_r = 0$ where $q = q_r + iq_i$. The real part q_r can be obtained from separating (13) in real and imaginary parts. The equation $q_r = 0$ leads to

$$(\sigma + 1 + \tau)(\sigma + \sigma\tau + \tau) - \sigma\tau - \sigma\{(\sigma + 1)R' - (\sigma + \tau)R_s'\} = 0 \tag{17}$$

This represents the straight line in the R-R_s' plane as indicated in Figs. XI-11 and 12. However, this line will cross the line $R' = R_s'$ for large values of R' and R_s' since τ is not 1. The crossing occurs at

$$R' = R_s' = \{(\sigma + 1 + \tau)(1 + \tau + \tau\sigma^{-1}) - \tau\}(1 - \tau) \approx \sigma + 1 \tag{18}$$

The approximation is for the water for which $\tau \approx 0.01$ and $\sigma \approx 10$. The more accurate value for the water is 11.14. This implies that for $R_s' > \sigma + 1$ the flow regime becomes oscillatory unstable when

$$R' > 0.91\ R_s' + 1 \tag{19}$$

for the water, even if it is statically unstable $(R' < R_s')$.

However, this kind of instability may not be possible for the brine pool in the Gulf. The ratio R_s'/R' or R_s/R is

$$R_s/R = R_s'/R = \beta\Delta S/\alpha\Delta T = \Delta\rho_s/\Delta\rho_T \tag{20}$$

where $\Delta\rho_s$ and $\Delta\rho_T$ are density differences within the layer due to salinity and temperature, respectively. For the brine pool of the Gulf, this ratio is 13.6 even if the smaller salinity of 41 ppt of the brine and larger temperature difference of about 1^oK are used (Table XI-3). This explains the observed condition that mechanical disturbances of the submersible did not cause dynamical instability of the interface, but only the internal seiches.

For comparison, examples of the Red Sea hot brine are listed also in Table XI-3 from Atlantis II Sta. 721 and Discovery Sta. 717 (Brewer et al., 1969). The data show depth, salinity and temperature of a layer where vertical distributions of temperature and salinity are almost linear. Also $\Delta\sigma_s$ and $\Delta\sigma_T$, differences in sigma-t due to salinity and temperature are listed in this table instead of $\Delta\rho_s$ and $\nabla\rho_T$. Although temperature difference in the Red Sea brine is much larger than in the Gulf brine, the

TABLE XI - 3

Density Differences due to Salinity and Temperature

Depth (m)	S(ppt)	T (°C)			R_s/R
		Brine Pool of East Flower Garden			
a	36	20	3.82	0.28	13.64
b	41	21			

(a: above the interface; b: below the interface)

		Atlantis II Deep Sta. 721			
2007	59.5	22	67.2	7.9	8.5
2017	151.5	44			
2037	152.0	44.5	123.7	4.6	26.9
2054	321.5	56.5			
		Discovery Sta. 717			
2004	44	25	199.3	6.4	31.3
2151	317	42			

is irregular; and non-uniform bottom topography is barely known. Second, the viscous friction at the bottom and along the shore may be important in the brine pond because of shallowness, but the theory is for an ideal fluid. Since the observed seiches seemed to oscillate near the center of the pond with apparently one almost circular nodal line, the symmetrical seiches will be considered for a circular pond with depth varying parabolically from the center. Equations of motion and continuity for such seiches are

$$\partial u/\partial t = -g'\partial\zeta/\partial r + \nu(\nabla^2 u - ur^{-2}) \tag{21}$$

$$\partial\zeta/\partial t = -\partial(uh)/\partial r \tag{22}$$

where r and u are the radial coordinates in this direction, respectively, ν is the kinematic viscosity of the brine, and ζ is the elevation of the interface. The Laplacian ∇^2 is given by

$$\nabla^2 = \partial^2/\partial r^2 + r^{-1}\partial/\partial r \tag{23}$$

the depth h is expressed by

$$h = h_o\ (1 - r^2/a^2) \tag{24}$$

where h_o is the central depth and a is the radius of the pond.

In order to determine a and h_o, the following procedure is taken. First, the map of the bottom is reproduced on the graph paper and rough depth contours are drawn from transcript of verbal

reports in the video tape. Then, the interface area and the volume of the pond are determined from the map. The result is listed in Table XI-4. The radius a is determined by equating the measured area with the area of a circle πa^2. Then h_o is determined by equating the measured volume with the theoretical volume $\frac{1}{2}\pi a^2 h_o$.

The first symmetrical mode (without viscosity)has a period given by

$$T = \pi(1.414)^{-1} a \, (g' h_o)^{-\frac{1}{2}} \tag{25}$$

according to Lamb (1932, p. 292). When we take $\Delta\rho = 0.125$ and $\rho_s = 1.15$ for the main body of the brine water, equation (25) gives the period as 78.4 seconds, which is close to the observed period of 1.5 minutes.

The effect of viscosity is difficult to calculate because the solution of the equation system (23) and (24) with the viscosity terms is complicated. Instead, the following approximation is used to incorporate the viscosity effect. It is assumed that the viscosity may change the period given by (25) only slightly. Then the brine water of the pond has a boundary layer at the bottom and along the coastline. The bottom boundary layer thickness δ can be determined from the calculation based on the oscillating horizontal flow over the flat bottom (Lamb, 1932, p. 622). The result is given by

$$\delta = (2\nu/\omega)^{\frac{1}{2}} \tag{26}$$

where ω is the frequency of the periodic motion.

TABLE XI - 4

Data for Calculation of Period and Friction Coefficient of the First Symmetrical Mode

$\Delta\rho = 0.125$ $\rho_b = 0.150$ $g' = 1.065$ m/sec^2

area = 583 m^2 a = 13.62 m volume = 40.8 m^3

$h_o = 0.14$ m $\omega_o = 0.80$ sec^{-1}

$\delta = 0.5$ cm $s_o = 0.982$ $\bar{n} = 0.0765$ sec^{-1}

$$h_m = h_o \{1-(1+s_o + s_o^2)/3\} = 0.25 \text{ cm}$$

When equation of motion (21) is integrated with depth z from the surface to the bottom excluding near the shoreline and then is divided by the depth, it leads to

$$\partial\bar{u}/\partial t = g'\partial\zeta/\partial r - \nu(\partial u/\partial z)_o h^{-1} \tag{27}$$

where $\bar{u}$ is the depth averaged velocity and $(\partial u/\partial z)_o$ is the shear along the vertical at the bottom. In obtaining (27), the friction force due to the horizontal shear is neglected because this shear is negligible except near the coastline. The vertical shear $\partial u/\partial r$ is considered negligible at the interface. The bottom shear can be expressed in terms of the boundary layer thickness and the velocity just above the boundary layer u_b as

$$(\partial u/\partial z)_o \approx u_b\delta^{-1} \approx \bar{u}\delta^{-1} \tag{28}$$

The last relation is justified because the vertical shear outside the boundary layer is almost negligible. Then equation (27) can be written as

$$\partial\bar{u}/\partial t = g'\partial\zeta/\partial r - \kappa\bar{u} \tag{29}$$

where

$$\kappa = \nu\ (\delta h)^{-1} \tag{30}$$

Equations (27) and (28) are not valid when the depth h becomes equal to δ. Also κ is dependent on h, and thus not constant. Therefore, the average of κ over the pond will be used. Thus equation (30) is considered valid in the range

of r from the origin to the value r_o where the depth h equals δ. From equation (24)

$$s_o = r_o/a = (1 - \delta/h_o)^{\frac{1}{2}} \tag{31}$$

Then in the range $r_o < r < a$, it is assumed that the friction coefficient κ_b is given by

$$\kappa_b = \nu(\delta h_m)^{-1} \tag{32}$$

instead of (30), where h_m is the mean value of h in $r_o < r < a$. This procedure is to avoid infinity of κ at the shoreline and also to incorporate the friction at the coast.

The value of κ given by (30) and κ_b are averaged over the whole circle. The averaged κ is given by

$$\bar{\kappa} = \nu\delta^{-1}\{h_m^{-1}(1 - s_o^2) - h_o^{-1} \log(1-s_o^2)\} \tag{33}$$

In the r.h.s. of (33) the terms with h_o^{-1} and h_m^{-1} represent the dissipation forces at the central portion and near the shoreline, respectively. The ratio of the former to the latter represents the ratio of the bottom friction to the shoreline friction and is about 1.67 for the present set of data. The value of $\bar{\kappa} = 0.0076\ \text{sec}^{-1}$.

The introduction of $\bar{\kappa}$ changes the frequency equation which is now given as

$$\omega^2 + i\bar{\kappa}\omega = \omega_o^2 \tag{34}$$

or

$$\omega = -\tfrac{1}{2}i\bar{\kappa} \pm (\omega_o{}^2 - \bar{\kappa}^2/4)^{\frac{1}{2}} \tag{35}$$

where

$$\omega_o = 2\pi\ T_o^{-1} \tag{36}$$

with T_o given by (25). Since $\omega_o = 0.0801$, decrease of frequency due to $\bar{\kappa}$ is about 0.1%. Therefore, calculation of δ based on ω_o is valid.

The e-folding time due to the friction is about 262 seconds or about 3.3 cycles of the computed period. In fact, the observed oscillations lasted only for four to five cycles, showing strong damping, even though the generation was not by an impulsive force, but by a force of some duration.

There are several points to be clarified in the future experiments on seiches of the pond. First, there is need for more accurate measurements of amplitudes and periods of the oscillations as well as the bathymetry and shoreline geometry. Second, since viscosity has rather strong effect in damping, it is desirable to determine molecular viscosity for the brine more accurately. Third, the amplitude seemed to be smaller than the central depth but almost comparable to the depth, near the shoreline. Therefore, some laboratory experimental works are necessary to study the finite amplitude internal seiches. Thorpe (1968) made experiments on the finite amplitude internal seiches but these were for the deep water (or short wave length)

internal waves. However, if his result is extrapolated to the shallow water seiches in the present example, the difference of the observed and calculated period may be attributed to lengthening of the period due to the finite amplitude effect.

CONCLUSIONS AND REMARKS CONCERNING HYDRODYNAMIC PROBLEMS

Three hydrodynamic problems are derived from review of the video tapes made by Bright of the brine pool. The first is the rapid decrease of salinity near the outlet from the pond. This is attributed to the entrainment of a stratified fluid flowing though a narrowed channel with slight inclination. The second is stability of the fluid with double diffusivities. It is confirmed that the interface of the pond is very stable, even if there is increase of temperature by $1^{o}C$ downward. The third is the observed oscillation of the interface. This is explained as the internal seiche of a circular pond. The observed period almost agrees with the calculated one of the first symmetrical mode. The viscous friction has a strong damping effect because of the shallowness of the pond.

Since the pond is accessible by the submersible, it is desirable to design future experiments with an intention of obtaining quantitive data. Particularly, we should determine microstructures of temperature and salinity in the pond and near the interface. Since depth of the brine is so small, it is advisable to use thermistor and conductivity sensors instead of water sampling, for measuring temperature and salinity. Also,

the current in the effluent should be measured with either the Lagrangian or Eulerian method. The former may be achieved by photographing either dye patches or plumes or plastic balls. The latter can be done with hot-film current sensors.

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CHAPTER XII

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS AND RECOMMENDATIONS

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CONCLUSIONS

BIOLOGY OF THE HARD BANKS

Our biological reconnaissance assessments confirmed that the crest of 28 Fathom Bank, southwest peak, is occupied by a clear-water Algal-Sponge Zone community above approximately 76 m depth. Below this, there is a transformation downward to a unique deep-water epibenthic community (below 120 m) typified by lithistid sponges and large solitary corals. The communities and zonation at 28 Fathom Bank are essentially the same as those found at the East and West Flower Gardens below the shallow coral reefs.

Claypile Bank is a broad, flat platform covered to a significant degree by filamentous and leafy algae with occasional, possibly seasonal, patches of Sargassum. Outcrops of tertiary bedrock around the edge of the bank bear significant, but sparse, developments of epifauna including large branching bryozoans and the hermatypic corals, Siderastrea and Stephanocoenia. All of these bank-edge epifauna seem well adapted to chronic high turbidity and sedimentation. More profuse epifaunal and leafy algal populations have developed on discarded drill pipes, anchors, tires, etc., which serve as effective artificial reefs around which numerous fish congregate.

Aransas Bank is a typical high-relief South Texas fishing bank bearing an Antipatharian Zone community which is best developed above 70 m where water turbidity is not as severe and persistent as it is lower on the bank.

Blackfish Ridge and Mysterious Bank are classified as

low-relief fishing banks. They are apparently almost always covered by highly turbid nepheloid layers. Consequently, the epifaunal populations there are sparse, though the large conspicuous attached organisms are the same ones found in the Antipatharian Zones of the high-relief banks to the north.

Post-drilling assessments at the East Flower Garden, Stetson, South Baker and Southern Banks revealed no obvious effects on epifaunal and groundfish populations due to drilling near the banks. In all cases, the benthic communities appeared as "healthy" in 1976 as in past years. No signs of catastrophic mortality were evident.

Quadrat counts at Southern Bank and Hospital Rock support the opinion that species diversity and abundance decreases with increasing depth on high-relief South Texas topographical highs in response to the high turbidity and sedimentation associated with chronic nepheloid layers investing the lower portions of the banks.

Accurate mapping of occurrences of biotic communities type above 50 m at the East Flower Garden indicates that there may be a recognizable upstream-downstream effect on the distribution of epifaunal populations at the bank. There appear to be more components of the Madracis zone upstream and more components of the Leafy Algae zone downstream.

At the East Flower Garden a unique brine seep was discovered and documented. The high salinity brine affects epifaunal communities only very locally (in a one meter or so band above the interface between brine and typical marine water.) Several unique

species of leafy algae grow in or adjacent to the brine, but not elsewhere on the bank.

In examining the health of hermatypic corals at the East Flower Gardens, we found numerous instances of mechanical damage to corals and an array of coral pathological conditions involving filamentous algae, zooxanthellae extrusions, discoloration, "rotting" of coral tissue, white inclusions in coral mucus and white flake-like coatings of the coral colony surface.

A detailed laboratory-field study of the white inclusions in the mucus of Montastrea cavernosa revealed that they are botryoidal masses of spherical organic cells, each approximately 10 microns in diameter. The cells do not respond to bacterial, algal or fungal marine culture techniques. Electron micrography reveals cellular structure analagous to that of secretory cells. Field observations indicate that the presence of these inclusions in the mucus does not affect normal daily behavior of the coral and possibly is not of pathological significance. The white material does not appear to be infectious.

During the past two years, a concept of "environmental prioritization" has emerged relating to the nature of the Texas-Louisiana fishing banks described and studied by our group. In general, it is felt that the banks can be categorized and prioritized as follows, depending on their hydrographic, geomorphic and biological characteristics:

1. Shelf-edge constructional carbonate banks of high relief harboring clear-water epibenthic communities, including coral reef and Algal-Sponge Zone communities in which the

predominant active frame builders are hermatypic corals and coralline algae, respectively. Such banks include:

West Flower Garden

East Flower Garden

28 Fathom Bank

Probably other banks to the east

2. Mid-shelf claystone-siltstone banks of shallow crest depth (25-30 m) bearing on their upper portions depauperate clear-water epibenthic communities, including several species of hermatypic corals and numerous tropical reef fishes. Such banks include:

   Stetson Bank

   Claypile Bank

   Sonnier Bank (3 Hickey Rock)

   Probably other banks off Louisiana

3. Mid-shelf carbonate banks of deeper crest depth (around 56-67 m) and high relief bearing moderately developed Antipatharian Zone epifaunal communities, including a severely limited population of small corals. These communities are subject to frequent influxes of turbid water. Such banks include:

   Baker Bank

   South Baker Bank

   Aransas Bank

   North Hospital Rock

   Hospital Rock

   Southern Bank

Dream Bank

4. Mid-shelf carbonate banks of deeper crest depth (60-70 m) and low relief bearing poorly developed Antipatharian Zone benthic communities which are subject to nearly constant conditions of high turbidity and sedimentation. Such banks include:

   Big Adam Rock

   Small Adam Rock

   Blackfish Ridge

   Mysterious Bank

BIOLOGY OF SOFT BOTTOM ADJACENT TO THE BANKS

The meiofauna of the flanks of the hard banks off the Texas coast form a stable community that varies in regard to depth, orientation downcurrent of the main mass of the bank, sediment grain size and, presumably, in regard to the amount of labile carbon compounds in the sediments, although the latter has not been tested.

The bank meiofaunal populations are, on balance, substantially higher than those on the adjacent level bottoms of the outer continental shelf. This may be a reflection of greater inputs of organic materials into the sediments from bank debris and detritus, but again, this is as yet untested. The latter is suspected, however, because harpacticoid copepods, which respond positively to organic inputs, are significantly more abundant on banks than on level bottoms in this area.

It is noted that the harpacticoid: nematode ratio is significantly greater at the banks than at transect stations. Also, the ratio

differs predictably among banks, indicating that banks have a signature ratio that will identify its condition of health. Whereas environmental impacts can be measured among the macro-epifauna, primarily by death or no death, such impacts can be estimated and predicted by ratio changes among these two components of the meiofauna.

The macroinfauna of the flanks of the hard banks off the Texas coast also form a stable community that varies less than the meiofauna in the depth range of this study. However, as in the case of the meiofauna, it is more abundant downstream of the bank proper, and it is significantly more abundant on the bank flanks than on the level bottoms of the transects.

The meiofaunal annual production in the Gulf is believed to be two to five times greater than the macroinfauna.

The true meiofauna: macroinfauna ratio is considered to be another important signature marker of individual banks. It appears to be stable from year to year.

Both the meiofauna and the macroinfauna respond to changes in the characteristics of the sediment bed. However, it appears that the usual division of sediments into gravel, sand, silt and clay is too gross. Rather, the individual grain sizes should be divided into at least 16 categories and percentages for each derived.

GEOLOGY

The classification of banks in the previous section is in agreement with our geological observations with the following

qualifications. The mid-shelf carbonate banks (categories 3 and 4) are also constructional features that are quite different from the mid-shelf claystone-siltstone banks (category 2). The carbonate is the result of the growth of corals and algae during the Pleistocene and Early Holocene epochs. The major difference between the mid-shelf carbonate banks and the shelf-edge carbonate banks (category 1) is that the mid-shelf carbonate banks are now dead. The mid-shelf carbonate banks have never been buried by terrigenous sediments, although they are now in the process of being buried. The mid-shelf claystone-siltstone banks are composed of lithified Tertiary sediments that have been brought to the surface by salt tectonics.

The sediments surrounding the category 2, 3 and 4 banks are primarily clays with admixtures of sand and silt. Only in close proximity to these banks do the sediments become prodominantly sand and gravel. The sands and gravels are derived from the submarine erosion of the banks.

The sediment aprons around category 1 banks are mainly carbonate sediments that are produced on the banks _in situ_. These sediments consist of the coral debris facies, surrounding the living reefs; the algal nodule facies; and the _Amphistegina_ sands. The latter sands grade into the surrounding normal shelf sediments which are primarily terrigenous.

Direct observations of dye diffusion experiments and time series STD and transmissometer show the turbulence within the mixed boundary layer (nepheloid layer) to occur on several time scales, ranging from a few seconds to several minute intervals.

This turbulence is due to a complex of forces that includes internal waves, continental shelf waves and tidal currents.

The study of fossil coccoliths in the bottom sediment has revealed a net transport direction for sediments on the South Texas OCS. The use of fossil coccoliths as "tracers" has proved to be a valuable tool.

RECOMMENDATIONS

Although our post-drilling surveys and monitoring efforts at certain banks in categories 1, 2 and 3 have not revealed obvious effects of drilling on epibenthic biota, it is nevertheless recommended that restrictive measures on drill related activities be continued as originally imposed at the East and West Flower Gardens (category 1), Stetson (category 2) and Southern and South Baker (category 3) Banks, and that similar restrictive regulations be extended to all other banks listed within each group.

In the case of banks in group 4, it is recommended that drilling not be allowed to occur on or within a reasonable distance from the bank. There should be no requirement for shunting in conjunction with drilling near group 4 banks because it is felt that such would serve to entrap drill effluents within the nepheloid layer which, though desirable in the vicinity of high-relief banks, is probably not advisable near low-relief banks whose crests are almost perpetually within the nepheloid layer.

It is recommended that all monitoring programs required for drilling at any of the banks include direct assessment of biotic communities by diver or underwater television and bottom photo-

graphy, in addition to a minimal bioassay effort designed to indicate the degree to which the drill effluent effects selected OCS hard-bank epifaunal organisms (the coral Madracis mirabilis is suggested) and primary producers in the water column (phytoplankton). Such potentially useful procedures have been ignored in some past monitoring efforts, even though regulations apparently require biologically oriented real-time monitoring assessments.

Because the clear-water epibenthic communities of the group 1 banks are those about which most environmental concern has been expressed (coral reefs, Algal-Sponge Zone), it is recommended that more be learned of the ecology, condition and dynamics of at least the predominant organisms structuring these active assemblages, namely, the reef building corals and the coralline algae. Thus, continued investigations are called for concerning the effects on reef corals of mechanical damage, naturally occurring coral pathogens and drill effluents. These studies should be expanded to include the effects of drill effluents on the primary species of coralline algae currently active in building the platforms associated with shelf-edge banks in the northwestern Gulf of Mexico. The type of information generated by such studies is distinctly management related. The inadequacy of such information is currently recognized among USGS and BLM personnel closest to the management decision-making process. Certainly we should have a more comprehensive understanding of such factors prior to the advent of production drilling near these banks, not only from the standpoint of revising existing environmental regulations

concerning drilling, but also because such information is essential to the proper implementation of long-term monitoring programs at the most sensitive sites.

It is recommended that the exploratory baseline studies of fishing banks in the northwestern Gulf of Mexico be continued until a complete and adequate inventory is achieved, and the characteristics of all of the banks are sufficiently understood to allow the sensible formulation to protective regulations relating to exploratory and production drilling.

Totally unique and scientifically invaluable features such as the brine seep at the East Flower Garden should be comprehensively documented and afforded the ultimate in conservative environmental protection.

It is recommended that meiofauna studies of the areas adjacent to hard banks be continued. The number of stations around and adjacent to at least one bank should be increased and carefully positioned in regard to the best possible bottom current information. Where there is evidence of a prevailing current, these stations should include upcurrent and downcurrent sites, with the downcurrent stations aligned on a transect of increasing distance from the bank. A determination of labile carbon content of the sediment should be made in each grab taken for meiofauna samples.

It is recommended that process oriented studies of the nepheloid layer be expanded to include long term current meter measurements. Only by understanding the processes active in the nepheloid layer can we begin to have a predictive capability

concerning the transportation of pollutants on the continental shelf.

The coccolith study should be expanded to include the Texas-Louisiana continental shelf. This can be accomplished at low cost as the samples have already been taken and are available for our use. We need to know the extent of the influence of the Mississippi River in terms of sediment transport.

It appears that the transport of sediment from the mouth of the Mississippi River towards the west and southwest is much greater than originally thought. The relative concentrations of clay minerals in the suspended sediment flowing out of the major passes between Corpus Christi and Sabine Pass are Kaolinite $\geq$ Illite > Montmorillonite. Yet in the bottom sediments just six miles offshore, the concentrations are reversed. Perhaps montmorillonite from the Mississippi River is transported as far south as Port Aransas. A monthly sampling of the passes seems to be in order and in addition, at least a seasonal sampling of the offshore areas from Port Aransas to Station 1 on Transect II at one mile intervals.

Geological sampling during rig monitoring studies should be conducted to determine the presence or absence of a nepheloid layer and to locate the drill effluent plume during drilling. Analyses for barium in the bottom sediment should be done by NAA. Atomic absorption techniques are not capable of distinguishing between calcium and barium without tedious preparation techniques that cannot be utilized by most analytical laboratories.

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APPENDIX I

BARIUM ANALYSES FROM THE DRILL SITE MONITORING STUDY

APPENDIX I

WELL SITE MONTIORING

Samples for trace metal analysis were taken from drill sites on the East Flower Garden Bank and 28 Fathom Bank, southwest peak. The East Flower Garden site had previously been occupied by a drilling rig and the 28 Fathom Bank, southwest peak site was a pre-drilling survey. The locations of the drill sites and sample stations are listed in Table AI-1 and shown graphically in Figures AI-1 and 2. The unusual distribution of sampling sites is due to errors in LORAC navigation that were not discovered until after the cruise had ended.

Analyses were conducted by the Center for Trace Characterization at Texas A&M University. The letter of transmittal of data is included in this appendix. The samples were analyzed for barium, cadmium, chromium, iron and zinc (see Table AI-2). If cadmium and zinc are present, they are below the detection limits for the samples at both sites (note paragraph 2 in the letter of transmittal).

As to be expected, the concentrations of barium, chromium and iron in the bottom sediment are high at the post-drilling sampling sites on the East Flower Garden Bank. However, at the pre-drilling site on 28 Fathom Bank, southwest peak, the concentrations of barium are very low and are what might be considered normal for marine sediments. The concentrations of chromium and iron are also lower at 28 Fathom Bank, southwest peak.

Table AI-1

SAMPLE LOCATIONS

PRE-DRILLING WELL SITE SURVEYS

		LORAC LANES DF NET		LAMBERT COORDINATES			
EAST FLOWER GARDEN BANK		GREEN	RED	X	Y	LAT.	LONG.
PROPOSED DRILLING SITE		756 03	867 10	3719445	82062	27°57'4.787"	93°40'23.92"
EFG GRAB	1	756 96	867 05	3720478	80855	27°56'52.3"	93°40'12.97"
	2	755 93	866 99	3719309	82382	27°57'7.96"	93°40'25.25"
	3	756 19	866 74	3719558	82442	27°57'8.42"	93°40'22.44"
	4	756 07	866 93	3719461	82290	27°57'6.95"	93°40'23.59"
	5	755 93	866 96	3719302	82434	27°57'8.46"	93°40'25.28"
	6	755 61	866 95	3718945	82891	27°57'13.14"	93°40'29.03"
	7	755 90	866 84	3719251	82675	27°57'10.84"	93°40'25.72"
	8	756 16	866 72	3719525	82516	27°57'9.18"	93°40'22.76"
	9	756 47	866 91	3719834	82439	27°57'8.24"	93°40'19.34"
	10	756 10	867 02	3719509	82098	27°57'5.04"	93°40'23.16"
	11	756 13	867 09	3719551	81939	27°57'3.42"	93°40'22.76"
	12	756 25	866 85	3719644	82176	27°57'5.76"	93°40'21.61"
28 Fathom Bank, southwest peak							
PROPOSED DRILLING SITE		820 40	828 51	3787904	59271	27°52'47.95"	93°27'53.58"
UNB GRAB	1	820 40	828 52	3787908	59244	27°52'47.57"	93°27'53.5"
	2	820 13	828 73	3787622	59243	27°52'47.71"	93°27'56.66"
	3	820 00	828 80	3787476	59203	27°52'48.36"	93°27'58.28"
	4	820 02	828 78	3787491	59309	27°52'48.43"	93°27'58.1"
	5	820 10	828 72	3787575	59306	27°52'48.36"	93°27'57.17"
	6	820 08	828 75	3787566	59279	27°52'48.07"	93°27'57.28"
	7	820 03	828 72	3887486	59409	27°52'49.4"	93°27'58.1"

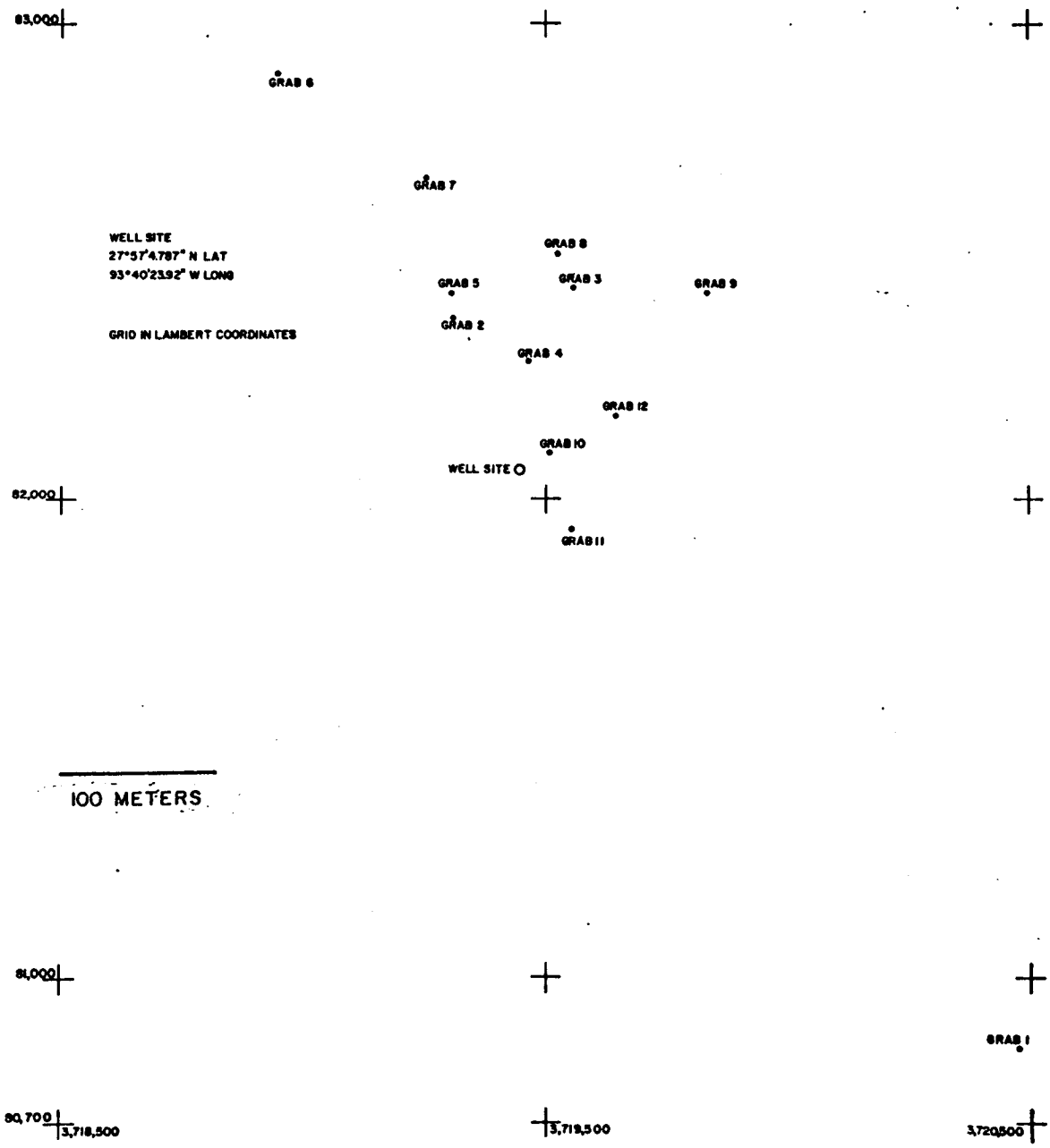

Figure AI-1. Sample location plot, drill site pre-drilling survey of selected trace metals in sediment: East Flower Garden Bank.

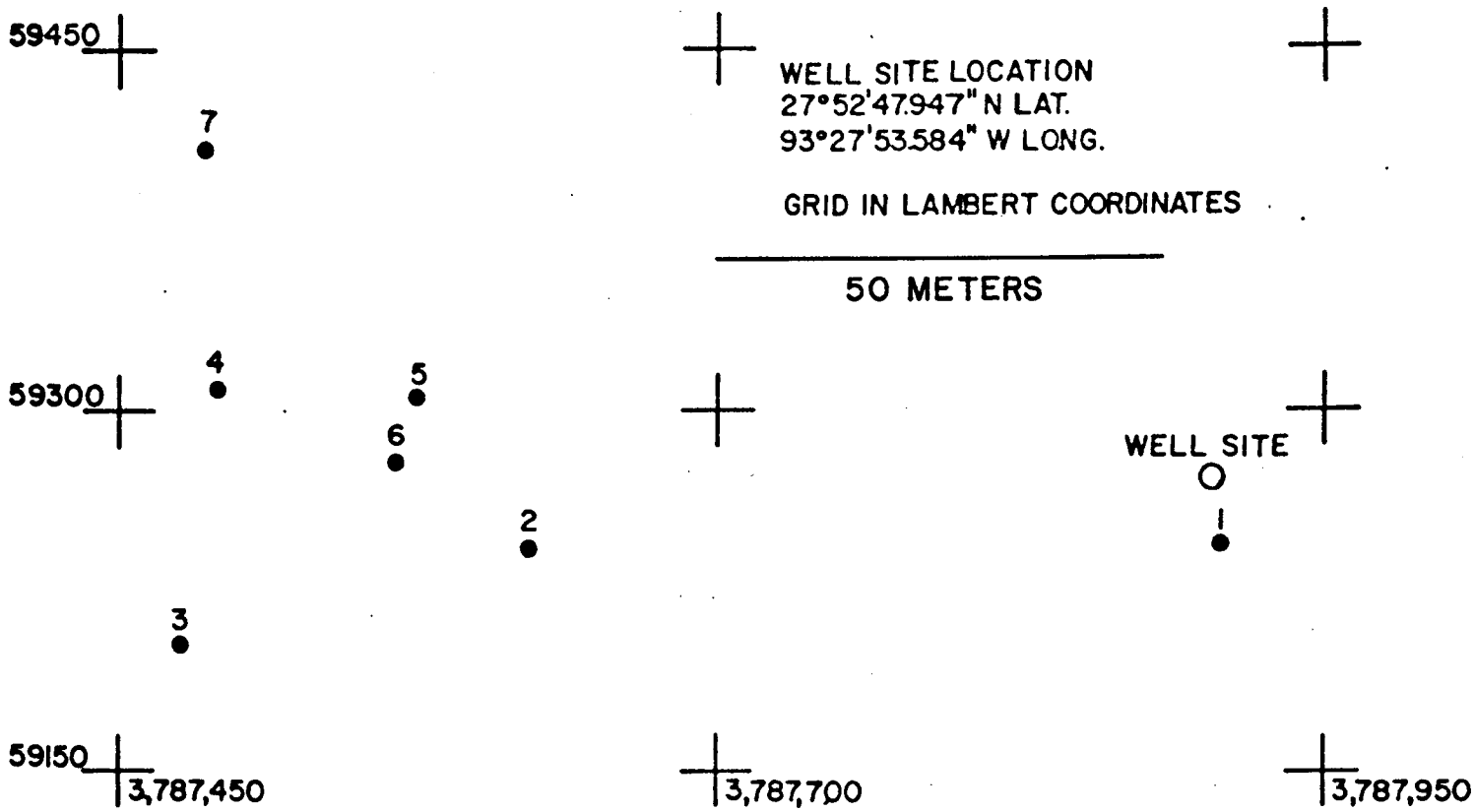

Figure AI-2. Sample location plot, drill site pre-drilling survey of selected trace metals in sediment: 28 Fathom Bank, southwest peak.

TEXAS A&M UNIVERSITY
CENTER FOR TRACE CHARACTERIZATION
Department of Chemistry
COLLEGE STATION, TEXAS 77843

Telephone: 713-845-2341

May 10, 1977

David Barrow
Geological Oceanography
Oceanography-Meterology Bldg.
C A M P U S

Dear Mr. Barrow:

I am enclosing a table of the results of our analyses for Barium, Cadmium, Chromium, Iron and Zinc in the sediment samples you requested. The INAA procedure used was identical to the one prescribed on pages 64-66 of the BLM Contract No. AA50-CT6-18 you sent over with the samples.

As I mentioned on the telephone, the procedure is not optimized for the Cd, Cr, Fe and Zn determinations but rather for Barium and the other elements were determined using these irradiation and counting conditions.

We will initiate the billing procedures for this analyses to Research Foundation Project 3327-2 as you requested ($760.00--19 samples @ $40/sample). I am enclosing a copy of our current price schedule for such analysis for your future reference. As you will note, the $150 lot charge was waivered in this instance.

If you need additional information or if we can be of any assistance with future analyses, please do not hesitate to contact either Dr. Schweikert or myself.

Sincerely,

David T. Moore

David T. Moore
Assistant Research Chemist

Table AI-2

AMOUNTS OF SELECTED ELEMENTS IN SEDIMENTS NEAR DRILL SITES

Sample	Barium	Cadmium	Chromium	Iron	Zinc
EFG-P GRAB 1	1521 (9.3)	< 47	29.5 (15)	1533 (5)	< 3.57
EFG-P GRAB 2	2472 (4.8)	< 44	26.9 (15)	1306 (5)	< 3.3
EFG-P GRAB 3	1060 (11)	< 43	28.4 (14)	1330 (4.4)	< 3.2
EFG-P GRAB 4	1157 (9.1)	< 35	29.8 (11)	1457 (3.4)	< 2.6
EFG-P GRAB 5	1045 (11)	< 41	31.9 (12)	1421 (4.4)	< 2.9
EFG-P GRAB 6	399 (21)	< 38	32.6 (11)	1713 (3.3)	< 2.7
EFG-P GRAB 7	826 (12)	< 41	34.2 (11)	1736 (3.4)	< 2.9
EFG-P GRAB 8	801 (11)	< 33	27.5 (11)	1384 (3.4)	< 2.3
EFG-P GRAB 9	1944 (5.3)	< 27	29.6 (10)	1466 (2.3)	< 1.7
EFG-P GRAB 10	947 (13)	< 44	30.1 (14)	1411 (4.2)	< 3.1
EFG-P GRAB 11	1033 (10)	< 36	32.5 (10)	1657 (3.2)	< 2.5
EFG-P GRAB 12	1244 (7.2)	< 35	31.7 (10)	1556 (2.9)	< 2.3
UNB BA-1	< 79	< 27	10.3 (25)	674 (6.2)	< 1.8
UNB BA-2	225.9 (32)	< 28	19.9 (13)	979 (3.9)	< 1.7
UNB BA-3	< 96	< 31	14.4 (20)	933 (4.2)	< 1.9
UNB BA-4	177 (40)	< 23	14.1 (15)	833 (3.6)	< 1.5
UNB BA-5	<107	< 34	17.7 (18)	983 (4.7)	< 2.2
UNB BA-6	294 (32)	< 26	18.9 (13)	919 (3.2)	< 1.63
UNB BA-7	201 (35)	< 23	12.0 (19)	891 (3.4)	< 1.5

All values are in parts per million (ppm). Numbers in parenthesis are percentage uncertainties in the value to the left, i.e. 1521 (9.3) indicates 1521 ± 141. "<" indicates that the element was not observed and the concentration value listed is an "upper" or detection limit for this sample under these conditions. It is derived from three standard deviations of the background or "noise" in the expected energy region.

APPENDIX II

DATA SUMMARY

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Table II-1

Cruise Dates, 1976

CRUISE		DATES
I. STOCS Cruises: Water Column Sampling		
STOCS Designation	TAMU Designation	
March Monthly	76LM18	March 18-20
April Monthly	76L3	April 2-4
Spring Seasonal	76L5	June 3-6
November Monthly	76L10	November 8-10
II. STOCS Cruises: Sediment Sampling		
Winter Seasonal		February 9-15
March Monthly		March 14-15
April Monthly		April 8-11
Spring Seasonal		June 24-29
July Monthly		July 16-19
August Monthly		August 4-7
Summer-Fall Seasonal		October 6-12
November Monthly		November 15-20
December Monthly		December 8-10
III. Topographic High Cruises		
76SH1 (Mapping)		July 17-27
76SH2 (Sampling)		July 28-August 6
76G8-II (Sampling/Submersible)		August 23-September 7
76G8-III (Sampling/Submersible)		September 10-27

TABLE II-2

Specimens For Hydrocarbon and Heavy Metal Analysis

Bank	Heavy Metal	Hydrocarbon
East Flower Garden	3 vermilion snapper 1 red snapper 3 *Spondylus americanus*	10 red snapper 1 graysby 3 *Spondylus americanus*
Stetson Bank	3 vermilion snapper 4 red snapper 3 *Spondylus americanus*	5 red snapper 1 vermilion snapper 3 hind 3 *Spondylus americanus*
28 Fathom Bank	4 vermilion snapper 5 red snapper 3 *Spondylus americanus*	6 red snapper 5 vermilion snapper 1 squirrel fish 3 *Spondylus americanus*
Unnamed Bank	10 vermilion snapper 5 red snapper	4 red snapper 8 vermilion snapper

TABLE II-3

Biological Specimens

Bank	Dives On Which Samples Were Taken	SCUBA Samples Taken	Grab Samples (Biological Specimens Taken)
East Flower Garden	76-6; 76-8; 76-16; 76-7; 76-35	yes	no
Stetson Bank	76-13	yes	no
Unnamed Bank	76-5; 76-11; 76-12; 76-16	no	no
28 Fathom Bank	76-9	no	yes
Claypile Bank	76-15	no	no
South Baker	76-31; 76-33	no	no
Southern Bank	76-21; 76-25	no	no
Hospital Rock	76-20; 76-24	no	no
Aransas Bank	76-29	no	no

Table II-4

TABLE OF DR/V DIAPHUS SUBMARINE DIVES

Dive No.	Date	Locality	Observer	Hr. & Min. Duration
76-5	8-27-76	Unnamed Bank	Bright	7:10
76-6	8-28-76	East Flower Gardens	Bright	2:52
76-7	8-29-76	East Flower Gardens	Bright	4:09
76-8	8-30-76	East Flower Gardens	Stamman	6:08
76-9	8-31-76	28 Fathom Bank	Bright	4:05
76-10	8-31-76	28 Fathom Bank	Wormuth	1:15
76-11	9-1-76	Unnamed Bank	Thompson	2:58
76-12	9-1-76	Unnamed Bank	Hubbard	2:13
76-13	9-2-76	Stetson Bank	Bright	4:28
76-14	9-3-76	Stetson Bank	Abbott	2:40
76-15	9-3-76	Claypile Bank	Bright	3:16
76-16	9-4-76	Unnamed Bank	Bernard	2:53
76-17	9-6-76	East Flower Gardens	Barrow	2:01
76-18	9-6-76	East Flower Gardens	Barksdale	1:00
76-19	9-6-76	East Flower Gardens	Bright	2:30
76-20	9-12-76	Hospital Rock	Bright	3:47
76-21	9-16-76	Southern Bank	Bright	4:47
76-22	9-16-76	Southern Bank	McGrail	1:54
76-23	9-17-76	Hospital Rock	McGrail	2:16
76-24	9-17-76	Hospital Rock	Bright	3:07
76-25	9-18-76	Southern Bank	Bright	2:28
76-26	9-18-76	Southern Bank	Lindquist	3:44
76-27	9-23-76	Southern Bank	Rezak	1:33
76-28	9-23-76	Southern Bank	Bright	1:33
76-29	9-23-76	Aransas	Teerling	2:08
76-30	9-23-76	Aransas	Barksdale	1:00
76-31	9-24-76	South Baker Bank	Cool	1:18
76-32	9-24-76	South Baker Bank	Tompkins	1:31
76-33	9-24-76	South Baker Bank	Bright	1:49
76-34	9-24-76	South Baker Bank	Kennicutt	0:37
76-35	9-25-76	East Flower Gardens	Bright	5:45

Total time for 76-G8- II & III was 87 hours 46 minutes.

Biological: 25 hours 15 minutes

Geological: 12 hours 16 minutes

Chemical Student: 37 minutes

Sub-Pilot Training: 1 hour

TABLE II-5

Table of SCUBA Dives

Date	Dive No.	Location	Duration of Dive/Divers	No. of Divers
8-28-76	1	East Flower Garden	31 min.	2
	2		28 min.	2
	3		33 min.	2
	4		27 min.	2
8-29-76	5		34 min.	2
	6		32 min.	2
	7		24 min.	2
	8		23 min.	2
	9		36 min.	2
	10		33 min.	2
8-30-76	11		27 min.	2
	12		34 min.	2
9-2-76	13	Stetson Bank	36 min.	3
	14		19 min.	2
9-3-76	15		32 min.	2
	16		40 min.	2
9-5-76	17	East Flower Garden	16 min.	3
9-6-76	18		33 min.	4
	19		35 min	3

Total time for dives: 21.65 hours.

Table II-6

FILM TYPES AND AMOUNTS USED DURING 1976 BIOLOGICAL RECONNAISSANCE

Bank	35 mm Handheld Camera DIAPHUS (rolls)*	35 mm time Lapse System 1 frame/30 sec (rolls)**	8 mm Time Lapse Movie System 1 frame/sec (rolls)***
Unnamed Bank	7	5	11
East Flower Garden	8	6	17
28 Fathom Bank	5	2	5
Stetson Bank	5	3	7
Claypile Bank	5	1	3
Hospital Rock	9	3	8
Southern Bank	4	6	13
Aransas Bank	3	1	3
South Baker	5	2	4
Total	51	29	71

*35 mm handheld camera, 1 roll = 36 frames.

**35 mm time lapse system = 1 roll = 250 frames.

***8 mm rolls have approximately 3600 frames.

Table II-7

VIDEO TAPES FROM DR/V DIAPHUS AND UNDERWATER T.V.

DIAPHUS T.V. Tapes	*Total Rolls Taken
Unnamed Bank	13.5
East Flower Garden	26.0
28 Fathom Bank	5.5
Stetson Bank	7.0
Claypile Bank	3.0
Hospital Bank	11.0
Southern Bank	19.0
Aransas Bank	3.0
South Baker Bank	6.0
Underwater T.V.	
East Flower Garden	10.0
Aransas Bank	2.5
Mysterious Bank	0.5
Blackfish Ridge	2.0
Total No. Of Rolls	109.0

* Each roll is approximately 30 minutes duration.

Table III-1

SALINITY WITH DEPTH AND TEMPERATURE WITH DEPTH AT EAST FLOWER GARDENS BANK, CRUISE 76G8-II

Station 2

Temperature	Depth
29.01	0
29.01	-24.088
26.975	-53.768
25.965	-56.779
25.165	-58.930
21.965	-70.544
21.87	-71.404
17.955	-93.772
18.23676324	-95.492
16.19880120	-117.43

Station 3

Temperature	Depth
29.31162325	0.4248
29.14128257	-3.3991
29.08116232	-6.3733
29.03106212	-20.394
28.89579158	-26.343
25.97995992	-41.639
25.72872873	-44.188
24.23223223	-48.012
24.18718719	-50.987
22.76076076	-60.334
21.96496497	-62.884
21.29329329	-65.858
21.07807808	-66.283
21.05305305	-68.832
17.96996997	-84.553
18.05717151	-85.828
17.84653962	-91.351
16.14142427	-99.424

Salinity	
36.26	-0.4142
36.258	-27.338
36.214	-29.410
36.302	-31.481
35.722	-36.037
36.102	-39.351
35.876	-41.008
36.104	-44.736
35.554	-46.393
36.21	-50.949
35.806	-52.192
36.21	-60.476
35.936	-61.305
36.12	-66.276
36.206	-70.004
35.72	-71.661
36.146	-74.146
35.828	-75.803
36.21	-80.359
36.228	-85.330
36.178	-86.987
36.252	-89.472
35.838	-91.543
36.096	-95.271
35.53	-95.271
36.116	-99.414

Table III-1 cont.

Station 4

Temperature	Depth
28.95295295	-0.836
28.96796797	-22.99
28.21721722	-28.43
28.21221221	-30.93
25.96496497	-41.81
25.76376376	-42.64
21.96996997	-60.20
21.72	-61.87
17.965	-87.38
18.07	-89.05
17.865	-96.16

Salinity	
36.16766767	-2.497
36.25775776	-24.14
35.95345345	-29.14
36.42992993	-33.30
36.08158158	-39.13
36.26376376	-41.63
35.95545546	-46.62
36.13963964	-48.70
36.22972973	-53.70
36.13563564	-54.95
36.18968969	-56.61
36.12162162	-56.61
36.12762763	-58.28
36.18968969	-58.69
36.21771772	-61.61
36.1056056	-62.86
36.21171171	-64.94
36.26576577	-67.85
36.26776777	-70.77
36.13363363	-71.18
36.27777778	-72.43
36.23373373	-74.93
36.29379379	-75.76
36.32182182	-77.84
36.09759760	-81.59
36.33583584	-82.42
36.33783784	-83.67
36.26376376	-85.75
36.33383383	-87.42
36.26976977	-88.67
36.32182182	-92.42
36.27377377	-93.66
36.33783784	-97.41

Station 5

Temperature	Depth
29.01603206	0.836
29.13126253	-9.556
28.46993988	-22.00
28.56012024	-24.5
25.97995992	-39.44
25.6773547	-44.84
21.98496994	-63.94
21.815	-65.19
17.975	-66.02
21.94	-67.27
21.75	-71.42
18.82	-86.37
18.43	-87.61
18.34	-93.01
18.19	-93.84
18.065	-97.16

Salinity	
35.792	0.406
35.826	-5.692
36.004	-9.759
35.898	-18.70
35.952	-21.95
36.012	-22.36
36.056	-24.39
35.982	-25.21
36.188	-31.71
36.042	-35.78
36.202	-38.63
36.374	-44.73
36.196	-45.54
36.272	-47.57
36.19	-56.52
36.132	-57.74
36.104	-64.65
36.23	-66.28
36.172	-69.12
36.244	-69.94
35.758	-71.56
36	-72.78
35.842	-74.41
36.256	-77.66
36.286	-78.07
36.296	-82.95
36.378	-83.36
36.364	-85.39
36.066	-85.80
36.326	-90.68
36.196	-93.12
36.33	-96.37

Table III-1 cont.

Station 6

Temperature	Depth
28.95795796	-0.8016
29.02302302	-14.028
28.83283283	-21.644
28.9029029	-25.252
28.83783784	-28.458
25.97497498	-40.483
25.69369369	-42.487
21.98498499	-62.528
21.93393393	-63.731
18.14014014	-83.371
17.97997998	-91.789
17.86386386	-94.595
17.72872873	-96.599

Salinity	
35.99448345	-0.7918
36.20310933	-16.628
36.14894684	-19.004
36.15095286	-21.775
36.23921765	-24.942
36.24122367	-29.297
36.06268806	-31.277
36.23721163	-33.653
36.2011033	-47.114
36.11484453	-58.2
35.82597793	-59.783
36.19709127	-61.763
35.92828485	-62.951
36.17903711	-66.118
35.99448345	-68.493
35.55516550	-73.640
36.07071214	-76.412
35.99448345	-77.995
36.31344032	-79.183
36.2011033	-81.559
36.25125376	-81.955
36.29939819	-91.457
36.32748245	-92.644
36.12086259	-93.040
36.17502508	-95.020
36.36359077	-95.020
36.30541625	-95.416
36.31344032	-96.604

Station 7

Temperature	Depth
29.045	-1.2020
28.895	-28.047
28.98	-30.451
25.995	-53.690
25.32	-56.094
22	-68.915
21.29670330	-70.518
18.65934066	-84.141
18.57942058	-88.548
18	-91.754
19.104	-93.757
15.948	-115.79
16.036	-117.39
15.932	-117.79

Salinity	
36.20858283	-2.3720
36.19061876	-26.883
36.16067864	-27.279
36.34431138	-30.046
36.21057884	-34.790
36.32435130	-38.348
36.12475050	-41.116
36.48003992	-43.488
36.22255489	-46.255
36.45808383	-51
36.17065868	-56.930
36.3023952	-58.116
36.21057884	-61.279
36.28642715	-64.837
36.04890220	-70.372
36.35628743	-80.651
36.36227545	-89.348
36.22255489	-89.744
36.29640719	-92.906
36.11477046	-94.883
36.22055888	-98.046
36.09081836	-98.441
36.14271457	-102.39
36.08083832	-102.79
36.0508982	-109.11
36.07485030	-111.09
36.03093812	-113.46
36.03892216	-117.02

Table III-1 cont.

Station 8

Temperature	Depth
29.0761523	0
29.03607214	-4.179
28.8757515	-6.037
28.87074148	-9.288
28.83066132	-12.53
28.98096192	-15.32
28.9759519	-28.32
25.98997996	-51.55
25.87887888	-54.80
21.96996997	-73.84
21.7562688	-76.62
18.57673019	-96.59
17.97492477	-99.85
17.93787575	-103.1
15.42785571	-123.5

Salinity	
36.234	0
36.174	-4.243
36.168	-10.37
36.272	-13.20
36.326	-26.40
36.404	-30.17
36.29	-33.94
36.478	-42.43
36.406	-43.84
36.45	-46.67
36.31	-48.09
36.42	-49.03
36.368	-49.50
36.38	-53.74
36.24	-59.40
36.306	-63.65
36.206	-62.70
36.294	-66.00
36.06	-73.07
36.2	-75.43
35.864	-76.38
36.342	-78.73
36.11	-81.09
36.392	-83.45
36.142	-86.75
36.306	-94.29
36.372	-96.18
35.934	-98.06
36.276	-101.8
35.908	-104.1
36.148	-107.0
36.06	-108.4
36.156	-110.7
35.694	-114.5
36.092	-122.5

Station 9

Temperature	Depth
29.21678322	-0.4222
29.26173826	-2.9555
29.07192807	-7.6000
28.89710290	-29.133
25.98001998	-46.444
24.98096192	-46.866
24.19438878	-49.400
21.98496994	-65.866
21.80761523	-67.133
17.96993988	-85.288
17.955	-86.133
17.045	-95.000

Salinity	
36.24974975	-0.9178
36.26976977	-24.782
36.28378378	-26.159
36.28778779	-33.043
36.31581582	-34.879
36.11561562	-37.173
36.25975976	-41.394
36.13763764	-41.763
36.23373373	-43.599
36.22372372	-50.942
36.27377377	-50.942
35.71321321	-52.318
36.25175175	-55.990
36.2057057	-57.826
36.3098098	-59.202
36.21371371	-61.956
36.3098098	-63.792
36.23373373	-66.086
36.28378378	-67.922
36.17167167	-70.217
36.24774775	-73.888
36.04754755	-74.806
36.27577578	-78.478
36.17967968	-83.067
36.32982983	-83.985
36.2057057	-86.739
36.32382382	-89.033
36.29379379	-89.492
36.32182182	-91.787
36.28178178	-93.164
36.31381381	-95.458

Table III-1 cont.

Station 10

Temperature	Depth
29.09118236	0.8858
29.18637275	-3.9863
28.64529058	-36.319
27.26252505	-38.534
26.72144289	-47.835
25.97995992	-48.278
25.22144289	-49.607
21.97995992	-63.337
21.71871872	-66.438
17.97497498	-86.812
17.92284569	-88.141
17.03607214	-97.885

Salinity	
36.14635365	-1.2991
36.26223776	-4.3303
36.27222777	-9.0937
36.23026973	-10.392
36.26823177	-10.825
36.25224775	-20.785
36.27822178	-24.683
36.25424575	-26.848
36.26823177	-32.910
35.75874126	-35.941
36.29820180	-43.736
36.14835165	-45.468
36.29620380	-47.633
35.51098901	-49.366
36.14835165	-55.428
35.85664336	-58.459
36.14235764	-61.924
35.67882118	-64.522
36.05244755	-67.120
35.66883117	-67.986
36.16633367	-70.584
35.96853147	-74.049
36.15634366	-74.482
35.99450549	-76.647
36.24425574	-79.245
35.98651349	-81.843
36.18431568	-86.174
36.07242757	-87.473
36.05044955	-90.504
36.14835165	-92.236
36.02847153	-93.535
36.14435564	-95.700
36.11638362	-96.566
36.18231768	-97.433

Station 11

Temperature	Depth
29.15684316	0.8675
29.15184815	-14.315
28.45754246	-28.196
25.98001998	-41.210
25.775	-43.812
21.985	-63.767
21.89	-65.936
19.4	-76.347
19.22	-82.420
18.35	-95

Salinity	
35.75888325	-1.2076
35.7609137	-13.686
36.18121827	-26.165
36.09796954	-26.970
36.10406091	-28.177
36.30101523	-30.593
36.10203046	-31.800
36.28477157	-32.605
36.20152284	-37.838
36.3680203	-38.644
36.24822335	-39.851
36.264467	-40.656
36.1751269	-41.864
36.27258883	-41.864
36.1893401	-43.474
36.27664975	-43.072
36.31725888	-45.084
36.29086294	-46.694
35.99847716	-47.5
36.29695431	-50.317
36.26243655	-50.720
36.28680203	-53.135
36.1467005	-54.745
36.25228426	-56.355
36.14467005	-59.576
36.31725888	-82.118
36.22791878	-85.338
36.36395939	-90.169

Table III-1 cont.

Station 12

Temperature	Depth
29.2	0
29.19	-13.1930
25.97	-39.5790
25.86044177	-42.1325
21.96987952	-62.1348
21.70611836	-63.4116
19.56469408	-71.9232
18.88766299	-83.4139
18.44132397	-87.2441
18.34102307	-91.5

Salinity	
35.75325325	-0.41590
35.74924925	-17.0522
35.78928929	-19.5477
36.13363363	-29.5295
35.86936937	-31.1931
36.21371371	-33.6886
35.92742743	-37.0159
35.96346346	-41.5909
36.18768769	-41.175
36.15365365	-43.2545
36.25175175	-45.3340
35.79329329	-47.8295
36.10568569	-53.2363
35.86936937	-61.5545
36.25575576	-63.6340
35.98148148	-66.1295
36.26376376	-68.625
35.91941942	-70.2886
36.39389389	-72.7840
36.33383383	-75.2795
36.39189189	-76.1113
36.38388388	-83.1818
36.27977978	-83.5977
36.32982983	-84.8454
36.33583584	-89.4204
36.36386386	-90.6681

Table III-1 cont.

DRILL SITE STATIONS

At Drill Site		1000 m East of Drill Site		1000 m West of Drill Site	
Temperature	Depth	Temperature	Depth	Temperature	Depth
24.82782783	-0.51639	24.71228771	0	24.86286286	0
24.82782783	-5.68032	24.73726274	-0.53225	24.84784785	-3.61475
24.91291291	-7.74590	24.75224775	-3.19354	24.92292292	-10.3278
24.87287287	-10.3278	24.88211788	-6.38709	24.91291291	-13.4262
24.9029029	-12.3934	24.8071928	-8.51612	24.93793794	-14.9754
24.84784785	-13.9426	24.81718282	-18.0967	24.9029029	-19.1065
24.85285285	-25.3032	24.84715285	-18.0967	24.93293293	-22.7213
24.91791792	-27.3688	24.83216783	-27.6774	25.02302302	-24.7868
24.87287287	-27.8852	24.56743257	-30.8709	24.84284284	-26.8524
24.89289289	-28.9180	24.56743257	-34.5967	24.83783784	-30.4672
24.89289289	-30.9836				

Salinity		Salinity		Salinity	
34.05305305	-1.05	33.8088088	1.11864	33.936	-0.53389
34.56156156	-13.65	34.42142142	-5.59322	34.754	-24.0254
34.53753754	-15.225	34.51151151	-9.50847	34.75225225	-22.4237
34.63563564	-18.375	34.53753754	-15.1016	35.42092092	-29.3644
34.65965966	-26.775	34.76376376	-17.8983	35.42492492	-31.5
34.8018018	-28.875	34.7022022	-17.8983		
34.79058116	-26.25	35.76326326	-33		
35.0270541	-29.4				
34.78857715	-28.35				
34.9268537	-29.4				
34.92885772	-31.5				

Table III-1 cont.

1000 m South of Drill Site

Temperature	Depth
24.81718282	0
24.77722278	0
24.77722278	-9.16363
24.85714286	-17.1818
24.85714286	-30.3545
24.71728272	-32.0727
24.8071928	-32.6454

Salinity	
33.93893894	-1.61538
34.25925926	-6.46153
34.55755756	-13.7307
34.64964965	-21.8076
34.65565566	-26.6538
34.71371371	-30.6923
36.17432567	-21
36.23026973	-31.5

1000 m North of Drill Site

Salinity	Depth
33.92092092	0.
34.57157157	-15.4528
34.72572573	-26.1509
34.74649299	-27.3396
35.32965932	-30.9056

Table III-2

SALINITY WITH DEPTH AND TEMPERATURE WITH DEPTH AT STETSON BANK, CRUISE 76G8-II

Station 1

Temperature	Depth
24.87	-0.859375
24.825	-13.32031
23.42	-21.05468
23.635	-22.34375
21.975	-27.07031
21.53353353	-28.78906
20.5025025	-29.21875
20.21221221	-37.38281
17.96996997	-40.39062
-0.92	-1.15
17.89389389	-43.39843
17.23823824	-53.71093

Salinity	Depth
35.66833667	0
36.08917836	-16.5
35.87074148	-18.61538
36.32364729	-23.69230
35.70841683	-28.34615
36.16933868	-30.88461
36.20741483	-38.92307
35.57414830	-37.23076
36.20741483	-40.61538
36.01703407	-40.19230
36.19338677	-42.73076
36.28557114	-53.30769

Station 2

Temperature	Depth
24.88577154	0.518518
24.9008016	-9.851851
24.42484970	-21.25925
24.48997996	-23.33333
21.97494990	-30.07407
21.72	-31.62962
19.315	-42

Salinity	Depth
35.75325325	-1.465116
35.76726727	-10.74418
36.0075075	-19.04651
35.93343343	-21.48837
36.05955956	-23.93023
35.62712713	-28.32558
36.07757758	-32.23255
35.96746747	-34.18604
36.15965966	-37.11627
35.97147147	-40.53488
36.18168168	-42

Station 3

Temperature	Depth
24.89289289	0.481218
24.87787788	-11.08181
24.51251251	-15.41818
24.64764765	-18.79090
21.97997998	-26.5
21.9089089	-27.46363
17.97997998	-50.10909
17.695	-51.55454
17.435	-53.96363

Salinity	Depth
35.8053053	-0.477477
35.83133133	-12.89189
36.17367367	-18.62162
35.14264264	-26.73873
36.04754755	-27.21621
35.78528529	-29.60360
36.17367367	-32.94594
35.84534535	-34.85585
36.22572573	-39.15315
36.02352352	-44.88288
36.24574575	-46.79279
35.97347347	-52.04504
36.26176176	-53.95495

Table III-2 cont.

Station 4

Temperature	Depth
25.02302302	0
24.79279279	-12.61764
24.9029029	-16.98529
21.96996997	-28.14705
21.335	-30.57352
17.985	-45.13235
15.83133733	-46.10294
13.97005988	-46.58823

Salinity	Depth
35.67434870	-1.441747
35.72044088	-13.93689
36.10921844	-18.26213
35.85470942	-21.14563
36.29158317	-28.35436
35.71242485	-30.27669
36.18937876	-34.60194
36.04709419	-37.48543
36.19939880	-39.40776
35.77855711	-41.81067
36.16933868	-43.25242
36.19739479	-50.94174
36.27354709	-51.42233

Station 5

Temperature	Depth
24.86	0.864864
24.855	-13.83783
21.965	-22.48648
21.74	-24.21621
18.24	-48.00000

Salinity	Depth
35.75125125	0
35.77127127	-13.47368
36.04554555	-19.36842
34.9004004	-20.21052
36.13563564	-26.94736
36.17767768	-29.89473
36.06956957	-33.26315
36.2077077	-37.47368
36.14564565	-40.84210
36.22972973	-41.68421
36.14164164	-45.47368
36.24574575	-48.00000

Station 6

Temperature	Depth
24.87287287	1.962962
24.86286286	-14.72222
21.97997998	-26.5
21.37337337	-27.97222
18.18018018	-53

Salinity	Depth
35.758	-0.486238
35.756	-13.12844
36.014	-22.85321
34.762	-24.31192
36.056	-33.55045
35.628	-37.92660
36.176	-41.33027
36.034	-43.76146
36.158	-47.65137
36.056	-50.56880
36.232	-53.97247

Table III-2 cont.

Station 7

Temperature	Depth
24.88076152	1.347457
24.86573146	-12.12711
24.7254509	-17.06779
21.97995992	-25.60169
21.74	-27.84745
18.205	-46.26271
17.98	-46.71186
17.75375375	-48.95762
17.8038038	-53.44915

Salinity	Depth
35.8	0
35.798	-10.78761
36.052	-17.82300
35.972	-20.16814
36.104	-22.98230
35.85	-24.38938
36.096	-26.26548
35.892	-27.20353
36.186	-31.89380
36.038	-33.76991
36.144	-36.58407
36.208	-46.43362
36.248	-47.37168
36.244	-51.12389
36.144	-51.12389
36.286	-52.06194

Station 8

Temperature	Depth
29.722	2.52475
29.722	-13.6336
29.518	-22.7227
27.988	-25.2475
21.95395395	-27.2673
18.96096096	-38.8811
18.83033033	-51.5049

Salinity	Depth
35.75725726	-0.94444
35.76726727	-11.3333
35.98148148	-18.4166
35.9034034	-20.3055
36.08558559	-20.7777
34.5	-23.1388
35.81131131	-26.9166
35.49699700	-28.3333
36.08358358	-32.5833
35.55505506	-37.7777
36.06556557	-40.6111
36.18168168	-47.2222
36.08158158	-50.0555
36.21971972	-51

Station 9

Temperature	Depth
24.84784785	1.44339
24.85285285	-10.5849
24.77777778	-15.3962
21.96996997	-24.0566
21.94894895	-27.4245
18.54554555	-49.5566

Salinity	Depth
35.76326326	0
35.76126126	-10.9626
36.04354354	-19.5420
35.2067067	-22.4018
35.62512513	-24.7850
35.24474474	-24.7850
35.43893894	-26.6915
35.23073073	-27.6448
36.03953954	-33.8411
35.8013013	-34.7943
36.1036036	-38.6074
36.04954955	-41.4672
36.14564565	-44.3271
35.96946947	-47.1869
36.24974975	-51

Table III-2 cont.

Station 10

Temperature	Depth
24.89	-0.933962
24.73	-9.806603
24.815	-13.54245
21.73373373	-29.88679
19.36136136	-41.09433
17.61361361	-45.76415
17.3033033	-48.56603

Salinity	Depth
35.66483516	0.457407
35.7067932	-9.148148
36.09040959	-13.72222
35.8026973	-15.55185
36.26223776	-17.38148
36.18631369	-18.29629
36.25824176	-18.29629
36.26823177	-23.32777
36.16633367	-22.87037
36.2082917	-23.78518
36.19830170	-30.64629
35.9005994	-31.10370
36.08041958	-32.47592
36.02847153	-33.39074
36.15634366	-34.30555
36.07642358	-34.76296
36.18231768	-37.05
36.19630370	-40.70925
35.89060939	-40.25185
36.25424575	-47.57037

Station 11

Temperature	Depth
24.96296296	1.919191
24.78778779	-8.156565
24.97297297	-11.51515
21.97997998	-21.11111
21.77	-23.51010
17.975	-44.62121
18.44444444	-45.58080
18.21421421	-46.54040

Salinity	Depth
35.62512513	1.439393
35.72322322	-8.156565
36.28978979	-11.03535
35.76726727	-12.47474
36.19169169	-16.31313
35.86536537	-19.67171
36.13763764	-21.11111
35.96546547	-22.55050
36.2077077	-25.42929
36.11761762	-26.86868
36.21971972	-27.82828
36.1016016	-31.66666
36.16566567	-33.58585
36.09559560	-34.54545
36.21171171	-36.94444
36.13163163	-37.42424
36.21571572	-40.78282
36.22172172	-44.14141
36.02752753	-42.70202
36.44594595	-46.06060
36.21171171	-47.02020

Station 12

Temperature	Depth
24.94705295	1.407079
24.79220779	-8.442477
24.93706294	-11.25663
21.97002997	-23.92035
21.8011988	-25.32743
17.98001998	-47.37168
17.83383383	-48.30973
17.27827828	-51.12389

Salinity	Depth
35.786	0.841269
35.714	-4.206349
36.2	-11.35714
36.026	-18.08730
36.1	-19.34920
35.924	-20.19047
36.138	-21.45238
35.97	-22.29365
36.09	-25.23809
35.836	-29.86507
36.22	-37.85714
36.01	-39.53968
36.242	-42.06349
35.774	-43.74603
36.282	-47.53174

Table III-3

SALINITY WITH DEPTH AND TEMPERATURE WITH DEPTH AT 28 FATHOM BANK, CRUISE 76G8-II

Station 1

Temperature	Depth
29.08	0
29.09	-13.314
29.125	-14.602
29.08	-22.762
27.84	-42.519
25.98	-51.108
25.47	-51.967
23.17	-60.987
22.985	-67.429
21.975	-70.435
21.46846847	-95.775
21.38338338	-101.78

Salinity	
36.32182182	0.8701
36.31981982	-9.1363
36.36986987	-11.311
36.36586587	-22.623
36.38988989	-24.798
36.38788789	-28.714
36.45595596	-31.324
36.49199199	-33.064
36.41791792	-36.110
36.45395395	-36.110
36.46396396	-43.071
36.33983984	-44.811
36.4019019	-45.681
36.39589590	-47.857
36.14364364	-49.162
36.26776777	-53.948
36.09759760	-56.123
36.03353353	-55.688
36.21971972	-57.428
36.27177177	-62.214
36.24174174	-67
36.0035035	-68.305
36.29579580	-71.785
36.09359359	-74.396
36.34584585	-76.571
36.24574575	-77.876
36.34184184	-79.616
36.28378378	-81.357
36.35985986	-85.272
36.22772773	-87.012
36.28578579	-95.714
36.32582583	-98.324
36.28778779	-98.759
36.29779780	-100.5

Station 2

Temperature	Depth
29.34334334	0.4181
29.34334334	-1.6724
29.12812813	-4.5991
29.17817818	-9.1982
28.97797798	-25.504
25.97497498	-46.827
25.23323323	-47.663
21.97997998	-69.405
21.97897898	-71.913
20.36736737	-73.168
17.97294589	-91.982
17.58717435	-94.491
17.6022044	-96.581

Salinity	
36.35771543	0
36.28557114	-3.3162
36.3757515	-9.1196
36.34168337	-17.824
36.35571142	-18.653
36.31963928	-20.726
36.39579158	-26.115
36.25951904	-28.188
36.36372745	-29.431
36.30561122	-30.675
36.37775551	-32.333
36.39178357	-34.820
36.31563126	-35.649
36.36573146	-37.722
36.19539078	-44.354
36.33567134	-46.012
35.18136273	-46.841
36.15330661	-50.158
36.19138277	-52.645
35.84268537	-53.863
36.25350701	-65.910
36.05711423	-69.641
36.20541082	-71.713
35.29158317	-72.128
36.37174349	-77.102
36.34168337	-79.589
36.0270541	-80.004
36.28757515	-84.564
36.0771543	-86.636
36.27154309	-89.123
36.13326653	-90.782
36.28757515	-95.756
36.37374750	-97.414

Table III-3 cont.

Station 3		Station 4	
Temperature	Depth	Temperature	Depth
24.695	0.90344	24.7027027	0.88636
24.535	-17.1655	24.5025025	-11.9659
21.965	-25.7482	21.96996997	-24.8181
25.31	-27.1034	21.915	-25.7045
21.985	-53.3034	17.97	-54.0681
18.25525526	-56.0137	17.87	-54.9545
15.84484484	-65.0482	17.845	-56.7272
15.82082082	-70.4689	14.025	-76.2272
15.11611612	-79.9551		

Salinity		Salinity	
35.77927928	0.88314	35.73723724	0.44571
35.89939940	-17.6629	35.75325325	-14.7085
35.52702703	-19.4292	36.26776777	-24.0685
36.06156156	-22.5202	36.22172172	-25.4057
35.53903904	-26.0528	36.24574575	-28.5257
36.13363363	-31.3516	35.99349349	-31.2
36.01951952	-32.6764	36.18968969	-32.9828
36.14964965	-34.8842	35.96146146	-34.32
36.01551552	-37.5337	36.18168168	-37.44
36.05155155	-40.6247	36.03153153	-38.7771
35.9074074	-44.1573	36.23773774	-42.7885
36.22572573	-48.5730	36.06756757	-46.8
36.27377377	-54.3134	36.26576577	-56.6057
35.68718719	-56.9629	36.12162162	-61.0628
35.96546547	-58.2876	36.24574575	-65.0742
35.51901902	-59.1707	35.57507508	-66.4114
36.3098098	-66.6775	36.24774775	-69.0857
36.34784785	-69.3269	36.19769770	-69.9771
36.05755756	-75.0674	36.29779780	-70.8685
36.19169169	-75.9505	36.17367367	-73.0971
36.06756757	-77.2752	36.27977978	-75.3257
36.34784785	-78.6	35.93143143	-76.2171
		36.35585586	-78.4457

Table III-3 cont.

Station 5

Temperature	Depth
24.77277277	1.24576
24.65265265	-4.98305
24.7077077	-12.4576
21.98998999	-21.5932
21.93893894	-23.6694
17.98498499	-46.5084
17.98	-47.7542
17.43	-61.8728
14.07	-82.2203
13.98	-83.4661
13.905	-85.1271
12.885	-98

Salinity	
35.78	1.23012
35.962	-12.3012
35.926	-15.5815
36.112	-20.0920
35.958	-22.1422
36.16	-21.3221
36.19	-25.4225
36.136	-29.1129
35.948	-34.8535
36.14	-41.0041
36.056	-43.4644
36.166	-44.6945
36.122	-46.7447
36.182	-48.3849
36.146	-50.0251
36.238	-54.9456
36.136	-56.9958
36.248	-60.2761
35.426	-63.9665
36.324	-73.8075
36.188	-74.6276
36.302	-76.6778
36.186	-79.1380
36.34	-82.4184
36.032	-84.8786
36.244	-87.7489
36.254	-91.4393
36.088	-95.9497
36.23	-98.0000

Station 6

Temperature	Depth
24.73773774	0.83261
24.65265265	-11.2403
24.75275275	-14.1545
21.96996997	-21.6480
21.94789579	-22.8969
17.98496994	-48.7081
18.004004	-50.3733
17.48348348	-57.8669
17.46846847	-62.0300
14.74574575	-72.4377
14.72572573	-74.5193
14.17517518	-80.7639
13.96996997	-81.5965
13.91891892	-82.8454
13.17817818	-98.2489

Salinity	
35.788	0.40756
35.836	-1.63025
35.882	-11.4117
36.218	-19.1554
36.026	-21.1932
36.21	-24.0462
36.158	-24.8613
36.204	-26.4915
36.118	-28.5294
36.164	-28.9369
36.138	-31.7899
36.198	-30.9747
36.23	-34.6428
36.174	-33.4201
36.222	-50.5378
36.25	-52.9831
36.218	-55.4285
36.276	-60.7268
35.966	-63.1722
36.402	-72.5462
36.326	-74.5840
36.372	-75.8067
36.37	-80.2899
36.262	-81.1050
36.302	-81.5126
36.298	-88.0336
36.226	-90.0714
36.288	-91.7016
36.256	-96.5924

Table III-3 cont.

Station 7		Station 8	
Temperature	Depth	Temperature	Depth
24.715	-0.3990	24.675	1.7121
24.5	-15.163	24.585	-12.840
21.97	-22.745	24.26	-16.265
		24.36	-18.833
21.68131868	-24.740	21.975	-25.681
18.01498502	-49.081		
		21.78621379	-27.393
18.05905906	-51.076	17.98001998	-51.791
13.98498499	-78.610		
		18.148	-53.075
14.03	-80.206	14.984	-84.750
13.685	-82.600		
		14.025	-86.034
		11.63	-113.42
Salinity		Salinity	
		35.732	2.1401
35.8046953	-1.1857	35.774	-4.2803
35.79470529	-9.0904	35.708	-14.125
35.85464535	-15.414	36.08	-21.401
36.24025974	-20.157	35.972	-23.969
36.02447552	-23.714	36.102	-26.537
36.16033966	-24.9	36.064	-28.25
36.22627373	-28.852	36.186	-28.678
36.11638362	-29.642	36.22	-44.515
36.21428571	-32.014	36.152	-47.083
36.13236763	-34.780	36.226	-56.500
36.21428571	-34.780	36.082	-58.640
36.24225774	-41.104	36.182	-59.924
36.19830170	-41.895	36.274	-65.488
36.22227772	-42.290	36.172	-69.340
36.24225774	-49.009	36.368	-71.481
36.27022977	-51.380	36.376	-77.901
36.24025974	-51.776	36.26	-77.901
36.27222777	-52.171	36.324	-79.185
36.27022977	-56.914	36.282	-92.026
36.16233766	-57.704	36.216	-92.454
36.28621379	-60.471	36.256	-93.738
35.85464535	-62.842	36.218	-95.450
36.3001998	-65.214	36.234	-98.018
36.12237762	-66.4	36.196	-99.303
36.41808192	-68.376	36.104	-106.57
36.36013986	-73.514	36.126	-107.43
36.21428571	-75.095	36.13	-109.14
36.33016983	-76.676	36.004	-109.14
36.3081918	-80.628	36.072	-113
36.24025974	-81.814		
36.31418581	-82.209		

Table III-3 cont.

Station 10

Temperature	Depth
28.93	0
28.92	-16.842
29.035	-22.736
25.97	-45.894
24.95295295	-49.684
23.7017017	-53.473
23.61661662	-56.842
21.97497498	-61.473
21.61222445	-64.421
17.97494990	-91.368
17.96396396	-94.315
17.23823824	-104.84
36.27577578	-1.9622
36.27177177	-16.875
36.35585586	-20.8
36.33383383	-21.584
36.34184184	-24.724
34.81831832	-39.245
34.91041041	-41.207
34.54204204	-42.384
34.68018018	-44.739
34.48998999	-45.524
36.25975976	-49.056
36.03553554	-50.233
36.24174174	-51.018
36.27377377	-52.196
36.06156156	-58.083
36.29179179	-60.830
36.12562563	-63.184
36.33183183	-64.754
36.35185185	-66.324
36.35585586	-73.781
36.25775776	-72.996
36.26776777	-76.528
36.34384384	-79.275
36.28378378	-80.452
36.33183183	-81.630
36.3058058	-85.947
36.32582583	-86.732
36.25175175	-89.479
36.32782783	-90.264
36.25575576	-91.049
36.26176176	-93.403
36.28978979	-94.973
36.25975976	-97.720
36.29979980	-98.898

Station 11

Temperature	Depth
25.3016983	0.4029
24.69730270	-2.0149
24.41758242	-11.686
21.97002997	-20.149
21.92	-21.761
17.97	-51.179
17.89110889	-52.791
13.96503497	-74.149
14.05688623	-75.761
14.00698603	-01.402
12.41017964	-106.79
35.472	-1.2
35.726	-6
35.68	-8
35.706	-10.8
35.576	-12.8
36.25	-22
36.124	-25.2
36.252	-28.8
36.052	-29.6
36.246	-31.2
36.266	-33.6
36.228	-34.8
36.282	-42.4
36.198	-43.6
36.244	-44.4
36.244	-52.4
35.98	-56
36.162	-57.2
36.066	-58.8
36.15	-59.6
35.986	-61.6
36.246	-64.8
35.932	-67.6
36.248	-72
36.144	-74
36.312	-76.4
36.34	-80.8
36.37	-81.6
36.176	-82
36.218	-83.6
36.218	-94
36.16	-94.4
36.19	-96.8
36.082	-99.6
36.158	-101.2
36.108	-105.2

Table III-4

SALINITY WITH DEPTH AND TEMPERATURE WITH DEPTH AT 28 FATHOM BANK, SOUTHWEST PEAK, CRUISE 76G8-II

Station 1

Temperature	Depth
14.05405405	-23.4971
11.63163163	-64.7280
11.6016016	-67.8314
11.05105105	-83.3484
10.91091091	-109.505

Salinity	
35.77927928	-2.12635
35.79129129	-11.4823
35.9034034	-15.3097
35.62712713	-15.3097
36.07957958	-22.1141
35.84134134	-25.0910
36.06356356	-27.6426
35.72722723	-28.9184
35.9094094	-30.1942
35.8093093	-32.3206
36.02552553	-44.2282
35.77927928	-44.6535
35.88938939	-47.6304
35.8093093	-50.1820
36.18568569	-55.7105
35.81131131	-58.2622
36.3058058	-65.4918
36.19569570	-66.7676
36.29379379	-70.1698
36.23373373	-71.0203
36.3038038	-76.9741
36.12962963	-78.6752
36.21171171	-80.8016
36.14964965	-81.6521
36.23573574	-83.3532
36.18968969	-85.9048
36.24174174	-87.1807
36.0095095	-96.1114
36.1096096	-98.6630
35.99149149	-98.6630
35.98748749	-103.766
36.08958959	-105.892
36.0055055	-107.168
36.07757758	-110.145
35.85335335	-112.697
36.04554555	-117.800
35.91341341	-118.650
35.96146146	-121.202
35.88138138	-122.903
35.97147147	-126.305
35.92142142	-133.110
35.96146146	-133.110
35.96346346	-157.350

Station 2

Temperature	Depth
24.98298298	0.40957
24.98798799	-11.4680
21.98498499	-24.1648
21.895	-24.9840
17.99	-45.8723
17.98601399	-47.1010
14.48451548	-63.8936
14.46453546	-66.7606
13.98501499	-72.4946
9.985014985	-74.9521
13.45654346	-75.7712
13.44155844	-77.4095

Salinity	
35.764	0.81052
35.76	-16.2105
35.97	-18.2368
35.674	-19.4526
36.054	-21.0736
35.936	-22.6947
36.114	-25.1263
35.838	-25.1263
36.138	-25.9368
35.954	-27.1526
36.136	-27.5578
36.024	-28.3684
36.214	-34.0421
36.168	-34.8526
36.196	-37.6894
36.158	-37.2842
36.18	-48.2263
36.016	-49.4421
36.204	-51.0631
36.054	-51.8736
36.26	-55.5210
36.19	-56.7368
36.27	-59.1684
36.042	-61.6
36.316	-64.0315
36.326	-70.9210
36.244	-70.9210
36.268	-73.7578
36.15	-73.3526
36.338	-76.1894

Table III-4 cont.

Station 3

Temperature	Depth
24.88288288	1.2
24.88288288	-10.8
21.97997998	-22
21.925	-23.2
17.98	-42.8
17.99399399	-44.8
15.1011011	-57.6
13.97997998	-68.8
13.97	-70.4
13.075	-82.8
12.92	-94
11.07	-132.4

Salinity	
35.77527528	0.39639
35.78528529	-12.6846
36.15765766	-23.7837
36.09159159	-25.7657
36.21971972	-32.9009
36.16566567	-33.6936
36.21171171	-36.0720
36.12362362	-38.0540
36.2057057	-46.7747
36.02752753	-48.3603
36.25175175	-53.1171
36.01951952	-55.8918
36.3018018	-58.6666
36.31581582	-68.5765
36.22972973	-68.9729
36.33383383	-70.5585
36.27777778	-71.7477
36.32982983	-71.7477
36.19769770	-82.4504
36.22572573	-83.2432
36.22572573	-94.3423
36.04954955	-110.990
36.06756757	-115.747
35.91341341	-130.018
36.07357357	-131.603

Station 4

Temperature	Depth
24.965	-1.25078
24.965	-12.9247
21.975	-26.6833
21.81	-29.1849
17.975	-50.0313
17.275	-55.0344
14.95	-63.3730
14.905	-67.5423
14.695	-68.7931
14.62	-72.1285
13.97	-79.6332
13.72872873	-82.5517
13.69369369	-91.3072
11.87687688	-110.485
11.86186186	-115.905
11.67167167	-117.156
11.56156156	-121.742
11.45145145	-122.159
11.44144144	-127.579
11.39139139	-130.081

Salinity	
35.76853707	-2.47058
35.77254509	-16.4705
35.72244489	-17.2941
35.80661323	-18.9411
35.44188377	-21.8235
35.99298597	-25.5294
35.73446894	-34.5882
35.98897796	-41.1764
35.8767535	-44.4705
36.1012024	-46.9411
36.01503006	-49.8235
35.66232465	-57.6470
36.06913828	-59.7058
35.85871743	-64.2352
36.29959920	-68.7647
36.16132265	-70.4117
36.09118236	-81.1176
36.26753507	-86.4705
36.19138277	-95.9411
36.11923848	-96.7647
36.06312625	-107.058
35.91482966	-109.529
36.08917836	-112.411
36.10721443	-115.705
35.93687375	-122.294
36.02104208	-125.176

Table III-4 cont.

Station 5

Temperature	Depth
24.91	1.18528
24.905	-11.4577
21.985	-18.1743
21.87612388	-20.9400
17.97002997	-43.8555
17.84615385	-46.2261
13.97502498	-69.9318
14.01	-72.6975
10.835	-145.395

Salinity	
35.72954092	-0.78804
35.75948104	-13.0027
35.65568862	-13.3967
35.98103792	-17.7309
35.67165669	-20.4891
36.08483034	-23.6413
35.60978044	-24.8233
36.11676647	-26.7934
36.15469062	-34.2798
35.9770459	-37.8260
36.13872255	-42.9483
35.84730539	-49.6467
36.18263473	-55.9510
35.8512974	-60.6793
36.27844311	-65.8016
36.12275449	-67.7717
36.19660679	-69.3478
36.12275449	-70.9239
36.32435130	-75.5521
36.14071856	-87.8668
36.15668663	-95.3532
36.01497006	-97.7173
36.07884232	-99.2934
35.94710579	-107.173
36.06686627	-111.902
35.95508982	-117.024
35.97305389	-118.994
35.91916168	-120.570
35.98303393	-123.722
35.93512974	-125.692
35.9770459	-130.815
35.96307385	-138.695
35.9251497	-139.483
35.94311377	-142.241
35.93912176	-143.423
35.9271457	-144.211
35.96506986	-145

Station 6

Temperature	Depth
24.985	-0.41724
24.94	-13.3519
21.97	-21.6969
21.94789579	-22.1142
17.97494990	-47.9836
17.745	-49.2354
13.985	-75.5221
14.035	-76.3566
11.185	-127.678
10.655	-176.913
10.565	-180.668

Salinity	
35.708	0.82488
35.772	-13.1981
36.072	-21.0345
35.89	-25.5714
36.074	-28.4585
35.904	-29.6958
36.136	-37.9447
36.028	-45.3686
35.758	-47.4308
36.166	-58.1543
35.866	-62.2788
36.3	-72.1774
36.124	-74.2396
36.272	-75.8894
35.858	-87.4377
36.122	-92.3870
35.974	-99.3986
36.058	-101.048
35.914	-174.050
35.848	-177.350
35.89	-178.587

Table III-4 cont.

Station 7		Station 8	
Temperature	Depth	Temperature	Depth
24.75	-0.38964	24.95795796	0.81773
24.825	-11.2997	24.94294294	-9.81280
21.96	-19.8719	21.97497498	-22.0788
21.7	-21.0408	21.795	-24.1231
17.955	-45.1989	17.98	-42.1133
17.88	-45.9782	17.99100899	-43.7487
13.955	-71.6948	13.98001998	-69.9162
13.915	-73.6430	13.99600400	-73.1871
10.805	-140.272	13.07692308	-83.0000
Salinity			
35.72122122	-0.78571		
35.81331331	-12.9642		
35.19669670	-16.8928		
36.07357357	-20.8214	Salinity	
35.52102102	-22.7857	35.77327327	-1.61165
36.19569570	-26.3214	35.76926927	-16.1165
35.79529530	-32.2142	36.16566567	-26.9951
36.06756757	-39.6785	36.02952953	-29.8155
35.99749750	-41.6428	36.18768769	-32.6359
36.15965966	-46.7500	36.16566567	-33.4417
35.69119119	-51.0714	36.21971972	-35.4563
36.06556557	-53.4285	36.16766767	-37.0679
35.99549550	-55.3928	36.21171171	-38.2766
36.04154154	-57.3571	36.12562563	-40.2912
35.8053053	-59.7142	36.2077077	-47.1407
36.25975976	-64.8214	36.1036036	-48.3495
36.12562563	-66.7857	36.24374374	-52.7815
36.28178178	-69.1428	36.26576577	-60.4368
36.2017017	-70.3214	36.11761762	-60.8398
36.29179179	-73.4642	36.29179179	-63.2572
36.04354354	-78.5714	36.2097097	-65.6747
36.15565566	-88.7857	36.31581582	-70.5097
36.01151151	-92.3214	36.27977978	-70.5097
36.05355355	-93.5000	36.31581582	-78.1650
35.99549550	-98.2142	36.13763764	-80.9854
36.09959960	-104.107	36.24374374	-83.8058
36.06356356	-108.821		
35.99549550	-109.607		
36.04554555	-112.357		
35.97747748	-113.535		
36.01551552	-118.25		
35.97947948	-119.428		
36.0095095	-122.964		
35.93343343	-128.071		
35.99149149	-131.607		
35.93743744	-133.178		
35.96346346	-135.142		
35.92142142	-140.642		

Table III-4 cont.

Station 9

Temperature	Depth
24.95295295	0.39285
24.96796797	-7.07142
21.97997998	-20.0357
21.88611389	-21.6071
18.8041958	-36.5357
18.8041958	-38.8928
17.97502498	-42.4285
19.095	-43.6071
13.98	-69.5357
13.99	-71.1071
11.595	-110

Salinity	
35.702	-0.78853
35.734	-3.54838
35.74	-9.06810
35.726	-11.8279
35.892	-13.7992
35.522	-15.7706
36.084	-16.9534
35.876	-17.7419
36.12	-26.0215
35.8	-30.7526
36.188	-40.2150
35.714	-48.4946
36.162	-53.2258
35.896	-56.7741
36.15	-58.7455
35.996	-59.9283
36.238	-66.6308
36.096	-68.2078
36.188	-70.9677
36.07	-71.7562
36.296	-75.6989
36.25	-79.2473
35.838	-82.4014
36.138	-87.1326
36.006	-89.4982
36.096	-93.0465
36.006	-94.2293
36.092	-98.1720
36.036	-100.537
36.07	-102.508
36.038	-108.817
35.946	-109.605
36.104	-110.394

Station 10

Temperature	Depth
25.006993	0.39541
24.98201798	-9.48997
21.97502498	-18.5845
21.875	-20.1661
18.83	-35.9828
18.785	-39.9369
17.97	-45.4727
16.36736737	-51.7994
16.23223223	-54.1719
16.13213213	-58.1260
14.78578579	-62.4756
14.44544545	-66.8252
14.02097902	-74.7335
12.01798202	-96.8767
11.04395604	-126.928
10.96903097	-136.418
10.99400599	-138.790

Salinity	
35.69030919	-0.78409
35.72077922	-12.1534
35.96253746	-15.6818
35.48101898	-17.6420
35.99650350	-22.3465
35.75874126	-23.9147
36.14835165	-26.2670
35.504995	-27.4431
36.12837163	-31.7556
36.19430569	-39.5965
35.78471528	-46.2613
36.06043956	-49.7897
35.69880120	-51.3579
36.24025974	-56.0625
35.84265734	-59.1988
36.09640360	-60.7670
35.89860140	-62.3352
36.28821179	-69.0000
36.16833167	-71.3522
36.31218781	-74.8806
36.21028172	-82.3295
35.88661339	-90.1704
36.11238761	-93.6988
35.95254745	-95.6590
36.09240759	-98.4034
36.06643357	-107.812
35.9085914	-121.926
35.94055944	-123.102
35.98251748	-128.590
35.96853147	-136.823
36.0004995	-137.215

Table III-4 cont.

Station 11		Station 12	
Temperature	Depth	Temperature	Depth
25.02197802	0.39795	24.89789790	-0.39759
24.45754246	-14.3265	24.93793794	-6.75903
21.97502498	-21.0918	21.98498499	-21.0722
21.82882883	-23.0816	21.76123876	-23.0602
17.97997998	-43.3775	19.17882118	-32.6024
		19.16883117	-35.7831
17.91391391	-45.3673	17.97002997	-44.5301
16.51251251	-51.3367		
13.95995996	-73.2244	18.02097902	-46.5180
		14.75424575	-63.6144
13.92607393	-74.4183	14.74925075	-66.3975
11.66333666	-96.3061	14.3046953	-69.5783
11.65334665	-99.0918	14.28971029	-71.5662
11.57842158	-101.081	13.96003996	-73.9518
11.56843157	-106.653		
11.26873127	-115.010	14.00698603	-75.9397
11.34865135	-115.408	13.96207585	-80.3132
11.34365634	-118.193	12.70958084	-89.0602
		12.52994012	-98.6024
Salinity		Salinity	
35.71721722	-1.60824		
35.71321321	-6.83505	35.71678322	-0.79518
35.63513514	-10.0515	35.75874126	-12.3253
36.16766767	-21.3092	35.86263736	-14.7108
36.18968969	-36.1855	35.77272727	-15.5060
36.13763764	-37.7938	35.9045954	-18.6867
36.2037037	-46.2371	35.63086913	-18.6867
36.12362362	-45.8350	35.99850150	-22.2650
36.2057057	-49.0515	35.89660340	-23.4578
35.81931932	-53.4742	36.14635365	-26.6385
36.15965966	-57.4948	35.97252747	-30.2168
35.93343343	-59.5051	36.14035964	-31.0120
36.13363363	-61.5154	36.22027972	-35.7831
35.99349349	-69.9587	36.2022977	-39.3614
36.28178178	-74.3814	35.87862138	-42.1445
36.13763764	-78.4020	36.12637363	-46.5180
36.24174174	-80.8144	36.13036963	-50.0963
36.08758759	-82.0206	35.54095904	-53.2771
36.16766767	-84.4329	36.19230769	-58.0481
36.06556557	-90.4639	35.81668332	-61.6265
35.96546547	-91.2680	36.34815185	-68.3855
36.11761762	-94.0824	36.08441558	-69.5783
35.81331331	-96.4948	36.3081918	-72.7590
36.05955956	-101.721	36.16633367	-75.9397
36.0095095	-104.134	36.33416583	-79.9156
36.06756757	-109.762	35.87262737	-83.8915
35.92542543	-110.969	36.19430569	-93.8313
36.02152152	-115.793	36.13836164	-99
35.96546547	-118.608	36.19230769	-99.3975

Table III-5

SALINITY WITH DEPTH AND TEMPERATURE WITH DEPTH AT HOSPITAL ROCK, CRUISE 76G8-III

Station 1

Temperature	Depth
24.67267267	0
24.68768769	-5.95
24.66766767	-6.8
24.65265265	-26.77
22.53053053	-36.55
22.41941942	-39.1
19.39139139	-48.45
19.3013013	-51.85
18.58558559	-53.97
18.62424850	-56.52
17.26152305	-65.45
17.59218437	-65.02
17.56212425	-67.15

Salinity	
35.938	-2.125
35.938	-18.27
35.888	-18.7
35.938	-19.55
35.94	-26.35
35.952	-28.9
35.928	-30.17
36.238	-36.12
36.108	-38.25
36.284	-39.1
35.598	-42.07
35.92	-43.35
35.902	-44.2
35.952	-45.05
35.92	-45.9
35.956	-46.32
35.934	-47.6
36.262	-46.75
35.88	-56.52
36.14	-58.65
36.006	-60.77
36.256	-62.47
36.032	-64.6
36.13	-65.87
36.066	-66.72
36.442	-68
36.288	-68.42

Station 2

Temperature	Depth
24.72772773	-0.42352
24.69269269	-0.42352
24.66266266	-19.4823
24.66266266	-27.1058
22.05505506	-32.6117
21.96793587	-34.3058
21.63727455	-36.0000
18.34068136	-52.9411
18.00501002	-52.9411
17.2264529	-57.1764
16.10420842	-65.2235
16.08416834	-65.6470
16.06913828	-67.3411
16.06412826	-72.0000

Salinity	
35.9074074	-1.69411
35.92742743	-1.69411
35.94344344	-11.4352
35.96346346	-14.4
35.93543544	-14.8235
35.96146146	-15.2470
35.98748749	-28.3764
35.93143143	-28.8
36.19769770	-30.9176
35.86736737	-33.4588
36.29779780	-35.5764
36.02152152	-38.9647
36.22572573	-40.6588
36.19169169	-41.9294
36.23173173	-43.2000
36.11561562	-44.0470
36.24174174	-46.5882
36.09359359	-48.7058
36.19569570	-50.4000
36.1056056	-51.2470
36.19969970	-54.2117
35.67917918	-55.4823
36.22772773	-58.8705
36.14564565	-60.5647
36.27377377	-61.8352
36.13763764	-63.5294
36.16366366	-65.2235
36.14764765	-65.6470
36.35385385	-70.3058

Table III-5 cont.

Station 3

Temperature	Depth
24.81781782	0.85714
24.74274274	0.42857
24.73773774	-0.85714
24.7027027	-0.85714
24.71771772	-2.57142
24.66266266	-3
24.65265265	-3.42857
24.64764765	-5.14285
24.61761762	-19.2857
24.45745746	-21.4285
22.005005	-27.8571
21.94	-30
21.43	-33
19.26	-45
17.74374374	-50.1428
15.85185185	-64.7142
15.84184184	-68.1428
15.77677678	-72.8571
15.77177177	-70.2857
15.76676677	-75

Salinity	
35.94544545	-0.84269
35.92942943	-8.84831
35.93143143	-10.5337
35.92342342	-10.5337
35.92342342	-11.7977
35.92742743	-12.2191
35.92542543	-13.4831
35.92542543	-20.6460
35.92142142	-22.7528
35.91541542	-23.5955
35.86736737	-24.0168
36.09159159	-25.7022
36.28978979	-29.4943
36.18968969	-30.3370
36.34184184	-31.6011
36.29979980	-38.7640
36.29779780	-40.0280
36.3078078	-46.3483
36.35585586	-57.3033
36.13963964	-59.8314
36.31981982	-60.6741
36.29179179	-65.3089
36.42392392	-66.9943
36.42392392	-70.7865
36.36786787	-71.2078
36.38388388	-72.0505
36.38588589	-73.3146
36.39589590	-75.8426

Station 4

Temperature	Depth
24.63	0.42105
24.61	-27.7894
22.565	-34.9473
22.26426426	-38.3157
20.57257257	-40.4210
20.08208208	-44.2105
19.99699700	-45.4736
19.96196196	-48.4210
19.87187187	-49.6842
19.61161161	-51.3684
18.5005005	-54.7368
18.19419419	-57.6842
17.87887888	-58.5263
17.09309309	-60.2105
16.98298298	-62.3157
16.93293293	-64.8421
16.85285285	-66.1052
16.76776777	-69.8947

Salinity	
35.93056943	-1.27810
35.94855145	-28.1183
35.96853147	-29.8224
35.85664336	-32.3786
35.98451548	-37.0650
35.53496504	-38.3431
35.67082917	-39.6213
35.6068931	-40.4733
36.07042957	-42.6035
36.04845155	-44.3076
36.12637363	-45.1597
36.06643357	-45.5857
36.26623377	-50.2721
36.24225774	-52.8284
35.76073926	-55.3846
35.84865135	-57.0887
35.55894106	-57.9408
35.86663337	-60.0710
35.74275724	-60.0710
35.78071928	-60.4970
35.73476523	-61.7751
36.27622378	-67.3136
36.21428571	-69.0177
36.34815185	-71.1479
36.3001998	-72.0000

Table III-5 cont.

Station 5

Temperature	Depth
24.70459082	-0.75
24.70958084	-7.875
24.69461078	-7.875
24.68463074	-12
24.67465070	-13.12
24.63972056	-15
24.61976048	-18.75
24.54990020	-20.62
23.7015968	-22.5
23.03792415	-24.37
22.86327345	-24.37
22.84331337	-25.12
22.43413174	-25.87
22.38922156	-27
22.34930140	-26.62
22.33433134	-27.75
22.07984032	-28.5
19.99600798	-36
19.7015968	-37.5
19.3772455	-39
19.05788423	-40.87
18.70359281	-41.62
16.76223776	-52.87
16.46753247	-54
16.21778222	-55.87
16.16283716	-56.25
16.15284715	-58.12
15.95304695	-61.12

Salinity

35.86926148	-0.375
35.86726547	-12
35.86327345	-12.37
35.86926148	-18.37
35.85528942	-19.5
35.61377246	-22.5
35.90319361	-24.75
36.09481038	-28.12
35.84930140	-30.37
35.87125749	-32.62
36.06087824	-34.12
36.05289421	-36
35.81137725	-42.75
36.06886228	-46.12
36.1766467	-49.5
35.96706587	-52.12
36.1766467	-54.75
36.28842315	-58.5
36.3023952	-61.12

Station 6

Temperature	Depth
24.62762763	0
24.62762763	-26.7305
24.03703704	-27.5928
24.55255255	-28.4550
21.99499500	-32.7664
21.75250501	-34.9221
18.30561122	-53.4610
18.28056112	-54.7544
17.99498998	-56.0479
17.38338338	-57.7724
15.96196196	-66.3952
15.89689690	-68.1197
15.87687688	-68.5503
15.85185185	-71.5688

Salinity

35.91883768	-1.30120
35.92084168	-15.1807
35.94288577	-15.6144
36.00300601	-27.3253
35.83867735	-27.7590
36.30360721	-29.9277
35.71442886	-28.6265
36.35571142	-34.2650
35.83867735	-39.4698
36.21943888	-44.2409
36.01102204	-47.2771
36.09719439	-49.0120
35.99699399	-53.3493
36.251503	-55.5180
35.68036072	-56.8192
36.29959920	-58.9879
36.20741483	-59.4216
36.05310621	-62.8915
36.43386774	-63.3253
36.16533066	-63.3253
36.19138277	-64.6265
35.94889780	-65.9277
36.31162325	-68.5301
36.26953908	-69.3975
36.38577154	-72.8674

Table III-5 cont.

Station 7

Temperature	Depth
35.88338338	0.428571
35.85935936	0.857142
35.87137137	-6
35.84934935	-6
35.87937938	-7.285714
35.83133133	-7.285714
35.85335335	-8.571428
35.86136136	-9
35.87337337	-19.71428
35.79529530	-21.85714
35.52502503	-22.28571
35.49299299	-22.71428
35.51901902	-23.14285
35.52102102	-24
35.7072072	-24.42857
35.63513514	-24.85714
35.68718719	-26.14285
35.79329329	-27
35.74324324	-27.85714
36.13163163	-31.28571
35.79329329	-32.57142
35.82932933	-33.42857
35.73723724	-33.85714
35.84534535	-36
35.7032032	-36.42857
35.85135135	-39
35.83333333	-40.28571
35.9094094	-41.57142
35.89739740	-43.28571
35.94144144	-45.42857
36.0095095	-45.85714
35.16266266	-47.14285
35.74924925	-49.71428
35.67917918	-51
36.03553554	-51.85714
36.04354354	-52.71428
36.11761762	-54
35.98148148	-54.85714
36.01351351	-55.28571
35.92542543	-56.57142
36.21371371	-59.57142
36.18568569	-60.85714
36.24374374	-62.14285
36.02952953	-63.42857
36.33583584	-68.14285
36.35985986	-72.42857
36.31381381	-72.85714
36.31981982	-73.71428
36.3018018	-73.71428
36.31981982	-75.42857
36.32582583	-76.71428
36.39589590	-77.14285

Station 8

Temperature	Depth
24.805	0.42553
24.805	-2.97872
24.755	-5.53191
24.76	-7.23404
24.625	-9.78723
24.575	-22.1276
22.98	-25.5319
22.97	-26.8085
22.06	-30.6382
22.04	-31.4893
17.97	-47.2340
17.855	-48.5106
17.73	-49.3617
17.435	-52.3404
17.27	-56.1702
16.25	-63.4042
16.21	-65.5319
15.81	-73.1914
15.79	-73.1914
15.79	-74.4680
15.745	-80.0000

Salinity

35.87937938	0
35.87937938	-3.40425
35.86536537	-3.82978
35.87737738	-4.68085
35.84934935	-8.93617
35.86536537	-8.93617
35.87337337	-10.2127
35.87537538	-14.0425
35.85135135	-23.8297
36.11761762	-25.1063
36.25975976	-31.0638
36.27377377	-32.3404
36.26776777	-33.1914
36.2097097	-40.8510
36.29579580	-41.7021
36.24374374	-42.1276
36.26376376	-43.4042
36.24974975	-43.8297
36.25775776	-44.6808
36.27377377	-50.2127
36.3018018	-57.8723
36.34584585	-60.8510
36.30186186	-69.7872
36.35585586	-71.9148
36.37387387	-73.6170
36.37587588	-75.7446
36.36186186	-77.8723

Table III-5 cont.

Station 9

Temperature	Depth
24.68768769	-0.43103
24.69269269	-15.5172
24.66266266	-21.1206
22.79079079	-30.6034
23.03603604	-31.8965
21.98498499	-34.9137
21.90781563	-36.2068
18.3757515	-56.4655
16.91791792	-64.6551
16.84284284	-68.5344
16.57757758	-70.2586
16.47747748	-74.5689
16.36236236	-75.4310

Salinity	
35.95490982	-0.84269
35.95290581	-13.9044
35.97094188	-16.4325
35.9769539	-18.5393
35.97494990	-21.4887
36.18336673	-28.2303
36.04509018	-29.9157
36.52404810	-32.4438
35.95891784	-35.8146
36.1252505	-37.5
35.79859719	-38.3426
36.15531062	-41.7134
36.0771543	-42.5561
36.24148297	-45.9269
36.13326653	-47.1910
36.2254509	-53.5112
36.18336673	-54.7752
36.23547094	-56.0393
36.09318637	-57.7247
36.24749499	-60.6741
36.14529058	-61.5168
36.27755511	-63.2022
36.30561122	-64.8876
36.33967936	-66.9943
36.26753507	-68.2584
36.33967936	-70.7865
36.3016032	-73.3146
36.43186373	-72.8932
36.35571142	-74.1573

Station 9C

Temperature	Depth
24.59481038	0.75376
24.59481038	-22.6130
23.79640719	-26.7587
23.20758483	-29.7738
23.07285429	-30.9045
22.91816367	-31.2814
20.20558882	-37.6984
19.83133733	-38.8190
19.4520958	-39.9497
19.38223553	-41.8341
19.2774451	-42.5879
19.19261477	-45.6030
18.70858283	-47.8643
18.56886228	-48.9949
17.3000997	-58.4170
17.16550349	-59.5477
17.03090728	-61.4321
16.57726820	-62.1859
16.51246261	-64.0703

Salinity	
35.94255744	4.97738
35.95054945	-18.3894
35.97052947	-19.5201
35.93256743	-19.8969
36.08041958	-21.4045
36.2062937	-23.6658
36.06843157	-25.5502
36.23626374	-27.4346
35.8026973	-29.3190
36.06793207	-33.5653
36.12787213	-34.6959
36.12587413	-36.9572
36.22777223	-37.7110
36.18981019	-39.9723
36.29970030	-41.1030
36.32367632	-45.2487
36.26373626	-46.0025
36.26573427	-50.5251
35.93313373	-57.6359
36.15668663	-59.5703
36.21057884	-61.4547
36.13073852	-61.8316
36.24451098	-64.4698

Table III-5 cont.

Station 10

Temperature	Depth
24.6776	-0.84153
24.6876	-3.36612
24.6376	-15.9890
24.6676	-21.0382
22.0050	-31.9781
21.74	-34.0819
18.035	-53.8579
17.9539	-56.3825
16.4974	-63.1147
16.4524	-65.6393
16.1021	-73.2131
15.7667	-74.8961
16.0020	-74.0546
15.9919	-76.1584

Salinity	
35.8326	-0.83695
35.8386	-2.92934
35.8707	-5.44021
35.9068	-7.95108
35.9148	-17.1576
35.9969	-20.9239
36.0551	-23.0163
36.0270	-24.2717
36.0951	-25.9456
35.8927	-28.0380
36.2494	-30.9673
35.5941	-33.0597
35.9008	-34.7336
35.8146	-35.1521
36.1873	-37.6630
36.1272	-38.5000
36.3016	-39.3369
36.0170	-40.1739
36.2394	-42.6847
36.2034	-43.5217
36.2454	-45.6141
36.1432	-46.0326
36.2454	-47.7065
36.0851	-49.3804
36.1873	-50.6358
35.9849	-51.0543
36.0430	-52.7282
35.8667	-54.8206
35.9989	-63.6066
36.2695	-66.1195
36.2234	-67.3750
36.3456	-74.0766
36.1292	-76.1630

Station 11

Temperature	Depth
24.61	0.42372
24.605	-25.8474
22.785	-35.1694
22.5495	-37.2881
19.4164	-48.3050
19.6416	-49.5762
19.3863	-50.0000
19.3663	-50.4237
19.3513	-52.5423
18.7907	-55.0847
18.7047	-55.9322
18.6346	-58.0508
18.5695	-60.1694
16.9629	-70.7627
16.9229	-75.0000

Salinity	
35.8443	-1.59574
35.8537	-6.78191
35.8584	-24.3351
35.8443	-25.5319
35.9077	-27.9255
35.6304	-29.5212
36.1991	-31.9148
35.6351	-34.3085
36.4177	-34.3085
35.9477	-35.1063
36.1028	-36.3031
35.8631	-37.8989
36.2297	-37.8989
36.2085	-38.2978
36.2179	-39.0957
36.1310	-40.2925
36.2132	-41.0904
36.1827	-42.2872
36.2062	-43.0851
36.1122	-51.8617
36.1427	-53.8563
36.2814	-55.0531
36.2955	-56.6489
35.8819	-58.2446
36.2508	-62.2340
36.1545	-62.2340
36.3072	-63.4308
36.2649	-64.2287
36.2884	-65.0265
36.2250	-67.0212
36.3918	-70.2127

Station 12

Temperature	Depth
24.5975	-0.42134
24.5925	-27.3876
24.3423	-31.1797
23.0310	-34.5505
22.4104	-35.3932
22.03	-37.5
19.505	-46.7696
19.37	-51.4044
18.74	-55.6179
18.435	-57.3033
18.5941	-59.4101
18.5040	-61.5168
17.7324	-62.3595
17.1713	-68.2584
16.8557	-69.9438
16.6553	-74.5786

Salinity	
35.9254	-2.07182
35.9394	-2.07182
35.9474	-27.3480
35.9054	-28.1767
35.9734	-30.6629
35.7772	-33.9779
36.1276	-36.0497
35.5310	-37.2928
36.1376	-41.0220
36.1356	-43.0939
36.2137	-43.5082
35.9294	-45.5801
36.2317	-46.8232
36.3158	-51.3812
36.2937	-52.6243
36.1056	-54.6961
36.2297	-55.5248
36.1416	-56.7679
36.2777	-60.4972
35.7672	-62.1546
36.2017	-64.2265
36.1856	-65.0552
36.2537	-65.8839
36.2117	-67.9558
36.0995	-68.7845
36.3038	-70.0276
36.3178	-71.2707
36.3118	-72.5138
36.3858	-75

Table III-6

SALINITY WITH DEPTH AND TEMPERATURE WITH DEPTH AT SOUTHERN BANK, CRUISE 76G8-III

Station 1		Station 2	
Temperature	Depth	Temperature	Depth
24.61761762	0.42245	24.64764765	0.42408
24.61261261	-1.68983	24.64264264	-5.08900
24.56256256	-2.95721	24.58258258	-5.93717
24.5075075	-21.1229	24.58258258	-18.2356
23.1061061	-24.9251	22.45045045	-27.5654
23.01501502	-27.0374	22.4044044	-30.1099
19.57657658	-45.2032	19.31131131	-47.9214
18.57557558	-47.3155	18.64064064	-50.0418
18.62424850	-49.8502	18.60921844	-52.5863
18.55911824	-50.2727	18.26853707	-59.3717
18.48897796	-56.1871	17.28156313	-64.8848
18.41883768	-57.4545	17.08116232	-69.5497
16.17434870	-67.5935	16.43987976	-72.9424
16.12925852	-68.0160	16.24448898	-80.5759
16.06913828	-69.7058	Salinity	
16.03406814	-72.2406		
16.00400802	-77.3101	35.92342342	-0.41968
15.99398798	-78.5775	35.92142142	-6.29533
		35.88738739	-6.29533
		35.94144144	-18.4663
		35.99149149	-21.4041
		35.94344344	-23.0829
		36.19969970	-26.4404
		36.1036036	-28.1191
		36.21771772	-30.2176
		36.11361361	-30.6373
		36.19369369	-31.4766
		36.14764765	-31.8963
		36.19969970	-33.1554
		36.06956957	-35.2538
		36.2077077	-39.0310
		36.17167167	-40.2901
		36.22572573	-42.3886
		36.17767768	-43.6476
		36.28578579	-48.6839
		36.11361361	-49.5233
		36.3098098	-54.1398
		36.18568569	-59.1761
		36.23573574	-59.5958
		36.18168168	-60.0155
		36.22572573	-61.2746
		36.18768769	-62.1139
		36.22372372	-63.3730
		36.08558559	-64.2124
		36.31581582	-67.9896
		36.13163163	-70.9274
		36.34184184	-74.2849
		36.3098098	-76.8031
		36.39389389	-80.5803

Table III-6 cont.

Station 3

Temperature	Depth
24.77277277	0.43315
24.68268268	-4.33155
24.66266266	-12.5614
24.71271271	-18.1925
22.29029029	-29.4545
22.18918919	-31.6203
18.46046046	-52.4117
18.32	-54.5775
16.535	-71.4705
16.395	-81

Salinity

35.922	-0.43315
35.982	-19.4919
35.888	-20.7914
36.304	-35.5187
36.08	-35.9518
36.234	-40.7165
36.168	-41.1497
36.232	-45.0481
36.164	-47.2139
36.256	-51.1122
36.048	-51.9786
36.24	-55.0106
36.144	-57.1764
36.292	-63.2406
36.184	-65.4064
36.384	-81

Station 4

Temperature	Depth
24.845	-0.85635
24.7	-2.14088
24.725	-18.4116
23.925	-20.5524
24.27	-24.4060
22.375	-28.6878
22.32932933	-30.8287
19.83683684	-42.3895
19.86186186	-44.5303
18.44544545	-52.2375
18.49050949	-55.2348
18.5004995	-57.3756
16.66733267	-68.9364
16.52747253	-71.0773
16.49250749	-72.7900
16.48751249	-75.3591
16.53246753	-74.9309
16.49750250	-77.9281

Salinity

35.992	-1.66666
35.868	-2.91666
36.004	-18.75
36.086	-19.5833
35.68	-20.8333
36.514	-22.0833
36.64	-24.1666
35.632	-30.4166
36.21	-35.8333
35.998	-36.2500
36.08	-37.9166
35.99	-38.7500
36.206	-42.0833
36.138	-42.5000
36.312	-45.4166
36.156	-48.7500
36.238	-50.4166
36.102	-52.0833
36.326	-56.2500
36.13	-60.0000
36.306	-68.7500
36.348	-70.4166
36.36	-71.2500
36.364	-73.3333
36.382	-75.4166
36.396	-76.2500

Table III-6 cont.

Station 5

Temperature	Depth
24.725	0.42631
24.7	-14.9210
24.69	-19.1842
24.575	-21.7421
22.545	-27.2842
22.5095095	-29.4157
21.003003	-35.3842
19.28628629	-47.3210
18.58558559	-51.1578
18.43043043	-52.0105
18.565	-54.1421
16.485	-68.2105
16.445	-71.1947
16.325	-72.9
16.245	-74.1789
16.225	-77.5894
16.215	-80.5736

Salinity	
35.93543544	-0.42857
35.93543544	-11.5714
35.94144144	-14.5714
35.92942943	-15.4285
35.93743744	-17.1428
35.93743744	-19.7142
35.9054054	-21.4285
35.92742743	-23.1428
35.43093093	-24.4285
35.99349349	-29.1428
36.07357357	-31.2857
35.81531532	-34.2857
35.83933934	-35.1428
35.8013013	-36
36.15765766	-39.4285
36.09959960	-49.7142
35.92342342	-51.8571
35.95545546	-53.5714
36.06956957	-54.4285
35.98348348	-55.2857
36.14364364	-57.8571
36.01151151	-58.7142
36.24174174	-67.7142
36.27377377	-69
36.22372372	-69.4285
36.34184184	-72
36.29579580	-73.2857
36.31381381	-74.1428
36.29579580	-75.4285
36.35985986	-80.1428

Station 8

Temperature	Depth
24.8256513	0
24.83066132	-3.05319
24.78557114	-5.67021
24.78557114	-7.85106
24.76553106	-7.85106
24.73046092	-20.5
22.69639279	-28.3510
22.71471471	-30.5319
18.39039039	-53.6489
18.32	-56.2659
16.435	-70.6595
16.38	-71.5319
16.355	-73.7127
16.315	-81.5638

Salinity	
35.97147147	-1.30851
35.96746747	-5.23404
35.93543544	-6.10638
35.96146146	-8.72340
35.94944945	-9.59574
35.96746747	-21.8085
35.45295295	-23.9893
36.09159159	-29.2234
36.02952953	-30.0957
36.19169169	-32.2765
35.98348348	-33.5851
36.06556557	-35.7659
35.81731732	-37.5106
36.24174174	-40.5638
35.95345345	-48.8510
36.07157157	-51.0319
35.94144144	-51.9042
36.13563564	-55.3936
35.89339339	-57.5744
36.14364364	-61.9361
36.02952953	-62.8085
36.25975976	-67.6063
35.9034034	-71.9680
36.18968969	-73.7127
36.33383383	-78.5106
36.32382382	-79.8191
36.36186186	-82.8723

Table III-6 cont.

Station 9

Temperature	Depth
24.74774775	-1.62303
24.72272272	-19.8821
23.79179179	-22.7225
23.84184184	-24.7513
22.2052052	-29.6204
22.004004	-31.6492
19.72672673	-41.3874
19.76176176	-43.0104
18.4054054	-50.7198
18.46446446	-53.1544
18.48948949	-54.3717
16.68268268	-64.9214
16.49749750	-68.5732
16.42242242	-75.8769

Salinity	
35.91883768	0
35.96893788	-4.55882
35.96492986	-12.4331
35.98096192	-16.5775
35.75250501	-19.0641
36.502004	-22.7941
38.002002	-24.0374
36.41241241	-23.2085
35.98198198	-29.0106
35.99349349	-32.3262
36.06756757	-33.5695
35.84934935	-36.4705
36.11361361	-38.5427
36.05155155	-40.6149
36.23573574	-41.0294
36.14764765	-42.2727
36.2037037	-44.3449
35.93743744	-47.2459
36.0055055	-47.6604
35.94744745	-49.3181
36.27777778	-53.0481
35.94344344	-55.5347
36.15765766	-57.6069
36.06356356	-59.6791
36.2057057	-61.7513
36.01551552	-62.5802
36.38388388	-71.6978
36.36186186	-72.9411
36.37987988	-76.6711

Station 10

Temperature	Depth
24.73773774	-0.43548
24.73273273	-7.40322
24.68268268	-10.0161
24.65265265	-16.5483
22.3003003	-27.4354
22.18418418	-29.6129
18.54054054	-50.5161
18.48548549	-53.1290
18.39039039	-55.3064
18.25525526	-56.1774
18.21	-58.7903
17.205	-64.8870
17	-69.6774
16.165	-72.7258
16.135	-74.4677
16.11	-76.6451
16.095	-80.5645

Salinity	
35.944	-0.42631
35.952	-18.3315
35.998	-18.7578
35.692	-20.8894
35.904	-22.1684
35.846	-22.5947
35.942	-23.8736
35.908	-24.3
36.136	-28.1368
35.994	-30.2684
36.102	-31.1210
35.708	-33.2526
36.106	-36.6631
35.892	-37.5157
35.976	-45.1894
36.04	-46.4684
36.014	-47.7473
36.15	-48.6
36.042	-49.8789
36.232	-54.5684
36.13	-56.7
36.142	-57.5526
35.964	-60.9631
36.23	-67.7842
35.874	-70.7684
36.222	-73.7526
36.31	-77.1631
36.374	-80.1473

Table III-6 cont.

Station 11

Temperature	Depth
24.7027027	0
24.63763764	-11.3837
24.65265265	-14.0108
24.61261261	-16.2
24.59759760	-13.5729
24.57757758	-17.0756
23.47147147	-19.2648
22.48396794	-27.1459
20.46492986	-38.0918
20.02905812	-38.5297
19.05711423	-48.1621
18.54	-53.8540
18.37	-56.4810
17.475	-62.6108
17.15	-65.6756
17.12	-69.1783
16.13	-74.4324
16.05	-77.0594
16.035	-80.5621

Salinity	
35.94544545	-0.41752
35.94144144	-8.76804
35.95945946	-10.8556
35.94544545	-11.6907
35.96146146	-15.4484
35.97547548	-16.2835
35.96346346	-17.5360
35.97547548	-18.3711
35.95745746	-20.0412
35.98548549	-27.5567
36.13563564	-30.0618
36.13763764	-32.1494
36.14964965	-33.4020
35.89339339	-35.0721
36.09759760	-37.1597
36.09159159	-46.3453
36.2037037	-47.5979
36.13563564	-48.8505
36.27377377	-49.6855
36.24774775	-52.1907
36.25975976	-53.0257
36.26776777	-54.2783
36.24374374	-63.8814
36.23373373	-64.7164
36.24574575	-65.1340
36.23173173	-65.9690
36.34384384	-68.0567
36.2037037	-71.3969
36.35385385	-78.0773
36.37187187	-79.7474

Station 12

Temperature	Depth
24.68036072	-1.28
24.59519038	-19.2
22.65631263	-25.7
22.67434870	-28.2
19.86873748	-39.8
19.60821643	-41.5
19.23246493	-48.4
18.48597194	-51.8
18.56913828	-54.8
16.17935872	-80.1

Salinity	
35.9268537	-1.62
35.93286573	-18.22
36.07114228	-21.06
35.92084168	-22.27
36.26753507	-24.30
35.99098196	-27.54
36.11523046	-31.18
35.84869739	-33.21
36.03907816	-35.23
35.94488978	-36.85
36.22144289	-45.36
36.19138277	-46.98
36.27755511	-48.19
35.86873748	-48.60
36.30561122	-53.05
36.20941884	-55.39
36.39579158	-57.10
36.00901804	-59.13
36.23346693	-59.94
36.19739479	-60.34
36.25551102	-62.37
36.19138277	-62.77
36.43186373	-64.39
36.26152305	-64.80
36.28957916	-65.20
36.26352705	-67.23
36.4018036	-68.04
36.16533066	-68.44
36.33967936	-73.30
36.2274549	-75.73
36.37174349	-78.57

Table III-6 cont.

Cruise 76G8-III
Time Series Station A

Hour 1		Hour 2	
Temperature	Depth	Temperature	Depth
24.3502994	0	24.34265734	-0.77
24.34530938	-1.5323	24.33766234	-4.62
24.33532934	-2.2985	24.32767233	-10.78
24.33532934	-16.855	24.32767233	-16.94
24.3502994	-19.537	24.34265734	-20.405
24.72455090	-21.452	24.34765235	-21.175
24.59481038	-22.601	24.62737263	-23.1
24.29041916	-23.751	24.43756244	-24.255
23.98602794	-24.134	24.41258741	-24.64
20.58483034	-33.328	24.03296703	-25.41
20.56487026	-33.711	24.01298701	-26.18
20.2255489	-34.860	23.92307692	-25.795
20.21057884	-35.626	23.5034965	-26.565
20.00598802	-36.009	23.47852148	-27.335
19.98602794	-36.393	22.78421578	-27.72
19.86626747	-37.159	22.39460539	-30.03
19.68163673	-38.691	19.88622754	-37.73
19.6766467	-38.691	19.88123753	-38.115
19.56686027	-39.457	19.78143713	-38.115
19.51696607	-39.840	19.5518962	-40.04
19.39221557	-40.606	19.40718563	-40.81
19.23253493	-41.756	19.36726547	-41.58
18.58125623	-48.268	19.02794411	-42.735
18.4117647	-49.417	19.00299401	-43.505
18.18245264	-51.333	18.86327345	-43.89
18.10767697	-52.482	18.80339321	-44.66
18.06779661	-52.865	18.48403194	-46.97
18.05782652	-53.631	18.43413174	-48.51
18.01794616	-53.631	17.68762475	-50.905
17.99302094	-55.164	17.54790419	-60.06
17.62911266	-57.845	17.39321357	-60.445
17.60917248	-58.611	17.19361277	-61.6
17.36989033	-60.144	17.07884232	-61.985
17.28015952	-61.293	17.06387226	-62.37
17.18045862	-61.293	16.81437126	-63.525
17.11565304	-62.825	16.79940120	-64.68
16.89132602	-63.208	16.73453094	-65.45
16.7118644	-63.975	16.74451098	-66.22
16.65702891	-65.890	16.61477046	-66.99
16.61714855	-66.656	16.59980040	-68.145
16.60219342	-69.338	16.60978044	-68.915
16.57726820	-72.402	16.57984032	-69.3
		16.56986028	-70.84
		16.56986028	-72.765
		16.55988024	-74.69

Table III-6 cont.

Hour 3

Temperature	Depth
24.4001996	-0.3869
24.4001996	-2.3216
24.3752495	-5.4170
24.37025948	-9.2864
24.36526946	-12.381
24.3752495	-14.703
24.3752495	-18.185
24.3752495	-22.055
24.40518962	-23.603
24.64471058	-24.376
24.51497006	-25.150
20.81936128	-34.437
20.71457086	-35.597
20.33033932	-36.758
20.28542914	-37.532
20.19061876	-37.145
20.16067864	-38.306
19.21257485	-42.919
18.37086939	-47.979
18.32203390	-50.301
18.16251246	-51.849
18.00797607	-53.783
17.93320040	-54.170
17.91824526	-54.557
17.85343968	-54.944
17.75872383	-56.492
17.69391825	-56.492
17.60917248	-58.427
17.444666	-60.361
16.96610169	-62.296
16.95114656	-62.683
16.80159521	-63.457
16.77168495	-63.844
16.65204387	-64.618
16.62213360	-65.778
16.60717846	-66.939
16.58225324	-68.100
16.58225324	-68.874
16.57228315	-69.648
16.56231306	-72.356
16.55732802	-75.452

Hour 4

Temperature	Depth
24.44510978	-0.7738
24.4500998	-5.4170
24.41017964	-5.4170
24.39520958	-6.5778
24.38522954	-16.251
24.40518962	-21.668
24.58982036	-23.989
24.49001996	-24.376
24.47005988	-24.763
24.05588822	-25.150
21.29012961	-34.437
21.26021934	-35.211
20.89132602	-35.597
20.54735793	-36.758
20.5224327	-37.145
20.33300100	-37.532
20.23330010	-37.919
20.21335992	-38.693
19.72482552	-40.628
19.60518445	-42.175
19.49052841	-42.949
19.3010967	-44.110
19.29112662	-44.497
19.19641077	-45.271
19.02193420	-46.045
18.38061938	-50.638
18.2057942	-51.075
18.1008991	-52.623
18.02097902	-53.396
17.76123876	-55.331
17.65634366	-56.492
17.51148851	-57.653
17.4065934	-58.427
17.36163836	-58.814
17.32667333	-60.361
17.31668332	-61.522
16.64235764	-65.778
16.61238761	-66.165
16.57742258	-69.261
16.57242757	-71.195
16.56243756	-73.904
16.57742258	-74.291
16.57242757	-75.839

Table III-6 cont.

Hour 5		Hour 6	
Temperature	Depth	Temperature	Depth
24.44510978	-1.925	24.49500998	-1.1608
24.43512974	-3.08	24.49001996	-3.4824
24.41017964	-3.465	24.44011976	-5.8040
24.4001996	-5.775	24.43013972	-9.2864
24.4001996	-6.93	24.41516966	-10.447
24.38522954	-15.78	24.42015968	-11.994
24.35528942	-22.33	24.4001996	-14.703
24.41017964	-22.71	24.4001996	-18.959
24.42015968	-23.1	24.36027944	-21.668
24.48502994	-23.48	24.49500998	-23.216
24.43512974	-24.64	24.1756487	-24.376
24.38023952	-24.64	24.1506986	-24.763
24.27045908	-25.41	23.9760479	-24.763
24.13572854	-26.18	23.96107784	-25.150
23.86127745	-26.56	23.79640719	-25.537
23.68163673	-26.95	23.7015968	-26.311
22.75349301	-28.10	21.12375250	-34.437
21.37151394	-35.42	20.71956088	-36.371
20.55478088	-37.34	20.45508982	-37.532
20.52490040	-38.11	20.25548902	-38.306
20.22111554	-38.5	20.0259481	-41.015
19.98207171	-39.27	19.84131737	-42.175
19.96215139	-40.04	19.62175649	-43.723
19.77788845	-40.04	19.39720559	-47.592
19.65338645	-41.19	19.26746507	-47.979
19.58864542	-42.73	18.96806387	-50.301
19.50398406	-42.73	18.93812375	-50.301
19.42928287	-44.66	18.79840319	-51.075
19.23007968	-46.2		
19.06075697	-46.97	18.38683948	-53.010
19.05079681	-47.35	18.21236291	-54.170
18.93625498	-48.12	17.93818544	-55.718
18.01296112	-54.67	17.7337986	-56.492
17.95314058	-55.44	17.71884347	-57.266
17.80358923	-56.59	17.63908275	-57.653
17.59421735	-57.75	17.62412762	-58.427
17.59421735	-58.13	17.37986042	-59.201
17.40478564	-58.52	17.25024925	-59.974
17.20538385	-60.06	17.02592223	-62.296
17.14057827	-61.21	16.74177468	-62.683
16.57726820	-65.06	16.71684945	-63.457
16.57228315	-66.60	16.62213360	-63.457
16.55732802	-68.91	16.54237288	-66.165
16.54735793	-68.91	16.54735793	-74.678
16.54237288	-71.61	16.53240279	-76.613
16.53738784	-74.69		
16.53240279	-76.23		

Table III-6 cont.

Hour 7		Hour 8	
Temperature	Depth	Temperature	Depth
24.53738784	-0.77	24.4750499	0.4010
24.53738784	-2.31	24.47005988	-3.6093
24.54735793	-3.465	24.4251497	-4.4114
24.54237288	-4.62	24.41516966	-6.0156
24.48255234	-6.16	24.39520958	-7.6197
24.45264207	-8.47	24.39520958	-10.026
24.41276171	-13.475	24.38023952	-12.432
24.40777667	-13.86	24.38023952	-19.25
24.38285145	-18.48	24.36027944	-22.458
24.36789631	-18.865	24.37025948	-23.260
24.36291127	-22.33	24.33033932	-24.062
24.51246261	-24.255	21.47305389	-30.479
24.42771685	-25.025	21.45808383	-31.281
21.11565304	-32.725	21.13872255	-31.682
21.04586241	-34.265	21.05389222	-32.083
20.74675972	-35.035	20.97405190	-33.687
20.68195414	-35.035	20.80938124	-35.291
20.4227318	-38.115	20.51996008	-36.895
20.27318046	-38.5	20.46007984	-37.697
20.25822532	-38.885	20.41516966	-38.5
20.03888335	-39.27	20.24051896	-38.901
19.79960120	-40.425	20.06586826	-40.104
19.7447657	-41.195	20.04590818	-40.104
19.72981057	-42.735	19.88622754	-40.906
19.59521436	-43.12	19.8013972	-41.307
19.54037886	-43.89	19.60678643	-44.114
19.49052841	-45.43	19.43712575	-46.921
19.29112662	-46.585	19.31237525	-47.322
19.27617149	-46.97	19.19760479	-48.125
19.25124626	-46.97	19.00299401	-49.328
19.24626122	-47.355	18.85828343	-49.729
19.07676969	-48.125		
18.90229312	-49.28	18.28143713	-52.536
		17.92215569	-54.541
18.3512974	-51.975	17.67265469	-55.343
18.0269461	-54.285	17.65768463	-56.145
17.79740519	-55.055	17.49800399	-56.145
17.30838323	-57.75	17.46806387	-56.947
17.29341317	-58.52	17.33832335	-56.947
17.14371257	-59.675	16.98902196	-58.953
16.65968064	-61.6	16.72954092	-60.557
16.57984032	-62.755	16.63473054	-61.359
16.53992016	-63.91	16.58483034	-61.760
16.53493014	-67.76	16.53992016	-62.963
16.53493014	-73.15	16.52495010	-63.765
16.52994012	-75.46	16.51497006	-76.598

Table III-6 cont.

Hour 9

Temperature	Depth
24.48753739	-0.7738
24.49750748	-7.7386
24.37288136	-11.994
24.3778664	-22.055
24.23828514	-22.839
24.26819541	-23.216
23.76969093	-24.763
21.8783649	-31.713
21.34995015	-32.889
20.8564307	-34.824
20.82652044	-35.597
20.5224327	-36.758
20.47258225	-37.532
20.46261216	-38.693
20.29810568	-39.854
20.19840479	-40.241
20.03888335	-43.336
19.57527418	-44.497
19.51545364	-46.045
19.49052841	-46.045
19.4556331	-47.206
19.36590229	-48.753
18.25796813	-53.723
17.95418327	-54.557
17.64541833	-55.331
17.33665339	-56.879
17.30179283	-57.653
17.14243028	-57.653
16.92330677	-58.814
16.68924303	-59.587
16.62948207	-59.974
16.57470120	-61.135
16.53984064	-62.296
16.50996016	-64.618
16.50498008	-67.713
16.50498008	-72.743
16.50996016	-74.291
16.49501992	-76.226

Hour 10

Temperature	Depth
24.41017964	-0.77
24.40518962	-4.235
24.4251497	-5.005
24.39520958	-6.16
24.39021956	-10.395
24.37025948	-13.09
24.38023952	-20.02
24.31037924	-20.79
24.19061876	-21.945
24.12075848	-21.945
24.10578842	-22.715
23.98602794	-22.715
23.7015968	-23.87
23.68662675	-24.64
23.41716567	-24.64
23.39221557	-25.41
20.77168495	-34.65
20.72183450	-35.035
20.65702891	-36.575
20.40777667	-37.345
20.38783649	-38.115
20.32801595	-38.115
20.18344965	-39.655
20.0787637	-40.81
19.9890329	-42.35
19.89431705	-43.505
19.65004985	-43.89
19.36091725	-44.66
19.28115653	-45.045
19.22632104	-46.585
19.10667996	-47.355
17.96809571	-53.9
17.76370887	-55.055
17.49451645	-56.98
17.32502493	-56.595
17.31006979	-57.365
16.93619143	-58.52
16.72183450	-58.905
16.64705882	-59.29
16.6121635	-60.06
16.55732802	-60.83
16.52741775	-61.6
16.50747757	-62.755
16.50249252	-71.995
16.50747757	-72.38
16.50249252	-74.305

Table III-6 cont.

Hour 11

Temperature	Depth
24.38285145	0
24.38285145	-1.9346
24.39780658	-3.4824
24.40777667	-5.4170
24.39780658	-8.1256
24.39282154	-11.608
24.38285145	-13.542
24.39282154	-21.281
24.25822532	-22.442
24.05882353	-23.603
23.96410768	-23.989
23.94915254	-23.989
23.77467597	-23.909
23.40578265	-25.537
23.27617149	-25.924
23.25124626	-26.311
23.05682951	-27.085
23.03688933	-27.472
22.95712861	-27.859
22.91226321	-28.246
22.79760718	-28.633
21.87112887	-31.341
21.54145854	-32.115
21.46153846	-32.502
21.31168831	-33.276
21.06693307	-34.437
20.75724276	-35.597
20.66233766	-36.758
20.61738262	-36.758
20.58741259	-37.919
20.14785215	-39.467
19.96803197	-42.949
19.89810190	-43.336
18.83416583	-49.527
18.61438561	-51.075
17.74625375	-55.718
17.73626374	-56.105
17.37662338	-57.653
17.14685315	-58.040
16.96703297	-59.587
16.57242757	-61.909
16.54245754	-62.683
16.51748252	-64.231
16.51248751	-74.678

Hour 12

Temperature	Depth
24.34031936	0
24.33532934	-3.8693
24.34530938	-6.5778
24.36526946	-8.1256
24.38023952	-11.221
24.39520958	-18.572
24.38023952	-20.507
24.31536926	-21.281
24.30538922	-21.668
24.21556886	-22.055
24.2005988	-22.829
24.06586826	-22.829
23.9510978	-23.216
23.77145709	-24.376
23.57185629	-25.537
23.26746507	-26.311
22.94311377	-26.698
22.72355289	-28.246
21.99201597	-31.341
21.34331337	-32.889
21.30339321	-34.050
21.11876248	-34.437
21.09880240	-34.824
20.62974052	-36.371
20.48502994	-38.306
20.20558882	-39.854
19.91117764	-43.336
19.17764471	-46.045
19.14770459	-47.592
18.85329341	-48.753
18.36626747	-52.236
18.04690619	-53.783
17.58782435	-55.718
17.23353293	-57.266
17.01397206	-58.040
16.99401198	-58.427
16.62974052	-59.587
16.52495010	-64.618
16.51497006	-73.904

Table III-7

SALINITY WITH DEPTH AND TEMPERATURE WITH DEPTH ALONG TRANSECT II, CRUISE 76G8-III

Station 2

Temperature	Depth
24.91291291	-0.875
24.92792793	-14.87
21.98498499	-36.75
21.67	-38.5
20.745	-40.25
20.965	-41.12
20.93	-42.87

Salinity	
35.512	0
35.554	-11.37
35.972	-22.75
35.936	-24.06
36.086	-29.31
35.946	-30.62
36.206	-35
35.934	-38.06
36.154	-38.93
35.986	-40.25
36.358	-40.68
36.162	-41.56

Station 3

Temperature	Depth
24.61261261	-0.4837
24.58758759	-9.6747
24.67267267	-10.642
24.69769770	-13.544
24.64764765	-14.512
24.64264264	-12.577
24.61261261	-11.609
24.59259259	-12.093
24.58758759	-14.995
24.07207207	-20.317
22.7007007	-24.670
22.40320963	-27.089
20.76328987	-34.829
19.31394183	-40.634
19.17352056	-43.536
19.10330993	-45.471
19.08324975	-47.406
18.95285858	-50.792
18.87763290	-51.760
18.59679037	-53.695
18.55165496	-43.052
18.52657974	-55.146
18.34869739	-58.048
17.54709419	-67.239
17.60721443	-65.304
17.56212425	-64.821
17.53707415	-65.788
17.51202405	-67.723
14.27054108	-83.203
14.38	-85.621
13.67	-93.845
13.595	-95.296
13.55	-99.650
13.255	-106.42
13.205	-107.87
13.145	-108.35
13.115	-109.80
13.09	-112.22
13.07	-114.16

Table III-7 cont.

Station 3		Station 4	
Salinity	Depth	Temperature	Depth
35.74924925	-0.4576	24.965	0
35.72522523	-1.3730	24.93	0
35.75325325	-2.2884	24.94	-0.925
35.73723724	-3.6615	24.945	-21.74
35.74924925	-11.442	24.945	-27.76
35.81531532	-15.561	24.955	-22.20
35.82932933	-17.392	24.95	-28.22
36.35185185	-20.138	24.935	-30.07
35.77927928	-21.969		
36.17367367	-26.088		
36.02552553	-27.461		
36.14164164	-28.376	35.2755511	-1.5
36.09359359	-29.75	35.29358717	-1.5
36.12362362	-30.207	35.29358717	-28.5
36.11761762	-31.123	35.3016032	-29.5
36.19969970	-31.123	35.29158317	-30.5
36.13563564	-32.496	35.30761523	-29.5
36.23773774	-33.869	35.30961924	-25
36.03553554	-35.242	35.30561122	-32
36.23573574	-36.157		
36.03153153	-37.530		
36.25975976	-40.734		
36.24574575	-41.65		
36.3038038	-42.565		
36.28578579	-43.938		
36.28378378	-45.311		
36.22972973	-50.803		
36.23973974	-54.465		
36.27177177	-55.380		
36.18968969	-56.296		
36.27777778	-59.042		
36.25575576	-60.415		
36.15765766	-61.330		
36.34184184	-62.246		
36.22972973	-63.161		
36.29379379	-64.534		
35.72722723	-70.942		
36.13963964	-75.976		
35.95945946	-78.265		
36.23773774	-79.638		
36.19769770	-80.096		
36.23173173	-81.926		
36.2037037	-82.842		
36.22172172	-84.215		
36.16966967	-85.130		
36.21371371	-96.115		
36.27577578	-97.488		
36.27977978	-99.319		
36.24774775	-108.93		
36.24574575	-109.84		
36.21571572	-110.30		
36.28578579	-112.13		
36.24774775	-111.67		
36.24174174	-113.50		

Table III-7 cont.

Station 5		Station 6	
Temperature	Depth	Temperature	Depth
24.48248248	-1.1096	24.48997996	-0.42346
24.47747748	-16.645	24.53507014	-13.9744
24.7027027	-16.090	21.97995992	-23.2908
24.69269269	-22.193		
24.67767768	-23.858	21.83	-24.9846
24.63263263	-27.187	17.975	-46.1581
22.87087087	-29.406		
22.91091091	-31.070	18.09318637	-47.0051
21.44344344	-37.174	18.07314629	-49.5459
19.13613614	-53.819	14.64128257	-69.8724
18.29529530	-62.141	14.31062124	-77.9183
19.09009009	-68.8	13.97995992	-80.0357
17.68868869	-69.354	13.92892893	-83.0000
16.86286286	-74.903		
16.24224224	-82.116		
16.15715716	-87.109		
		35.67117117	-0.39712
		35.69919920	-15.8851
35.696	-2.1234	35.78728729	-19.0622
35.7	-16.456	35.55505506	-21.0478
35.82	-16.987	36.25175175	-27.0047
35.818	-24.419	35.89139139	-29.7846
36.246	-34.506	36.24974975	-31.3732
36.176	-35.567	35.96146146	-33.3588
36.238	-36.098	36.23373373	-33.7559
36.158	-37.160	35.95145145	-36.5358
36.286	-39.814	36.2037037	-37.7272
36.182	-40.345	36.01351351	-38.9186
36.224	-42.469	36.23773774	-44.0813
36.132	-43	36.08758759	-45.6698
36.514	-45.123	36.23573574	-46.4641
36.22	-46.185	36.03553554	-48.8468
36.236	-47.777	36.31181181	-50.4354
35.986	-48.839	36.12962963	-53.2153
36.3	-49.370	36.27777778	-55.9952
36.218	-49.901	36.19969970	-57.9808
36.262	-52.024	36.37987988	-58.3779
36.204	-53.617	36.23173173	-59.5693
36.082	-63.703	36.27177177	-61.9521
36.27	-64.765	36.0095095	-63.5406
36.208	-65.827	36.16166166	-66.3205
36.248	-66.358	35.99549550	-67.1148
36.214	-68.481	36.13563564	-68.3062
36.236	-69.543	36.35985986	-77.8373
36.274	-71.135	36.16766767	-80.2200
36.196	-73.259	36.34984985	-83.3971
36.324	-74.320		
36.16	-77.506		
36.278	-78.567		
36.21	-80.691		
36.398	-81.222		
36.318	-82.814		

Table III-8

TRANSMISSIVITY WITH DEPTH AT EAST FLOWER GARDENS BANK

Station 1

XMS	DEPTH
82.85144566	-1.176
81.65503490	-5.586
80.65802592	-11.172
80.25922233	-15.288
80.25922233	-18.228
79.46161515	-21.168
77.4675972	-24.108
77.4675972	-27.636
77.06879362	-30.576
77.26819541	-34.104
76.17148554	-38.514
75.27417747	-42.042
75.87238285	-44.982
75.27417747	-47.04
73.8783649	-48.804
72.68195414	-49.98
69.09272183	-50.862
68.09571286	-52.332
70.68793619	-53.802
72.38285145	-54.684
66.4007976	-57.33
71.48554337	-58.506
69.29212363	-59.976
69.99002991	-60.858
64.50648056	-63.21
68.09571286	-67.326
62.21335992	-70.266
68.09571286	-72.618
70.38883350	-74.676
73.57926221	-77.322
75.17447657	-79.674
76.96909272	-82.614
76.27118644	-85.848
70.68793619	-89.67
68.09571286	-90.552

Station 2

XMS	DEPTH
75.62437562	-2.408773679
75.32467532	-7.226321037
74.82517483	-9.333998006
74.72527473	-15.95812562
73.62637363	-24.6899302
73.62637363	-31.01296112
73.52647353	-37.63708873
72.72727273	-41.55134596
73.02697303	-43.05682951
72.02797203	-46.06779661
72.22777223	-47.87437687
71.82817183	-49.68095713
72.12787213	-59.31605184
69.13086913	-66.54237288
69.53046953	-68.34895314
68.03196803	-70.4566301
68.43156843	-73.4675972
69.53046953	-75.57527418
71.82817183	-78.28514457
72.12787213	-80.69391825
71.42857143	-83.10269192
68.33166833	-84.90927218
66.03396603	-87.92023928
62.93706294	-89.12462612
58.44155844	-92.73778664
56.94305694	-96.35094716
57.74225774	-99.96410768
68.93106893	-102.3728814
71.12887113	-103.5772682
72.72727273	-108.9970090
70.92907093	-112.007976
60.73926074	-114.7178465

Station 3

XMS	DEPTH
81.23752495	-1.477045908
81.13772455	-6.794411178
81.53692615	-11.2255489
81.23752495	-15.06586826
80.43912176	-21.56487026
80.73852295	-25.10978044
80.03992016	-32.19960080
78.74251497	-37.51696687
76.44710579	-43.12974052
75.54890220	-44.60678643
77.64471058	-49.03792415
76.64670659	-52.28742515
72.35528942	-54.6506986
71.05788423	-57.30938124
71.35728543	-61.14970060
70.65868263	-62.03592814
72.05588822	-64.39920160
72.75449102	-67.05788423
75.94810379	-68.23952096
76.94610778	-75.03393214
77.04590818	-76.51097804
75.14970060	-78.57884232
72.65469062	-80.64670659
70.95808383	-80.94211577
69.16167665	-83.30538922
68.76247505	-85.07784431
66.86026747	-87.44111776
63.17365269	-89.50898204
63.27345309	-94.23552894
61.5768463	-96.00798403

Table III-8 cont.

Station 4

XMS	DEPTH
77.44510978	-0.614157527
77.14570858	-4.035892323
76.54690619	-5.527417747
75.14970060	-28.60219342
74.4510978	-29.47956132
74.251497	-32.72582253
74.6506986	-33.60319043
74.5508982	-34.48055833
72.35528942	-37.99002991
71.65668663	-41.06081755
68.76247505	-44.30707876
65.36926148	-46.23728814
65.36926148	-47.29012961
67.46506986	-51.23828514
69.56087824	-51.94017946
67.66467066	-55.44965105
64.97005988	-56.15154536
62.87425150	-58.43270189
65.46906188	-59.66101695
63.67265469	-60.62612164
64.77045908	-66.59222333
66.86626747	-70.10169492
69.76047904	-71.24227318
71.55688623	-73.43569292
72.55489022	-76.1555334
71.75648703	-78.17347956
68.66267465	-80.63010967
66.36726547	-82.12163509

Station 5

XMS	DEPTH
83.13373253	-1.566866267
82.63473054	-5.640718563
81.93612774	-12.22155689
80.73852295	-16.60878244
80.83832335	-19.11576846
80.23952096	-21.30938124
79.64071856	-24.12974052
79.04191617	-27.26347305
79.34131737	-30.08383234
79.04191617	-31.33732535
79.44111776	-34.78443114
79.14171657	-37.29141717
76.14770459	-40.73852295
76.14770459	-43.55888224
76.84630739	-45.1257485
75.04990020	-46.37924152
76.84630739	-48.25948104
78.24351297	-49.8263473
78.04391218	-54.21357285
76.64670659	-57.66067864
69.96007984	-60.16766467
71.95608782	-62.36127745
71.75648703	-63.61477046
69.76047904	-64.86826347
69.26147705	-67.68862275
68.36327345	-68.94211577
65.96806387	-70.50898204
65.26946108	-74.26946108
66.56686627	-75.52295409
69.16167665	-76.46307385
70.15968064	-78.65668663
73.15369261	-79.59680639
76.64670659	-80.8502994
78.54291417	-82.41716567
79.84031936	-85.86427146
78.84231537	-88.05788423
77.54491018	-89.31137725
74.3512974	-90.56487026
73.25349301	-92.44510978
71.35728543	-93.69860279
69.56007824	-95.26540906

Station 6

XMS	DEPTH
83.64905284	0
83.44965105	-5.493519442
82.15353938	-13.8783649
81.95413759	-25.73280160
81.1565304	-28.91326022
81.1565304	-31.80458624
79.56131605	-33.82851446
79.76071785	-36.43070788
78.26520439	-38.45463609
78.16550349	-40.1894317
72.88135593	-43.36989033
74.47657029	-49.44167498
76.76969093	-52.04386839
75.27417747	-56.38085743
71.68494516	-57.82653044
70.98703888	-61.29611166
65.10468594	-67.0787637
70.38883350	-71.99401795
69.39182453	-73.72881356
77.666999	-76.90927218
79.46161515	-80.3788634
74.17746760	-85.58325025
75.67298106	-87.31804586
75.47357926	-89.63110668

Table III-8 cont.

Station 7

XMS	DEPTH
74.9500998	0.291417166
72.75449102	-27.9760479
73.35329341	-30.01596806
72.15568862	-39.92415170
71.25748503	-52.16367265
71.15768463	-58.28343313
68.86227545	-67.0259481
66.46706587	-69.94011976
67.86427146	-71.68862275
68.16367265	-74.31137725
70.95808383	-76.64271457
71.75648703	-80.72255489
70.55888224	-85.6766467
66.56686627	-87.4251497
67.96407186	-90.04790419
55.68862275	-97.62475050
68.76247505	-105.7844311
74.0518962	-113.3612774
74.1516966	-117.4411178
62.57485030	-118.8982036

Station 8

XMS	DEPTH
74.82517483	-0.28
74.02597403	-7.28
73.32667333	-19.88
73.02697303	-31.08
72.72727273	-35
70.52947053	-44.8
69.83016983	-57.4
68.43156843	-60.76
65.13486513	-63.84
68.53146853	-71.12
71.02897103	-76.72
70.12987013	-79.8
70.02997003	-82.88
68.13186813	-85.96
63.93606394	-87.64
55.84415584	-90.44
54.84515485	-91.56
58.84115884	-98.28
68.53146853	-101.92
68.53146853	-104.72
71.02897103	-107.52
72.72727273	-110.04
72.42757243	-113.4
65.73426573	-117.32
59.94005994	-120.68
59.44055944	-123.2

Station 9

XMS	DEPTH
79.74051896	0.586825347
79.04191617	-8.802395210
79.54091816	-11.73652695
78.14371257	-31.68862275
76.14770459	-41.07784431
74.4510978	-44.01197605
73.9520958	-49.88023952
77.14570858	-51.64071856
74.251497	-57.50898204
73.15369261	-61.61676647
72.05588822	-69.24550898
74.9500998	-69.24550898
75.84830339	-71.88622754
75.04990020	-75.7005988
67.56487026	-80.39520958
61.7764471	-87.14371257
61.6766467	-89.78443114
62.2754491	-92.71856287

Table III-8 cont.

Station 10

XMS	DEPTH
79.84031936	0
79.94011976	-13.6023976
79.24151697	-17.44655345
78.64271457	-31.34465534
77.94411178	-36.07592408
76.14770459	-42.58141858
75.94810379	-46.42557443
76.54690619	-50.26973027
76.94610778	-53.81818182
76.24750499	-57.36663337
74.5508982	-59.14085914
72.85429142	-62.39360639
71.95608782	-65.35064935
73.45309381	-67.12487512
74.3512974	-69.78621379
74.4510978	-73.33466533
75.34930140	-75.4045954
75.14970060	-78.36163836
71.25748503	-80.43156843
67.66467066	-83.68431568
65.56886228	-85.75424575
63.07385230	-87.52847153
62.3752495	-88.71128871
62.1756487	-99.65234765

Station 11

XMS	DEPTH
79.84031936	0.551448551
78.54291417	-7.72027972
77.84431138	-15.71628372
77.44510978	-19.02497503
75.94810379	-24.26373626
75.74850299	-29.5024975
74.251497	-33.08691309
73.65269461	-34.46553447
72.65469062	-48.52747253
68.16367265	-50.45754246
72.45508982	-52.66333666
69.06187625	-55.69630370
67.26546906	-61.76223776
62.77445110	-62.86513487
72.55489022	-68.65534466
74.4510978	-73.61838162
73.25349301	-81.33866134
72.15568862	-81.61438561
69.56087824	-89.05894106

Station 12

XMS	DEPTH
84.58748867	0.285714286
82.13961922	-23.71428571
80.68902992	-28.85714286
80.32638259	-34.57142857
78.96645512	-39.14285714
78.0598368	-50.28571429
77.06255666	-56.00000000
74.07071623	-60.00000000
72.71078876	-62.57142857
68.54034451	-65.42857143
75.97461469	-69.42857143
78.78513146	-74.57142857
79.69174977	-80.00000000
78.78513146	-82.85714286
76.79057117	-84.85714286
76.06527652	-90.85714286
70.89755213	-93.14285714
70.71622847	-94.28571429
38.07796917	-97.42857143

Table III-8 cont.

DRILL SITE STATIONS

At Drill Site

XMS	DEPTH
55.98802395	-0.54
55.58882236	-4.95
54.79041916	-7.47
56.38722555	-10.08
60.97804391	-13.68
61.07784431	-15.3
59.28143713	-16.65
62.57485030	-19.08
63.07385230	-21.69
63.47305389	-24.12
60.47904192	-26.64
55.98802395	-26.91
4.291417166	-28.26

1000 m East of Drill Site

XMS	DEPTH
0.099900100	-0.09
51.64835165	-2.07
55.64435564	-8.91
59.44055944	-11.16
59.94005994	-19.35
58.04195804	-20.97
59.74025974	-23.49
58.04195804	-24.93
52.14785215	-26.73
43.45654346	-27.99
4.995004995	-29.61
3.596403596	-30.42

1000 m West of Drill Site

XMS	DEPTH
51.39442231	-1.3554
49.80079681	-4.8795
54.08366534	-6.3253
56.87250996	-8.7650
58.86454183	-9.8493
60.15936255	-14.457
58.86454183	-15.451
55.97609562	-15.903
47.70916335	-16.355
6.374501992	-16.626

1000 m North of Drill Site

XMS	DEPTH
46.36091725	-2.5250
50.74775673	-2.8857
56.82951147	-9.6492
59.1226321	-10.190
61.71485543	-26.963
56.23130608	-27.865
6.181455633	-29.849

1000 m South of Drill Site

XMS	DEPTH
55.48902196	-1.08
56.38722555	-6.12
56.18762475	-9.9
59.98003992	-13.14
63.87225549	-15.84
64.87025948	-22.41
64.57085828	-27.09
51.89620758	-29.16
23.65269461	-29.16

Table III-9

TRANSMISSIVITY WITH DEPTH AT STETSON BANK

Station 1

XMS	DEPTH
81.03792415	0.495504496
80.13972056	-5.45054945
80.23952096	-13.87412587
80.43912176	-18.58141858
80.03992016	-22.29770230
78.94211577	-25.27072927
78.14371257	-29.48251748
77.94411178	-33.44655345
76.94610778	-36.17182817
74.4510978	-37.9060939
72.95409182	-40.87912088
72.65469062	-45.09090909
58.28343313	-46.08191808
58.08383234	-49.05494505
45.90818363	-49.3026973
45.40918164	-52.52347652
33.23353293	-53.26673327

Station 2

XMS	DEPTH
82.71728272	0.205588822
80.61938062	-5.345309381
80.11988012	-9.868263473
79.22077922	-14.8023952
79.02097902	-19.94211577
78.12187812	-20.76447106
78.02197802	-26.31536926
76.32367632	-28.5768463
70.72927073	-29.60479042

Station 3

XMS	DEPTH
85.9	0
84.9	-4.595404595
85	-6.793206793
84.5	-10.18981019
84.5	-12.58741259
83.9	-15.78421578
83.3	-15.78421578
82.9	-21.77822178
81.3	-27.37262737
80.1	-30.36963037
78.2	-30.76923077
78.3	-36.16383616
77.9	-39.36063936
77.6	-41.95804196
77.1	-46.35364635
76.5	-47.75224775
76.6	-50.54945055
53.5	-50.74925075
52.8	-53.74625375
40.1	-53.94605395
1.3	-53.74625375

Station 4

XMS	DEPTH
80.91908092	0.407592408
81.01898102	-4.483516484
80.41958042	-8.355644356
80.31968032	-14.46953047
81.01898102	-17.11888112
77.82217782	-26.28971029
77.82217782	-28.53146853
76.42357642	-28.53146853
74.32567433	-31.79220779
74.12587413	-35.05294705
70.42957043	-39.33266733
62.33766234	-39.74025974
61.63836164	-40.96303696
58.44155844	-41.16683317
56.84315684	-44.01998002
50.44955045	-44.01998002
50.24975025	-46.66933067
45.85414585	-46.87312687
45.55444555	-47.89210789
43.25674326	-48.29970030
0.699300699	-48.29970030

Table III-9 cont.

Station 5

XMS	DEPTH
83.21678322	0.307692308
82.61738262	-3.384615385
81.81818182	-7.23076923
81.31868132	-16.00000000
79.42057942	-22.3076923
75.12487512	-24.3076923
75.72427572	-36.3076923
73.72627373	-36.3076923
73.12687313	-39.69230769
70.92907093	-41.23076923
70.92907093	-43.07692308

Station 6

XMS	DEPTH
82.1	0
80.4	-7.984031936
78.8	-13.57285429
78.2	-17.08582834
79.6	-21.07784431
78.3	-24.43113772
75.1	-25.06986028
74.5	-38.64271457
71.1	-42.95409182
69.9	-43.27345309

Station 7

XMS	DEPTH
85.52894212	0.2
84.53093812	-8.2
83.63273453	-14.8
83.83233533	-16.6
82.93413174	-18
82.93413174	-22.2
81.83632735	-22.6
81.83632735	-28.2
79.64071856	-28.8
80.53892216	-31
78.34331337	-31.6
77.44510978	-34.6
77.44510978	-39.6
76.64670659	-46
75.84830339	-46.4
76.04790419	-48.4
73.65269461	-49.4
73.15369261	-51.8
63.17365269	-52.4
62.87425150	-55
51.49700599	-55.4

Table III-9 cont.

Station 9

XMS	DEPTH
81.10808356	-0.169660679
81.01725704	-2.3752495
79.92733878	-6.447105788
79.65485922	-11.53692615
79.29155313	-15.60878244
79.38237965	-17.98403194
78.38328792	-18.66267465
77.65667575	-24.77045908
75.7493188	-25.61876247
74.75022707	-26.9760479
74.38692098	-30.02994012
74.75022707	-32.23552894
74.4777475	-35.28942116
73.02452316	-39.87025948
73.11534968	-43.26347305
68.30154405	-46.8263473

Station 10

XMS	DEPTH
80.91908092	0.177822178
80.31968032	-2.311688312
80.01998002	-4.445554446
79.82017982	-11.91408591
79.32067932	-14.4035964
79.12087912	-17.07092907
78.82117882	-20.8051948
78.42157842	-22.58341658
75.12487512	-22.4055944
73.92607393	-27.56243756
72.52747253	-27.56243756
72.52747253	-32.89710290
71.82817183	-35.74225774
72.52747253	-40.00999
62.33766234	-41.07692308
60.53946054	-41.78821179
57.24275724	-42.49950050
51.34865135	-43.21078921

Station 11

XMS	DEPTH
76.12387612	-0.087912088
76.12387612	-1.23076923
76.32367632	-2.461538462
76.02397602	-5.186813187
76.62337662	-6.065934066
75.92407592	-7.824175824
73.62637363	-10.37362637
70.92907093	-11.69230769
70.22977023	-12.3076923
70.12987013	-14.68131868
68.73126873	-15.73626374
65.83416583	-15.91208791
64.33566434	-16.79120879
62.93706294	-16.96703297
61.13886114	-16.87912088
58.94105894	-17.84615385
56.34365634	-18.02197802
53.84615385	-19.6043956
52.74725275	-19.42857143
51.14885115	-20.83516484
50.14985015	-20.83516484
48.85114885	-22.15384615

Station 12

XMS	DEPTH
85.21478521	0.183449651
85.21478521	-3.302093719
84.31568432	-9.906281156
84.91508492	-10.27318046
84.81518482	-15.40977069
83.91608392	-17.9780658
83.01698302	-17.9780658
83.11688312	-20.54636092
82.71728272	-23.66500498
82.11788212	-24.76570289
80.51948052	-26.23330010
78.92107892	-26.41674975
78.32167832	-28.98504487
76.72327672	-29.16849452
76.22377622	-31.92023928
76.12387612	-34.48853440
75.42457542	-35.9561316
76.32367632	-42.00997009
79.52047952	-42.37686939
79.62037962	-44.76171486
75.92407592	-44.9451645
74.82517483	-46.41276171
48.85114885	-46.41276171

Table III-10

TRANSMISSIVITY WITH DEPTH AT 28 FATHOM BANK

Station 1

XMS	DEPTH
84.73053892	0
84.43113772	-6.935064935
83.63273453	-13.33666334
83.43313373	-20.8051948
83.33333333	-30.4075924
82.43512974	-33.07492508
81.83632735	-44.27772228
79.94011976	-48.54545455
78.14371257	-58.14785215
76.84630739	-59.74825175
75.84830339	-65.08291708
75.64870259	-68.81718282
77.54491018	-74.15184815
79.14171657	-75.21878122
77.64471058	-82.15384615
75.24950100	-84.28771229
71.25748503	-92.28971029
71.15768463	-104.025974

Station 2

XMS	DEPTH
75.74850299	-1.653731343
74.4510978	-17.08855721
73.8522954	-24.25472637
73.35329341	-30.31840796
72.95409182	-42.99701493
71.85628743	-46.85572139
70.15968064	-51.81691542
69.66067864	-52.91940299
70.65868263	-55.67562189
70.05988024	-58.98308458
66.06786427	-64.49552239
67.16566866	-66.70049751
64.47105788	-72.21293532
67.16566866	-73.86666667
69.46107784	-76.07164179
70.85828343	-77.17412935
71.35728543	-79.93034826
70.85828343	-83.23781095
69.36127745	-88.19900498
66.76646707	-92.60895522
63.27345309	-94.81393035

Station 3

XMS	DEPTH
77.04590818	-0.375249501
76.44710579	-6.566866267
76.14770459	-10.88223553
76.24750499	-16.32335329
76.04790419	-21.5768463
74.4510978	-24.57884232
75.14970060	-27.20558882
73.45309381	-30.01996008
73.25349301	-38.83832335
73.65269461	-45.21756487
74.0518962	-48.78243513
73.55289421	-54.59880240
72.85429142	-54.78642715
72.45508982	-55.72455090
67.86427146	-56.09980040
67.76447106	-60.03992016
70.75848303	-60.41516966
71.25748503	-64.73053892
53.39321357	-65.29341317
-0.998003992	-62.47904192

Table III-10 cont.

Station 4

XMS	DEPTH
86.3273453	-0.366899302
85.92814371	-3.485543370
85.52894212	-13.20837488
85.02994012	-15.59322034
83.83233533	-16.51046859
83.83233533	-18.89531406
83.03393214	-19.99601196
83.43313373	-24.58225324
82.83433134	-30.26919242
81.93612774	-36.13958126
82.33532934	-39.07477567
82.43512974	-41.64307079
81.43712575	-48.24725823
80.33932136	-49.53140578
81.43712575	-51.54935194
80.93812375	-55.03489531
78.04391218	-55.76869392
77.24550898	-56.31904287
69.36127745	-56.86939182
68.26347305	-58.15353938
69.26147705	-59.25423729
75.64870259	-59.98803589
79.34131737	-60.90528415
78.54291417	-61.4556331
78.44311377	-63.10667996
71.55688623	-64.02392822

Station 5

XMS	DEPTH
82.43512974	0.644710579
80.73852295	-10.96007984
79.94011976	-17.40718563
79.44111776	-23.85429142
77.54491018	-25.14371257
78.54291417	-32.23552894
79.04191617	-39.3273453
78.24351297	-43.99800399
75.84830339	-51.5768463
74.8502994	-56.73453094
74.0518962	-62.53692615
71.55688623	-64.47105788
74.9500998	-67.04990020
75.24950100	-70.27345309
77.54491018	-70.27345309
77.74451098	-74.14171657
80.63872255	-75.43113772
80.23952096	-83.81237525
77.54491018	-85.1017964
75.04990020	-88.97005988
75.24950100	-97.99600798

Station 6

XMS	DEPTH
79.74051896	0
78.74251497	-8.802395210
78.44311377	-14.67065868
76.34730539	-18.77844311
75.84830339	-26.99401198
76.04790419	-34.03592814
75.94810379	-39.90419162
74.4510978	-41.07784431
74.3512974	-42.83832335
74.6506986	-48.70658683
72.65469062	-49.88023952
72.35528942	-56.92215569
70.25948104	-58.68263473
67.26546906	-62.20359281
69.96007984	-65.13772455
72.65469062	-68.07185629
76.64670659	-69.83233533
77.44510978	-76.28742515
78.04391218	-77.46107784
72.25548902	-78.63473054
72.55489022	-86.26347305
71.15768463	-86.8502994
71.05788423	-96.8263473

Table III-10 cont.

Station 7

XMS	DEPTH
84.81518482	0
84.31568432	-3.75672981
84.31568432	-7.513459621
83.11688312	-8.765702891
82.31768232	-15.65304088
81.31868132	-17.53140578
80.81918082	-30.67996012
81.31868132	-36.31505484
80.81918082	-48.83748754
78.52147852	-53.84646062
76.22377622	-56.97706879
73.02697303	-56.97706879
73.22677323	-61.35992024
71.72827173	-62.6121635
75.52447552	-63.86440678
75.92407592	-66.36889332
80.51948052	-68.24725823
81.21878122	-73.88235294
76.52347652	-78.26520439
76.12387612	-83.9002991
74.42557443	-86.40478564

Station 8

XMS	DEPTH
83.03393214	0
82.33532934	-8.443113772
81.63672655	-14.54091816
79.94011976	-24.86027944
78.64271457	-29.5508982
78.24351297	-35.64870259
76.84630739	-37.05588822
76.94610778	-42.21556886
75.44910180	-44.56087824
75.14970060	-49.72855888
75.24950100	-54.88023952
75.24950100	-59.57085828
75.44910180	-62.85429142
73.55289421	-63.79241517
71.15768463	-64.73053892
70.65868263	-69.89021956
69.06187625	-70.82834331
69.86027944	-77.86427146
71.95608782	-83.49301397
74.5508982	-86.30738523
71.95608782	-87.71457086
71.45708583	-95.21956088
70.05988024	-94.750499
69.86027944	-100.3792415
68.76247505	-101.3173653
68.66267465	-107.8842315
65.66866267	-108.3532934

Station 9

XMS	DEPTH
86.11388611	0
85.61438561	-6.894211577
85.01498501	-17.54890220
84.51548452	-24.44311377
84.51548452	-30.08883234
83.41658342	-34.47105788
83.71628372	-40.11177645
80.21978022	-54.5269461
80.61938062	-58.28742515
78.02197802	-65.18163673
74.42557443	-70.19560878
75.82417582	-73.32934132
78.82117882	-74.58283433
80.41958042	-80.22355289
80.51948052	-87.11776447
79.32067932	-96.51896208
75.92407592	-101.5329341
72.22777223	-107.8003992
73.32667333	-114.0678643
72.72727273	-119.0818363

Table III-10 cont.

Station 10

XMS	DEPTH
83.73253493	-7.421157685
82.93413174	-18.26746507
82.43512974	-29.68463074
81.03792415	-35.96407186
80.93812375	-42.24351297
79.64071856	-47.9520958
78.44311377	-51.3772455
76.84630739	-60.51097804
75.04990020	-65.07784431
78.14371257	-71.92814371
79.04191617	-79.92015968
76.74650699	-85.05788423
73.9520958	-91.33732535
72.55489022	-95.33333333
70.55888224	-97.61676647
70.05988024	-106.1796407
70.05988024	-113.6007984

Station 12

XMS	DEPTH
84.61538462	-1.397205589
84.41558442	-7.684630739
83.11688312	-11.8762475
81.91808192	-19.56087824
82.11788212	-23.75249501
81.21878122	-29.34131737
81.01898102	-34.23153693
81.21878122	-40.51896208
80.11988012	-46.80638723
79.12087912	-50.29940120
77.82217782	-55.18962076
75.52447552	-57.98403194
70.62937063	-60.07984032
70.42957043	-62.1756487
73.12687313	-67.76447106
75.32467532	-69.86027944
77.62237762	-69.86027944
78.82117882	-81.73652695
79.52047952	-88.72255489
81.21878122	-92.21556886
79.12087912	-94.31137725
77.72227772	-95.70858283
77.02297702	-99.9001996
74.72527473	-101.9960080
66.23376623	-106.1876248
65.53446553	-108.9820359
61.03896104	-111.7764471
60.03996004	-113.8722555
50.84915085	-117.3652695

Station 11

XMS	DEPTH
84.01598402	-2.039880359
82.41758242	-9.519441675
81.01898102	-17.67896311
80.51948052	-26.51844467
79.72027972	-34.6779661
79.12087912	-42.15752742
78.82117882	-45.55732802
76.22377622	-48.27716849
74.52547453	-51.67696909
73.02697303	-55.75672981
71.62837163	-61.19641077
71.82817183	-64.59621137
73.62637363	-67.99601196
75.12487512	-72.07577268
76.42357642	-74.79561316
77.32267732	-82.95513460
78.52147852	-91.79461615
77.92207792	-97.2342971
76.22377622	-99.27417747
70.62937063	-101.9940179
70.02997003	-106.0737787
70.62937063	-112.1934197
73.42657343	-112.1934197
74.22577423	-116.9531406
75.42457542	-119.672981

Table III-11

TRANSMISSIVITY WITH DEPTH AT 28 FATHOM BANK, SOUTHWEST PEAK

Station 1 XMS	DEPTH	Station 2 XMS	DEPTH	Station 3 XMS	DEPTH
81.91808192	-2.708124373	81.77290837	-1.985957874	86.44067797	0.602409639
82.21778222	-7.221664995	80.77689243	-4.784353059	86.24127617	-3.313253012
79.12087912	-12.03610833	80.47808765	-8.214643932	85.0448654	-7.831325301
76.42357642	-19.85957874	79.98007968	-10.2006018	84.34695912	-7.831325301
79.02097902	-20.16048144	80.07968127	-11.6449348	83.84845464	-11.74698795
74.82517483	-25.27582748	79.88047809	-12.72818455	81.05682951	-12.6506024
74.82517483	-28.58575727	77.88844622	-13.17953862	79.56131605	-15.96385542
69.23076923	-30.69207623	77.39043825	-16.79037111	81.55533400	-15.96385542
75.82417582	-35.80742227	76.59362550	-16.97091274	80.75772682	-19.57831325
77.82217782	-41.82547643	76.29482072	-18.32497492	82.25324028	-20.78313253
73.82617383	-55.667001	77.19123506	-18.32497492	79.76071785	-21.38554217
70.52947053	-57.47241725	76.59362550	-19.22768305	79.26221336	-24.69879518
79.92007992	-59.2778335	78.0876494	-19.76930792	75.97208375	-25.60240964
81.31868132	-61.98595787	78.38645418	-22.02607823	75.77268195	-28.01204819
80.51948052	-66.19859579	77.49003984	-22.29689067	74.47657029	-28.01204819
78.72127872	-66.49949850	76.79282869	-24.0120361	72.98105683	-29.51807229
78.32167832	-69.20762287	77.09163347	-26.1785356	74.57627119	-32.22891566
74.12587413	-71.01303912	76.09561753	-26.26880642	76.17148554	-32.53012048
		74.00398406	-27.53259779	76.57028913	-34.63855422
		72.31075697	-27.6228686	78.76370887	-34.93975904
		70.11952191	-28.97693079	82.15353938	-45.18072289
		70.01992032	-30.15045135	79.56131605	-48.4939759
		74.00398406	-32.6780341	73.18045862	-50.00000000
		75.39840637	-36.64994985	73.67896311	-53.01204819
		77.19123506	-38.45536610	72.38285145	-56.02409639
		77.58964143	-41.70511535	81.75473579	-56.62650602
		76.39442231	-42.78836510	82.45264207	-58.73493976
		74.50199203	-43.78134403	84.44666002	-59.03614458
		74.10358566	-45.40621866	85.0448654	-61.14457831
				84.64606181	-62.95180723
				80.55832502	-63.25301205
				82.45264207	-66.26506024
				82.15353938	-69.87951807
				80.45862413	-71.38554217
				85.64307079	-71.9879518
				87.13858425	-74.39759036
				83.64905284	-76.50602410
				85.1445063	-78.61445783

Table III-11 cont.

Station 4

XMS	DEPTH
81.61838162	0.301204819
81.41858142	-3.91566265
79.52047952	-11.44578313
76.82317682	-12.6506024
77.02297702	-15.36144578
74.82517483	-16.86746988
78.32167832	-20.48192771
76.62337662	-21.9879518
76.52347652	-23.4939759
74.92507493	-23.4939759
74.82517483	-26.20481928
74.02597403	-28.01204819
70.22977023	-28.31325301
68.83116883	-29.51807229
70.62937063	-31.62650602
74.82517483	-33.43373494
77.02297702	-37.34939759
76.72327672	-42.77108434
75.02497502	-43.67469880
75.32467532	-51.20481928
72.92707293	-52.10843373
72.62737263	-56.92771084
77.92207792	-57.22891566
78.62137862	-59.03614458
79.92007992	-59.03614458
80.81918082	-61.14457831
79.82017982	-62.6506024
80.11988012	-63.55421687
79.42057942	-64.1566265
79.12087912	-67.77108434
75.42457542	-67.77108434
74.72527473	-70.18072289
71.62837163	-70.18072289
70.82917083	-74.39759036
66.53346653	-74.69879518
65.73426573	-78.31325301

Station 5

XMS	DEPTH
82.75174477	-3.309929789
82.85144566	-7.221664995
80.75772682	-11.1334002
77.666999	-12.03610833
76.66999003	-15.64694082
79.16251246	-19.25777332
78.06580259	-22.5677031
76.07178465	-23.77131394
75.87238285	-27.68304915
68.69391825	-30.09027081
71.88434696	-31.89568706
72.38285145	-33.4002006
76.07178465	-34.00200602
76.37088734	-40.32096289
78.76370887	-40.9227683
78.76370887	-42.72818455
81.2562313	-43.02908726
81.1565304	-46.63991976
72.18344965	-46.94082247
72.98105683	-49.34804413
69.79062812	-49.94984955
70.58823529	-53.56068205
74.87537388	-53.86158475
74.07776670	-55.96790371
78.56430708	-56.56970913
81.55533400	-62.28686058
83.94815553	-62.88866600
80.45862413	-66.8004012
83.84845464	-67.40220662
82.65204387	-71.31394183

Station 6

XMS	DEPTH
86.1	0
84.8	-8.991008991
83.2	-9.59040959
82.6	-11.68831169
80.8	-11.98801199
80.6	-13.18681319
78.5	-14.08591409
81.4	-16.48351648
80.3	-21.57842158
77.9	-22.17782218
77.4	-24.27572428
75.9	-24.87512488
75.7	-27.27272727
68.7	-27.57242757
70.2	-29.37062937
75.2	-30.86913087
75.6	-32.06793207
79.1	-32.06793207
80.2	-35.96403596
77.9	-38.96103896
78	-40.45954046
85.3	-41.05894106
86.2	-44.65534466
84.8	-46.75324675
77.9	-47.35264735
77.1	-51.24875125
84.3	-51.54845155
84.9	-53.64635365
86.1	-56.04395604
76.7	-56.04395604

Table III-11 cont.

Station 7

XMS	DEPTH
88.33499501	-2.104208417
86.44067797	-6.913827655
85.34396810	-11.42284569
81.75473579	-12.02404810
80.55832502	-15.03006012
81.55533400	-20.44088176
79.36191426	-21.04208417
76.96909272	-26.45290581
81.2562313	-27.65531062
74.17746760	-29.75951904
73.8783649	-30.66132265
70.98703888	-31.86372745
73.778664	-33.06613226
79.66101695	-33.96793587
76.47058824	-36.67334669
81.85443669	-37.8757515
80.45862413	-39.97995992
83.05084746	-42.08416834
85.0448654	-42.68537074
85.34396810	-44.48897796
83.54935194	-44.78957916
83.34995015	-46.59318637
77.666999	-46.89378758
77.4675972	-48.99799599
75.67298106	-49.29859719
80.35892323	-53.20641283
72.68195414	-54.70941884
61.11665005	-58.31663327
82.85144566	-58.91783567
85.74277168	-61.92384770
83.64905284	-66.73346693
88.43469591	-67.33466934
88.93320040	-71.54308617

Station 8

XMS	DEPTH
81.4556331	-0.721442886
81.1565304	-2.5250501
80.25922233	-12.53507014
77.4675972	-12.89579158
78.36490528	-15.33066132
76.57028913	-18.21643287
76.76969093	-19.29859719
78.36490528	-19.38877756
78.56430708	-21.73346693
77.5672981	-25.52104208
75.57328016	-25.43086172
74.37686939	-26.1523046
71.18644068	-25.97194389
71.38584247	-29.66933868
73.8783649	-30.12024048
75.87238285	-35.71142285
77.5672981	-38.23647295
77.7666999	-39.49899300
80.65802592	-44.45891784
81.55533400	-45.09018036
79.86041874	-45.9018036
79.16251246	-47.07414830
77.7666999	-47.25450902

Station 9

XMS	DEPTH
86.8263473	0.300902708
86.9261477	-0.902708124
81.73652695	-1.805416249
87.0259481	-3.911735206
86.3273453	-8.124373119
85.02994012	-11.73520562
81.33732535	-12.93881645
83.63273453	-15.94784353
81.73652695	-17.15145436
82.23552894	-21.66499498
84.13173653	-21.96589769
83.93213573	-25.87763290
77.44510978	-26.47943831
75.64870259	-30.99297894
78.54291417	-33.09929789
79.04191617	-34.90471414
81.03792415	-35.50651956
81.83632735	-39.41825476
83.23353293	-39.41825476
83.93213573	-41.22367101
87.52495010	-43.02908726
85.22954092	-48.14443330
74.251497	-48.445336
79.64071856	-50.55165496
79.14171657	-53.56068205
83.83233533	-54.76429288
81.63672655	-56.87061184
83.03393214	-58.67602808
80.73852295	-59.2778335
80.53892216	-60.48144433
78.54291417	-61.68505517
78.24351297	-62.88866600
75.34930140	-64.39317954
82.43512974	-65.59679037
69.26147705	-66.49949850

Table III-11 cont.

Station 10		Station 11		Station 12	
XMS	DEPTH	XMS	DEPTH	XMS	DEPTH
85.21478521	-4.195804196	85.24426720	-3.607214429	83.54935194	-1.8
84.51548452	-9.29070929	83.15054835	-19.53907816	82.75174477	-6
81.51848152	-11.68831169	75.97208375	-23.44689379	81.05682951	-8.1
80.51948052	-17.98201798	81.4556331	-33.96793587	80.55832502	-10.2
82.51748252	-21.57842158	79.46161515	-36.07214429	78.56430708	-11.1
81.31868132	-26.37362637	83.15054835	-37.8757515	77.7666999	-19.2
72.52747253	-28.47152847	83.44965105	-39.37875752	78.96311067	-20.4
76.52347652	-31.16883117	86.73978066	-40.58116232	78.96311067	-24
77.82217782	-35.06493506	86.73978066	-45.09018036	76.27118644	-24
81.41858142	-35.96403596	87.23828514	-48.39679359	75.27417747	-27
79.12087912	-39.26073926	87.03888335	-50.2004008	69.19242273	-28.8
80.81918082	-41.65834166	84.64606181	-50.8016032	69.79062812	-32.7
86.71328671	-41.95804196	84.44666002	-55.01002004	74.57627119	-32.7
87.01298701	-45.85414585	80.55832502	-55.31062124	74.47657029	-34.5
83.61638362	-50.34965035	80.15952144	-56.81362725	77.666999	-37.2
78.02197802	-50.94905095	75.17447657	-57.71543086	78.36490528	-41.1
83.11688312	-52.44755245	74.27716849	-61.62324649	82.35294118	-43.8
75.82417582	-55.14485514	66.89930209	-61.32264529	78.96311067	-47.7
79.02097902	-62.93706294	72.18344965	-63.1262525	62.7118644	-51.6
87.61238761	-65.93406593	64.20737787	-63.7274549	73.57926221	-54.9
79.22077922	-68.33166833	72.38285145	-64.92985972	72.38285145	-57
81.41858142	-73.42657343	66.4007976	-66.13226453	81.75473579	-60.9
				76.17148554	-66.9

Table III-12

TRANSMISSIVITY WITH DEPTH AT HOSPITAL ROCK

Cruise 76L3

Station 3		Station 4	
XMS	DEPTH	XMS	DEPTH
80	-0.179640719	75.22477522	-0.269192423
79.7	-2.065868263	74.52547453	-8.703888335
80.8	-4.131736527	74.82517483	-10.85742772
80.5	-5.658682635	75.62437562	-14.08773679
81.1	-7.814371258	76.72327672	-18.03589232
81.3	-12.66467066	78.92107892	-21.44566301
84	-15.80838323	81.51848152	-23.59920239
82.4	-24.43113772	84.31568432	-26.111665
80.4	-26.6766467	84.71528472	-28.444666
57.7	-29.19161677	83.71628372	-38.67397807
80	-30.80838323	83.21678322	-45.0448654
79.8	-33.68263473	81.61838162	-48.90329013
74.2	-34.22155689	80.41958042	-52.40279163
82.4	-37.54491018	78.82117882	-56.53040877
83.3	-38.98203593	76.62337662	-58.59421735
82.3	-39.88023952	74.02597403	-62.27318046
79.8	-40.68862275	70.52947053	-63.61914257
83.5	-43.38323353	65.03496503	-65.05483549
81.8	-45.98802395	56.84315684	-66.31106680
79.7	-46.61676647	55.94405594	-69.72083749
77.7	-47.69461078	50.04995005	-69.54137587
78.5	-48.50299401	44.25574426	-70.97706879
81.1	-48.86227545	36.06393606	-70.97706879
77.3	-53.62275449	29.17082917	-71.0667996
68.2	-54.61077844	22.57742258	-71.69491525
66.3	-55.77844311	18.38161838	-72.05383848
66.1	-57.39520958	13.68631369	-72.68195414
66.8	-59.28143713	9.59040959	-73.75872383
72	-60.08982036	8.491508492	-75.55333998
78.8	-62.15568862	6.893106893	-76.09172483
79.7	-63.14371258		
78.7	-64.13173653		
72.2	-64.67065868		
66.8	-66.01796407		
63.8	-67.45508982		
61.9	-69.7005988		
59	-71.58682635		
53.8	-73.92215569		
42.1	-75		
28.8	-75.53892216		
19.4	-76.16766467		
13.7	-77.78443114		

Table III-12 cont.

Cruise 76L5

Station 7

XMS	DEPTH
66.99900299	-0.084745763
72.28315055	-1.016949153
72.48255234	-3.220338983
71.98404786	-6.016949153
71.38584247	-9.237288136
68.09571286	-10.59322034
64.50648056	-11.3559322
63.11066800	-12.20338983
65.90229312	-14.49152542
68.39481555	-15
72.48255234	-14.32203390
75.37387836	-15.6779661
76.57028913	-17.45762712
77.26819541	-19.83050847
78.06580259	-23.55932203
78.46460618	-25.6779661
78.16550349	-31.94915254
77.5672981	-35.33898305
77.36789631	-39.06779661
77.86640080	-42.96610169
76.86939182	-46.52542373
75.27417747	-48.3898305
70.88733799	-50.93220339
64.90528415	-52.54237288
60.31904287	-54.23728814
57.02891326	-55.84745763
53.43968096	-57.37288136
48.0558325	-58.13559322
40.17946162	-58.55932203
34.89531406	-59.32203390
31.40578265	-59.23728814
30.60817547	-61.01694915
32.00398804	-62.37288136
32.10368893	-65.25423729
30.80757727	-66.44067797
29.6111665	-66.18644068
28.61415753	-68.13559322
24.52642074	-68.3898305
24.32701894	-69.49152542
19.94017946	-71.3559322
16.15154536	-72.96610169

Station 8

XMS	DEPTH
62.73726274	-0.274353877
67.83216783	-0.914512922
68.03196803	-3.017892644
69.83016983	-4.48111332
69.53046953	-12.07157058
58.24175824	-13.26043738
69.93006993	-13.62624254
71.32867133	-14.54075547
63.53646354	-15.82107356
65.63436563	-18.01590457
63.83616384	-19.75347913
68.03196803	-20.85089463
71.92807193	-23.32007952
74.52547453	-24.87475149
75.52447552	-26.79522863
75.42457542	-29.53876740
74.02597403	-31.55069583
71.92807193	-34.2027833
70.12987013	-36.4890656
69.13086913	-38.22664016
71.12887113	-42.06759443
64.13586414	-43.43936382
62.53746254	-47.28031809
52.24775225	-48.46918489
45.25474525	-48.83499006
39.16083916	-49.56660040
34.96503497	-50.48111332
33.56643357	-52.40159046
33.16683317	-55.14512923
30.56943057	-56.05964215
28.07192807	-56.5168986
24.57542458	-57.24850895
22.97702298	-58.07157058
22.07792208	-61.82107356
16.78321678	-63.37574553
16.08391608	-67.30815109
11.48851149	-68.03976143
9.69030969	-69.41153082

Table III-12 cont.

Cruise 76G8-III

Station 1

XMS	DEPTH
63.93606394	-2.607392607
69.93006993	-3.236763237
67.83216783	-30.92907093
68.03196803	-32.9070929
66.83316683	-33.89610390
65.93406593	-58.71128871
64.53546454	-61.58841159
60.33966034	-62.93706294
46.35364635	-68.78121878
46.35364635	-70.57942058
24.27572428	-70.66933067

Station 2

XMS	DEPTH
87.05179283	-1.624874624
86.35458167	-14.26278837
80.67729084	-16.60982949
85.35856574	-18.68605817
86.15537849	-21.12337011
82.27091633	-24.28284855
84.56175299	-26.53961886
85.35856574	-30.15045135
78.88446215	-33.12938816
82.6693227	-35.11534604
80.87649402	-37.37211635
83.16733068	-40.7121364
81.1752988	-49.91975928
82.56972112	-51.81544634
82.47011952	-53.07923771
74.10358566	-55.42627884
79.18326693	-57.59277834
79.18326693	-58.94684052
75.09960159	-59.93981946
69.02390438	-62.91875627
47.80876494	-65.44633902
42.23107570	-67.79338014
41.33466135	-71.04312939
38.64541833	-72.03610833
31.87250996	-72.93881645

Station 3

XMS	DEPTH
91.62512463	-1.507537688
98.90329013	-2.713567839
95.21435693	-29.84924623
92.92123629	-37.08542714
93.41974078	-41.00502513
92.72183450	-45.22613065
93.41974078	-48.24120603
84.14755733	-54.27135678
83.84845464	-60.60301508
81.85443669	-65.42713568
71.08673978	-68.74371859
63.80857428	-76.88442211
30.10967099	-80.8040201

Station 4

XMS	DEPTH
71.58524427	-2.344689379
78.96311067	-3.426853707
76.17148554	-32.91583166
75.17447657	-34.62925852
74.27716849	-41.57314629
73.37986042	-43.01603206
74.07776670	-44.36873748
74.07776670	-56.63326653
64.40677966	-61.0521042
50.54835494	-64.02805611
47.65702891	-65.2004008
46.56031904	-66.55310621
21.23629113	-70.16032064
15.45363908	-72.95591182
12.76171486	-73.40681363

Station 5

XMS	DEPTH
68.82470120	-0.631895687
71.01593625	-1.083249749
69.12350598	-26.99097292
68.02788845	-27.89368104
67.23107570	-44.3229689
68.02788845	-48.74623872
61.15537849	-51.18355065
64.44223108	-53.16950853
61.25498008	-55.78736209
57.6693227	-57.95386159
57.37051793	-60.03009027
58.96414343	-60.93279840
58.46613546	-62.73821464
46.51394422	-64.6339017
44.52191235	-68.78635908
44.92031873	-70.86258776
39.74103586	-72.93881645
35.45816733	-77.001003
32.7689243	-77.54262788
32.6693227	-78.98696088

Station 6

XMS	DEPTH
69.66067864	-0.542168675
64.57085828	-1.807228916
72.45508982	-4.969879518
73.35329341	-6.686746988
72.45508982	-17.71084337
70.75848303	-18.88554217
71.75648703	-23.76506024
69.46107784	-35.06024096
68.66267465	-54.03614458
63.67265469	-56.92771084
66.46706587	-59.27710843
63.17365269	-60.72289157
62.1756487	-63.25301205
41.31736527	-65.87349398
37.4251497	-68.4939759
35.92814371	-71.20481928
[illegible]	[illegible]

Table III-12 cont.

Cruise 76G8-III

Station 7

XMS	DEPTH
79.72027972	-0.270541082
79.52047952	-8.83767535
77.12287712	-9.559118237
78.52147852	-11.18236473
78.22177822	-13.70741483
76.62337662	-15.1503006
78.22177822	-16.32264529
77.52247752	-19.02805611
72.52747253	-20.47094188
78.22177822	-22.27454910
78.02197802	-25.07014028
76.42357642	-25.97194389
76.02397602	-33.36673347
72.72727273	-34.08817635
74.22577423	-35.8016032
73.62637363	-42.11422846
67.73226773	-43.3767535
75.02497502	-47.34468938
75.12487512	-48.96793587
64.83516484	-51.31262525
66.43356643	-52.93587174
64.53546454	-54.28857715
64.03596404	-61.23246493
50.94905095	-64.56913828
48.15184815	-72.23446894
42.95704296	-73.31663327
38.56143856	-77.28456914

Station 8

XMS	DEPTH
61.03896104	-2.254509018
87.71228771	-3.607214429
85.61438561	-11.99398798
86.61338661	-16.95390782
84.51548452	-27.86573146
83.21678322	-28.2264529
84.11588412	-33.00601202
82.61738262	-37.33466934
83.11688312	-47.70541082
73.52647353	-48.87775551
79.02097902	-51.94388778
74.72527473	-52.5751503
74.12587413	-55.28056112
71.02897103	-57.17434870
72.32767233	-59.51903808
74.32567433	-60.33066132
73.72627373	-62.85571142
64.73526474	-66.73346693
45.25474525	-68.6272545
42.95704296	-69.88977956
46.45354645	-71.24248497
46.35364635	-74.03807615
43.05694306	-77.19438878
33.16683317	-78.2765531
28.47152847	-80.62124249

Station 9(A)

XMS	DEPTH
66.5004985	-3.881644935
70.1894317	-4.423269809
68.09571286	-27.98395186
66.69990030	-29.60882648
67.09870389	-54.4332999
61.51545364	-60.48144433
61.51545364	-62.55767302
40.77766700	-66.0782347
40.3788634	-71.49448345
25.52342971	-74.83450351
25.6231306	-76.00802407
17.24825523	-78.26479438
13.16051844	-78.26479438

Station 9(B)

XMS	DEPTH
63.90827517	-0.902708124
67.89631107	-1.624874624
67.19840479	-26.81043129
64.80558325	-31.41424273
66.20139581	-35.20561685
65.60319043	-56.50952859
63.31006979	-58.67602808
61.51545364	-58.94684052
60.91724826	-61.0230692
43.36989033	-73.93179539
21.43569292	-74.83450351
14.6560319	-76.09829489

Table III-12 cont.

Cruise 76G8-III

Station 9(C)

XMS	DEPTH
69.96007984	-1.983967936
71.65668663	-3.156312625
69.76047904	-31.2024048
68.66267465	-33.63727455
68.16367265	-54.64929860
66.26746507	-57.26452906
65.56886228	-61.23246493
55.28942116	-64.83967936
54.29141717	-68.71743487
47.50499002	-69.79959920
46.40718563	-72.86573146
18.26347305	-74.84969940

Station 10

XMS	DEPTH
82.95114656	-1.983967936
87.23828514	-4.238476954
83.54935194	-31.65330661
82.75174477	-54.01803607
75.17447657	-62.04408818
60.51844467	-65.2004008
53.04087737	-69.16833667
51.8444666	-73.58717435
26.32103689	-75.03006012

Station 11

XMS	DEPTH
84.13173653	-0.279812437
81.93612774	-33.03911735
82.53493014	-35.11534604
81.33732535	-35.5567001
79.04191617	-60.57171515
72.25548902	-63.9117352
64.97005988	-66.16850552
64.97005988	-68.15446339
62.87425150	-68.42527583
62.1756487	-71.67502508
60.07984032	-73.93179539
54.39121756	-76.54964895
30.13972056	-77.09127382

Station 12

XMS	DEPTH
78.44311377	-0.09
81.73652695	-0.9
78.84231537	-32.04
77.04590818	-56.61
75.24950100	-61.83
70.25948104	-63.54
67.26546906	-65.88
57.18562874	-69.48
55.78842315	-73.53
52.19560878	-74.88
51.59680639	-76.68

Table III-12 cont.

Cruise 76L40

Station 1

XMS	DEPTH
84.96015936	0
84.2629482	-6.31895687
83.26693227	-13.54062187
81.27490040	-17.75325978
81.37450199	-20.76228686
77.68924303	-32.19658977
78.0876494	-50.25075226
79.38247012	-53.25977934
79.88047809	-59.2778335
79.78087649	-61.08324975
73.4063745	-61.68505517
66.13545817	-62.88866600
61.95219124	-63.1895687
56.36653386	-64.09227683
55.17928287	-66.8004012
35.8565737	-68.00401204
30.37848606	-70.11033099
29.08366534	-70.7121364

Station 2

XMS	DEPTH
84.74576271	0.901803607
84.24725823	-9.018036072
83.54935194	-19.53907816
83.05084746	-24.34869739
82.15353938	-28.25651303
81.4556331	-34.26853707
78.46460618	-40.58116232
78.96311067	-47.49498998
79.76071785	-50.8016032
80.95712861	-53.20641283
81.65503490	-63.4268537
75.17447657	-63.4268537
71.98404786	-65.53106212
13.16051844	-70.64128257
10.9670987	-72.14428858
7.178464606	-72.74549098

Table III-13

TRANSMISSIVITY WITH DEPTH AT SOUTHERN BANK

Cruise 76L3

Station 2

XMS	DEPTH
63	-0.09
62.8	-33.39
61.7	-42.48
61.8	-55.8
61.6	-68.94
58.4	-70.83
52.8	-71.28
46.5	-71.55
45.1	-72.45
46.8	-73.62
54.9	-74.52
65.3	-75.96
67.9	-77.67
64.4	-80.1
57.1	-81.36
4	-81.81

Station 3

XMS	DEPTH
87.58758759	-0.089820359
89.48948949	-1.077844311
90.09009009	-3.323353293
91.69169169	-6.19760479
90.29029029	-11.6766467
88.38838839	-14.64071856
86.08608609	-16.25748503
84.38438438	-16.34730539
81.98198198	-19.58083832
81.38138138	-20.65868263
84.68468468	-22.81437126
89.08908909	-25.41916168
90.39039039	-26.58682635
90.29029029	-42.75449102
89.28928929	-49.4011976
88.08808809	-59.46107784
87.08708709	-65.47904192
86.08608609	-69.52095808
70.67067067	-71.40718563
63.76376376	-71.6766467
59.15915916	-72.21556886
57.05705706	-73.92215569
59.05905906	-75.08982036
62.96296296	-75.17964072
63.46346346	-75.71856287
63.36336336	-76.34730539
53.85385385	-76.5269461
44.84484484	-77.15568862
32.13213213	-78.32335329
26.12612613	-78.50299401
20.82082082	-79.04191617

Table III-13 cont.

Cruise 76L5

Station 3		Station 4	
XMS	DEPTH	XMS	DEPTH
67.5	-0.670658683	71.15768463	-0.251748252
69	-1.676646707	71.45708583	-1.174825175
69.7	-3.688622755	71.95608782	-4.195804196
69	-6.371257485	70.45908184	-9.146853147
66.6	-9.556886228	68.86227545	-9.902097902
68.7	-10.73053892	70.75848303	-10.99300699
70.3	-12.07185629	73.35329341	-11.83216783
71.2	-15.25748503	72.85429142	-13.93006993
70.5	-16.93413174	71.45708583	-15.77622378
67	-17.68862275	66.86626747	-16.27972028
69.9	-18.5269461	75.44910180	-16.95104895
72.7	-18.86227545	75.54890220	-20.64335664
73.8	-21.46107784	75.24950100	-21.98601399
72.7	-23.38922156	76.24750499	-23.32867133
72.9	-27.58083832	75.74850299	-27.94405594
73.3	-29.34131737	75.24950100	-30.04195804
73	-38.05988024	75.04990020	-35.07692308
72.2	-39.31736527	75.24950100	-38.09790210
73.1	-43.84431138	75.74850299	-42.71328671
72.6	-47.02994012	75.34930140	-47.07692308
72.6	-52.81437126	74.8502994	-50.68531469
71.8	-56.251497	74.6506986	-54.79720280
71	-60.94610778	74.3512974	-56.81118881
67.4	-61.61676647	70.75848303	-58.15384615
62.2	-62.20359281	66.96606786	-59.74825175
55.5	-62.95808383	63.17365269	-61.006993
48.6	-63.62874252	59.68063872	-62.68531469
44.2	-64.88622755	54.29141717	-63.27272727
39.3	-66.22754491	51.19760479	-63.35664336
37.2	-67.48502994	48.70259481	-64.61538462
39.5	-68.8263473	47.70459082	-66.29370629
43.7	-69.49700599	44.21157685	-66.88111888
44.4	-70	39.92015968	-67.88811189
43.6	-70.50299401	35.32934132	-68.72727273
38.1	-71.17365270	31.53692615	-69.56643357
32.6	-71.25748503	29.04191617	-70.99300699
28.8	-71.92814371	28.04391218	-73.67832168
24	-72.76646707	26.74650699	-75.35664336
21.2	-73.1017964	23.65269461	-75.6083916
18.3	-73.85628743	20.65868263	-75.86013986
14.5	-75.28143713	17.76447106	-76.78321678
13.5	-75.86826347	15.26946108	-77.79020979
		14.47105788	-78.29370629

Table III-13 cont.

Cruise 76G8-III

Station 1

XMS	DEPTH
87.1257485	0
73.8522954	-1.082164329
89.32135729	-2.705410822
88.42315369	-6.763527054
87.92415170	-8.116232465
88.22355289	-9.739478958
87.3253493	-11.90380762
86.7265469	-17.13426854
85.82834331	-24.61923848
84.23153693	-27.41482966
84.33133733	-30.3006012
84.53093812	-33.45691383
83.13373253	-36.79358717
83.63273453	-38.05611222
83.03393214	-39.85971944
82.93413174	-51.49298597
83.03393214	-57.71543086
82.93413174	-60.51102204
81.43712575	-63.03607214
79.14171657	-67.09418838
75.94810379	-68.35671343
70.95808383	-68.89779559
62.57485030	-68.98797595
47.80439122	-70.43086172
42.61477046	-72.59519038
38.82235529	-75.03006012
33.13373253	-77.28456914
28.94211577	-78.72745491
24.0518962	-79.17835671
19.36127745	-79.44889780

Station 2

XMS	DEPTH
85.02994012	0.450450450
68.26347305	-0.720720721
78.64271457	-2.432432432
79.74051896	-3.693693694
77.74451098	-13.87387387
76.64670659	-22.97297297
74.8502994	-26.3063063
75.34930140	-27.65765766
73.25349301	-45.4054054
73.15369261	-46.48648649
73.45309381	-50.81081081
73.05389222	-52.16216216
73.752495	-52.88288288
74.1516966	-54.59459459
73.8522954	-59.81981982
72.95409182	-61.44144144
72.75449102	-64.86486486
70.35928144	-68.73873874
60.67864271	-70.72072072
57.08582834	-72.88288288
52.39520958	-75.4054054
47.70459082	-79.9099099
40.61876248	-80.45045045
34.43113772	-81.35135135
27.34530938	-82.7027027

Station 3

XMS	DEPTH
69.16167665	-0.090361446
67.06586826	-2.530120482
69.06187625	-4.518072289
66.86626747	-26.83734940
65.36926148	-28.01204819
66.36726547	-32.89156627
65.46906188	-33.88554217
65.76846307	-40.30120482
64.97005988	-41.56626506
63.97205589	-54.4879518
63.37325349	-64.06626506
54.49101796	-66.50602410
45.30938124	-68.94578313
27.54491018	-72.37951807
29.34131737	-74.54819277
28.04391218	-75.09036145
23.9520958	-75.90361446
18.26347305	-77.89156627
8.383233533	-80.42168675
0.598802395	-81.41566265

Table III-13 cont.

Cruise 76G8-III

Station 4

XMS	DEPTH
65.96806387	-0.811623246
70.55888224	-1.35270541
68.96207585	-24.25851703
67.56487026	-26.33266533
68.36327345	-27.86573146
66.56686627	-54.10821643
65.56886228	-56.45290581
65.16966068	-59.42885772
65.66866267	-60.6012024
62.2754491	-66.28256513
63.77245509	-69.88977956
61.5768463	-70.7014028
43.31337325	-71.87374750
32.23552894	-75.751503
26.94610778	-77.64529058

Station 5

XMS	DEPTH
67.36526946	-0.450450450
57.68463074	-2.522522523
67.16566866	-3.513513514
68.86227545	-4.504504505
67.46506986	-22.88288288
66.06786427	-25.04504505
66.96606786	-26.12612613
65.56886228	-29.27927928
64.37125749	-39.72972973
63.17365269	-40.99099099
64.97005988	-42.52252252
64.37125749	-54.77477477
61.5768463	-56.39639640
63.37325349	-58.19819820
63.07385230	-61.26126126
60.47904192	-62.79279279
60.97804391	-65.67567568
61.6766467	-67.38738739
59.48103792	-67.56756757
59.68063872	-69.54954955
61.4770459	-70.9009009
61.4770459	-73.06306306
55.48902196	-73.6036036
38.82235529	-75.4054054
29.74051896	-79.27927928
29.24151697	-84.14414414

Station 6

XMS	DEPTH
58.5	-2.072072072
70	-3.153153153
67.4	-28.1081081
66.1	-29.36936937
66.5	-30.45045045
65.9	-36.39639640
65.8	-39.36936937
66.4	-42.25225225
66.4	-47.92792793
65	-54.86486486
62.9	-56.12612613
64.4	-57.83783784
64	-60.54054054
62.9	-61.44144144
63	-62.88288288
59.8	-70.18018018
49.1	-72.52252252
53.1	-74.41441441
33.5	-77.29729730
31.9	-81.53153153
31.9	-81.17117117

Table III-13 cont.

Cruise 76G8-III

Station 7

XMS	DEPTH
67.82868526	-0.361083250
70.2191235	-1.173520562
67.62948207	-2.61785356
70.71713147	-4.332998997
65.93625498	-46.85055166
67.1314741	-59.39819458
64.94023904	-66.0782347
60.05976096	-69.86960883
51.89243028	-73.48044132
38.14741036	-74.92477432
31.97211155	-76.18856570
25.59760956	-77.09127382
22.21115538	-78.80641926
23.00796813	-82.50752257
16.93227092	-82.86860582

Station 8

XMS	DEPTH
59.92023928	-2.792792793
70.2891326	-4.594594595
67.89631107	-27.02702703
66.3010967	-29.18918919
64.90528415	-53.24324324
62.7118644	-55.76576577
64.00797607	-57.11711712
62.7118644	-60.81081081
63.01096710	-61.71171171
62.01395813	-62.88288288
61.21635095	-67.47747748
38.88334995	-70.09009009
36.39082752	-71.98198198
40.3788634	-74.68468468
34.89531406	-76.39639640
34.69591226	-77.56756757
25.7228315	-79.81981982
22.43270189	-82.61261261

Station 9

XMS	DEPTH
43.86839482	-1.533066132
69.49152542	-3.607214429
66.99900299	-25.16032064
65.50348953	-26.1523046
66.10169492	-27.86573146
65.90229312	-34.62925852
66.3010967	-36.79358717
65.20438684	-38.14629259
64.40677966	-46.08216433
54.83549352	-47.5250501
63.11066800	-49.77955912
63.60917248	-53.4769539
62.41276171	-57.71543086
63.50947159	-59.06813627
61.51545364	-61.86372746
59.222333	-64.38877756
59.52143569	-66.82364730
61.51545364	-68.1763527
61.31605184	-69.52905812
44.76570289	-71.51302605
42.17347956	-72.86573146
38.18544367	-72.7755511
37.18843470	-74.12825651
13.26021934	-76.92384770
12.10350947	-78.2765531
3.389830508	-78.00601202

Table III-13 cont.

Cruise 76G8-III

Station 10

XMS	DEPTH
66.03396603	-0.81
68.93106893	-1.8
67.43256743	-24.3
66.13386613	-25.74
64.73526474	-41.85
65.53446553	-44.1
64.63536464	-45.81
64.93506494	-57.96
65.73426573	-59.58
64.73526474	-60.57
65.03496503	-63.54
65.63436563	-63.9
64.93506494	-66.87
60.23976024	-69.57
53.74625375	-70.74
40.15984016	-72.09
19.68031968	-77.4
16.88311688	-82.35

Station 11

XMS	DEPTH
66.99900299	-0.810810811
69.69092722	-1.891891892
67.59720037	-22.43243243
66.10169492	-24.5045045
66.89930209	-26.66666667
65.80259222	-36.75675676
64.80558325	-38.64864865
65.10468594	-59.81981982
64.00797607	-62.16216216
65.00498504	-64.77477477
64.70588235	-68.55855856
60.01994018	-71.53153153
39.48155533	-75.13513514
28.31505484	-76.75675676
24.92522433	-78.28828829
22.33300100	-79.54954955
21.33599202	-81.62162162
18.14556331	-81.71171171

Station 12

XMS	DEPTH
48	-0.720720721
65.9	-1.621621622
68.3	-4.504504505
65.2	-5.135135135
66.3	-5.945945946
65.6	-6.756756757
68.3	-10.18018018
60.9	-13.69369369
67.5	-15.04504505
67.5	-16.66666667
66.9	-17.47747748
67.7	-19.09909910
64.5	-41.71171171
64.8	-43.24324324
63.6	-45.31531532
65.2	-59.27927928
63.7	-61.35135135
64.6	-63.51351351
62	-68.37837838
55.4	-70.36036036
52.8	-74.41441441
48	-75.94594595
23.9	-80.45045045
20	-83.15315315

Table III-13 cont.

Cruise 76G8-III

Time Series Station A

Hour 1		Hour 2		Hour 3	
XMS	DEPTH	XMS	DEPTH	XMS	DEPTH
70.11952191	-2.52758	66.6001994	-2.708124	68.36327345	-1.17
71.812749	-2.97893	70.0897308	-3.249749	70.75848303	-2.7
68.82470120	-38.3650	68.09571286	-28.34503	68.16367265	-29.07
67.23107570	-39.8094	66.3010967	-38.63590	69.06187625	-30.51
68.82470120	-47.1213	65.10468594	-39.17753	67.06586826	-32.22
70.11952191	-49.0170	65.30408774	-41.61484	67.66467066	-35.64
70.2191235	-53.1695	68.49451645	-55.24573	65.76846307	-41.22
70.81673307	-55.0651	66.89930209	-60.93279	65.66866267	-42.84
69.82071713	-58.0441	67.39780658	-67.34202	67.36526946	-46.98
70.01992032	-67.0712	54.83549352	-68.42527	68.46307385	-53.91
53.68525896	-70.1404	53.33998006	-70.41123	66.76646707	-62.1
51.99203187	-72.4874	45.56331007	-71.58475	64.57085828	-63.18
44.02390438	-74.8345	40.6779661	-72.66800	66.06786427	-65.79
43.82470120	-77.3620	40.27916251	-73.84152	50.79840319	-67.5
33.96414343	-80.0702	35.09471585	-75.55667	44.41117764	-70.74
27.19123506	-80.5215	32.10368893	-77.18154	41.81636727	-73.8
				29.94011976	-75.15
				28.14371257	-76.23

Table III-13 cont.

Cruise 76G8-III

Time Series Station A

Hour 4

XMS	DEPTH
60.07984032	-2.60479
72.65469062	-3.77245
70.15968064	-27.4850
70.25948104	-29.4610
69.36127745	-30.6287
67.96407186	-36.1976
68.86227545	-38.3532
66.56686627	-39.5209
66.76646707	-44.4610
68.76247505	-48.4131
70.15968064	-54.4311
70.75848303	-60.5389
67.26546906	-65.2994
60.27944112	-66.0179
50.79840319	-68.1736
46.60678643	-69.4311
46.00798403	-70.9580
39.72055888	-73.1137
38.42315369	-75.7185
35.62874251	-76.9760
-999	-999

Hour 5

XMS	DEPTH
72.65469062	-0.54054
70.75848303	-4.68468
69.76047904	-27.6576
70.85828343	-28.6486
69.06187625	-30.1801
68.06387226	-33.1531
68.66267465	-35.3153
68.76247505	-37.4774
67.56487026	-40.8108
65.86826347	-42.0720
65.86826347	-44.5045
68.46307385	-49.5495
70.15968064	-54.9549
71.15768463	-61.1711
69.96007984	-64.6846
51.89620758	-66.1261
44.91017964	-69.0090
44.51097804	-70.7207
36.8263473	-73.5135
35.82834331	-75.9459
33.73253493	-76.6666
32.43512974	-77.7477
20.65868263	-78.6486
-999	-999

Hour 6

XMS	DEPTH
71.72827173	-0.54108
71.52847153	-5.41082
70.92907093	-6.31262
68.43156843	-27.8657
67.63236763	-32.4649
66.63336663	-33.8176
67.03296703	-35.4408
67.23276723	-39.5891
63.93606394	-44.8196
69.53046953	-58.6172
69.13086913	-62.6753
68.13186813	-63.0360
67.53246753	-64.6593
50.24975025	-65.3004
43.55644356	-67.3647
40.85914086	-67.5450
40.85914086	-71.7835
38.86113886	-72.6853
39.26073926	-74.5791
38.36163836	-76.1122
-999	-999

Table III-13 cont.

Cruise 76G8-III

Time Series Station A

Hour 7

XMS	DEPTH
59.2629482	-1.80360
69.42231076	-3.24649
69.02390438	-7.03406
69.02390438	-9.55911
69.02390438	-13.2565
69.62151394	-15.7815
66.93227092	-28.4969
68.22709163	-30.0300
67.82868526	-33.2765
65.73705179	-34.3587
66.63346614	-37.4248
67.43027888	-42.2044
66.43426295	-43.9178
64.84063745	-45.3607
63.9442231	-48.4268
66.83266932	-53.3867
68.625498	-58.0761
69.22310757	-62.8557
66.23505976	-64.5691
39.24302789	-68.0861
38.64541833	-70.5210
36.85258964	-70.7014
37.54980080	-72.4148
36.05577689	-74.9398
33.36653386	-75.1202

Hour 8

XMS	DEPTH
67.76447106	-3.42342
65.36926148	-29.0990
66.66666667	-31.6216
64.67065868	-34.3243
64.37125749	-36.3963
65.66866267	-42.6126
65.26946108	-44.9549
63.57285429	-45.7657
63.07385230	-51.0810
65.86826347	-54.2342
67.06586826	-58.7387
67.26546906	-61.3513
65.66866267	-61.8918
65.16966068	-63.3333
38.12375250	-66.3063
35.22954092	-67.9279
35.32934132	-71.7117
33.53293413	-75.1351
35.02994012	-77.2072

Hour 9

XMS	DEPTH
67.06586826	-1.98795
66.66666667	-16.5361
65.36926148	-20.5120
65.06986028	-23.7650
65.36926148	-27.5602
64.97005988	-30.8132
65.46906188	-36.2349
63.47305389	-39.9397
64.57085828	-41.2048
65.16966068	-45.2710
64.77045908	-48.5240
62.97405190	-51.3253
63.27345309	-54.3975
63.87225549	-56.3855
65.56886228	-57.9216
66.16766467	-62.2590
63.97205589	-63.6144
45.00998004	-66.6867
37.0259481	-69.4879
33.53293413	-73.8253
33.23353293	-76.8975
29.64071856	-78.5240
31.03792415	-79.4277
27.74451098	-80.2409
24.8502994	-81.7771
10.17964072	-82.8614

Table III-13 cont.

Cruise 76G8-III

Time Series Station A

Hour 10

XMS	DEPTH
65.26946108	0.179820180
65.26946108	-2.877122877
64.37125749	-9.44055944
65.26946108	-12.22777223
64.87025948	-16.003996
63.97205589	-20.94905095
64.47105788	-23.37662338
64.27145709	-26.7032967
64.27145709	-29.76023976
64.17165669	-32.9070929
63.57285429	-37.4025974
64.37125749	-41.08891109
64.57085828	-45.04495505
63.37325349	-48.1018981
63.47305389	-50.43956044
65.16966068	-55.47452547
65.76846307	-59.34065934
64.17165669	-61.67832168
38.42315369	-64.82517483
33.23353293	-69.95004995
34.63073852	-72.01798202
33.33333333	-74.53546454

Hour 11

XMS	DEPTH
65.23476523	-3.701103310
64.93506494	-10.74222668
66.03396603	-13.17953862
64.13586414	-24.82447342
63.63636364	-29.15747242
64.33566434	-30.69207623
63.23676324	-39.89969910
64.33566434	-45.85757272
64.23576424	-48.56569709
62.93706294	-51.27382146
62.63736264	-54.4332999
63.63636364	-56.50952859
65.23476523	-61.11334002
65.43456543	-63.9117352
33.66633367	-69.86960883
32.66733267	-76.18856570
31.26873127	-78.71614845

Hour 12

XMS	DEPTH
64.77045908	-3.423423423
64.37125749	-13.42342342
65.16966068	-15.13513514
64.87025948	-23.42342342
64.07185629	-29.09909910
64.07185629	-33.51351351
63.77245509	-40.18018018
63.77245509	-41.98198198
64.57085828	-44.59459459
64.27145709	-47.92792793
63.47305389	-49.45945946
63.27345309	-52.7027027
64.07185629	-55.13513514
65.26946108	-58.46846847
65.76846307	-61.53153153
61.9760479	-64.41441441
47.60479042	-65.22522523
47.10578842	-67.11711712
34.43113772	-69.36936937
32.03592814	-71.44144144
32.13572854	-74.32432432
30.73852295	-75.4054054
30.73852295	-79.45945946

Table III-13 cont.

Cruise 76L40

Station 1

XMS	DEPTH
68.46307385	-1.803607214
68.06387226	-9.318637275
67.56487026	-18.93787575
66.66666667	-30.06012024
66.16766467	-37.5751503
65.66866267	-44.78957916
64.77045908	-51.40280561
64.27145709	-57.11422846
61.7764471	-58.91783567
60.67864271	-63.1262525
62.57485030	-65.23046092
65.16966068	-64.62925852
66.36726547	-67.33466934
65.36926148	-69.13827655
62.2754491	-70.34068136
55.88822355	-70.34068136
49.8003992	-71.24248497
43.91217565	-71.54308617
38.72255489	-70.64128257
33.83233533	-72.44488978
31.83632735	-72.44488978
29.54091816	-75.751503
29.14171657	-80.86172345

Station 2

XMS	DEPTH
77.8	-0.901803607
76.7	-18.33667335
75.5	-27.35470942
75.4	-36.37274549
74.6	-44.78957916
73.8	-53.50701403
73.6	-60.72144289
71.1	-63.1262525
67.6	-65.23046092
65.9	-67.63527054
60.8	-70.04008016
53.2	-70.94188377
45.1	-73.34669339
43.5	-78.75751503
40.1	-79.05811623
33.6	-80.86172345
27.1	-80.56112224
22.2	-81.16232465
16.2	-81.76352705
10.5	-82.36472946
6.4	-83.26653307

Table III-14

TRANSMISSIVITY WITH DEPTH ON TRANSECT II
Cruise 76LM18

Station 1		Station 2	
XMS	DEPTH	XMS	DEPTH
20.26755853	-0.494117647	53.45345345	-0.152103560
19.96655518	-2.223529412	53.65365365	-1.064724919
17.85953177	-4.447058824	58.95895896	-1.216828479
17.55852843	-7.658823529	59.65965966	-2.281553398
18.46153846	-10.62352941	58.75875876	-3.650485437
27.090301	-12.6	51.85185185	-4.411003236
23.87959866	-13.83529412	55.05505506	-5.475728155
27.29096990	-17.04705882	57.75775776	-5.932038835
22.97658863	-18.03529412	58.05805806	-11.55987055
13.74581940	-19.02352941	58.85885886	-14.14563107
4.715719064	-18.77647059	59.55955956	-15.97087379
0.401337793	-19.27058824	58.95895896	-17.18770227
		60.56056056	-18.40453074
		62.46246246	-21.5987055
		63.86386386	-25.40129450
		63.16316316	-29.35598705
		62.46246246	-32.55016181
		61.66166166	-38.33009709
		59.15915916	-40.45954693
		55.85585586	-41.82847896
		51.45145145	-42.28478964
		46.94694695	-43.34951456
		42.84284284	-43.9579288
		34.43443443	-45.4789644

Table III-14 cont.

Cruise 76LM18

Station 4

XMS	DEPTH
43.1	-0.240601504
43.3	-7.939849624
56.6	-10.58646617
54.5	-18.76691729
34.1	-20.93233083
31.3	-22.37593985
31.8	-25.9849624
37.5	-28.15037594
36.1	-29.11278195
30.1	-30.31578947
25.9	-31.03759398
21.4	-31.03759398
7.3	-30.79699248

Station 5

XMS	DEPTH
54.1	-1.504702194
62.9	-4.514106583
60.8	-6.921630094
62.6	-8.727272727
61.6	-27.08463950
60.4	-39.42319749
57.8	-46.34482759
55.6	-52.96551724
58.2	-55.97492163
61	-59.88714734
61.6	-65.30407524
60	-68.01253919
62.1	-68.9153605
62.1	-70.72100313
60.9	-72.8275862
55.3	-75.23510972
50.5	-78.2445141
45.8	-82.15673981
42	-84.26332288
38.6	-85.46708464
35.4	-89.98119122
32.8	-92.99059561
28.4	-93.59247649

Station 6

XMS	DEPTH
71.87187187	-0.154958678
71.87187187	-1.084710744
74.77477477	-2.63429752
75.07507508	-7.438016529
75.07507508	-14.10123967
74.67467467	-20.7644628
73.57357357	-28.35743802
73.37337337	-31.45661157
72.37237237	-35.02066116
71.37137137	-40.9090909
69.26926927	-42.61363636
70.97097097	-44.16322314
73.27327327	-44.78305785
73.17317317	-47.41735537
72.07207207	-49.74173554
67.16716717	-50.98140496
63.86386386	-53.61570248
61.56156156	-56.40495868
58.45845846	-60.12396694
54.55455455	-61.20867769
49.74974975	-63.06818182
47.24724725	-64.92768595
44.34434434	-67.71694215
42.24224224	-70.04132231
41.04104104	-71.59090909
38.33833834	-72.36570248
34.23423423	-73.6053719
10.61061061	-73.6053719
2.602602603	-73.6053719

Table III-14 cont.

Cruise 76L3

Station 1		Station 2		Station 3	
XMS	DEPTH	XMS	DEPTH	XMS	DEPTH
20.7	-0.089361702	58.04195804	-0.717846461	81.48148148	-0.598205384
21.4	-1.608510638	56.64335664	-4.845463609	77.97797798	-4.486540379
21.8	-2.144680851	57.34265734	-12.65204387	75.67567568	-10.7676969
23	-2.94893617	60.23976024	-13.1006979	75.27527528	-14.6560319
24.7	-3.663829787	60.63936064	-13.90827517	76.07607608	-17.64705882
25	-4.110638298	58.44155844	-17.40777667	77.07707708	-18.54436690
24.8	-4.557446809	60.33966034	-19.0229312	77.17717718	-20.63808574
23.7	-4.914893617	59.44055944	-20.81754736	74.47447447	-21.83449651
22.7	-6.165957447	61.73826174	-23.24027916	73.67367367	-26.91924227
18.3	-7.327659575	63.43656344	-27.00897308	74.07407407	-30.50847458
16.9	-8.668085106	62.93706294	-30.14955135	75.07507508	-32.90129611
15.1	-8.84680851	62.73726274	-32.0338983	75.07507508	-38.28514457
14.2	-9.382978723	64.63536464	-33.02093719	74.37437437	-40.3788634
7.3	-10.09787234	64.33566434	-37.41774676	74.27427427	-47.55732802
7	-10.27659574	60.83916084	-38.40478564	73.87387387	-56.23130608
7.5	-10.63404255	54.14585415	-39.57128614	68.66866867	-61.01694915
11.1	-11.17021277	50.54945055	-41.81455633	69.36936937	-75.67298106
7.1	-11.52765957	48.35164835	-44.32701894	66.46646647	-79.26221336
4.4	-12.42127660	44.65534466	-46.30109671	62.36236236	-80.15952144
3.9	-13.04680851	39.66033966	-47.19840479	59.15915916	-80.45862413
4.6	-13.40425532	36.76323676	-48.27517448	58.55855856	-81.3559322
8.1	-13.67234043			59.35935936	-84.64696181
8	-14.02978723			65.86586587	-84.9451645
7.9	-14.47659574			64.56456456	-88.23529412
4.6	-15.01276596			62.76276276	-89.13260219
3	-16.17446809			65.96596597	-90.02991027
1.8	-18.31914894			67.46746747	-90.92721834
1.6	-18.85531915			69.46946947	-95.41375872
0.9	-19.03404255			67.56756757	-102.2931206
0.1	-20.55319149			64.66466466	-106.779661
-0.9	-19.39148936			60.56056056	-110.3688933
				54.25425425	-110.9670987
				48.34834835	-111.8644068
				43.04304304	-118.444666
				38.33833834	-120.8374875
				31.93193193	-120.5383848

Table III-14 cont.

Cruise 76L3

Station 4

XMS	DEPTH
30.43043043	-1.616766467
42.54254254	-2.065868263
45.64564565	-3.772455090
48.34834835	-5.658682635
49.04904905	-7.724550898
49.44944945	-10.32934132
49.74974975	-11.85628743
49.14914915	-14.91017964
48.24824825	-18.14371257
45.94594595	-19.94011976
42.84284284	-20.83832335
38.93893894	-21.64670659
34.53453453	-22.45508982
30.63063063	-23.44311377
28.32832833	-24.34131737
25.92592593	-24.79041916
22.22222222	-26.04790419
19.71971972	-27.21556886
16.71671672	-28.20359281
10.61061061	-28.65269461
1.701701702	-28.56287425

Station 5

XMS	DEPTH
58.8	-0.359640360
59.5	-1.528471528
60.8	-3.326673327
60	-4.675324675
59.9	-6.203796204
61	-8.181818182
60.7	-10.24975025
62.4	-12.85714286
65.8	-13.39660340
65.7	-17.44255744
63.3	-23.01698302
63.4	-25.53446553
62.4	-26.7032967
62.3	-30.47952048
64.7	-51.15884116
61.4	-61.49850150
59	-64.46553447
52.6	-65.45454545
46.3	-67.07292707
38.6	-68.24175824
28.8	-69.95004995
17.4	-71.11888112
9.3	-72.73726274

Station 6

XMS	DEPTH
73.92607393	-0.299700300
74.82517483	-6.893106893
74.72527473	-14.08591409
73.82617383	-19.78021978
73.12687313	-24.87512488
72.52747253	-37.16283716
72.12787213	-42.55744256
71.12887113	-49.15084915
69.43056943	-56.04395604
67.43256743	-61.73826174
64.93506494	-67.13286713
61.83816184	-69.83016983
58.04195804	-71.62837163
52.74725275	-72.82717283
49.35064935	-76.12387612
50.54945055	-78.22177822
54.14585415	-78.82117882
54.84515485	-79.72027972
54.24575425	-80.91908092
52.04795205	-82.41758242
51.44855145	-83.31668332
51.84815185	-85.41458541
55.24475524	-90.5094905
59.94005994	-92.007992
60.13986014	-93.8061938
59.54045954	-95.3046953
51.64835165	-96.8031968
37.86213786	-98.001998
29.77022977	-98.001998
25.17482517	-99.5004995
21.97802198	-101.8981019
18.68131868	-104.2957043

Table III-14 cont.

Cruise 76L5

Station 1

XMS	DEPTH
69.80942828	0
70.21063190	-1.02584493
71.41424273	-1.795228628
71.41424273	-3.077534791
71.61484453	-4.872763419
71.81544634	-6.838966203
71.51454363	-8.548707753
70.31093280	-9.232604374
67.60280843	-9.831013917
64.89468405	-10.68588469
62.48746239	-11.19880716
62.78836510	-11.88270378
57.57271815	-12.65208748
49.74924774	-13.16500994

Station 2

XMS	DEPTH
86.5	0.202783300
86.4	-1.825049702
71.5	-2.027833002
71.5	-7.705765402
71.2	-12.67395626
70.9	-14.70178926
71.2	-17.74353877
71.2	-20.27833002
63.8	-20.78528827
71.3	-21.59642147
71.9	-22.20477137
71.2	-23.42147117
71	-25.14512922
68.5	-26.46322068
67.9	-28.08548708
67.8	-28.69383698
57.8	-29.91053678
65.4	-30.72166998
69	-31.22862823
69.9	-33.15506958
69.9	-34.67594433
68.7	-36.60238569
67.8	-39.03578529
68.2	-41.06361829
66.7	-42.48310139
63	-42.38170974
36	-44.51093439
6.1	-51.00000000

Station 3

XMS	DEPTH
86.3273453	0
86.8263473	-6.929212363
86.7265469	-9.700897308
84.93013972	-12.19541376
87.1257485	-13.85842473
86.8263473	-16.07577268
88.32335329	-23.55932203
88.72255489	-27.43968096
88.02395210	-32.15154536
88.02395210	-41.29810568
87.4251497	-46.84147557
88.12375249	-50.444666
87.3253493	-55.98803589
87.82435130	-65.96610169
87.4251497	-68.18344965
87.72455090	-75.94416750
89.12175649	-80.6560319
90.11976048	-92.85144566
90.11976048	-98.94915254
90.51896208	-100.839332
90.51896208	-111.1445663
88.72255489	-115.0249252
85.22954092	-118.6281157
54.19161677	-126.6660020

Table III-4 cont.

Cruise 76L5

Station 4

XMS	DEPTH
61.13886114	-0.911088911
69.93006993	-1.366633367
71.02897103	-2.163836164
71.42857143	-6.035964036
70.62937063	-9.338661339
71.82817183	-15.26073926
70.82917083	-16.85514486
71.62837163	-17.88011988
70.02997003	-20.38561439
67.53246753	-22.09390609
68.93106893	-23.23276723
64.63536464	-25.05494505
62.13786214	-26.07992008
55.84415584	-27.1048951
57.04295704	-27.9020979
63.43656344	-28.47152847
65.23476523	-29.49650350
63.43656344	-29.83816184
57.84215784	-30.52147852
52.34765235	-30.4075924

Station 5

XMS	DEPTH
49.94994995	-0.526420738
64.36436436	-0.877367896
66.46646647	-2.544366899
66.36636637	-6.667996012
65.86586587	-9.563310070
66.76676677	-12.01994018
66.76676677	-17.28414756
57.85785786	-18.68793619
68.26826827	-20.09172483
67.66766767	-29.91824526
68.66866867	-32.81355932
68.96896897	-37.11266201
67.46746747	-40.70987039
68.06806807	-42.02592223
68.46846847	-53.78265204
67.66766767	-57.02891326
67.76776777	-62.90727817
67.56756757	-67.03090728
62.96296296	-67.90827517
56.25625626	-69.3120638
53.05305305	-70.27716849
49.14914915	-70.45264207
45.34534535	-70.62811565
38.93893894	-71.41774676
39.03903904	-72.99700897
43.54354354	-74.31306082
42.44244244	-76.50648056
38.33833834	-77.03290130
34.53453453	-77.91026919
31.83183183	-78.96311067
27.32732733	-79.22632104
22.62262262	-79.4895314
16.81681682	-80.10368893
12.61261261	-81.24426720

Station 6

XMS	DEPTH
75.47547548	0.253746254
77.77777778	-4.059940060
77.77777778	-5.836163836
79.77977978	-8.119880120
78.97897898	-11.67232767
80.78078078	-13.95604396
81.08108108	-27.4045954
80.78078078	-36.03196803
80.28028028	-41.36063936
80.38038038	-47.45054945
80.58058058	-52.01798202
79.97997998	-54.55544456
80.28028028	-59.63036963
80.78078078	-66.22777223
81.78178178	-74.85514486
81.38138138	-80.94505494
76.37637638	-83.73626374
76.07607608	-86.52747253
70.17017017	-89.31868132
62.76276276	-90.33366633
27.82782783	-95.4085914

Table III-14 cont.

Cruise 76G8-III

Station 1

XMS	DEPTH
34.33133733	-0.451354062
34.33133733	-2.888665998
35.02994012	-4.332998997
35.02994012	-5.506519559
34.93013972	-6.860581745
34.73053892	-7.492477432
35.32934132	-8.665997994
34.23153693	-10.11033099
34.73053892	-11.55466399
34.63073852	-13.0892678
34.53093812	-14.62387161
31.43712575	-16.06820461
30.63872255	-18.23470411
28.24351297	-19.67903711
26.64670659	-20.22066199
28.04391218	-21.39418255
24.6506986	-22.29689067

Station 2

XMS	DEPTH
54.84515485	-1.441441441
65.43456543	-2.612612613
60.73926074	-5.495495495
67.23276723	-7.297297297
67.43256743	-10.54054054
69.03096903	-12.25225225
65.43456543	-14.41441441
68.83116883	-16.3063063
70.12987013	-17.83783784
71.72827173	-18.46846847
68.03196803	-20.54054054
71.42857143	-23.43343343
69.53046953	-25.4054054
69.53046953	-26.93693694
71.52847153	-28.55855856
70.02997003	-29.36936937
66.13386613	-30.18018018
68.33166833	-33.78378378
65.63436563	-34.95495495
62.23776224	-36.21621622
55.94405594	-38.46846847
51.34865135	-39.63963964
39.66033966	-40.27027027
29.87012987	-41.53153153

Station 3

XMS	DEPTH
66.99900299	-0.3
67.89631107	-6
67.39780658	-16.2
66.10169492	-22.8
65.60319043	-29.1
64.80558325	-34.8
64.40677966	-38.4
63.21036889	-41.7
61.21635095	-44.7
63.90827517	-46.5
64.70588235	-54.3
63.70887338	-54.9
63.60917248	-60.6
60.61814556	-63.9
60.71784646	-69.9
62.01395813	-75.3
64.30707876	-76.8
67.89631107	-78.6
68.69391825	-81.6
68.79361914	-86.4
68.99302094	-92.7
60.41874377	-96.9
61.91425723	-98.4
68.49451645	-102
68.49451645	-105.3
60.41874377	-107.4
61.51545364	-110.1
67.79661017	-114.3
63.01096710	-117
54.83549352	-118.2
49.75074776	-119.7
47.25822532	-125.4
43.07078764	-124.8

01802
81682
12913
23423
154054
05105
765766
975976
376577
936937
567568
009009
129129
399399
639640
939940
042042
06006
081081
129129
015015
165165
174174
225225

Table III-14 cont.

Cruise 76G8-III

Station 4

XMS	DEPTH
56.98602794	-0.541082164
56.88622754	-3.426853707
56.38722555	-5.771543086
58.38323353	-7.845691383
58.78243513	-10.1002004
58.88223553	-11.72344689
57.48502994	-13.0761523
57.88423154	-14.60921844
56.98602794	-18.5771543
55.08982036	-20.2004008
55.28942116	-23.44689379
51.79640719	-24.88977956
54.79041916	-27.32464930
51.39720559	-28.2264529
44.81037924	-29.48897796
41.21756487	-31.11222445
34.03193613	-32.37474950
26.04790419	-32.8256513
10.97804391	-33.54709419

Station 5

XMS	DEPTH
73.8522954	-2.434869740
83.63273453	-3.78757515
81.13772455	-25.250501
79.74051896	-26.60320641
79.54091816	-30.84168337
78.14371257	-32.37474950
76.94610778	-42.29458918
76.34730539	-47.79559118
75.44910180	-49.95991984
73.35329341	-50.9519038
73.45309381	-54.37875752
73.55289421	-55.19038076
72.45508982	-56.18236473
74.6506986	-57.44488978
75.04990020	-59.42885772
71.35728543	-59.69939880
61.5768463	-61.14228457
54.09181637	-62.40480962
31.33732535	-64.11823647
26.24750499	-66.64328657
24.3512974	-69.97995992
21.75648703	-71.60320641

Station 6

XMS	DEPTH
73.8783549	-1.445783133
75.17447657	-3.614457831
73.778664	-21.77710843
72.38285145	-22.3192771
70.98703888	-35.78313253
70.38883350	-53.31325301
69.19242273	-54.66867470
65.00498504	-57.10843374
64.70588235	-59.36746988
66.3010967	-60.90361446
64.80558325	-61.71686747
59.72083749	-63.25301205
59.82053838	-67.95180723
67.89631107	-70.03012048
67.79661017	-72.46987952
70.58823529	-73.46385542
70.1894317	-76.08433735
69.79062812	-78.34337349
66.5004985	-79.24698795
59.42173480	-81.14457831
45.06480558	-82.86144578
37.98604187	-84.30722892

Table III-14 cont.

Cruise 76L10

Station 1

XMS	DEPTH
48.8023952	-0.300601202
45.50898204	-0.901803607
51.19760479	-2.705410822
48.60279441	-6.613226453
46.20758483	-7.51503006
43.31337325	-8.116232465
33.33333333	-9.619238477
44.81037924	-10.52104208
53.09381238	-11.42284569
53.39321357	-13.5270541
20.55388224	-14.42885772
1.996007984	-15.33066132

Station 2

XMS	DEPTH
53.14685315	0
52.84715285	-41.78356713
51.54845155	-42.98597194
51.44855145	-46.59318637
45.85414585	-48.99799599

Station 3

XMS	DEPTH
83.74875374	-0.3
86.04187438	-4.2
83.84845464	-6.9
85.44366899	-9
85.24426720	-14.1
84.04785643	-15.6
85.0448654	-18.3
83.94815553	-27.3
84.44666002	-43.2
85.74277168	-56.4
79.76071785	-59.4
81.55533400	-63.3
74.97507478	-66
80.05982054	-70.2
83.15054835	-71.4
87.13858425	-74.1
84.24725833	-78.9
86.83948156	-82.5
85.0448654	-84
72.08374875	-87.9
73.28015952	-90.9
72.58225324	-95.4
69.89032901	-99.9
67.79661017	-102.3
66.3010967	-103.5
65.50348953	-110.7
65.60319043	-113.4
36.19142572	-113.4

Table III-14 cont.

Cruise 76L10

Station 4

XMS	DEPTH
66.63336663	0.602409639
68.33166833	-1.204819277
62.03796204	-1.807228916
62.13786214	-5.722891566
66.13386613	-8.13253012
67.43256743	-10.24096386
64.63536464	-20.48192771
63.43656344	-21.68674699
48.45154845	-23.79518072
54.54545455	-25.60240964
46.35364635	-27.10843373
46.35364635	-30.42168675
49.05094905	-31.3253012
34.66533467	-34.33734940

Station 5

XMS	DEPTH
78.94211577	0.601805416
77.34530938	-15.64694082
76.74650699	-24.67402207
75.94810379	-33.4002006
73.45309381	-37.61283852
73.45309381	-42.12637914
72.05588822	-42.42728185
71.55688623	-46.33901705
72.35528942	-54.16248746
73.05389222	-56.87061184
75.54890220	-57.17151454
76.24750499	-60.18054162
76.34730539	-63.1895687
69.46107784	-67.70310933
64.87025948	-69.20762287
55.38922156	-71.01303912
49.1017964	-72.21664995
43.81237525	-73.11935807
39.22155689	-71.91574724
35.72854291	-72.21664995
32.03592814	-72.81845537
29.74051896	-75.82748245
28.44311377	-77.03109328

Station 6

XMS	DEPTH
69.83016983	-0.300300300
70.22977023	-4.804804805
69.43056943	-12.31231231
68.63136863	-21.32132132
68.13186813	-40.24024024
68.33166833	-51.05105105
68.43156843	-61.56156156
62.63736264	-65.16516517
63.83616384	-69.06906907
61.33866134	-72.97297297
55.44455544	-73.87387387
50.24975025	-74.17417417
45.25474525	-75.37537538
42.65734266	-76.27627628
42.35764236	-80.48048048
40.65934066	-81.38138138
39.36063936	-97.59759760
37.16283716	-98.49849850

TABLE III-15. EAST FLOWER GARDENS BANK SUSPENDED SEDIMENT DATA, CRUISE 76G8-II.

SAMPLE STATION-DEPTH(M)	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
1-1	0.0	0.0	14.72	85.28	9.12	9.23	0.99	-1.09	3.40
1-58	0.0	0.0	8.30	91.70	9.51	9.90	1.01	-1.69	5.11
1-95	0.0	0.0	4.66	95.34	9.59	9.82	0.88	-2.53	11.22
2-1	0.0	0.0	13.21	86.79	9.01	8.93	0.98	-0.85	3.35
2-33	0.0	0.0	11.11	88.89	9.26	9.38	1.02	-1.17	3.39
2-66	0.0	0.0	5.62	94.38	9.70	10.06	0.92	-2.53	10.14
3-1	0.0	0.0	10.06	89.94	9.20	9.34	0.94	-1.41	5.14
3-70	0.0	0.0	4.80	95.20	9.42	9.53	0.92	-1.79	7.46
4-1	0.0	0.0	13.45	86.55	9.09	9.13	0.98	-1.06	3.60
4-60	0.0	0.0	7.07	92.93	9.44	9.74	0.96	-1.79	6.20
4-90	0.0	0.0	9.76	90.24	9.41	9.72	0.99	-1.63	5.05

TABLE III-16. STETSON BANK SUSPENDED SEDIMENT DATA

SAMPLE STATION-DEPTH	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
STA1-1	0.0	0.0	58.20	41.80	7.38	7.26	1.91	0.07	-1.34
STA1-21	0.0	0.0	55.93	44.07	7.35	7.57	1.93	-0.06	-1.34
STA1-42	0.0	0.0	47.12	52.88	8.06	8.21	1.95	-0.33	-1.26
STA2-1	0.0	0.0	55.21	44.79	7.57	7.60	1.92	-0.07	-1.31
STA2-15	0.0	0.0	43.49	56.51	7.96	8.35	1.78	-0.50	-0.91
STA2-28	0.0	0.0	52.47	47.53	7.74	7.81	2.08	-0.12	-1.46
STA3-1	0.0	0.0	51.60	48.40	7.64	7.88	1.94	-0.15	-1.34
STA3-25	0.0	0.0	46.03	53.97	7.86	8.27	1.86	-0.41	-1.13
STA3-50	0.0	0.0	57.40	42.60	7.73	7.45	1.80	0.05	-1.22
STA4-1	0.0	0.0	63.91	36.09	7.13	6.86	1.90	0.19	-1.28
STA4-24	0.0	0.0	43.25	56.75	8.00	8.51	1.97	-0.41	-1.26
STA4-45	0.0	0.0	47.53	52.47	8.12	8.26	1.97	-0.30	-1.35

TABLE III-17 28 FATHOM BANK SUSPENDED SEDIMENT DATA

SAMPLE STATION-DEPTH	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
1-1	0.0	0.0	50.95	49.05	7.66	7.94	1.93	-0.21	-1.29
1-58	0.0	0.0	40.40	59.60	8.27	9.12	2.14	-0.51	-1.32
1-96	0.0	0.0	62.39	37.61	7.40	7.33	1.81	0.05	-1.08
2-1	0.0	0.0	51.99	48.01	7.59	7.82	1.98	-0.15	-1.41
2-33	0.0	0.0	43.17	56.83	8.03	8.42	1.92	-0.41	-1.19
2-66	0.0	0.0	33.14	66.86	8.55	9.29	1.82	-0.72	-0.92
3-1	0.0	0.0	54.00	46.00	7.51	7.49	2.09	-0.06	-1.48
3-54	0.0	0.0	43.82	56.18	7.95	8.41	1.93	-0.39	-1.25
3-73	0.0	0.0	51.22	48.78	7.58	7.78	2.35	-0.10	-1.70
4-1	0.0	0.0	57.21	42.79	7.42	7.43	1.79	0.01	-1.25
4-35	0.0	0.0	59.76	40.24	7.38	7.19	1.89	0.10	-1.32
4-74	0.0	0.0	39.97	60.03	8.27	9.11	2.02	-0.54	-1.24

TABLE III-18. 28 FATHOM BANK, SOUTHWEST PEAK, SUSPENDED SEDIMENT DATA

SAMPLE STATION-DEPTH	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
STA1-1	0.0	0.0	63.38	36.62	7.21	6.91	1.92	0.21	-1.29
STA1-75	0.0	0.0	41.16	58.84	8.12	8.48	1.86	-0.44	-1.08
STA1-150	0.0	0.0	53.51	46.49	7.85	7.75	1.88	-0.12	-1.20
STA2-1	0.0	0.0	36.57	63.43	8.33	9.19	2.06	-0.64	-1.11
STA2-38	0.0	0.0	68.16	31.84	6.91	6.52	1.77	0.34	-1.15
STA2-54	0.0	0.0	40.54	59.46	8.13	8.82	2.03	-0.50	-1.24
STA3-1	0.0	0.0	40.84	59.16	8.21	9.06	2.07	-0.48	-1.35
STA3-45	0.0	0.0	53.54	46.46	7.60	7.68	2.09	-0.08	-1.46
STA3-95	0.0	0.0	67.82	32.18	6.92	6.25	2.11	0.45	-1.29
STA4-1	0.0	0.0	54.94	45.06	7.41	7.46	2.02	-0.04	-1.44
STA4-60	0.0	0.0	51.10	48.90	7.68	7.88	2.11	-0.12	-1.49
STA4-128	0.0	0.0	27.13	72.87	8.78	9.63	1.77	-0.95	-0.30

TABLE III-19. HOSPITAL ROCK SUSPENDED SEDIMENT DATA

SAMPLE CRUISE-STA-DEPTH	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
76LM18-1-1	0.0	0.0	45.53	54.47	7.89	8.35	2.00	-0.35	-1.35
76LM18-1-33	0.0	0.0	52.40	47.60	7.56	7.13	2.29	-0.03	-1.77
76LM18-1-65	0.0	0.0	72.39	27.61	7.19	6.69	1.79	0.50	-0.84
76LM18-2-1	0.0	0.0	8.58	91.42	9.66	10.03	1.08	-2.56	6.80
76LM18-2-35	0.0	0.0	40.17	59.83	8.27	9.53	2.21	-0.59	-1.29
76LM18-2-70	0.0	0.0	49.42	50.58	7.88	8.07	2.17	-0.25	-1.46
76L3-3-1	0.0	0.0	27.48	72.52	8.77	9.63	1.83	-1.06	-0.26
76L3-3-33	0.0	0.0	62.56	37.44	7.26	6.93	2.00	0.16	-1.32
76L3-3-66	0.0	0.0	50.17	49.83	7.89	7.99	1.67	-0.17	-1.07
76L3-4-1	0.0	0.0	52.73	47.27	7.64	7.88	1.72	-0.06	-1.10
76L3-4-40	0.0	0.0	64.88	35.12	7.13	6.77	1.90	0.26	-1.20
76L3-4-64	0.0	0.0	53.69	46.31	7.86	7.80	1.76	-0.05	-1.21
76L3-4-74	0.0	0.0	49.92	50.08	8.06	8.00	1.46	-0.35	-0.11

TABLE III-19. HOSPITAL ROCK SUSPENDED SEDIMENT DATA, cont.

SAMPLE CRUISE-STA-DEPTH	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
76L5-3-2	0.0	0.0	66.61	33.39	7.08	6.65	1.89	0.36	-1.20
76L5-3-35	0.0	0.0	33.84	66.16	8.41	9.39	1.92	-0.84	-0.78
76L5-4-1	0.0	0.0	42.66	57.34	8.11	8.38	1.64	-0.51	-0.68
76L5-4-34	0.0	0.0	59.47	40.53	7.41	7.55	2.00	0.02	-1.33
76L5-4-69	0.0	0.0	57.47	42.53	7.63	7.56	1.49	0.03	-1.07
76L40-1-1	0.0	0.0	48.30	51.70	7.88	8.18	1.90	-0.19	-1.38
76L40-1-40	0.0	0.0	45.73	54.27	7.93	8.27	1.87	-0.32	-1.24
76L40-1-70	0.0	0.0	76.21	23.79	6.41	5.70	1.91	0.82	-0.71
76L40-2-1	0.0	0.0	66.92	33.08	7.21	6.53	1.88	0.46	-1.20
76L40-2-39	0.0	0.0	58.29	41.71	7.39	7.37	1.89	0.02	-1.30
76L40-2-69	0.0	0.0	71.71	28.29	6.86	6.25	1.84	0.58	-0.98

TABLE III-20. SOUTHERN BANK SUSPENDED SEDIMENT DATA

SAMPLE CRUISE-STA-DEPTH	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
76LM18-4-1	0.0	0.0	64.69	35.31	7.01	6.07	2.26	0.40	-1.51
76LM18-4-71	0.0	0.0	80.55	19.45	6.83	6.62	1.53	0.60	-0.13
76LM18-4-35	0.0	0.0	60.06	39.94	7.82	7.75	1.30	0.03	0.08
76LM18-1-1	0.0	0.0	73.92	26.08	6.51	5.71	2.08	0.76	-0.92
76LM18-1-36	0.0	0.0	68.42	31.58	6.88	6.09	2.11	0.51	-1.30
76LM18-1-70	0.0	0.0	46.56	53.44	8.12	9.09	2.05	-0.19	-1.75
76L3-2-1	0.0	0.0	30.63	69.37	8.63	9.25	1.70	-0.90	-0.38
76L3-2-45	0.0	0.0	36.00	64.00	8.38	9.06	1.88	-0.69	-0.85
76L3-2-74	0.0	0.0	43.34	56.66	8.31	8.64	1.85	-0.48	-1.06
76L3-2-80	0.0	0.0	58.63	41.37	7.65	6.89	1.87	0.22	-1.52
76L3-3-1	0.0	0.0	65.08	34.92	7.03	6.73	1.75	0.21	-1.20
76L3-3-28	0.0	0.0	52.40	47.60	7.83	7.84	1.88	-0.14	-1.37
76L3-3-70	0.0	0.0	31.43	68.57	8.66	9.06	1.70	-0.85	-0.27
76L3-3-75	0.0	0.0	57.03	42.97	7.27	7.56	2.18	-0.10	-1.46

TABLE III-20. SOUTHERN BANK SUSPENDED SEDIMENT DATA, CONTINUED

SAMPLE CRUISE-STA-DEPTH	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
76L5-3-2	0.0	0.0	33.19	66.81	8.42	9.17	1.98	-0.78	-0.78
76L5-3-36	0.0	0.0	76.02	23.98	6.39	5.70	1.91	0.71	-0.84
76L5-3-74	0.0	0.0	61.84	38.16	7.35	7.16	1.93	0.13	-1.29
76L5-4-2	0.0	0.0	43.24	56.76	8.01	8.38	1.96	-0.36	-1.28
76L5-4-33	0.0	0.0	77.17	22.83	6.40	5.95	1.89	0.60	-0.86
76L5-4-77	0.0	0.0	85.77	14.23	6.46	6.07	1.36	1.36	1.17
76L10-1-1	0.0	0.0	51.56	48.44	7.66	7.87	1.94	-0.14	-1.36
76L10-1-60	0.0	0.0	67.79	32.21	6.98	6.59	1.81	0.34	-1.11
76L10-4-1	0.0	0.0	50.04	49.96	7.74	8.00	1.99	-0.18	-1.41
76L10-4-60	0.0	0.0	62.49	37.51	7.37	6.93	1.85	0.27	-1.26
76L10-4-76	0.0	0.0	66.55	33.45	7.18	6.60	1.78	0.44	-1.06

TABLE III-21. TRANSECT II SUSPENDED SEDIMENT DATA, CRUISE 76LM18.

SAMPLE STATION-DEPTH	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
1-1	0.0	0.0	71.58	28.42	7.00	6.44	1.71	0.63	-0.75
1-10	0.0	0.0	69.51	30.49	7.43	7.35	1.82	0.13	-0.96
1-20	0.0	0.0	76.47	23.53	6.66	5.92	1.91	0.91	-0.61
1-20	0.0	0.0	68.61	31.39	6.88	5.90	2.08	0.64	-1.25
2-1	0.0	0.0	53.93	46.07	7.47	7.39	2.09	0.02	-1.57
2-24	0.0	0.0	82.56	17.44	5.96	5.28	2.00	1.06	-0.16
2-45	0.0	0.0	87.05	12.95	5.95	5.49	1.75	1.37	0.96
2-45	0.0	0.0	29.67	70.33	8.70	9.88	2.05	-0.95	-0.77
3-1	0.0	0.0	84.75	15.25	5.58	4.62	1.91	1.47	0.74
3-64	0.0	0.0	29.12	70.88	8.57	9.48	1.99	-0.98	-0.52
3-128	0.0	0.0	79.31	20.69	6.74	6.77	1.47	0.15	-0.75
4-1	0.0	0.0	30.90	69.10	8.61	9.71	1.98	-0.85	-0.84
4-16	0.0	0.0	63.31	36.69	7.32	6.90	2.18	0.14	-1.42
4-33	0.0	0.0	76.19	23.81	6.74	6.01	1.94	0.87	-0.67
5-1	0.0	0.0	37.61	62.39	8.34	9.09	1.99	-0.68	-0.94
5-36	0.0	0.0	41.66	58.34	8.09	9.31	2.11	-0.40	-1.59
5-73	0.0	0.0	67.43	32.57	7.33	7.21	1.78	0.20	-0.93
6-1	0.0	0.0	15.44	84.56	9.39	10.05	1.58	-2.00	2.90
6-49	0.0	0.0	41.80	58.20	8.19	9.28	2.18	-0.44	-1.48
6-95	0.0	0.0	61.42	38.58	7.19	6.50	2.24	0.21	-1.57

TABLE III-22. TRANSECT II SUSPENDED SEDIMENT DATA, CRUISE 76L3.

SAMPLE STATION-DEPTH(M)	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
1-1	0.0	0.0	30.01	69.99	8.75	9.72	1.81	-1.01	-0.46
1-6	0.0	0.0	51.82	48.18	7.88	7.76	2.08	-0.09	-1.56
1-16	0.0	0.0	86.88	13.12	6.38	6.13	1.40	0.94	0.60
2-1	0.0	0.0	67.93	32.07	6.97	6.23	2.21	0.44	-1.35
2-42	0.0	0.0	46.57	53.43	8.03	8.42	1.93	-0.37	-1.29
2-50	0.0	0.0	64.68	35.32	7.27	6.83	1.84	0.25	-1.21
3-1	0.0	0.0	24.66	75.34	8.94	9.95	1.86	-1.27	0.34
3-72	0.0	0.0	48.17	51.83	7.84	8.12	1.86	-0.35	-1.15
3-90	0.0	0.0	64.48	35.52	7.45	7.52	1.59	-0.07	-0.64
3-115	0.0	0.0	69.49	30.51	6.95	6.37	1.88	0.47	-1.10
3-124	0.0	0.0	32.59	67.41	8.59	8.85	1.55	-0.66	-0.54
4-1	0.0	0.0	56.12	43.88	7.26	6.59	2.20	0.11	-1.67
4-22	0.0	0.0	37.36	62.64	8.30	8.96	1.85	-0.52	-1.22
4-30	0.0	0.0	79.34	20.66	6.93	6.58	1.49	0.78	-0.15
5-1	0.0	0.0	45.84	54.16	7.89	8.26	1.97	-0.29	-1.41
5-65+	0.0	0.0	30.95	69.05	8.71	10.00	2.09	-0.94	-0.78
5-65	0.0	0.0	38.29	61.71	8.33	9.71	2.20	-0.65	-1.24
5-75	0.0	0.0	61.07	38.93	7.38	6.97	2.13	0.12	-1.45
6-1	0.0	0.0	58.88	41.12	7.37	6.72	1.99	0.15	-1.43
6-66	0.0	0.0	77.81	22.19	6.18	5.65	2.02	0.75	-0.78
6-80	0.0	0.0	80.21	19.79	6.65	6.41	1.69	0.64	-0.40

TABLE III-23. TRANSECT II SUSPENDED SEDIMENT DATA, CRUISE 76L5.

SAMPLE STATION-DEPTH(M)	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
1-2	0.0	0.0	65.33	34.67	7.40	7.23	1.54	0.01	-0.66
1-7	0.0	0.0	64.85	35.15	7.57	7.00	1.82	0.31	-1.27
1-14	0.0	0.0	50.37	49.63	7.78	7.98	1.65	-0.19	-1.01
2-2	0.0	0.0	43.44	56.56	8.08	8.58	1.94	-0.48	-1.16
2-27	0.0	0.0	48.36	51.64	7.89	8.10	1.91	-0.33	-1.15
2-46	0.0	0.0	85.67	14.33	6.75	6.56	1.30	0.92	0.87
2-46	0.0	0.0	54.64	45.36	7.70	7.82	1.45	-0.37	-0.40
3-2	0.0	0.0	68.74	31.26	6.72	6.08	2.02	0.47	-1.24
3-65	0.0	0.0	33.86	66.14	8.47	9.19	1.86	-0.79	-0.71
3-119	0.0	0.0	38.15	61.85	8.24	8.25	1.38	-0.42	-0.20
4-2	0.0	0.0	42.93	57.07	8.03	8.51	2.01	-0.41	-1.33
4-15	0.0	0.0	48.68	51.32	7.80	8.13	2.12	-0.26	-1.44
4-32	0.0	0.0	85.91	14.09	6.08	5.57	1.42	1.57	1.39
5-38	0.0	0.0	43.99	56.01	7.79	8.37	1.83	-0.48	-1.13
5-77	0.0	0.0	45.45	54.55	7.87	8.48	2.12	-0.35	-1.42
6-2	0.0	0.0	63.83	36.17	6.94	6.46	2.08	0.26	-1.38
6-46	0.0	0.0	66.22	33.78	7.06	6.84	1.92	0.24	-1.22
6-95	0.0	0.0	57.77	42.23	7.26	7.42	1.72	-0.01	-1.31

TABLE III-24. TRANSECT II SUSPENDED SEDIMENT DATA, CRUISE 76L10.

SAMPLE STATION-DEPTH(M)	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
1-1	0.0	0.0	59.28	40.72	7.61	7.41	1.91	-0.03	-1.22
1-19	0.0	0.0	66.17	33.83	7.07	6.22	2.02	0.46	-1.32
2-1	0.0	0.0	54.66	45.34	7.59	7.42	2.02	0.01	-1.48
2-30	0.0	0.0	62.47	37.53	7.24	6.82	1.87	0.23	-1.30
2-43	0.0	0.0	75.66	24.34	6.96	6.62	1.71	0.56	-0.65
3-1	0.0	0.0	53.35	46.65	7.68	7.75	1.88	-0.09	-1.29
3-91	0.0	0.0	80.78	19.22	7.01	6.63	1.53	0.88	0.12
3-126	0.0	0.0	43.72	56.28	7.79	8.54	1.99	-0.33	-1.38
4-1	0.0	0.0	53.76	46.24	7.57	7.65	1.92	-0.12	-1.33
4-31	0.0	0.0	71.12	28.88	6.97	6.31	1.74	0.69	-0.85
5-1	0.0	0.0	39.98	60.02	8.09	8.64	1.98	-0.58	-0.98
5-60	0.0	0.0	54.02	45.98	7.54	7.57	2.02	-0.06	-1.48
5-73	0.0	0.0	47.94	52.06	7.96	8.29	2.16	-0.26	-1.52
6-1	0.0	0.0	55.91	44.09	7.44	7.44	2.04	-0.01	-1.44
6-63	0.0	0.0	64.38	35.62	7.17	7.00	1.76	0.19	-1.13
6-78	0.0	0.0	39.76	60.24	8.16	8.90	2.03	-0.47	-1.39
6-93	0.0	0.0	80.46	19.54	6.88	6.64	1.40	0.70	0.13

Table IV-1

EAST FLOWER GARDENS SEDIMENT TEXTURE DATA. SAMPLES TAKEN ON CRUISE 76SH2 AND CRUISE 76G8-II (station 1 only).

CRUISE	SAMPLE STATION/GRAB	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
76SH2-	1/A	0.03	89.34	5.12	5.52	3.29	2.91	1.76	2.43	6.06
	1/B	0.0	90.94	5.05	4.02	2.93	2.40	1.66	2.69	7.82
	1/C	0.0	82.66	8.23	9.11	3.76	3.23	2.04	1.88	2.60
	1/D	0.0	87.37	7.39	5.24	3.40	3.06	1.72	2.39	5.94
	1/E	0.0	89.14	6.73	4.13	3.18	2.78	1.62	2.54	7.16
	1/F	0.0	86.09	8.02	5.89	3.60	3.40	1.77	2.05	4.77
76G8-II	1/4	0.0	90.32	7.63	2.04	3.18	3.00	1.35	2.43	7.96
	1/5	0.0	91.85	4.68	3.48	3.01	2.54	1.57	2.89	9.57
	1/6	0.0	88.64	5.23	6.13	3.42	3.03	1.79	2.29	4.99
76SH2	2/B	0.38	6.28	46.54	46.80	7.43	7.83	2.19	-0.98	1.06
	2/C	0.16	6.19	34.86	58.79	7.88	8.35	2.06	-1.40	2.25
	2/D	0.80	8.58	42.05	48.57	7.40	7.92	2.38	-1.02	0.89
	2/E	0.54	7.03	48.03	44.41	7.30	7.66	2.28	-0.79	0.52
	2/F	0.15	6.21	46.39	47.25	7.48	7.87	2.08	-0.79	0.37
	2/J	0.84	7.19	42.01	49.97	7.46	8.00	2.34	-1.22	1.64
	3/A	0.06	17.68	60.86	21.40	5.88	5.21	2.17	0.59	-0.49
	3/B	0.09	31.10	41.44	27.37	5.91	5.04	2.48	0.37	-1.12
	3/C	0.36	31.90	44.63	23.11	5.62	4.85	2.52	0.38	-0.82
	3/D	0.0	19.96	58.68	21.36	5.82	5.11	2.19	0.62	-0.80
	3/E	0.36	26.14	51.57	21.92	5.72	5.02	2.35	0.41	-0.65
	3/F	0.12	27.57	27.42	44.89	6.90	7.62	2.69	-0.38	-1.24
	3/J	0.0	15.75	38.13	46.12	7.19	7.78	2.25	-0.50	-0.96

Table IV-1 cont.

CRUISE	SAMPLE STATION/GRAB	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
76SH2	4/A	9.20	76.25	10.30	4.25	2.30	2.08	2.33	1.08	2.36
	4/B	0.49	82.43	13.04	4.04	3.18	2.77	1.76	1.87	4.82
	4/C	0.86	46.38	32.50	20.26	4.73	4.32	2.85	0.41	-0.79
	4/D	0.50	88.84	7.30	3.36	2.76	2.30	1.70	2.26	6.94
	4/E	1.47	84.17	11.20	3.16	2.72	2.29	1.84	1.62	4.88
	4/F	0.08	91.85	4.33	3.74	2.63	2.19	1.69	2.65	8.38

Table IV-2

STETSON BANK SEDIMENT TEXTURE DATA

CRUISE	SAMPLE STATION/GRAB	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
76SH2	1/A	36.59	37.33	11.69	14.39	2.04	0.75	3.87	0.82	-0.68
	1/B	41.63	28.91	13.41	16.05	2.10	0.47	4.13	0.73	-1.02
	1/C	65.43	23.33	4.95	6.29	0.13	******	3.12	1.93	2.70
	1/D	43.93	15.07	21.56	19.44	2.67	1.28	4.41	0.40	-1.45
	1/E	21.03	51.34	15.82	11.82	2.85	2.19	3.44	0.50	-0.78
	1/F	29.56	48.38	10.51	11.55	2.27	1.94	3.44	0.74	-0.30
	1/J	31.69	50.81	7.26	10.24	1.73	1.17	3.39	1.08	0.26
	2/A	8.45	84.53	3.77	3.25	2.22	2.11	1.93	1.21	4.55
	2/A	23.21	58.87	8.27	9.65	2.39	1.97	3.15	0.74	-0.04
	2/D	19.74	64.37	8.61	7.28	2.14	1.91	2.89	0.92	0.77
	2/E	22.18	56.21	12.82	8.79	2.47	2.13	3.12	0.69	0.07
	2/F	47.61	35.51	7.34	9.53	1.35	0.09	3.59	1.08	0.02
	2/J	26.65	54.28	10.40	8.68	2.10	1.95	3.19	0.80	0.02
	3/A	3.04	58.47	15.94	22.55	4.59	3.39	3.06	0.43	-0.93
	3/B	2.40	60.76	21.73	15.11	4.26	3.45	2.65	0.65	-0.20
	3/C	2.94	53.60	20.49	22.97	4.78	3.73	2.95	0.41	-0.74
	3/D	3.04	60.62	15.35	20.98	4.50	3.26	2.94	0.51	-0.75
	3/E	1.92	57.38	25.68	15.02	4.40	3.59	2.63	0.66	-0.22
	3/F	6.78	64.15	20.37	8.69	3.38	2.92	2.67	0.61	0.60
	3/J	5.79	65.41	11.73	17.07	3.81	2.61	3.05	0.71	-0.30

Table IV-2 cont.

CRUISE	SAMPLE STATION/GRAB	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
76SH2	4/A	55.19	31.15	11.08	2.58	0.46	******	2.87	1.35	1.01
	4/B	49.99	34.30	13.15	2.56	0.59	-1.00	2.84	1.28	0.88
	4/C	43.74	41.68	6.07	8.50	1.14	0.29	3.33	1.31	0.81
	4/D	45.78	41.37	7.86	5.00	0.69	-0.36	3.06	1.50	1.38
	4/E	52.19	34.75	7.18	5.88	0.60	******	3.13	1.53	1.39
	4/F	49.62	35.03	11.31	4.03	0.68	-0.92	3.00	1.35	1.07
	4/J	24.36	54.24	17.29	4.12	1.95	1.37	2.94	0.68	-0.18

Table IV-3

28 FATHOM BANK SEDIMENT TEXTURE DATA. SAMPLES TAKEN ON CRUISE 76SH2 (GRABS DENOTED BY LETTERS) AND CRUISE 76G8-II (GRABS DENOTED BY NUMBERS).

CRUISE	SAMPLE STATION/GRAB	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
76SH2	1/A	9.93	66.81	13.67	9.59	2.54	1.69	3.03	1.02	0.40
	1/B	13.16	55.38	22.33	9.13	2.71	2.08	3.11	0.68	-0.18
	1/C	13.89	58.39	17.44	10.27	2.67	1.92	3.20	0.79	-0.09
	1/D	6.57	57.54	25.39	10.50	3.21	2.59	3.07	0.61	-0.42
	1/E	7.50	59.74	19.48	13.28	3.10	1.84	3.40	0.64	-0.85
	1/F	5.10	61.92	22.51	10.46	3.28	2.28	3.10	0.62	-0.61
76G8-II	1/4	15.89	72.74	4.29	7.07	1.89	1.40	2.78	1.27	1.56
	1/5	8.08	60.60	13.73	17.59	3.35	2.01	3.56	0.62	-0.93
	1/6	8.12	63.67	11.24	16.96	3.03	1.69	3.49	0.78	-0.71
76SH2	2/A	6.69	79.67	4.43	9.21	2.35	1.67	2.81	1.37	1.37
	2/B	8.70	70.34	8.05	12.90	2.81	1.88	3.18	0.94	-0.07
	2/C	11.02	69.45	9.46	10.06	2.52	1.84	3.04	1.03	0.51
	2/D	5.98	83.80	6.73	3.48	2.00	1.65	2.14	1.51	3.51
	2/E	10.47	70.85	13.75	4.93	2.06	1.65	2.55	1.13	1.51
	2/F	10.32	71.09	7.12	11.48	2.57	1.75	3.08	1.08	0.41
76G8-II	2/4	5.57	84.58	6.19	3.65	1.85	1.39	2.19	1.67	3.78
	2/5	14.88	68.93	7.72	8.47	2.21	1.66	2.97	1.12	0.86
	2/6	11.45	71.79	5.08	11.68	2.36	1.51	3.17	1.21	0.62

Table IV-3 cont.

CRUISE	SAMPLE STATION/GRAB	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
76SH2	3/A	5.72	93.11	0.38	0.80	0.99	1.08	1.24	2.28	16.64
	3/B	4.77	94.05	0.47	0.71	0.95	1.04	1.17	2.69	20.37
	3/C	8.50	90.31	0.49	0.70	0.84	0.86	1.26	2.31	15.93
	3/D	12.28	85.14	1.15	1.43	0.67	0.74	1.60	2.50	12.19
	3/E	18.60	79.99	0.65	0.75	0.54	0.69	1.46	1.78	10.43
	3/F	3.23	95.27	0.54	0.96	1.12	1.15	1.22	3.06	20.81
76G8-II	3/4	7.07	91.91	0.31	0.71	1.01	0.88	1.41	1.72	8.65
	3/5	2.41	97.10	0.16	0.34	1.00	0.96	0.96	2.33	20.64
	3/6	1.64	97.73	0.20	0.44	1.19	1.09	1.03	2.62	18.04

Table IV-4

28 FATHOM BANK, SOUTHWEST PEAK SEDIMENT TEXTURE DATA. SAMPLES TAKEN ON CRUISE 76SH2

CRUISE	SAMPLE STATION/GRAB	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
76SH2	1/A	17.67	68.87	7.63	5.83	1.48	0.80	2.79	1.44	1.70
	1/B	5.31	59.03	17.40	18.27	3.65	2.37	3.42	0.58	-0.87
	1/C	11.02	62.62	12.96	13.39	2.50	1.04	3.46	0.93	-0.45
	1/D	4.83	71.05	15.17	8.95	2.92	1.96	2.80	0.99	0.32
	1/E	12.50	64.17	19.00	4.33	2.56	2.42	2.56	0.50	0.60
	1/F	14.29	71.86	6.16	7.70	2.19	1.84	2.80	1.08	1.11
	1/J	3.17	77.36	5.90	13.58	2.26	0.81	3.26	1.37	0.41
	2/A	10.89	87.01	0.90	1.20	0.89	0.76	1.56	1.99	8.55
	2/B	15.79	82.54	0.60	1.07	0.42	0.44	1.43	2.52	13.75
	2/C	30.99	63.08	1.98	3.95	0.42	0.19	2.35	2.40	6.54
	2/D	15.27	81.93	0.84	1.96	0.73	0.62	1.71	2.37	10.17
	2/E	24.70	73.45	0.58	1.27	0.27	0.26	1.63	2.29	10.43
	2/F	14.57	81.38	1.94	2.11	0.78	0.54	1.91	2.25	7.48
	2/J	19.86	80.10	0.02	0.02	0.93	1.35	1.48	-0.38	-0.35
	3/A	0.08	13.94	46.94	39.04	6.94	7.40	2.30	-0.41	-0.83
	3/B	0.77	44.20	31.67	23.35	5.20	4.41	2.90	0.14	-1.15
	3/H	0.16	15.44	27.68	56.72	7.52	8.27	2.56	-1.25	0.72
	3/B	0.77	44.20	31.67	23.35	5.20	4.41	2.90	0.14	-1.15
	3/C	0.0	14.97	46.74	38.29	6.82	7.24	2.38	-0.35	-0.96
	3/D	0.10	9.73	40.92	49.24	7.50	7.97	2.04	-0.87	0.28
	3/E	0.14	18.23	52.29	29.34	6.36	6.32	2.43	-0.24	-0.56
	3/F	0.14	17.48	44.75	37.63	6.67	7.17	2.53	-0.39	-0.90
	3/J	0.25	19.18	28.87	51.71	7.16	8.07	2.66	-0.93	-0.13

Table IV-4 cont.

CRUISE	SAMPLE STATION/GRAB	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
76SH2	4/A	25.22	59.48	8.68	6.62	1.81	1.67	2.93	0.92	0.42
	4/B	17.34	59.58	9.10	13.99	2.05	0.70	3.56	1.09	-0.25
	4/C	18.59	66.20	5.10	10.12	1.66	0.75	3.16	1.40	0.97
	4/D	20.66	64.47	8.98	5.89	2.07	1.94	2.76	0.89	0.97
	4/E	19.42	72.28	3.28	5.02	1.47	1.50	2.54	1.50	2.91
	4/F	25.84	66.65	2.07	5.44	1.56	1.75	2.64	1.09	1.70
	4/J	24.73	65.52	3.91	5.84	1.44	1.28	2.77	1.24	1.49

Table IV-5

HOSPITAL BANK SEDIMENT DATA: STOCS MONTHLY AND SEASONAL CRUISES AND TOPOGRAPHIC HIGH CRUISE 76SH2

CRUISE MONTH	SAMPLE STATION-GRAB-CODE	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
February	HR1-1A-JFS	18.16	45.77	15.89	20.18	2.96	0.88	4.03	0.52	-1.29
	HR1-2A-JGI	33.08	45.82	10.73	10.37	1.62	0.33	3.60	1.06	-0.15
	HR1-3A-JGN	38.45	46.52	7.17	7.86	0.97	0.15	3.24	1.50	1.20
	HR1-4-JGS	26.80	52.65	11.47	9.07	1.59	0.41	3.38	1.17	0.24
	HR1-5-JGU	22.19	53.53	10.85	13.43	1.94	0.40	3.69	1.06	-0.30
	HR1-6-JGW	27.27	51.72	12.86	8.15	1.48	0.31	3.31	1.23	0.44
	HR1-8-JHF	24.96	57.82	6.78	10.45	1.47	0.34	3.33	1.34	0.63
	HR1-9-JHJ	19.56	51.70	14.20	14.54	2.25	0.44	3.80	0.89	-0.69
March	HR1-1-KAR	25.22	43.46	19.02	12.30	2.18	0.32	3.84	0.79	-0.86
	HR1-2-KAT	18.93	46.92	21.54	12.61	2.49	0.58	3.76	0.68	-0.96
	HR1-3-KAV	29.27	52.11	10.68	7.94	1.31	0.12	3.36	1.28	0.44
	HR1-4-KAY	22.82	55.50	14.81	6.87	1.43	0.26	3.20	1.26	0.49
	HR1-5-KAZ	13.75	64.03	13.43	8.79	1.85	0.40	3.29	1.16	0.16
	HR1-6-KBB	32.28	45.75	10.67	11.30	1.63	0.39	3.66	1.14	-0.04
	HR1-7-KCK	20.91	56.50	12.11	10.48	2.50	2.06	3.34	0.73	-0.26
July	HR1-1-OQA	23.42	52.88	8.18	15.52	2.20	0.61	3.83	0.93	-0.57
	HR1-2-OQC	19.49	56.45	10.85	13.20	2.30	0.80	3.63	0.87	-0.53
	HR1-3-OQE	34.68	43.32	10.86	11.13	1.58	0.23	3.69	1.09	-0.20
	HR1-4-OQG	33.37	52.97	6.57	7.08	1.00	0.18	3.13	1.57	1.51
	HR1-5-OQI	32.09	48.70	9.97	9.24	1.41	0.34	3.44	1.27	0.42
	HR1-6-OQK	32.99	43.92	9.75	13.35	1.91	0.45	3.82	0.94	-0.50
	HR1-7-OQT	38.88	47.95	6.98	6.19	0.77	0.03	3.06	1.67	1.91

Table IV-5 cont.

CRUISE MONTH	SAMPLE STATION-GRAB-CODE	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
October	HR1-2-SOQ	37.83	44.82	10.54	6.82	1.00	0.07	3.22	1.40	0.88
	HR1-3-SOS	28.94	45.41	14.34	11.30	2.01	0.51	3.78	0.85	-0.78
	HR1-4-SOU	26.37	48.86	16.66	8.11	1.97	0.63	3.54	0.84	-0.67
	HR1-5-SOW	38.19	44.17	10.53	7.11	1.04	0.13	3.29	1.38	0.69
	HR1-6-SOY	28.92	47.28	16.46	7.34	1.63	0.30	3.49	1.00	-0.37
	HR1-7-SPH	32.74	45.60	12.96	8.69	1.58	0.23	3.56	1.04	-0.28
November	HR1-NOV-1	43.97	50.67	3.78	1.58	-0.13	-0.41	2.11	2.64	7.80
	HR1-NOV-2	53.93	36.63	6.57	2.87	0.05	******	2.69	2.16	3.98
	HR1-NOV-3	31.19	55.55	9.10	4.17	0.90	0.21	2.87	1.58	1.75
	HR1-NOV-4	44.40	49.33	3.88	2.40	-0.07	-0.47	2.32	2.61	6.94
	HR1-NOV-5	46.71	47.57	2.67	3.05	-0.08	-0.49	2.32	2.65	7.36
	HR1-NOV-6	47.95	44.20	5.37	2.48	-0.05	-0.61	2.44	2.49	5.91
	HR1-7-VKG	34.83	56.92	4.14	4.12	0.31	-0.05	2.55	2.34	5.19

Table IV-5 cont.

CRUISE MONTH	SAMPLE STATION-GRAB-CODE	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
February	HR2-1A-JHR	0.0	3.31	71.48	25.21	6.57	6.39	1.79	0.24	-1.03
	HR2-2A-JHW	0.0	6.01	66.36	27.63	6.42	5.65	2.09	0.52	-1.11
	HR2-3A-JIB	0.0	4.48	74.12	21.40	6.22	5.56	1.90	0.75	-0.64
	HR2-4-JIG	0.0	8.82	38.33	52.85	7.69	8.10	1.89	-0.82	-0.09
	HR2-5-JII	0.0	6.35	45.21	48.44	7.44	7.91	2.10	-0.39	-1.09
	HR2-6-JIK	0.0	0.0	45.10	54.90	7.93	8.13	1.45	-0.51	-0.32
	HR2-8-JIT	0.0	5.34	53.52	41.14	7.28	7.49	1.95	-0.23	-1.05
	HR2-9-JIX	0.0	7.00	48.28	44.72	7.36	7.69	2.00	-0.32	-1.06
March	HR2-1-KBK	0.0	7.38	55.22	37.40	7.13	7.15	2.03	-0.12	-1.10
	HR2-2-KBM	0.0	9.63	49.92	40.45	7.33	7.45	1.97	-0.39	-0.68
	HR2-3-KBO	0.50	19.95	48.65	30.91	6.48	6.25	2.34	0.04	-0.74
	HR2-4-KBQ	0.0	10.79	42.28	46.93	7.52	7.79	2.09	-0.49	-0.81
	HR2-5-KBS	0.0	5.90	43.30	50.80	7.76	8.04	1.92	-0.55	-0.66
	HR2-6-KBU	0.0	11.66	44.34	44.01	7.33	7.50	2.15	-0.29	-1.10
	HR-6-KCL	0.0	8.00	54.57	37.43	7.03	7.04	2.10	-0.05	-1.22
July	HR2-1-OQV	0.16	4.78	42.31	52.75	7.83	8.14	1.90	-0.74	0.42
	HR2-2-OQX	0.0	5.19	44.30	50.52	7.65	8.03	2.02	-0.47	-0.87
	HR2-3-OQZ	0.0	8.28	43.69	48.03	7.57	7.90	1.95	-0.54	-0.64
	HR2-4-ORV	0.0	5.13	39.73	55.15	7.94	8.23	1.82	-0.78	0.06
	HR2-5-ORY	0.0	5.62	31.33	63.05	8.17	8.69	2.01	-0.90	-0.20
	HR2-6-ORZ	0.0	5.09	38.33	56.59	7.97	8.33	1.86	-0.77	-0.07
	HR2-7-OSI	0.0	6.38	36.00	57.62	7.98	8.51	1.97	-0.76	-0.42

Table IV-5 cont.

CRUISE MONTH	SAMPLE STATION-GRAB-CODE	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
October	HR2-1-SPJ	0.0	11.85	44.89	43.26	7.36	7.69	2.00	-0.51	-0.68
	HR2-2-SPL	0.0	8.18	47.89	43.93	7.53	7.80	1.80	-0.69	-0.11
	HR2-3-SPN	0.0	8.49	52.46	39.06	7.32	7.62	1.84	-0.47	-0.51
	HR2-4-SPP	0.0	40.53	29.72	29.75	6.22	6.87	2.40	0.06	-1.57
	HR2-5-SPR	0.0	3.04	55.48	41.48	7.60	7.72	1.61	-0.37	-0.26
	HR2-6-SPT	0.0	3.71	57.89	38.40	7.53	7.64	1.57	-0.44	-0.02
	HR2-7-SQC	0.0	3.88	59.63	36.49	7.60	7.59	1.48	-0.44	0.48
November	HR2-NOV-1	0.0	6.93	54.62	38.45	7.30	7.55	1.84	-0.41	-0.59
	HR2-NOV-2	0.08	8.07	47.41	44.44	7.64	7.83	1.76	-0.88	0.86
	HR2-NOV-3	0.0	8.40	48.18	43.42	7.59	7.83	1.74	-0.92	0.62
	HR2-NOV-4	0.0	17.37	46.10	36.53	6.89	7.37	2.15	-0.33	-1.07
	HR2-NOV-5	0.0	7.90	41.70	50.40	7.72	8.02	1.85	-0.77	0.02
	HR2-NOV-6	0.0	9.87	37.40	52.73	7.61	8.12	2.03	-0.71	-0.56
	HR2-7-VLF	0.0	18.67	39.97	41.36	7.16	7.68	2.11	-0.51	-0.90

Table IV-5 cont.

CRUISE MONTH	SAMPLE STATION-GRAB-CODE	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
April	HR3-1-KRS	0.0	0.0	47.78	52.22	8.04	8.10	1.49	-0.14	-1.06
	HR3-2-KRU	0.0	0.0	44.83	55.17	8.15	8.25	1.50	-0.24	-1.02
	HR3-3-KRW	0.0	0.0	42.48	57.52	8.15	8.33	1.53	-0.43	-0.73
	HR3-4-KRY	0.0	0.0	47.77	52.23	8.02	8.11	1.50	-0.19	-1.00
	HR3-5-KSA	0.0	0.0	49.97	50.03	7.86	8.00	1.63	-0.16	-1.13
	HR3-6-KSC	0.0	0.0	44.68	55.32	8.17	8.22	1.36	-0.19	-0.87
	HR3-7-KSI	0.0	0.0	48.22	51.78	8.00	8.09	1.53	-0.20	-1.00
June	HR3-1-MTF	0.0	0.0	43.42	56.58	8.14	8.16	1.23	-0.34	-0.04
	HR3-2-MTH	0.0	0.0	38.76	61.24	8.30	8.42	1.38	-0.50	-0.37
	HR3-3-MTJ	0.0	0.0	40.90	59.10	8.19	8.33	1.39	-0.44	-0.49
	HR3-5-MTN	0.0	0.0	39.29	60.71	8.12	8.30	1.39	-0.52	-0.36
	HR3-6-MTP	0.0	0.0	36.76	63.24	8.31	8.43	1.34	-0.53	-0.26
	HR3-7-MUC	0.0	0.0	37.71	62.29	8.25	8.41	1.39	-0.58	-0.25

Table IV-5 cont.

CRUISE MONTH	SAMPLE STATION-GRAB-CODE	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
August	HR3-1-PBP	0.0	0.0	34.20	65.80	8.46	8.57	1.31	-0.48	-0.46
	HR3-2-PBR	0.0	0.0	33.04	66.96	8.51	8.63	1.29	-0.51	-0.37
	HR3-3-PBT	0.0	0.0	26.42	73.58	8.72	8.83	1.14	-0.51	-0.28
	HR3-4-PBV	0.0	0.0	45.82	54.18	8.04	8.20	1.54	-0.24	-1.03
	HR3-6-PBZ	0.0	0.0	39.54	60.46	8.27	8.44	1.49	-0.57	-0.35
	HR3-7-PCI	0.0	0.0	34.13	65.87	8.49	8.61	1.31	-0.44	-0.61
December	HR3-1-WFN	0.0	0.0	46.27	53.73	8.00	8.20	1.65	-0.33	-0.99
	HR3-2-WFQ	0.0	0.0	49.11	50.89	7.97	8.03	1.54	-0.25	-0.82
	HR3-3-WFT	0.0	0.0	43.68	56.32	8.19	8.32	1.49	-0.25	-1.06
	HR3-4-WFW	0.0	0.0	50.51	49.49	7.94	7.97	1.57	-0.15	-1.03
	HR3-5-WFZ	0.0	0.0	55.79	44.21	7.67	7.63	1.68	-0.02	-1.18
	HR3-6-WGZ	0.0	0.0	50.62	49.38	7.94	7.96	1.60	-0.10	-1.17
	HR3-7-WGJ	0.0	0.0	44.48	55.52	8.12	8.33	1.63	-0.31	-1.10

Table IV-5 cont.

CRUISE MONTH	SAMPLE STATION-GRAB-CODE	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
April	HR4-1-KSM	0.0	0.0	47.67	52.33	8.01	8.11	1.52	-0.20	-0.99
	HR4-2-KSO	0.0	0.0	47.35	52.65	8.01	8.13	1.55	-0.22	-1.03
	HR4-3-KSQ	0.0	0.0	44.40	55.60	8.14	8.23	1.41	-0.22	-0.92
	HR4-4-KSS	0.0	0.0	46.09	53.91	8.06	8.18	1.52	-0.27	-0.90
	HR4-5-KSU	0.0	0.0	47.55	52.45	8.01	8.12	1.52	-0.20	-1.01
	HR4-6-KSW	0.0	0.34	44.57	55.09	8.06	8.21	1.51	-0.36	-0.72
	HR4-7-KTE	0.0	0.0	51.05	48.95	7.89	7.95	1.51	-0.09	-1.05
June	HR4-1-MTZ	0.0	0.0	51.96	48.04	7.97	7.93	1.33	-0.04	-0.69
	HR4-2-MUB	0.0	0.0	41.14	58.86	8.19	8.30	1.36	-0.44	-0.41
	HR4-3-MUDA	0.0	0.0	50.45	49.55	7.98	7.99	1.26	-0.21	-0.21
	HR4-4-MUF	0.0	0.0	46.83	53.17	7.96	8.09	1.39	-0.35	-0.46
	HR4-5-MUH	0.0	0.0	48.72	51.28	7.97	8.03	1.24	-0.36	0.11
	HR4-6-MUJ	0.0	0.0	47.29	52.71	8.07	8.05	1.10	-0.19	0.28
	HR4-7-NUD	0.0	0.0	39.58	60.42	8.20	8.40	1.45	-0.53	-0.43

Table IV-5 cont.

CRUISE MONTH	SAMPLE STATION-GRAB-CODE	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
August	HR4-1-PCK	0.0	0.0	34.30	65.70	8.48	8.63	1.37	-0.54	-0.47
	HR4-2-PCM	0.0	0.0	41.92	58.08	8.18	8.38	1.56	-0.41	-0.83
	HR4-3-PCO	0.0	0.0	32.91	67.09	8.52	8.75	1.41	-0.56	-0.61
	HR4-4-PCQ	0.0	0.0	28.60	71.40	8.70	8.95	1.32	-0.66	-0.42
	HR4-5-PCS	0.0	0.0	34.41	65.59	8.53	8.82	1.43	-0.54	-0.75
	HR4-6-PCU	0.0	0.0	40.76	59.24	8.20	8.42	1.55	-0.46	-0.78
	HR4-7-PDD	0.0	0.0	34.61	65.39	8.45	8.65	1.43	-0.55	-0.60
December	HR4-6-WHR	0.0	0.0	56.52	43.48	7.60	7.58	1.71	-0.03	-1.13
	HR4-1-WGM	0.0	0.0	46.82	53.18	8.03	8.14	1.50	-0.27	-0.79
	HR4-2-WGP	25.18	40.29	17.24	17.29	2.80	1.41	4.07	0.52	-1.21
	HR4-3-WGS	0.0	0.0	34.81	65.19	8.50	8.75	1.44	-0.54	-0.66
	HR4-4-WGV	0.0	0.0	58.74	41.26	7.59	7.44	1.67	0.05	-1.14
	HR4-5-WGY	0.0	0.0	54.71	45.29	7.68	7.67	1.75	-0.01	-1.30

Table IV-5 cont.

CRUISE MONTH	SAMPLE STATION-GRAB-CODE	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
August Cruise 76SH2 Topographic High Stations	76SH2-HB1A	33.60	50.35	8.53	7.53	1.05	0.12	3.24	1.50	1.16
	76SH2-HB2A	0.0	3.04	45.87	51.10	7.84	8.05	1.73	-0.49	-0.48
	76SH2-HR3A	0.0	0.0	49.16	50.84	7.97	8.04	1.54	-0.13	-1.10
	76SH2-HB4B	24.68	22.21	27.67	25.45	4.16	5.16	4.26	-0.14	-1.52
	76SH2-HB-5	0.0	2.75	48.80	48.45	7.73	7.91	1.77	-0.37	-0.61
	76SH2-HB-7	0.0	8.18	44.99	46.83	7.51	7.82	1.98	-0.47	-0.77
	76SH2-HR-8	0.0	0.0	38.02	61.98	8.35	8.55	1.45	-0.45	-0.77
	76SH2-HR-9	0.0	0.0	38.20	61.80	8.35	8.47	1.41	-0.47	-0.49
	76SH2-HR-10	0.0	0.0	40.19	59.81	8.28	8.42	1.44	-0.37	-0.83
	76SH2-HB11	0.08	3.94	41.98	54.00	7.90	8.17	1.85	-0.98	1.18
	76SH2-HB12	5.11	29.08	27.60	38.21	5.73	7.13	3.75	-0.58	-1.09

Table IV-6

SOUTHERN BANK SEDIMENT DATA: STOCS MONTHLY AND SEASONAL CRUISES AND TOPOGRAPHIC HIGH CRUISE 76SH2

CRUISE MONTH	SAMPLE STATION-GRAB-CODE	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
February	1-1A-JDB	0.0	23.82	53.65	22.53	5.80	4.89	2.18	0.73	-0.89
	1-2A-JDH	0.0	8.34	52.19	39.47	6.98	7.04	2.11	-0.05	-1.34
	1-3A-JDN	0.0	22.23	55.09	22.68	5.90	5.12	2.15	0.71	-0.89
	1-5-JDT	0.21	20.47	58.18	21.14	5.89	5.22	2.14	0.63	-0.47
	1-5-JDV	0.0	18.16	57.31	24.53	6.24	5.79	2.10	0.39	-1.00
	1-6-JDX	0.0	29.50	46.34	24.16	5.88	5.09	2.27	0.61	-1.06
	-1-JEH	0.16	25.66	52.82	21.36	5.78	5.05	2.16	0.65	-0.61
	1-9-JEL	0.0	19.05	60.55	20.40	5.81	5.09	2.10	0.78	-0.67
March	1-1-JZF	0.0	10.30	49.12	40.59	7.08	7.22	2.24	-0.07	-1.37
	1-2-JZH	0.0	21.43	52.30	26.27	6.26	5.90	2.20	0.37	-1.14
	1-3-JZJ	0.0	18.85	57.98	23.17	6.15	5.66	2.10	0.55	-0.94
	1-4-JZL	0.70	8.88	63.34	27.08	6.42	6.02	2.17	0.03	-0.03
	1-5-JZN	0.16	11.36	63.19	25.29	6.09	5.10	2.34	0.79	-0.67
	1-6-JZP	0.0	8.71	53.03	38.26	7.07	7.12	2.12	-0.10	-1.19
	1-7-KCI	0.0	20.87	45.88	33.25	6.63	6.57	2.29	0.09	-1.35
July	1-1-ONZ	0.05	27.58	29.98	42.40	6.95	7.39	2.38	-0.15	-1.42
	1-2-OOB	0.0	9.61	48.03	42.36	7.29	7.50	2.05	-0.26	-1.04
	1-3-OOD	0.0	12.76	45.22	42.02	7.14	7.43	2.17	-0.22	-1.21
	1-4-OOF	0.0	5.90	52.78	41.32	7.17	7.36	2.06	-0.13	-1.22
	1-5-OOH	0.0	13.40	37.92	48.68	7.45	7.94	2.16	-0.56	-0.83
	1-6-OOJ	0.38	5.42	48.84	45.36	7.43	7.66	2.08	-0.60	0.30
	1-7-OOS	0.0	14.37	39.67	45.95	7.35	7.77	2.20	-0.48	-0.96

Table IV-6 cont.

CRUISE MONTH	SAMPLE STATION-GRAB-CODE	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
October	1-1-SMY	0.0	16.62	69.37	14.01	6.32	6.53	1.78	-0.01	-0.71
	1-2-SNA	0.0	19.81	50.12	30.07	6.57	7.00	2.16	-0.07	-1.27
	1-3-SNC	0.0	20.95	61.73	17.32	6.40	6.74	1.92	-0.16	-0.72
	1-4-SNE	0.0	19.04	52.98	27.98	6.42	6.07	2.10	0.16	-1.12
	1-5-SNG	0.29	16.88	57.29	25.54	6.66	6.92	1.97	-0.33	-0.09
	1-6-SNI	0.08	15.31	51.71	32.90	7.10	7.46	1.96	-0.57	-0.28
	1-7-SNR	0.17	18.17	50.19	31.47	6.86	7.36	2.06	-0.44	-0.48
November	1-NOV-1	0.0	24.73	37.53	37.73	6.92	7.39	2.27	-0.29	-1.23
	1-NOV-2	0.03	7.16	42.91	49.91	7.61	8.00	1.91	-0.65	-0.33
	1-NOV-3	0.06	12.43	47.54	39.97	6.96	7.27	2.21	-0.18	-1.17
	1-NOV-4	0.08	10.53	39.79	49.60	7.47	7.98	2.10	-0.71	-0.40
	1-NOV-5	0.03	15.43	36.25	48.30	7.43	7.93	2.14	-0.67	-0.56
	1-NOV-6	0.0	11.12	39.47	49.41	7.48	7.98	2.01	-0.63	-0.68
	1-7-VII	0.09	18.19	45.13	36.60	6.83	7.45	2.22	-0.31	-1.06

Table IV-6 cont.

CRUISE MONTH	SAMPLE STATION-GRAB-CODE	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
February	2-1A-JDL	0.0	0.0	48.51	51.49	7.89	8.06	1.59	-0.36	-0.76
	2-2A-JEV	0.0	0.0	40.00	60.00	8.23	8.33	1.32	-0.46	-0.22
	2-3A-JFA	0.0	0.0	36.39	63.61	8.34	8.39	1.24	-0.42	-0.26
	2-4-JFF	0.0	0.0	50.48	49.52	7.93	7.99	1.30	-0.24	-0.30
	2-5-JFH	0.0	0.0	64.37	35.63	7.37	7.33	1.51	0.14	-0.89
	2-6-JFJ	0.0	0.19	56.37	43.45	7.59	7.70	1.62	-0.13	-0.94
	2-9-JFX	0.0	0.0	46.70	53.30	7.95	8.12	1.46	-0.43	-0.45
April	2-1-KTG	0.0	0.0	36.02	63.98	8.45	8.55	1.31	-0.42	-0.61
	2-2-KTI	0.0	0.0	39.06	60.94	8.32	8.41	1.36	-0.39	-0.63
	2-3-KTK	0.0	0.0	41.56	58.44	8.26	8.32	1.34	-0.28	-0.78
	2-4-KTM	0.0	0.0	41.68	58.32	8.24	8.36	1.44	-0.31	-0.93
	2-5-KTO	0.0	0.0	46.05	53.95	8.12	8.16	1.42	-0.19	-0.88
	2-6-KTQ	0.0	0.0	45.81	54.19	8.11	8.17	1.42	-0.22	-0.83
	2-7-KTZ	0.0	0.0	45.56	54.44	8.04	8.19	1.53	-0.37	-0.69
July	2-1-OPF	0.0	0.0	41.21	58.79	8.19	8.39	1.46	-0.43	-0.73
	2-2-OPH	0.0	0.0	42.15	57.85	8.20	8.36	1.54	-0.37	-0.87
	2-3-OPJ	0.0	0.0	36.82	63.18	8.44	8.55	1.43	-0.44	-0.71
	2-4-OPL	0.0	0.0	40.45	59.55	8.27	8.32	1.33	-0.31	-0.65
	2-5-OPN	0.0	0.0	25.34	74.66	8.78	8.88	1.14	-0.47	-0.48
	2-6-OPP	0.0	0.0	36.27	63.73	8.48	8.59	1.43	-0.46	-0.65
	2-7-OPY	0.0	0.0	42.41	57.59	8.21	8.34	1.47	-0.32	-0.90

Table IV-6 cont.

CRUISE MONTH	SAMPLE STATION-GRAB-CODE	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
October	2-1-SNT	0.0	0.0	65.31	34.69	7.48	7.51	1.40	-0.01	-0.46
	2-2-SNV	0.0	3.10	61.05	35.85	7.38	7.51	1.60	-0.26	-0.39
	2-3-SNX	0.0	0.0	57.32	42.68	7.86	7.79	1.28	-0.07	-0.19
	2-4-SNZ	0.0	0.0	55.83	44.17	7.93	7.84	1.22	0.04	-0.32
	2-5-SOB	0.0	0.0	61.04	38.96	7.82	7.69	1.15	0.29	-0.32
	2-6-SOD	0.0	0.0	53.71	46.29	7.96	7.91	1.26	-0.15	-0.09
	2-7-SOM	0.0	0.0	42.33	57.67	8.27	8.24	1.21	-0.17	-0.49
November	2-NOV-1	0.0	0.0	42.22	57.78	8.26	8.23	1.22	-0.22	-0.38
	2-NOV-2	0.0	0.0	53.89	46.11	7.83	7.87	1.44	-0.19	-0.61
	2-NOV-3	0.0	0.0	60.96	39.04	7.58	7.45	1.45	0.12	-0.87
	2-NOV-4	0.0	0.0	36.96	63.04	8.38	8.41	1.23	-0.35	-0.41
	2-NOV-5	0.0	0.0	47.48	52.52	8.05	8.08	1.29	-0.26	-0.30
	2-NOV-6	0.0	0.0	50.48	49.52	8.04	7.99	1.25	-0.06	-0.48
	2-7-NOV	0.0	0.0	57.05	42.95	7.95	7.86	1.10	-0.06	0.62

Table IV-6 cont.

CRUISE MONTH	SAMPLE STATION-GRAB-CODE	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
APRIL	3-1-KUB	13.16	51.57	17.27	18.00	3.03	1.12	3.91	0.60	-1.12
	3-2-KUD	15.83	46.65	18.80	18.72	3.04	0.96	4.01	0.53	-1.25
	3-3-KUF	16.36	46.23	20.47	16.94	2.91	0.93	3.93	0.57	-1.17
	3-4-KUH	21.90	42.80	20.36	14.94	2.73	0.99	3.92	0.57	-1.12
	3-5-KUJ	19.91	57.18	13.61	9.30	1.84	0.61	3.34	1.15	0.20
	3-6-KVB	6.06	32.54	39.88	21.52	4.65	5.35	3.61	-0.14	-1.25
	3-7-KUS	19.36	51.95	16.18	12.50	2.26	0.70	3.69	0.89	-0.61
JUNE	3-1-MUT	13.28	57.21	13.09	16.42	2.82	1.24	3.63	0.69	-0.83
	3-2-MUV	27.87	65.89	3.37	2.87	0.43	0.18	2.22	2.30	6.13
	3-3-MUX	27.81	60.47	6.70	5.02	0.80	0.19	2.79	1.82	2.58
	3-4-MUZ	25.40	56.00	7.52	11.08	1.60	0.42	3.44	1.25	0.30
	3-5-MVB	48.11	40.78	5.25	5.86	0.36	-0.54	2.95	1.99	3.16
	3-6-MVD	36.29	57.58	2.46	3.67	0.16	-0.03	2.30	2.64	7.55
	3-7-NUE	26.73	63.05	4.78	5.44	0.64	0.17	2.67	2.21	4.46

Table IV-6 cont.

CRUISE MONTH	SAMPLE STATION-GRAB-CODE	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
August	3-1-OZZ	21.49	64.62	5.34	8.55	1.38	0.39	3.15	1.50	1.34
	3-2-PAB	20.34	52.23	8.99	18.44	2.59	0.76	3.97	0.76	-0.94
	3-3-PAD	23.87	51.33	10.98	13.82	2.18	0.63	3.77	0.90	-0.59
	3-4-PAF	22.57	57.30	8.85	11.28	1.81	0.54	3.47	1.15	0.10
	3-5-PAH	14.40	59.83	13.60	12.16	2.31	0.76	3.54	0.96	-0.40
	3-6-PAJ	19.69	55.59	9.77	14.95	2.22	0.68	3.74	0.97	-0.47
	3-7-PAS	18.29	52.82	14.67	14.22	2.43	0.76	3.76	0.81	-0.79
December	3-1-WHL	16.30	39.88	23.36	20.47	3.61	3.14	4.03	0.23	-1.43
	3-2-WHO	11.30	62.96	9.68	16.06	2.76	1.16	3.65	0.84	-0.63
	3-3-WHR	12.37	22.45	37.53	27.64	4.95	6.01	3.97	-0.39	-1.27
	3-4-WHU	9.21	34.92	30.68	25.19	4.54	5.35	3.94	-0.10	-1.47
	3-5-WHX	12.82	48.46	19.33	19.39	3.24	1.51	3.99	0.48	-1.33
	3-6-WIA	10.39	42.33	24.55	22.73	3.87	3.57	4.06	0.18	-1.54
	3-7-WIH	1.60	49.53	27.27	21.60	4.84	3.97	3.21	0.06	-1.03

Table IV-6 cont.

CRUISE MONTH	SAMPLE STATION-GRAB-CODE	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
March	4-2-KAA	0.0	28.32	47.90	23.78	6.02	5.70	2.27	0.38	-1.10
	4-3-KAC	0.37	14.25	56.81	28.57	6.37	5.92	2.23	0.19	-0.70
	4-4-KAE	0.60	13.76	58.59	27.05	6.37	6.05	2.18	0.05	-0.25
	4-5-KAG	0.0	9.40	46.71	43.89	7.33	7.64	2.09	-0.35	-0.99
	4-6-KAI	0.46	9.52	54.44	35.58	6.96	6.94	2.16	-0.39	0.12
June	4-1-MVN	0.0	11.90	60.66	27.44	6.80	7.16	1.84	-0.23	-0.86
	4-1-MVP	0.15	12.37	57.99	29.49	6.56	6.31	2.14	0.07	-0.76
	4-3-MVR	0.55	23.78	36.73	38.94	6.77	7.12	2.52	-0.36	-0.68
	4-4-MVT	0.0	6.43	43.38	50.19	7.72	8.01	1.89	-0.59	-0.49
	4-5-MVV	0.43	19.68	67.22	12.67	5.32	4.83	1.94	0.75	1.13
	4-6-MVX	0.33	8.73	42.67	48.27	7.54	7.92	2.08	-0.93	0.89
	4-7-NUF	1.89	11.19	49.02	37.90	6.80	7.03	2.48	-0.63	0.50

Table IV-6 cont.

CRUISE MONTH	SAMPLE STATION-GRAB-CODE	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
August	4-1-PAU	0.31	13.25	34.78	51.66	7.55	8.11	2.30	-0.83	0.13
	4-2-PAW	1.64	24.67	35.16	38.53	6.47	7.09	2.89	-0.62	-0.35
	4-3-PAY	0.52	19.64	32.25	47.59	7.21	7.86	2.58	-0.82	-0.05
	4-4-PBA	1.78	22.89	48.24	27.09	5.92	5.61	2.68	-0.28	-0.17
	4-5-PBC	1.78	25.86	24.65	47.71	6.91	7.83	2.91	-0.74	-0.31
	4-6-PBE	5.52	20.35	27.21	46.92	6.72	7.78	3.28	-0.99	0.15
	4-7-PBN	0.39	30.19	36.71	32.71	6.25	6.05	2.60	-0.02	-1.09
December	4-1-WIK	0.20	28.83	52.54	18.43	5.62	4.92	2.18	0.63	-0.34
	4-2-WIN	0.05	22.14	54.47	23.33	6.11	5.72	2.18	0.45	-0.96
	4-3-WIG	4.26	31.84	41.85	22.05	5.23	5.55	3.18	-0.32	-0.71
	4-4-WJC	0.72	29.91	36.58	32.79	6.36	6.45	2.63	-0.20	-0.73
	-4-WJG	0.20	28.83	52.61	18.36	5.62	4.92	2.19	0.61	-0.36
	4-5-WOJ	2.37	25.53	39.66	32.44	6.14	6.51	2.99	-0.54	-0.39
	4-6-WJZ	0.30	8.31	68.36	23.03	6.24	5.77	2.08	0.23	-0.13
	4-7-WIH	7.54	15.50	48.00	28.96	5.58	6.21	3.54	-0.66	-0.64

Table IV-6 cont.

CRUISE MONTH	SAMPLE STATION-GRAB-CODE	GRAVEL	SAND	SILT	CLAY	MEAN	MEDIAN	STD DEV	SKEWNESS	KURTOSIS
September	SH2-SB-1	7.63	42.05	22.51	27.81	4.91	4.08	3.67	-0.07	-1.18
Topographic High Cruise 76SH2	SH2-SB-1B	0.18	19.62	38.10	42.10	7.03	7.15	2.52	-0.17	-1.23
	SH2-SB-2A	0.0	0.0	36.45	63.55	8.50	8.75	1.49	-0.43	-1.00
	SH2-SB-2B	0.0	0.0	31.36	68.64	8.68	9.07	1.54	-0.68	-0.64
	SH2-SB-3	1.48	20.40	25.78	52.34	7.27	8.22	2.97	-0.91	-0.04
	SH2-SB-4	0.0	23.31	31.07	45.62	7.14	7.57	2.53	-0.23	-1.46
	SH2-SB-4B	0.0	25.41	42.66	31.93	6.48	6.17	2.41	0.25	-1.40
	SH2-SB-5	0.0	0.0	26.77	73.23	8.81	9.19	1.42	-0.80	-0.33
	SH2-SB-6	0.0	0.0	36.98	63.02	8.46	8.70	1.51	-0.47	-0.87
	SH2-SB-7	0.0	0.0	31.03	68.97	8.64	9.02	1.50	-0.70	-0.55
	SH2-SB-8	0.0	0.0	35.84	64.16	8.51	8.84	1.55	-0.50	-0.95
	SH2-SB-9	0.0	0.0	37.58	62.42	8.40	8.65	1.51	-0.44	-0.90
	SH2-SB-10	0.0	0.0	35.22	64.78	8.38	8.72	1.61	-0.68	-0.55
	SH2-SB-11	0.0	0.0	38.34	61.66	8.31	8.58	1.55	-0.49	-0.83
	SH2-SB-12	0.0	0.0	36.16	63.84	8.43	8.60	1.41	-0.51	-0.57

Table IV-7

Total Carbonate Percentage and Particle Identification of the Coarse Fraction

(All Values in %)

Station	Quartz	Forams Planktonic	Forams Benthonic	Shells Echinoderm	Shells Mollusc	Coral	Algae	Lithoclasts	Miscellaneous	Total Carbonate
East Flower Gardens Bank										
1	28.5	28.5	3.0	15.5	10.0	1.5	1.5	7.0	4.5	72.5
2	22.0	38.5	6.5	10.5	12.5	1.0	4.0	0.0	5.0	25.3
3	43.0	25.0	7.0	9.0	9.5	0.0	1.0	0.0	5.5	27.5
4	31.5	9.5	2.0	9.5	28.0	0.5	4.0	11.5	3.5	86.3
Stetson Bank										
1	7.5	8.0	1.0	8.5	22.5	4.0	2.5	36.5	9.5	19.1
2	18.5	3.0	0.0	1.5	33.0	3.0	0.5	33.5	7.0	24.6
3	19.0	4.0	1.5	2.5	45.0	2.5	0.0	22.5	4.0	10.6
4	16.5	4.5	0.5	2.5	28.5	1.0	1.5	42.5	3.5	43.8
28 Fathom Bank										
1	17.0	19.5	4.0	11.0	26.0	3.0	2.0	8.0	9.5	49.7
2	25.0	27.0	6.0	11.5	19.0	0.1	1.0	4.5	5.5	86.9
3	15.5	13.5	3.5	10.5	38.0	3.5	3.5	10.0	2.0	100.0
28 Fathom Bank, southwest peak										
1	3.5	21.5	13.0	14.0	29.5	0.0	0.5	14.0	4.0	35.0
2	7.5	18.5	10.0	19.5	12.5	1.0	6.0	20.5	4.5	>100.0
3	48.0	7.0	11.0	6.0	0.0	1.0	2.5	1.5	23.0	32.4
4	50.5	5.5	5.5	5.5	21.0	2.0	1.5	1.0	7.5	53.7

Table IV-7 cont.

Station	Quartz	Forams Planktonic	Forams Benthonic	Shells Echinoderm	Shells Mollusc	Coral	Algae	Lithoclasts	Miscellaneous	Total Carbonate
Hospital Rock										
1	12.5	8.0	2.0	12.0	12.0	1.0	2.5	46.5	3.5	64.5
2	28.0	28.5	5.5	24.0	4.0	0.0	1.0	2.0	7.0	5.3
3	48.0	11.0	7.0	6.0	0.0	0.5	1.5	1.0	25.0	3.8
4	14.5	29.0	3.5	33.5	4.5	3.5	2.0	5.5	4.0	37.5
5	36.0	23.0	4.0	24.5	2.5	0.0	1.0	3.5	5.5	4.5
7	26.0	21.0	17.0	24.0	0.0	0.0	0.0	1.0	11.0	5.1
8	2.0	19.0	12.0	53.0	0.0	0.0	0.0	1.5	12.5	3.0
9	35.0	33.0	6.0	15.0	6.5	0.0	0.0	1.5	3.0	5.7
10	34.5	31.5	9.0	10.0	6.5	0.0	0.0	4.0	4.5	3.9
11	15.0	34.0	10.0	25.5	3.0	0.0	1.5	1.5	9.5	7.8
12	20.5	30.0	3.0	27.0	0.5	0.5	1.5	7.5	9.5	27.3
Southern Bank										
1	21.5	12.5	21	28.0	1.0	0.0	0.0	1.0	5.0	33.6
2	62.0	21.0	0.0	5.0	4.0	0.0	1.0	2.5	4.5	5.0
3	15.0	12.5	4.0	7.0	18.0	5.0	0.0	36.0	2.5	20.4
4	19.0	26.0	8.0	16.0	7.5	0.0	1.5	19.5	1.5	7.5
5	26.5	43.5	11.5	2.0	2.5	2.5	2.0	1.5	8.0	4.8
6	33.5	42.5	4.0	6.0	5.5	0.0	0.0	3.0	5.5	5.1
7	48.0	27.5	6.5	1.5	7.5	2.0	0.5	3.5	3.0	4.8
8	13.0	24.5	4.5	23.0	14.0	1.5	0.5	16.5	12.5	4.3
9	40.5	14.0	1.0	10.0	14.0	0.5	3.0	4.5	12.5	3.7
10	51.0	29.0	6.0	4.0	2.0	0.0	0.5	2.0	5.5	5.6
11	33.0	35.0	9.0	2.5	5.0	1.5	2.5	3.5	8.0	5.5
12	53.0	21.5	3.5	1.5	9.0	1.0	2.0	2.0	6.5	5.6

Table VI-8

CORE DESCRIPTION

LEGEND

Clay

Sand/Silt
Sand/Silt Laminae

Silty Clay

Shell
Shell Hash

Coral/Algal Fragments

Burrows

Lithoclasts

"Extremely shelly" is a shell hash with little or no clay matrix. "Very shelly" refers to a shell hash with < 10% clay matrix. A "shelly clay" can vary from 10% to 90% shell debris in a clay matrix; lower than 10% shell is noted as "shell fragments". "Turbated" refers to a chaotic arrangement of grains within a sediment and when evidence is present that the disturbance was caused by biological organisms, such as burrowing, it is referred to as "bioturbation". Significant sand or silt laminae are further described as "continuous, wavy, parallel, etc".

Table IV-8 cont.

CORE DESCRIPTIONS

Cruise 76-SH-2 Core No. EFGB 1 No. Sections 1 Date 1-14-77

Position E. Flower Garden Station 1 Total Length 40 cm Described by P. Lindquist

Depth	Lithology & Color		Radiography	Samples	Smear Slides	Miscellaneous Remarks
	5Y 4/1 Well sorted sand & shell		Coarse carbonate sand	5		carb. sand
10		VERY SANDY & SHELLY	shell very turbated carbonate sand & shell hash with occasional lg shell fragments	10		Shelly coarse sand
20	5GY 4/1					
30	Large shell fragments		large shell fragments	30		large shell fragments
40				39		shell hash

Table IV-8 cont.

CORE DESCRIPTIONS

Cruise 76-SH-2 Core No. EFGB #2 No. Sections 2 Date 1-18-77

Position E Flower Garden Station 2 Total Length 220 cm Described by P. Lindquist

Depth	Lithology & Color	Radiography	Samples	Smear Slides	Miscellaneous Remarks
10	5Y 4/1	sparse shell layer shell fragments (1mm-1 cm)	10		Core was disturbed either by gas or during transportation, gaps in core made splitting difficult and resulted in further disruption.
20		some shell fragments (turbated)			
30	5GY 4/1 except 5Y 4/1 along cracks				Sparse shell layer
40			40		clay
50					
60					
70		burrow	70		burrow
80		shell fragments-large			
90					
100					
110			110		clay
120					
130		fine sand or silt laminae, inclined, parallel, straight	126		sand laminae
140	Shell fragments	shell fragments layer, large fragments-2 cm	142		shell layer and large fragments
150					
160	5GY 4/1				
170					
180			180		clay
190					
200					
210					
220			219		clay

CORE VERY DISRUPTED SILTY CLAY WITH SOME SHELL FRAGMENTS

CLAY

Table IV-8 cont.

CORE DESCRIPTIONS

Cruise 76-SH-2 Core No. EFG8 #3 No. Sections 1 Date 1-18-77

Position East Flower Garden Station 3 Total Length 165 cm Described by P. Lindquist

Depth	Lithology & Color		Radiography		Samples	Smear Slides	Miscellaneous Remarks
	5GY 5/1 Sandy and disturbed			SILTY CORE	10		sandy clay
	shelly		whole shell				
20	shelly		whole shell (conch shaped)	CLAY DISTURBED	24		large shell fragments
40		CLAY					
	gradually to 5GY 4/1	WITH	shell fragments (pocket)	WITH			
60					60		clay
		OCCASSIONAL		OCCASSIONAL CRACKS			
80							
100					100		clay
		SHELL		SMALL SHELL			
120							
			burrowed				
140	5GY 4/1	FRAGMENTS	shelly	SHELL FRAGMENTS	142		shelly clay
160					164		clay
180							

Table IV-8 cont.

CORE DESCRIPTIONS

Cruise 76-SH-2 Core No. EFGB #4 No. Sections 1 Date 1-18-77

Position E. Flower Garden Station 4 Total Length 172 cm Described by P. Lindquist

Depth	Lithology & Color	Radiography	Samples	Smear Slides	Miscellaneous Remarks
	5Y 5/2 coarse sand, some shell	Coarse carbonate sand and shell fragments	10		coarse sand
20	5G 4/1	sharp contact	26		above contact (sand-
		Silty clay with few shell fragments	30		below contact (clay & shell)
40	sand & shell pocket (5Y 5/2)	shelly zone			
60			65		clay
80	shell & sand	shell fragments & coarse $CaCO_3$ sand (burrow)	80		shell & sand
		Silty clay with few shell fragments	95		clay
100					
	shell & sand	CLAY WITH SOME SHELL			
120					
140	shell fragments	pocket of shell fragments	140		shelly clay
		Shelly, silty clay			
160		very shelly clay			
	shell fragments		170		very shelly
180					

Table IV-8 cont.

CORE DESCRIPTIONS

Cruise 76-SH-2 Core No. STB 2 No. Sections 1 Date 1-18-77

Position Stetson Station 2 Total Length 101 cm Described by P. Lindquist

Depth	Lithology & Color	Radiography	Samples	Smear Slides	Miscellaneous Remarks
	shell hash				
10	large shell	large shell	10		large shell and shelly
20					
30	5GY 4/1	coral fragments	30		coral fragments & shelly
40		large shell fragments (1 cm-2cm)			
50	shell fragments black cavity	gap with large shell fragments & lithoclasts			possibly reduced organic matter?
60			60		very shelly
		indistinct contact			
70		Shelly clay (burrowed)	70		shelly clay
	shell fragments	shell fragments burrow?	76		burrow
80	5G 3/1	shell fragments			
		heavily bioturbated			
90	very stiff clay	burrowed			
100			100		clay

VERY SHELLY CLAY

VERY SHELLY FINE CLAY MATRIX

SHELL FRAGMENTS 1mm-15cm

Table IV-8 cont.

CORE DESCRIPTIONS

Cruise 76-SH-2 Core No. STB #3 No. Sections 1 Date 1-18-77

Position Stetson Station 3 Total Length 28 cm Described by P. Lindquist

Depth	Lithology & Color	Radiography	Samples	Smear Slides	Miscellaneous Remarks
	siltstone fragments shell fragments				
5	VERY SHELLY CLAY	VERY SHELLY CLAY LG SHELL FRAGMENTS	5		siltstone & shelly
10					
	5GY 4/1				
15			15		shelly
20					
		fairly sharp contact			
25	very stiff clay	shelly clay	27		shelly clay

Table IV-8 cont.

CORE DESCRIPTIONS

Cruise 76-SH-2 Core No. HB #1 No. Sections 1 Date 1-14-77

Position Hospital Station #1 Total Length 144cm Described by P. Lindquist

Depth	Lithology & Color	Radiography		Samples	Smear Slides	Miscellaneous Remarks
10	5Y 4/1			10		shell hash
20	5GY 4/1					
30						
40						
50						
60	(SHELL HASH)	lg shell fragments (1 cm)		55		large shell fragments & hash
70	lg clay & shell fragments			68		algal nodule
80						
90		large shell, whole 3 cm conical		90		large shell & hash
100		large shell fragments				
110		large shell fragments				
120				120		shell hash
130						
140		large shell fragments		143		shell hash

VERY SHELLY

LARGE SHELL FRAGMENTS IN SMALL SHELL FRAGMENTS + MUD MATRIX

Table IV-8 cont.

CORE DESCRIPTIONS

Cruise 76-SH-2 Core No. HB #2 No. Sections 1 Date 1-14-77

Position Hospital Station 2 Total Length 144cm Described by P. Lindquist

Depth	Lithology & Color	Radiography	Samples	Smear Slides	Miscellaneous Remarks
10	5GY 4/1 mottled with 5Y 4/1	burrowed	10		core disturbed during splitting clay
20					
30	CLAY				
40	Shell fragments	burrowed			
50		silty clay			
60		silty clay	62		silty clay
70		silty clay			
80	Shell fragments	burrowed			
90	5GY 4/1	shell fragments	88		shell fragments
100		fine parallel, wavy, continuous sand or silt laminations.			
110		fine parallel, wavy, turbated sand or silt laminations.	110		sand laminations
120		silty clay	125		clay and silt
130		silty clay			
140			143		clay
150					

Table IV-8 cont.

CORE DESCRIPTIONS

Cruise 76-SH-2 Core No. HB #3 No. Sections 1 Date 1-14-77

Position Hospital Station 3 Total Length 127 cm Described by P. Lindquist

Depth	Lithology & Color	Radiography	Samples	Smear Slides	Miscellaneous Remarks
	Mostly N 4 med. dark gray with streaks of 5Y 4/1 along fracture.				Core disturbed during recovery or storage or possible gas.
10		burrowed	10		burrowed clay
20		shell fragments			
30					
40	Mostly 5GY 4/1 with streaks of 5Y 4/1 along fractures		40		Clay
50					
60					
70			70		Clay
80	5GY 4/1				
90					
		fine sand or silt laminae wavy non parallel, discontinuous	95		Sand Laminae
100			102		Below sand laminae
110		fine sand or silt laminae parallel, slightly wavy, continuous	111		Sand Laminae
120					
			126		Clay
130					

CLAY - disturbed

VERY DISTURBED

Table IV-8 cont.

CORE DESCRIPTIONS

Cruise 76-SH-2 Core No. HB #4 No. Sections 1 Date 1-14-77

Position Hospital Station 4 Total Length 60 cm Described by P. Lindquist

Depth	Lithology & Color	Radiography	Samples	Smear Slides	Miscellaneous Remarks
	5GY 4/1	Clay			
10	N 4 Med. dark gray (CLAY)		10		Clay
		bioturbated 1g burrow			
20		sharp contact			
		fine silt or sand laminae	22		Silty clay
30		Silty turbated clay burrowed with small (< 1 mm) shell frag-ments			
40	shelly clay	sharp contact	40		silty clay
	5GY 4/1	very shelly clay with shelly clay zones.	44		shelly clay
50	Very shelly				
60	Large shell fragments	large (1-5 m) shell fragments in small shell matrix	59		very shelly clay

Table IV-8 cont.

CORE DESCRIPTIONS

Cruise 76-SH-2 Core No. S08# 1 No. Sections 1 Date 1-15-77

Position Southern Station #1 Total Length 61cm Described by P. Lindquist

Depth	Lithology & Color	Radiography	Samples	Smear Slides	Miscellaneous Remarks
	5Y 4/1 mixed with 5 GY 4/1 disturbed, fine grained	disturbed clay	10		core disturbed before and by splitting clay
10	5 GY 4/1	fine sand or silt	16		sand
20			25		clay above sand
30	CLAY	fine sand or silt laminae			
		sand or silt in clay matrix	34		clay below sand
40		circular burrow (?) silty clay			
		fine sand or silt laminae	50		sand
50	sandy feel	very fine sand or silt laminae, some bioturbation, burrows			
60			60		clay

Table IV-8 cont.

CORE DESCRIPTIONS

Cruise 76-SH-2 Core No. SOB # 2 No. Sections 1 Date 1-14-77

Position Southern Station 2 Total Length 117cm Described by P. Lindquist

Depth	Lithology & Color	Radiography	Samples	Smear Slides	Miscellaneous Remarks
	5 Y 4/1 SPLOTCHY COLOR				core disturbed in splitting
10		burrowed (?)	10		burrowed clay
20	5 GY 4/1				
30		lenticular, laminated fine sand or silt (fines upward?)	32 33		top of sand lens bottom sand lens
40	CLAY				
50		burrows	50		clay possible gas pockets or separation due to gas.
60					
		fine silt lamination	65		silt lamination
70		shell fragment (1) turbated silt, burrows			
			75		clay and silt
80	sandy feel	parallel, wavy sand or silt laminations, discontinuous, sharp contacts	82		sand laminations
90					
100					
		silt laminations	105		silt laminations
110					
			116		clay
120					

Table IV-8 cont.

COPE DESCRIPTIONS

Cruise 76-SH-2 Core No. SOB #3 No. Sections 1 Date 1-14-77

Position Southern Station # 3 Total Length 74cm Described by P. Lindquist

Depth	Lithology & Color	Radiography		Samples	Smear Slides	Miscellaneous Remarks
	5 Y 4/1 on upper 1 cm	shelly clay	MOSTLY SMALL FRAGMENTS ↓ SOME LARGE FRAGMENTS			
10	some clay			10		clay in shell
		extremely shelly (shell hash)				
20	shelly clay	shelly clay zone				
				25		shelly clay
30		extremely shelly				
				35		shell hash
40	some clay	shelly clay zone				
				44		below shelly clay
50		extremely shelly				
60		shelly clay zone		60		shelly clay
70		extremely shelly		73		shell hash

VERY SHELLY

5 GY 4/1

Table IV-8 cont.

CORE DESCRIPTIONS

Cruise 76-SH-2 Core No. SOB #4 No. Sections 1 Date 1-14-77

Position Southern Station #4 Total Length 132cm Described by P. Lindquist

Depth	Lithology & Color	Radiography	Samples	Smear Slides	Miscellaneous Remarks
	5GY 4/1 with mottled 5Y 4/1	some shell fragments (burrowed)			Core slightly disturbed during splitting
10			10		Clay
	CLAY	shell fragments			
20		parallel shell layers			
			25		shell layer
30	5GY 4/1				
40	Clay	shell fragments			
50	Coral fragments	shelly clay	50		shelly clay
60	Clay with shell fragments	shelly clay; some large shell fragments (>1mm) shell layers, parallel continuous & discontinuous			
70			70		very shelly clay
	Shelly clay	very shelly clay			
80		shelly clay			
		clay with some small shell fragments			
90	Sharp contact		88		clay
		shell hash-extremely shelly	92		shell hash
100	VERY SHELLY				
		shelly clay zone			
110		shell hash			
	(SHELL HASH)				
120					
130			130		shell hash

TABLE IV-9

CONCENTRATION OF TRACE ELEMENTS IN BOTTOM SEDIMENTS
(PPM)

BANK	STATION	SAMPLE	Ba	Cd	Cr	Cu	FE	Mn	Ni	Pb	V	Zn
Baker	2	4	59.9	0.31	12.9	9.1	14900	120	21.6	6.7	7.8	64.7
Baker	4	5	44.8	0.22	24.8	12.9	29000	113	20.0	11.1	13.7	89.2
Baker	6	8	53.4	0.22	21.3	15.4	30500	112	22.7	11.3	13.5	83.1
Baker	25	3	47.0	0.25	18.4	8.8	17900	131	15.8	9.9	11.7	58.0
Baker	33	2	57.4	0.27	26.2	9.0	24200	118	16.5	8.9	12.7	72.2
S. Baker	7	6	62.7	0.21	27.4	11.7	26700	127	18.5	11.1	13.2	73.3
S. Baker	8	10	50.3	0.26	29.4	11.4	28700	125	18.8	10.5	11.3	82.6
S. Baker	9	7	54.4	0.26	30.5	11.9	26400	165	16.6	12.2	11.5	79.4
S. Baker	10	9	60.3	0.20	29.8	17.7	32000	108	22.7	14.3	11.0	92.0
Southern	37	14	69.7	0.24	23.4	15.2	30900	144	20.3	16.2	14.3	83.6
Southern	39	12	88.9	0.34	11.3	8.3	15900	135	13.3	7.2	7.0	59.4
Southern	40	13	67.0	0.17	22.2	15.3	31100	123	24.0	13.4	13.1	88.1
Southern	41	17	71.1	0.17	22.0	15.1	30000	129	23.4	12.7	12.2	81.8
Southern	42	11	53.0	0.23	20.7	11.0	24900	117	16.2	9.1	11.8	64.7
Big Adam	78	23	84.1	0.23	25.2	16.0	30500	129	18.1	12.2	10.0	74.4
Big Adam	80	15	96.6	0.18	21.4	13.0	25900	143	19.9	9.4	10.2	68.3
Big Adam	84	24	83.7	0.24	24.1	13.8	25600	143	16.2	9.1	10.0	72.1
Big Adam	85	16	109.4	0.16	17.9	13.2	24600	114	19.7	9.6	10.3	74.0
Dream	59a	25	81.8	0.29	22.9	19.1	27600	189	18.3	13.0	10.1	100.3
Dream	59b	18	78.7	0.23	22.1	18.5	31100	134	21.7	13.8	10.4	84.6
Dream	61	21	91.2	0.23	24.6	13.4	26700	860	19.8	11.5	9.2	77.7
Dream	64	22	65.0	0.25	22.5	14.0	28600	180	18.5	13.6	11.6	76.1
Dream	65	19	75.5	0.29	21.4	11.5	20600	123	15.7	7.4	7.3	67.1
Small Adam	87	20	98.3	0.24	21.3	13.4	26100	150	18.2	10.5	10.8	70.4
	1gs-b	1	59.7	0.24	26.6	10.1	24600	143	20.7	9.4	13.8	73.5

Table V-1. Counts of benthonic foraminiferans from the second priority banks. These counts can be converted into ind./10cm^2 by multiplying by .6. The number in ( ) is the amount of each sample picked of the working 1/2, samples referred to in the text as "worked in detail" refer to the ($\frac{1}{2}$) samples in this appendix.

	STB1 (1/16)	STB2 ($\frac{1}{2}$)	STB3 ($\frac{1}{2}$)	STD4 (1/16)	EFC1 ($\frac{1}{2}$)	EFC2 ($\frac{1}{2}$)	EFC3 ($\frac{1}{2}$)	EFG4 (1/32)	28SF1 ($\frac{1}{2}$)	28SF2 ($\frac{1}{2}$)	28SF3 (1/16)	28SF4 ($\frac{1}{2}$)	28F1 ($\frac{1}{2}$)	28F2 ($\frac{1}{2}$)	28F3 ($\frac{1}{2}$)
Alveolophragum sp.		2													
Amphistigina				1							1				
Ammonia beccarri				1							1				
Angulogerina sp.															5
Archaias				1				1							
Bigenerina irregularis		8	7											4	
Bolivina albatrossi		4													
Bolivina lowmani		60	30	1						1	1		1		
Bolivina minima					1										
Bolivina sp.									3						
Brizalina fragilis		9	22										7	3	2
Brizalina sp.															21
Brizalina spinata	3	46		1		1	5			5	2	1	11	3	10
Brizalina subaeraninsis var. mexicana		2													
Brizalina subspinescens	1		2		1										1
Buccella hannai														3	
Bulimina marginata									2			2	2		
Bulimina cf. spicata					1										1
Buliminella cf. bassendorfensis	6	2	3	2	1			1		1	1	1			
Calcarina								1							
Cancris oblonga					1				1			11	15	4	
Cancris sagra					15	4	3		1	2		14	18	12	14
Cassidulina laevigata			3						11						3
Cassidulina norcrossi var. australis			6												6
Cassidulina subglobosa								3							
Cibicides aff. floridanua					5	5		2							2
Cibicides mollis					4	1				1			1	16	1
Cibicides lobatous								2							
Cibicides umbonatus	5	2							13		1		6	1	
Cornuspira ?				3				1			1				
Dentalina sp.										1			1		
Discorbis candeiana					1										
Discorbis floridensis										1		3			3
Elphidium sp.								3							
Epistominella vitrea	5			1											

Table V-1 cont.

	STB1	STB2	STB3	STB4	EFG1	EFG2	EFG3	EFG4	28FS1	28FS2	28FS3	28FS4	28F1	28F2	28F3
Florilus atlanticus		1									1				
Florilus grateloupe		33				1			1	1			1	2	19
Fursenkoina pontoni	4	92		3			1		1	1		1	6		
Hanzawaia strattoni		10				4			3						1
Lagena halstedi						1									
Lagena nenulosa		2													
Lagena spirata					1										
Lenticulina calcar									1			1			
Loxostomum getbi															6
Marginulina sp.									1					3	
Marginulinopsis marginulinoides												1			
Melonis poplioides											1				
Miliolid sp.								3			1				
Nonionella basiloba		1					1	2				3			
Nonionella cf. basiloba		5				1									4
Panetella sp.											1				
Planorbulinella								1							
Proteonina diffugiformis														4	
Pseudoclabrulina mexicana													3		
Pullenia quinqueloba														1	1
Quinqueloculina sp.	1	25		1	15	1		4	6			9	1	7	
Reophax atlantica		16				1							6	8	
Reophax comprima		1													
Reophax diffugiformis										1					
Reophax scorpiuris														1	
Reussella atlantica		38			1		1							5	6
Robulus sp.														1	
Sagrina pulchella primitiva		6													
Sigmoilina distorta															4
Siphonina bradyana	2	25			2	1		1	2	5			1	5	4
Siphonina pulchra		1							1						1
Siphotextularia affinis		5													
Spirillina decorata															4
Textularia earlandi		36													1
Textularia parvula		2													
Trifarina bella	11	86			1		1		1						7
Uvigerina bellula									15	1			1	2	
Uvigerina flintii					5							2	3	1	
Uvigerina parvula					1		1		1			5			
Uvigerina peregrina									20			1			
Uvigerina sp.								2			1				
Vaginulosis		1													
Virgulinella spinicostata		1													
other calcareous spp.	9			5				1			3				1
other arrenaceous spp.	3			1				6			3				18

Table VI-1

COUNTS OF MEIOFAUNA (BOTH TRUE AND TEMPORARY) FOR REPLICATE CORES, A AND B, FROM ONE SMITH-McINTYRE GRAB PER STATION. SAMPLES TAKEN AT STETSON BANK IN AUGUST 1976.

STATION NUMBER	1		2		3		4		$\bar{x}$
TAXA	A	B	A	B	A	B	A	B	
Nematoda	75	60	405	419	277	543	206	219	276
Harpacticoida	6	10	234	91	45	103	229	512	154
Kinorhyncha	1	1	36	7	22	34	1	3	13
Ostracoda	0	0	8	3	1	11	22	49	
Halacaridae	1	1	0	0	1	1	0	0	
Nauplii	3	0	45	28	26	65	49	10	
Turbellaria	1	0	0	0	0	0	6	0	
True Other	0	0	1	1	0	1	4	0	
True Meiofauna Total	87	72	729	549	372	758	517	793	
Mean True Meiofauna	86.5*		695.6*		615.1*		713.0*		528*
Foraminifera	21	25	150	267	65	96	247	95	121
Protozoa	0	0	0	0	0	0	17	0	
Polychaeta	5	4	106	37	20	96	180	90	67
Bivalvia	0	1	15	1	6	5	0	4	
Gastropoda	0	0	1	0	0	1	0	0	
Peracarid Crust	0	0	9	1	1	1	0	41	
Temporary Other	0	0	0	0	0	6	0	0	
Total	113	102	1010	855	464	963	961	1023	
Mean	117.0*		1015.1*		776.7*		1079.9*		747*

* Numbers are averages of individuals from replicate samples adjusted to 10 cm^2.

TABLE VI-2

COUNTS OF MEIOFAUNA (BOTH TRUE AND TEMPORARY) FOR REPLICATE CORES: A AND B, FROM ONE SMITH-McINTYRE GRAB PER STATION. SAMPLES TAKEN AT EAST FLOWER GARDEN BANK IN AUGUST 1976.

STATION NUMBER	1		2		3		4		$\bar{x}$
TAXA	A	B	A	B	A	B	A	B	
Nematoda	119	219	29	35	11	17	335	351	140
Harpacticoida	1	4	2	0	0	0	43	32	10
Kinorhyncha	0	0	0	0	0	0	10	9	
Ostracoda	0	0	1	0	0	0	1	0	
Halacaridae	0	2	0	0	0	0	0	2	
Nauplii	0	6	0	0	1	0	60	41	
Turbellaria	0	0	0	0	0	0	0	0	
True Other	0	0	0	0	0	0	0	0	
True Meiofauna Total	120	231	32	35	12	17	449	435	
Mean True Meiofauna	191.0*		36.5*		15.8*		481.2*		181*
Foraminifera	11	13	6	7	1	3	40	19	13
Protozoa	0	0	0	1	0	0	0	0	
Polychaeta	4	7	3	4	0	0	16	13	6
Bivalvia	1	0	0	0	0	0	3	3	
Gastropoda	0	0	0	0	0	0	0	0	
Peracarid Crust	0	0	0	0	0	0	0	0	
Temporary Other	0	0	0	0	0	0	0	5	
Total	136	251	41	48	13	20	508	475	
Mean	210.6*		48.4*		18.0*		535.0*		203*

* Numbers are averages of individuals from replicate samples adjusted to 10 cm^2.

TABLE VI-3

COUNTS OF MEIOFAUNA (BOTH TRUE AND TEMPORARY) FOR REPLICATE CORES; A AND B, FROM ONE SMITH-McINTYRE GRAB PER STATION. SAMPLES TAKEN AT 28 FATHOM BANK IN AUGUST 1976.

STATION NUMBER	1		2		3		$\bar{x}$
	A	B	A	B	A	B	
TAXA							
Nematoda	140	106	117	123	54	26	94
Harpacticoida	3	14	4	36	50	20	21
Kinorhyncha	2	0	0	1	0	0	
Ostracoda	0	0	1	2	5	1	
Halacaridae	0	0	0	1	0	0	
Nauplii	2	1	0	22	16	13	
Turbellaria	0	0	0	0	11	3	
True Other	0	0	0	0	2	0	
True Meiofauna Total	147	121	122	185	138	64	
Mean True Meiofauna	145.8*		167.1*		109.9*		141*
Foraminifera	22	21	26	7	10	57	24
Protozoa	0	0	0	0	0	0	
Polychaeta	1	9	2	13	11	6	7
Bivalvia	1	1	1	1	0	0	
Gastropoda	1	0	0	0	0	1	
Peracarid Crust	0	1	0	0	1	0	
Temporary Other	0	0	0	0	0	2	
Total	172	153	151	206	160	130	
Mean	176.9*		194.3*		157.8*		176*

* Numbers are averages of individuals from replicate samples adjusted to 10 cm^2.

TABLE VI-4

COUNTS OF MEIOFAUNA (BOTH TRUE AND TEMPORARY) FOR REPLICATE CORES; A AND B, FROM ONE SMITH-McINTYRE GRAB PER STATION. SAMPLES TAKEN AT 28 FATHOM BANK, SOUTHWEST PEAK IN AUGUST 1976.

STATION NUMBER	1		2		3		4		$\bar{x}$
	A	B	A	B	A	B	A	B	
TAXA									
Nematoda	103	117	44	55	66	50	123	77	79
Harpacticoida	9	8	114	61	1	2	30	39	33
Kinorhyncha	0	1	0	0	0	0	1	0	0.3
Ostracoda	0	1	14	5	0	2	2	7	
Halacaridae	0	1	0	3	0	0	0	1	
Nauplii	0	1	30	17	0	0	15	15	
Turbellaria	0	0	0	4	0	0	0	0	
True Other	0	0	1	1	0	0	0	0	
True Meiofauna Total	112	129	203	146	67	54	171	139	
Mean True Meiofauna	131.2*		190.0*		65.9*		168.7*		139*
Foraminifera	16	25	48	39	13	17	88	58	38
Protozoa	0	0	0	0	0	0	0	0	
Polychaeta	4	11	19	17	8	6	19	17	13
Bivalvia	0	0	2	2	0	0	3	2	
Gastropoda	0	0	0	2	0	0	0	0	
Peracarid Crust	0	0	1	0	0	0	1	1	
Temporary Other	0	0	0	0	0	0	0	0	
Total	132	165	273	206	88	77	282	217	
Mean	161.7*		260.7*		89.8*		271.6*		196

* Numbers are averages of individuals from replicate samples adjusted to 10 cm^2.

TABLE VI-5

COUNTS OF MACROINFAUNA FROM SIX REPLICATE SMITH-McINTYRE GRABS PER STATION SAMPLES TAKEN AUGUST 1976 AT STETSON BANK

STATION 1

	A	B	C	D	E	F	$\bar{x}$
Polychaeta	60	72	59	81	71	73	69.33
Sipunculida	30	16	49	19	11	19	24.00
Bivalvia	31	24	5	11	24	6	16.83
Gastropoda	0	0	0	0	0	1	0.17
Scaphopoda	0	0	0	0	0	0	0.00
Foraminifera	0	0	0	0	0	0	0.00
Nematoda	0	0	2	3	0	3	1.33
Ostracoda	4	4	2	0	0	1	1.83
Copepoda	5	1	0	0	1	2	1.50
Cumacea	0	0	2	1	1	1	0.83
Tanaidacea	3	2	0	0	3	4	2.00
Isopoda	0	1	1	1	1	3	1.17
Gammaridea	4	6	1	6	4	1	3.67
Caprellidea	0	0	0	0	0	0	0.00
Natantia	1	0	0	3	0	2	1.00
Brachyura	0	4	2	1	2	2	1.83
Ophiuroidea	4	1	0	1	1	2	1.50
Asteroidea	0	0	0	0	0	0	0.00
Holothuroidea	1	1	0	0	0	0	0.33
Echinoidea	0	0	0	0	0	0	0.00
Crinoidea	0	0	0	0	0	0	0.00
TOTAL	143	132	123	127	119	120	127.33

STATION 2

	A	B	C	D	E	F	$\bar{x}$
Polychaeta	65	127	125	122	52	53	90.67
Sipunculida	19	56	25	67	20	112	49.83
Bivalvia	1	35	58	85	57	18	42.33
Gastropoda	0	6	6	2	5	6	4.17
Scaphopoda	0	0	0	0	0	0	0.00
Foraminifera	0	0	0	0	0	0	0.00
Nematoda	0	6	0	0	0	3	1.50
Ostracoda	3	5	8	10	4	19	8.17
Copepoda	0	1	1	2	0	0	0.67
Cumacea	6	2	7	4	6	10	5.83
Tanaidacea	5	7	25	0	1	12	8.33
Isopoda	24	5	10	3	2	3	7.83
Gammaridea	8	3	8	7	2	2	5.00
Caprellidea	0	0	0	0	0	0	0.00
Natantia	0	0	0	0	0	0	0.00
Brachyura	0	1	3	5	2	0	1.83
Ophiuroidea	4	2	0	2	3	15	4.33
Asteroidea	0	0	1	0	0	0	0.17
Holothuroidea	0	1	1	2	0	0	0.67
Echinoidea	1	0	0	0	0	0	0.17
Crinoidea	0	0	0	0	0	1	0.17
TOTAL	136	257	278	311	154	254	231.67

TABLE VI-5 CONCLUDED

COUNTS OF MACROINFAUNA FROM SIX REPLICATE SMITH-McINTRYE GRABS PER STATION SAMPLES TAKEN AUGUST 1976 AT STETSON BANK

STATION 3

	A	B	C	D	E	F	$\bar{x}$
Polychaeta	39	41	32	26	39	69	41.00
Sipunculida	6	6	11	11	6	10	8.33
Bivalvia	21	21	9	41	37	33	27.00
Gastropoda	0	0	0	0	1	0	0.17
Scaphopoda	0	0	0	0	0	0	0.00
Foraminifera	0	0	0	0	0	0	0.00
Nematoda	0	0	0	0	0	0	0.00
Ostracoda	0	0	1	0	0	0	0.17
Copepoda	0	0	0	1	1	0	0.33
Cumacea	0	0	0	3	2	2	1.17
Tanaidacea	0	0	1	2	0	2	0.83
Isopoda	0	0	0	1	0	0	0.17
Gammaridea	1	1	2	2	5	4	2.50
Caprellidea	0	0	0	0	0	0	0.00
Natantia	1	0	0	0	0	0	0.17
Brachyura	1	1	4	1	2	4	2.17
Ophiuroidea	0	0	0	0	4	1	0.83
Asteroidea	1	0	0	1	0	0	0.33
Holothuroidea	0	0	0	0	0	0	0.00
Echinoidea	1	0	0	0	0	0	0.17
Crinoidea	0	0	0	0	0	0	0.00
TOTAL	71	70	60	89	97	125	85.33

STATION 4

	A	B	C	D	E	F	$\bar{x}$
Polychaeta	55	83	65	86	135	75	83.17
Sipunculida	2	9	2	10	12	5	6.67
Bivalvia	0	2	4	3	8	5	3.67
Gastropoda	0	0	0	0	0	0	0.00
Scaphopoda	0	0	0	0	0	0	0.00
Foraminifera	0	0	0	0	0	0	0.00
Nematoda	0	2	2	4	6	2	2.67
Ostracoda	5	9	14	15	30	14	14.50
Copepoda	0	0	3	1	3	0	1.17
Cumacea	12	1	9	9	18	10	9.83
Tanaidacea	4	5	6	6	22	6	8.17
Isopoda	1	4	2	11	7	9	5.67
Gammaridea	3	3	8	5	19	9	7.83
Caprellidea	0	0	0	0	0	0	0.00
Natantia	0	0	0	0	0	0	0.00
Brachyura	0	0	0	3	1	7	1.83
Ophiuroidea	1	3	5	6	4	10	4.83
Asteroidea	0	0	0	0	0	0	0.00
Holothuroidea	0	0	1	0	0	0	0.17
Echinoidea	0	1	0	0	0	0	0.17
Crinoidea	0	0	0	0	0	0	0.00
TOTAL	83	122	121	159	265	152	150.33

TABLE VI-6

COUNTS OF MACROINFAUNA FROM SIX REPLICATE SMITH-McINTYRE GRABS PER STATION SAMPLES TAKEN AUGUST 1976 AT EAST FLOWER GARDEN BANK

STATION 1

	A	B	C	D	E	F	$\bar{x}$
Polychaeta	0	1	0	1	0	1	0.50
Sipunculida	9	2	1	0	3	0	2.50
Bivalvia	0	1	1	1	1	0	0.67
Gastropoda	0	0	1	0	0	0	0.17
Scaphopoda	0	2	0	0	0	0	0.33
Foraminifera	0	0	0	0	0	0	0.00
Nematoda	8	24	33	22	8	23	19.67
Ostracoda	14	5	6	4	3	3	5.83
Copepoda	0	0	0	0	0	0	0.00
Cumacea	0	1	1	1	0	2	0.83
Tanaidacea	0	0	0	1	0	0	0.17
Isopoda	2	0	1	0	1	2	0.10
Gammaridea	0	0	0	0	0	0	0.00
Caprellidea	0	0	0	0	0	0	0.00
Natantia	0	0	0	0	0	0	0.00
Brachyura	0	0	0	0	0	0	0.00
Ophiuroidea	0	0	0	0	0	0	0.00
Asteroidea	0	0	0	0	0	0	0.00
Holothuroidea	0	0	0	0	0	0	0.00
Echinoidea	0	0	0	0	0	0	0.00
Crinoidea	0	0	0	0	0	0	0.00
TOTAL	33	36	44	30	16	31	31.67

STATION 2

	A	B	C	D	E	F	$\bar{x}$
Polychaeta	19	11	6	9	14	5	10.67
Sipunculida	8	1	3	1	3	0	2.67
Bivalvia	0	0	0	2	3	1	1.00
Gastropoda	0	0	0	0	0	0	0.00
Scaphopoda	0	0	0	0	0	0	0.00
Foraminifera	0	0	0	0	0	0	0.00
Nematoda	0	0	0	1	1	0	0.33
Ostracoda	2	1	0	0	0	0	0.50
Copepoda	10	2	0	1	2	2	2.83
Cumacea	0	0	0	0	0	0	0.00
Tanaidacea	1	0	0	0	0	0	0.17
Isopoda	0	2	0	0	0	0	0.33
Gammaridea	0	1	0	0	0	0	0.17
Caprellidea	0	0	0	0	0	0	0.00
Natantia	0	0	0	0	0	0	0.00
Brachyura	0	0	0	0	0	0	0.00
Ophiuroidea	0	0	0	0	0	1	0.17
Asteroidea	0	0	0	0	0	0	0.00
Holothuroidea	0	0	0	0	0	0	0.00
Echinoidea	0	0	0	1	1	0	0.33
Crinoidea	0	0	0	0	0	0	0.00
TOTAL	40	18	9	15	24	9	19.17

TABLE VI-6 CONCLUDED

COUNTS OF MACROINFAUNA FROM SIX REPLICATE SMITH-McINTYRE GRABS PER STATION SAMPLES TAKEN AUGUST 1976 AT EAST FLOWER GARDEN BANK

STATION 3

	A	B	C	D	E	F	$\bar{x}$
Polychaeta	23	13	14	12	13	22	16.17
Sipunculida	2	0	2	2	2	6	2.33
Bivalvia	0	0	1	0	0	0	0.17
Gastropoda	1	0	0	0	0	0	0.17
Scaphopoda	1	0	0	0	0	1	0.33
Foraminifera	0	0	0	0	0	0	0.00
Nematoda	0	0	3	0	0	0	0.50
Ostracoda	0	0	0	0	1	0	0.17
Copepoda	12	1	2	6	0	0	3.50
Cumacea	0	0	0	0	0	1	0.17
Tanaidacea	0	0	0	0	0	0	0.00
Isopoda	0	0	0	0	0	0	0.00
Gammaridea	0	0	0	0	0	0	0.00
Caprellidea	0	0	0	0	0	0	0.00
Natantia	0	0	0	0	0	0	0.00
Brachyura	2	0	0	0	0	0	0.33
Ophiuroidea	0	0	0	0	0	0	0.00
Asteroidea	0	0	0	0	0	0	0.00
Holothuroidea	0	0	0	0	0	0	0.00
Echinoidea	0	0	0	0	0	0	0.00
Crinoidea	0	0	0	0	0	0	0.00
TOTAL	41	14	22	20	16	30	23.83

STATION 4

	A	B	C	D	E	F	$\bar{x}$
Polychaeta	29	14	44	19	21	21	24.67
Sipunculida	20	23	13	18	49	27	25.00
Bivalvia	1	18	4	18	9	7	9.50
Gastropoda	0	0	0	0	0	0	0.00
Scaphopoda	0	0	0	0	0	0	0.00
Foraminifera	0	0	0	0	0	0	0.00
Nematoda	8	1	8	2	10	1	5.00
Ostracoda	29	12	14	45	38	36	29.00
Copepoda	0	0	1	1	3	2	1.17
Cumacea	2	2	2	3	0	1	1.67
Tanaidacea	1	0	0	4	1	0	1.00
Isopoda	1	0	2	1	2	0	1.00
Gammaridea	3	1	1	4	0	2	1.83
Caprellidea	0	0	0	0	0	0	0.00
Natantia	0	0	0	0	0	0	0.00
Brachyura	0	0	0	0	0	1	0.17
Ophiuroidea	1	2	0	0	0	0	0.50
Asteroidea	0	0	0	0	0	0	0.00
Holothuroidea	0	0	0	0	0	0	0.00
Echinoidea	0	0	1	0	0	0	0.17
Crinoidea	0	0	0	0	0	0	0.00
TOTAL	95	73	90	115	133	98	100.67

TABLE VI-7

COUNTS OF MACROINFAUNA FROM SIX REPLICATE SMITH-McINTYRE GRABS PER STATION SAMPLES TAKEN AUGUST 1976 AT 28 FATHOM BANK

STATION 1

	A	B	C	D	E	F	$\bar{x}$
Polychaeta	2	5	1	3	4	2	2.67
Sipunculida	2	5	1	3	5	2	2.83
Bivalvia	0	0	0	1	0	0	0.17
Gastropoda	0	0	3	0	1	0	0.67
Scaphopoda	0	0	0	0	0	0	0.00
Foraminifera	0	0	0	0	0	1	0.17
Nematoda	12	3	7	7	10	6	7.50
Ostracoda	0	1	2	1	0	4	1.33
Copepoda	0	1	0	3	0	0	0.67
Cumacea	0	0	0	0	0	1	0.17
Tanaidacea	0	0	1	0	3	1	0.83
Isopoda	2	5	4	2	11	8	5.33
Gammaridea	0	0	0	0	0	7	1.17
Caprellidea	0	0	0	0	0	0	0.00
Natantia	0	0	0	0	0	0	0.00
Brachyura	0	0	0	0	0	0	0.00
Ophiuroidea	0	0	0	0	2	0	0.33
Asteroidea	0	0	0	0	0	0	0.00
Holothuroidea	0	0	0	0	0	0	0.00
Echinoidea	0	0	0	0	0	0	0.00
Crinoidea	0	0	0	0	0	0	0.00
TOTAL	18	18	19	20	36	32	23.83

STATION 2

	A	B	C	D	E	F	$\bar{x}$
Polychaeta	41	67	27	8	10	13	27.67
Sipunculida	24	23	8	10	8	11	14.00
Bivalvia	0	10	3	0	0	1	2.33
Gastropoda	0	0	0	1	0	0	0.17
Scaphopoda	0	0	0	0	0	0	0.00
Foraminifera	0	0	0	0	0	0	0.00
Nematoda	11	12	26	10	31	22	18.67
Ostracoda	0	2	1	1	1	1	1.00
Copepoda	1	0	3	5	1	1	1.83
Cumacea	2	5	2	2	1	1	2.17
Tanaidacea	1	0	0	0	0	0	0.17
Isopoda	10	3	6	4	7	2	5.33
Gammaridea	1	0	0	0	0	1	0.33
Caprellidea	0	0	0	0	0	0	0.00
Natantia	0	0	0	0	0	0	0.00
Brachyura	0	0	0	0	0	0	0.00
Ophiuroidea	1	1	0	1	3	0	1.00
Asteroidea	0	0	0	0	0	0	0.00
Holothuroidea	0	0	0	0	0	0	0.00
Echinoidea	0	1	0	0	0	0	0.17
Crinoidea	0	0	0	0	0	0	0.00
TOTAL	92	124	76	42	62	53	74.83

TABLE VI-7 CONCLUDED

COUNTS OF MACROINFAUNA FROM SIX REPLICATE SMITH-McINTYRE GRABS PER STATION SAMPLES TAKEN AUGUST 1976 AT 28 FATHOM BANK

STATION 3

	A	B	C	D	E	F	$\bar{x}$
Polychaeta	186	182	171	277	282	184	213.67
Sipunculida	145	204	195	72	129	52	132.83
Bivalvia	9	6	23	13	22	2	12.5
Gastropoda	0	0	0	3	1	3	1.17
Scaphopoda	0	0	0	0	0	0	0.00
Foraminifera	0	0	0	1	0	0	0.17
Nematoda	52	51	44	42	61	100	58.33
Ostracoda	61	64	62	30	20	28	44.17
Copepoda	16	15	20	40	35	21	24.50
Cumacea	6	3	1	4	6	3	3.83
Tanaidacea	17	30	5	9	16	40	19.50
Isopoda	8	6	11	4	4	6	6.50
Gammaridea	0	3	3	4	3	1	2.33
Caprellidea	0	0	0	0	0	0	0.00
Natantia	0	0	0	0	0	3	0.50
Brachyura	1	0	1	2	0	0	0.67
Ophiuroidea	1	0	0	1	2	1	0.83
Asteroidea	0	0	0	0	0	0	0.00
Holothuroidea	1	0	0	0	0	0	0.17
Echinoidea	0	1	1	1	0	1	0.67
Crinoidea	0	0	0	4	2	2	1.33
TOTAL	503	565	537	507	583	447	523.67

TABLE VI-8

COUNTS OF MACROINFAUNA FROM SIX REPLICATE SMITH-McINTYRE GRABS PER STATION SAMPLES TAKEN AUGUST 1976 AT 28 FATHOM BANK, SOUTHWEST PEAK

STATION 1

	A	B	C	D	E	F	$\bar{x}$
Polychaeta	113	91	64	38	34	7	57.83
Sipunculida	6	26	7	135	54	22	41.67
Bivalvia	67	9	47	8	8	16	25.83
Gastropoda	0	0	0	0	0	1	0.17
Scaphopoda	0	0	0	2	1	2	0.83
Foraminifera	9	16	3	0	0	0	4.67
Nematoda	5	0	23	0	1	5	5.67
Ostracoda	0	0	1	3	3	7	2.33
Copepoda	1	0	9	1	0	0	1.83
Cumacea	0	0	2	5	6	6	3.17
Tanaidacea	0	0	0	1	0	0	0.17
Isopoda	0	0	2	6	0	1	1.50
Gammaridea	0	0	1	0	0	0	0.17
Caprellidea	0	0	6	0	0	0	1.00
Natantia	0	0	0	0	0	4	0.67
Brachyura	1	0	0	0	0	0	0.17
Ophiuroidea	8	7	8	4	3	5	5.83
Asteroidea	0	0	0	1	0	0	0.17
Holothuroidea	0	0	0	1	0	0	0.17
Echinoidea	1	0	0	0	0	0	0.17
Crinoidea	0	0	0	0	0	0	0.00
TOTAL	211	149	173	205	110	76	154.00

STATION 2

	A	B	C	D	E	F	$\bar{x}$
Polychaeta	144	220	183	115	209	149	170.00
Sipunculida	21	2	22	14	13	3	12.50
Bivalvia	8	9	6	8	6	12	8.17
Gastropoda	0	2	0	0	0	2	0.67
Scaphopoda	1	0	0	0	0	0	0.17
Foraminifera	0	0	0	0	0	0	0.00
Nematoda	15	10	6	15	9	6	10.17
Ostracoda	9	12	9	10	8	14	10.33
Copepoda	7	26	8	7	49	5	17.00
Cumacea	4	1	2	1	4	1	2.17
Tanaidacea	16	33	8	25	17	10	18.17
Isopoda	9	15	12	4	13	3	9.33
Gammaridea	1	0	0	1	0	0	0.33
Caprellidea	0	0	0	0	0	0	0.00
Natantia	1	0	2	0	0	0	0.50
Brachyura	0	0	0	0	0	0	0.00
Ophiuroidea	0	1	1	1	2	1	1.00
Asteroidea	0	0	0	0	0	0	0.00
Holothuroidea	0	0	0	0	0	0	0.00
Echinoidea	0	1	0	0	1	2	0.67
Crinoidea	0	0	2	0	1	0	0.50
TOTAL	236	332	261	201	332	208	261.67

TABLE VI-8 CONCLUDED

COUNTS OF MACROINFAUNA FROM SIX REPLICATE SMITH-McINTYRE GRABS PER STATION SAMPLES TAKEN AUGUST 1976 AT 28 FATHOM BANK, SOUTHWEST PEAK

STATION 3

	A	B	C	D	E	F	$\bar{x}$
Polychaeta	15	18	15	10	18	22	16.33
Sipumculida	27	209	38	39	23	111	74.50
Bivalvia	1	0	0	2	2	0	0.83
Gastropoda	0	0	0	0	0	0	0.00
Scaphopoda	1	0	0	0	0	0	0.17
Foraminifera	0	0	0	0	0	0	0.00
Nematoda	0	2	0	0	0	0	0.33
Ostracoda	8	3	1	0	2	1	2.50
Copepoda	4	5	0	0	0	6	2.50
Cumacea	2	0	0	0	0	0	0.33
Tanaidacea	0	0	0	0	0	0	0.00
Isopoda	0	0	0	0	0	0	0.00
Gammaridea	0	0	0	0	0	0	0.00
Caprellidea	0	0	0	1	0	0	0.17
Natantia	0	3	0	0	0	0	0.50
Brachyura	1	0	0	1	0	1	0.50
Ophiuroidea	1	1	0	0	0	1	0.50
Asteroidea	0	0	0	0	0	0	0.00
Holothuroidea	0	0	0	0	0	0	0.00
Echinoidea	0	0	0	0	0	0	0.00
Crinoidea	0	0	0	0	0	0	0.00
TOTAL	60	241	54	53	45	142	99.17

STATION 4

	A	B	C	D	E	F	$\bar{x}$
Polychaeta	56	32	59	54	31	61	48.83
Sipunculida	7	12	14	10	1	1	7.50
Bivalvia	5	7	41	5	59	6	20.50
Gastropoda	0	0	0	0	0	0	0.00
Scaphopoda	0	0	0	0	0	0	0.00
Foraminifera	0	0	0	0	0	0	0.00
Nematoda	1	2	3	4	0	1	1.83
Ostracoda	2	0	7	2	0	0	1.83
Copepoda	0	0	1	2	0	1	0.67
Cumacea	1	2	1	8	2	1	2.50
Tanaidacea	0	0	0	0	0	0	0.00
Isopoda	5	3	3	11	5	2	4.83
Gammaridea	0	0	0	0	0	0	0.00
Caprellidea	0	0	0	0	0	0	0.00
Natantia	2	0	2	0	0	0	0.67
Brachyura	0	0	0	0	0	0	0.00
Ophiuroidea	9	6	11	16	15	3	10.00
Asteroidea	0	0	0	1	0	1	0.33
Holothuroidea	0	0	0	0	0	0	0.00
Echinoidea	0	0	0	0	0	0	0.00
Crinoidea	0	0	0	0	0	0	0.00
TOTAL	88	64	142	113	113	77	99.50

TABLE VI-9

NEMATODE TAXA FOUND AT THE FOUR BANK STATIONS.
NOTE STETSON BANK HAS THE RICHEST AND MOST VARIED NEMATODE FAUNA
THIS MAY BE A FUNCTION OF DEPTH.

TAXON	NUMBERS AT BANK STATIONS			
	28-FATHOM-3	28-FATHOM, SW PEAK-2	STETSON BANK-4	EAST FLOWER GARDEN-1
Mesacanthoides	54	1	7	0
Chromaspirina	23	1	0	10
Sabatieria	20	1	17	52
Epacanthion	19	3	1	28
Acanthopharynx	17	5	1	0
Viscosia	16	5	29	0
Phanodermopsis	13	3	0	28
Symplocostoma	12	0	8	0
Spilophorella	0	3	19	0
Perspira	0	0	15	1
Quadricoma	2	3	15	2
Microlaimus	2	2	14	2
Tricoma	6	13	12	3
Halalaimus	4	1	9	6
Pomponema	5	1	9	2
Theristus	2	1	8	8
Anticoma	9	1	1	0
Richtersia	0	6	1	13
Catanema	8	0	0	3
Desmodora	8	1	0	2
Zalonema	7	4	0	0
Desmoscolex	0	2	8	0
Chromadorina	0	0	6	0
Mesacanthion	1	1	1	7
Mesonchium	1	0	4	0
Pselionema	0	0	1	6
Neotonchus	0	0	2	4

TABLE VI-9 CONTINUED

NEMATODE TAXA FOUND AT THE FOUR BANK STATIONS.

TAXON	NUMBERS AT BANK STATIONS			
	28-FATHOM-3	28-FATHOM, SW PEAK-2	STETSON BANK-4	EAST FLOWER GARDEN-1
Spirinia	6	0	0	0
Filoncholaimus	0	0	3	4
Leptosomatid	10	4	1	0
Stilbonematid	24	1	1	6
Rhabdodemania	0	0	0	39
Halichoanolaimus	5	0	0	8
Ptycholaimellus	1	1	4	0
Prochromadorella	0	0	3	1
Metalinhomoeus	0	0	3	0
Leptolaimus	0	0	0	4
Campylaimus	0	0	1	3
Camocolaimus	0	1	1	0
Oncholaimid	7	2	0	0
Synonchiella	3	0	0	0
Leptonemella	2	0	0	0
Enoplolaimus	2	0	0	0
Paramesacanthion	2	0	0	0
Southernia	2	0	0	0
Euchromadora	1	0	0	0
Marylynnia	1	0	0	0
Pareurystomina	1	0	1	0
Cheironchus	1	0	1	0
Eurystomina	4	0	0	0
Monocholaimus	2	0	0	0
Croconema	1	0	0	0
Odontophora	1	0	0	2
Didelta	1	0	0	0
Oxystomina	2	0	0	0
Litinium	1	0	2	0
Trefusia	1	0	0	0

TABLE VI-9 CONTINUED

NEMATODE TAXA FOUND AT THE FOUR BANK STATIONS.

TAXON	NUMBERS AT BANK STATIONS			
	28-FATHOM-3	28-FATHOM, SW PEAK-2	STETSON BANK-4	EAST FLOWER GARDEN-1
Metachromadora	1	0	0	0
Ceramonema	1	0	0	0
Latronema	1	0	0	2
Enoplida	1	0	0	1
Monhysterid	6	0	0	0
Choanolaimid	1	0	0	0
Ceramonematid	3	0	0	1
Calyptronema	0	1	1	0
Actinonema	0	1	0	0
Epsilonematid	0	3	0	0
Chromadoris	0	1	0	0
Comesomatid	1	0	0	0
Mirmithid	1	0	0	0
Linhomoeid	1	0	4	0
Leptolaimid	1	0	0	0
Crenopharynx	0	0	1	0
Micoletzkyia	0	0	1	0
Onchium	0	0	1	0
Acoma	0	0	1	0
Actinolaimus	0	0	2	2
Haliplectus	0	0	2	1
Desmolaimus	0	0	1	0
Rhips	0	0	1	0
Dorylaimopsis	0	0	1	0
Eubostrichus	0	0	1	0
Metacyatholaimus	0	0	1	1
Paramonohystera	0	0	1	0
Paralongicyatholaimus	0	0	1	0
Antomicron	0	0	0	1
Dasynemella	0	0	0	3

TABLE VI-9 CONCLUDED

NEMATODE TAXA FOUND AT THE FOUR BANK STATIONS.

TAXON	NUMBERS AT BANK STATIONS			
	28-FATHOM-3	28-FATHOM, SW PEAK-2	STETSON BANK-4	EAST FLOWER GARDEN-1
Desmodorella	0	0	0	1
Synonchiella	0	0	0	5
Lyranema	0	0	0	1
Wieseria	0	0	0	1
Elzalia	0	0	0	1
Symplocostomid	0	0	1	0
Monohysterid	0	0	1	0
Oxystominid	0	0	0	1
Diplopeltid	0	0	0	2
New genus	3	1	1	0
TOTAL TAXA	55	30	47	40
TOTAL NO. INDIVIDUALS	331	74	232	268
UNIQUE/GROUPS	18	3	13	10

98 different taxa

TABLE VI-10

TAXA AND RELATIVE NUMBERS OF POLYCHAETE ANNELIDS FOUND AT THE BANK STATIONS.

TAXON	NO. OF INDIVIDUALS
Lumbrineris parvapedata	34
Paraonis gracilis	33
Notomastus hemipodus	20
Notomastus latericeus	20
Maldane sarsi	19
Lumbrineris coccinea	15
Dodecaceria dicera	15
Aedicira belgicae	13
Magelona riojai	12
Pareurythoe americana	12
Nephtys picta	10
Syllis cornuta	9
Mediomastus californiensis	8
Aglaophamus verrilli	7
Paramphinome pulchella	7
Onuphis eremitaoculata	7
Onuphis magna	7
Drilonereis magna	6
Cossura delta	6
Dorvillea rudolphi	6
Eunice kinbergi	6
Laonice cirrata	6
Nereida sp	5
Bhawnia goodei	5
Sigambra tentaculata	4
Axiothella mucosa	4
Glycera tessellata	4
Praxillella elongata	4
Prionospio dayi	3
Pherusa inflata	3
Maldanidae sp. B	3
Ampharetidae sp. A	3
Goniada teres	3
Typosyllis corallicoides	3
Tharyx marioni	3
Tharyx annulosus	3
Goniadella gracilis	3
Namalycastis abiuma	3
Aricidea taylori	2
Branchioasychis americana	2
Diopatra cuprea	2
Dodecaceria concharum	
Clymenella torquata calida	2
Paraonis fulgens	2
Anaitides erythrophyllus	2
Autolytus prolifer	2
Capitella capitata	2
Cirrophorus branchiatus	2
Eunice mutilata	2
Exogone dispar	2

TABLE VI-10 CONCLUDED

TAXA AND RELATIVE NUMBERS OF POLYCHAETE ANNELIDS FOUND AT THE BANK STATIONS.

TAXON	NO. OF INDIVIDUALS
Orbiniidae	2
Prionospio sp. A	2
Progoniada regularis	2
Scoloplella capensis	2
Sabellidae sp.	2
Amaeana trilobata	1
Amphinome rostrata	1
Ancistrosyllis papillosa	1
Capitellidae sp.	1
Capitellides jonesi	1
Lepidonotus sublevis	1
Lumbrineris tenuis	1
Magellona pettiboneae	1
Maldanidae sp. A	1
Marphysa aransensis	1
Marphysa bellii	1
Micromaldane ornithochaeta	1
Nephtys homberqi	1
Ninoe nigripes	1
Odontosyllis enopla	1
Paleanotus heteroseta	1
Paraonis lyra	1
Prionospio cerrifera	1
Spio setosa	1
Spiochaetopterus costarum	1
Ampharetida sp. B	1
Dispio uncinata	1
Euclymene sp. A	1
Goniada maculata	1
Gyptis vittata	1
Haploscoloplos follosus	1
Harmothoe aculeata	1
Lumbrineris paradoxa	1
Maldanidae sp. C	1
Marphysa regalis	1
Myriochele sp.	1
Ophioglycera exemia	1
Paleanotus heteroseta	1
Paecilochaetus johnsoni	1
Prionospio saldanha	1
Prionospio steenstrupi	1
Pseudeurythoe ambigua	1
Scolophos rubra	1
Terebellides stroemi	1
Tharyx setigera	1
Thelepus setosus	1

TABLE VI-11

ISOPOD TAXA FOUND AT THE FOUR BANK STATIONS.

TAXON	NUMBERS AT BANK STATIONS			
	28-FATHOM	28-FATHOM	STETSON	EAST FLOWER GARDEN
Gnathia pranzia	0	1	3	0
Gnathia sp. 1 n. sp.	9	1	2	0
Gnathia sp. 2 n. sp.	3	2	3	0
Gnathia sp. 3 n. sp.	1	0	0	0
Anthuridae	0	2	0	0
Accalathura crenulata	0	0	2	0
Paranthuridae n. gen., n. sp.	0	1	0	0
Xenanthura brevitelson	4	8	34	1
Mesanthura sp. 1 n. sp.	4	0	3	0
Mesanthura sp. 2	1	3	0	0
Ptilanthura tricarina	0	1	0	1
Pananthura formosa	0	1	1	0
Horoloanthura irpex	12	14	2	0
Apanthura magnifica	29	4	20	4
Apanthura sp. 1	0	3	0	1
Apanthura sp. 2 n. sp.	0	3	0	0
Eurydice littoralis	0	0	0	1
Excorallana tricornis	1	0	1	0
Nalicora rapax	3	0	0	0
Cirolana parva	1	3	0	0
Cirolanidae	1	0	0	0
Serolis mgrayi	1	0	0	0
Serolis sp.	2	0	0	0
Asellote 1 n. gen., n. sp.	11	1	1	0
Asellote 2	0	3	0	0
Jaeropsis n. sp.	0	2	0	0
TOTAL INDIVIDUALS	83	53	72	8
TOTAL TAXA	15	17	11	5

TABLE VI-12

TANAIDACEA TAXA FOUND AT THE FOUR BANK STATIONS.

TAXON	NUMBERS AT BANK STATIONS			
	28-FATHOM	28-FATHOM, SW PEAK	STETSON	EAST FLOWER GARDEN
Leptochelia sp. A	6	2	33	1
Apseudes sp. A	101	0	0	0
Apseudes sp. B	0	82	4	0
Apseudes sp. C	0	0	9	0
Apseudes sp. D	3	0	11	0
Apseudes sp. E	0	0	8	0
Kalliapseudes sp. A	3	0	6	0
Metapseudes sp. A	0	0	2	1
Leptognathia sp. A	2	0	3	7
Typhlotanais	0	2	4	0
Typhlotanais sp. A	30	0	39	6
cf. *Paratanais* sp. A	0	0	2	0
TOTAL INDIVIDUALS	145	86	121	15
TOTAL TAXA	6		11	4

The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Minerals Revenue Management** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.