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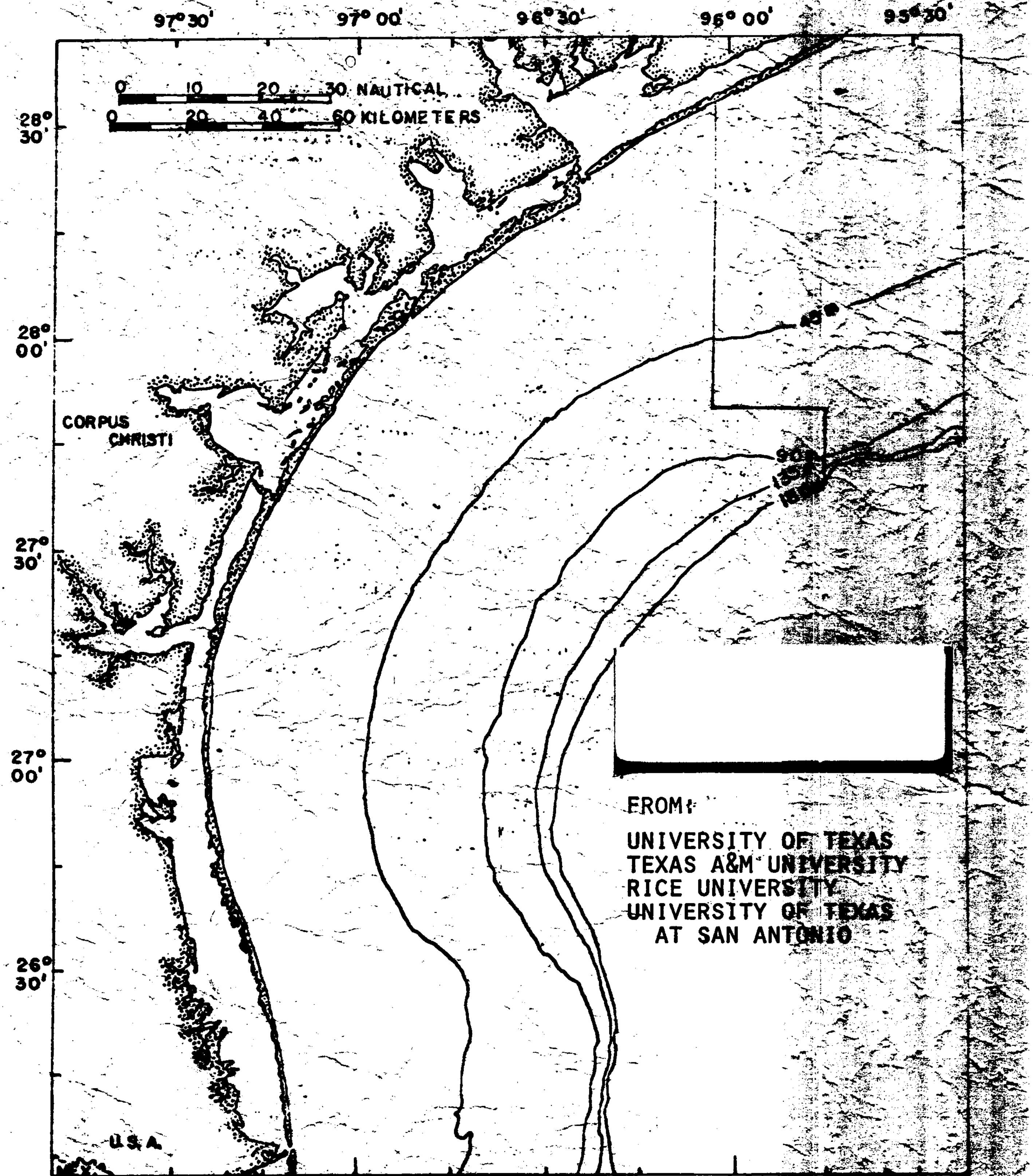
ENVIRONMENTAL STUDIES, SOUTH TEXAS OUTER CONTINENTAL SHELF, BIOLOGY AND CHEMISTRY



FROM:

UNIVERSITY OF TEXAS
TEXAS A&M UNIVERSITY
RICE UNIVERSITY
UNIVERSITY OF TEXAS
AT SAN ANTONIO

EXECUTIVE SUMMARY

ENVIRONMENTAL STUDIES, SOUTH TEXAS OUTER CONTINENTAL SHELF, CHEMISTRY AND BIOLOGY

Submitted to:

Bureau of Land Management
Washington, D. C.

by

University of Texas Marine Science Institute
Port Aransas Marine Laboratory
Port Aransas, Texas 78373

Acting for and on behalf
of a consortium program
conducted by:

Rice University
Texas A&M University
The University of Texas

EXECUTIVE SUMMARY

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Compiled and Edited by

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FOREWORD

The chemical, physical and biological interactions both within and external to the world's oceans are among the most complex within the natural sciences. If, in fact, the aspects and processes of these various interactions were understood, their scope and magnitude could be predicted for a given time and place. There are, however, many unknowns that still must be quantified.

The information contained within this report is a summary of a multidisciplinary study conducted during 1976 on the South Texas Outer Continental Shelf (STOCS) to obtain a better definition of some of these processes within a marine ecosystem. It should be noted by the reader that since this material is presented in the form of an executive summary, there are a number of general statements made concerning the results of the 1976 research. For a more detailed account of the conclusions implicated, one is referred to the Final Report to the Bureau of Land Management edited by R. D. Groover (1977).

This report has been reviewed by the Bureau of Land Management and approved for publication. Approval does not signify the contents reflect the views and policies of the Bureau, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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CONCLUSIONS

Climatology and Hydrology

1. The lack of major tributary inputs to the South Texas Outer Continental Shelf (STOCS) between Port Aransas and the Rio Grande has a direct influence on the pattern of marine processes in the study area.

2. STOCS hydrology showed patterns consistent for a semi-tropical body of water. There was a seasonal variation from unstratified to stratified conditions over the shelf. With few exceptions, the stratification of the water column, which occurred in May, did not appear to be particularly strong.

3. Observed periodicities and variations in the hydrographic parameters were thought to be strongly influenced by the encroachment of offshore waters onto the shelf.

Water Column

1. Total particulate hydrocarbons appeared to show a trend of higher concentration at the shallowest stations sampled with highest values observed in March and July. The production and introduction of these materials inshore with subsequent movement offshore was suspected.

2. Low-Molecular-Weight hydrocarbons were sparse and those measured were felt to be derived chiefly from natural sources. Methane was high at the zone of peak temperature stratification (thermocline) and directly related to biological decomposition.

3. Dissolved oxygen, as well as several measures of nutrients during 1976, definitively illustrated the intrusion of deep western Gulf water onto the shelf.

4. Phytoplankton biomass was generally much higher at the shallow collection sites and also higher in the northern part of the study area. Two distinct seasons of species assemblages were apparent for the shallow stations. Less seasonality was evident at the deeper offshore sites. Occasional blooms by single species resulted in very low species diversity within the floral communities.

5. There was a general decrease in microzooplankton abundances offshore and in a southerly direction. This trend correlated well with phytoplankton biomass. The neuston showed a very patchy distribution.

6. Several species of the microzooplankton proved to be good indicators of water mass movements on the outer shelf defining ponds of offshore water moving over the shelf, upwelling in the spring, and estuarine-derived water masses. These species were felt to be valuable in defining small scale seasonal trends in physical oceanographic conditions.

7. Macrozooplankton densities followed the general trend of decreasing biomass in a seaward gradient. Copepods comprised the greatest majority of this group. Zooplankton densities appeared to be greatest when

salinities were lowest and temperatures were in the middle of their annual range.

8. Zooplankton were felt to be excellent indicators of petroleum pollution. Zooplankton samples generally showed more hydrocarbon contamination in 1976 than 1975 which may have been related to microscopic "tar balls" observed in the samples.

Sea Floor

1. Seasonal variations in sediment structure, when evident, were greatest at the shallower collection sites and directly related to greater water movement. Extreme patchiness observed in these sediments was felt to be affected by several factors ranging from small scale variation from mottles of sand and clay in otherwise uniform sediment to larger scale features related to biological disturbances.

2. Heavy metal content of the sediments was observed to follow the patchy pattern indicated for sediment texture. Variation in some of the metals, such as cadmium, were suspected to be related directly to biological activity.

3. The hydrocarbon patterns of the sediment indicated that there was very little petroleum related contribution and that much of what was measured was related to plankton, bacteria and infauna sources. The results suggested that the sediment was a final but active sink for marine hydrocarbons, contributing new hydrocarbons to the deposit.

4. Benthic zooplankton including foraminiferans appeared to be indicative of overlying water masses. The harpacticoid/nematode ratio was felt to be related to environmental perturbation.

5. The combination of sediment structure and depth related bottom-water variability was influential in structuring the benthic macroinfaunal communities of the STOCS.

6. Three distinct community separations were observed for the macroinfauna with increasing water depth. The biomass of these organisms decreased in an offshore gradient.

7. As with the infauna, invertebrate epifauna showed a very distinct separation of species assemblages with depth. Temporal and spatial patterns of abundance were generally due to recruitment of young age classes. Large variations in the epifauna were confined to species with shallow shelf or estuarine association. The young of species were observed inshore with adults found in greater abundances offshore.

8. The distribution of demersal fishes appeared to be related to depth, temperature and associated movements into and out of the estuaries. Seasonality, related directly to reproductive cycles, was also quite evident.

9. The variability of heavy metal content and of the species of the benthic organisms collected did not allow for an accurate measure of con-

tamination in these organisms.

10. The measured occurrences of hydrocarbons in benthic fauna, although low, were related to their trophic structure and diets. Phytane, one of the more prevalent petroleum-derived hydrocarbons found in the animal tissue, suggested possible low levels of localized petroleum pollution. The data were not sufficient however, to indicate wide-spread contamination with hydrocarbons.

11. The histopathological study of demersal fish demonstrated parasitism as the major cause of lesions observed.

12. Most of the organ samples obtained from fish that were exposed to crude oil did not show lesions which could be attributed to the oil. Gill epithelium and liver, and possibly the subcutaneous areas did show a response to the oil. It was felt that the level of exposure and concentration were both too low to produce adverse effects.

Rig Monitoring

1. Obvious foreign material was seen in sediments taken from the drill site.

2. Zinc, barium, and cadmium levels in the sediment increased markedly at the drill site. Lead levels in the sediment increased two-fold probably as a result of the drilling activity via the fuel used by the rig and supply vessels.

3. Petroleum contamination was measured in one of the three sediment samples collected at the drill site.

4. Macroinfauna populations were definitely diminished at the drill site.

5. Montmorillonite was detected in the suspended sediment samples. This was thought to be a result of the drilling activity since spring waters in the area are usually devoid of montmorillonite and one of the drilling muds used (bentonite) contained montmorillonite.

6. No obvious impacts were noted more than 100 m from the drill site.

INTRODUCTION

The Gulf of Mexico, South Texas Outer Continental Shelf (STOCS) serves as a prime marine area for two important natural resources, commercial-recreational fisheries and gas and oil. Inferences are often made implicating the incompatability of these two activities. Before it is possible to understand the effect of the latter on the former, however, one must be able to characterize the natural spatial and temporal variability of the ecosystem that supports the fisheries.

The Texas coastal area is biologically and chemically a two-part marine system, the coastal estuaries and the broad continental shelf. These two components of the marine system are separated by barrier islands and connected by inlets or passes. The area is rich in finfish and crustaceans, many of which are commercially and recreationally important. Many of the finfish and decapod crustaceans of the STOCS area exhibit a marine-estuarine dependent life cycle, *i.e.* spawning offshore, migrating shoreward as larvae and postlarvae, and utilizing the estuaries as nursery grounds (Galtsoff, 1954; Gunter, 1945). The broad continental shelf supports a valuable shrimp fishery which contributes significantly to the local economy. An excellent overview of the zoogeography of the northwestern Gulf of Mexico is provided by Hedgepeth (1953).

In 1974, the Bureau of Land Management (BLM), as the administrative agency responsible for leasing of submerged federal lands, was authorized to initiate a National Outer Continental Shelf Environmental Studies Program. The broad objectives of this program were:

a) to provide information about the OCS environment to enable the Department of the Interior to make management decisions regarding OCS oil and gas development; and

(b) to fill environmental information needs of management, regulatory and advisory agencies, both Federal and State, for a broad range of OCS activities, including the preparation and review of environmental impact statements under the National Environmental Policy Act (NEPA) of 1969, issuance of regulations and permits, and implementation of certain other laws, such as the OCS Lands Act, Fish and Wildlife Coordination Act, the Coastal Zone Management Act, and counterpart state laws.

As part ot this national program to meet the above two objectives, the BLM developed the Marine Environmental Study Plan for the STOCS. This plan was developed to meet the following four specific study objectives for the STOCS:

(a) provide information for predicting the effects of OCS oil and gas development activities upon the components of the ecosystem;

(b) provide a description of the physical, chemical, geological and biological components, and their interactions, against which subsequent changes or impacts could be compared;

(c) identify critical parameters that should be incorporated into a monitoring program; and,

(d) identify and conduct experimental and other special studies as required to meet the basic objectives.

BLM contracted the University of Texas to act for and on behalf of a consortium program of research conducted by Rice University, Texas A&M University and the University of Texas to implement the Environmental Study Plan. The University of Texas Marine Science Institute, Port Aransas Laboratory (UTMSI/PAML), provided overall project management, logistics, ship time, data management and certain scientific efforts. Additional scientific effort was provided by subcontracts between the University of

Texas and the above listed institutions. This plan called for an intensive multidisciplinary three-year period of study to characterize the physical, geological, chemical and biological temporal and spatial variation of the outer shelf marine ecosystem.

The central theme of the biological and chemical studies was to provide an understanding of the living resources of the outer shelf so that the impact of drilling for and production of petroleum could be assessed and controlled. In order to approach the outlined objectives a broad program was designed which included:

(a) water mass characterization;

(b) pelagic primary and secondary productivity as described by floral and faunal abundances, standing crop, and nutrient levels;

(c) benthic productivity as described by infaunal and epifaunal densities;

(d) natural petroleum hydrocarbon levels in biota, water and sediment; and,

(e) natural trace metal levels in biota and particulate matter.

This program of study was initiated on the STOCS in 1975. The general study area corresponded to an area outlined by the Department of the Interior for oil and gas leasing. The area covered approximately 19,250 km^2 and was bounded by 96°W longitude on the east, the Texas coastline on the west, and the Mexico-United States international border on the south (Figure 1). The continental shelf off Texas has an average width of approximately 88.5 km and a relatively gentle seaward gradient that averages 2.3 in/km.

The first year of study (1975) concentrated on three seasonal sampling efforts at 12 collection sites on four transects on the STOCS (Figure 2).

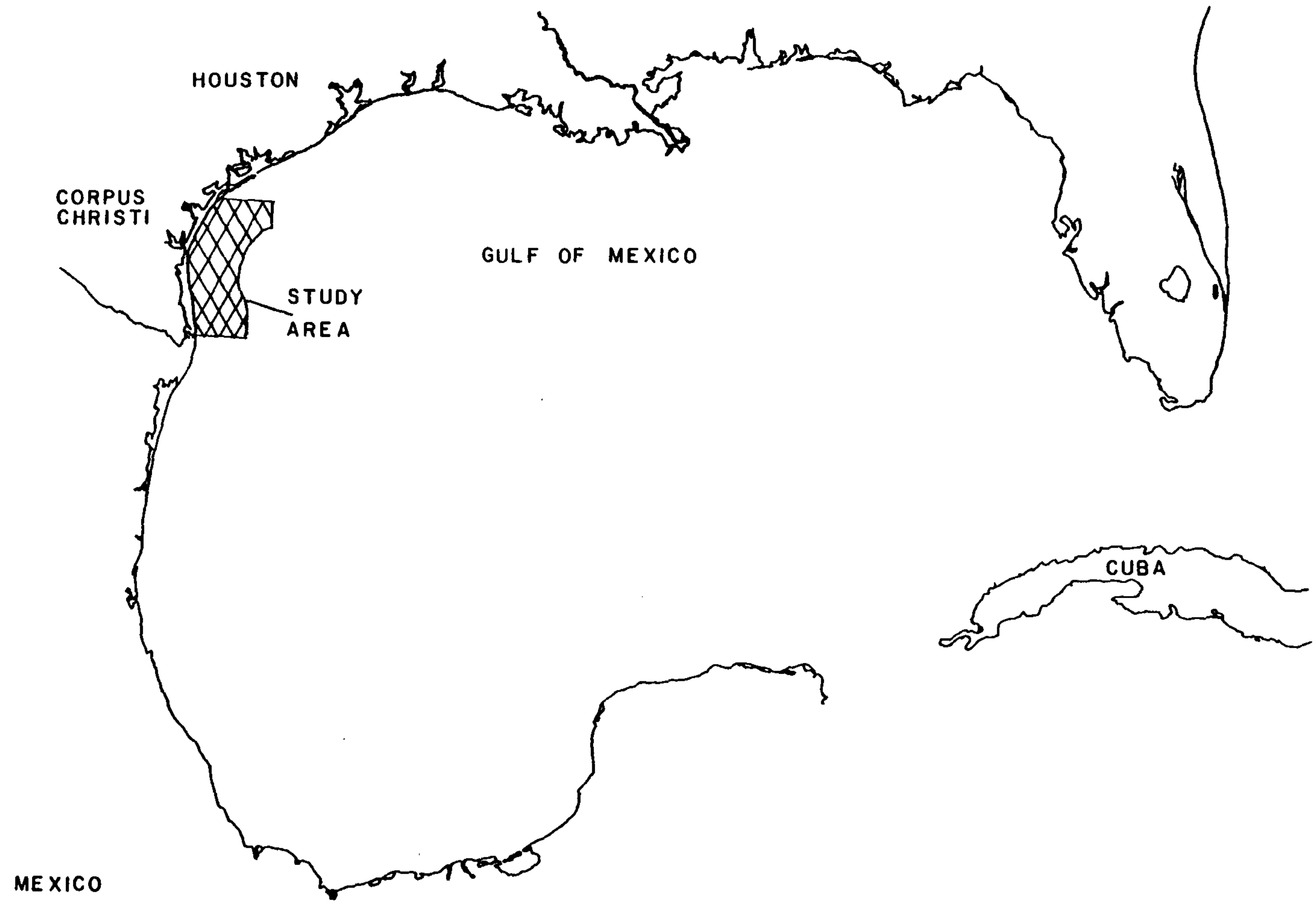


Figure 1. Location of the study area in relation to the Gulf of Mexico.

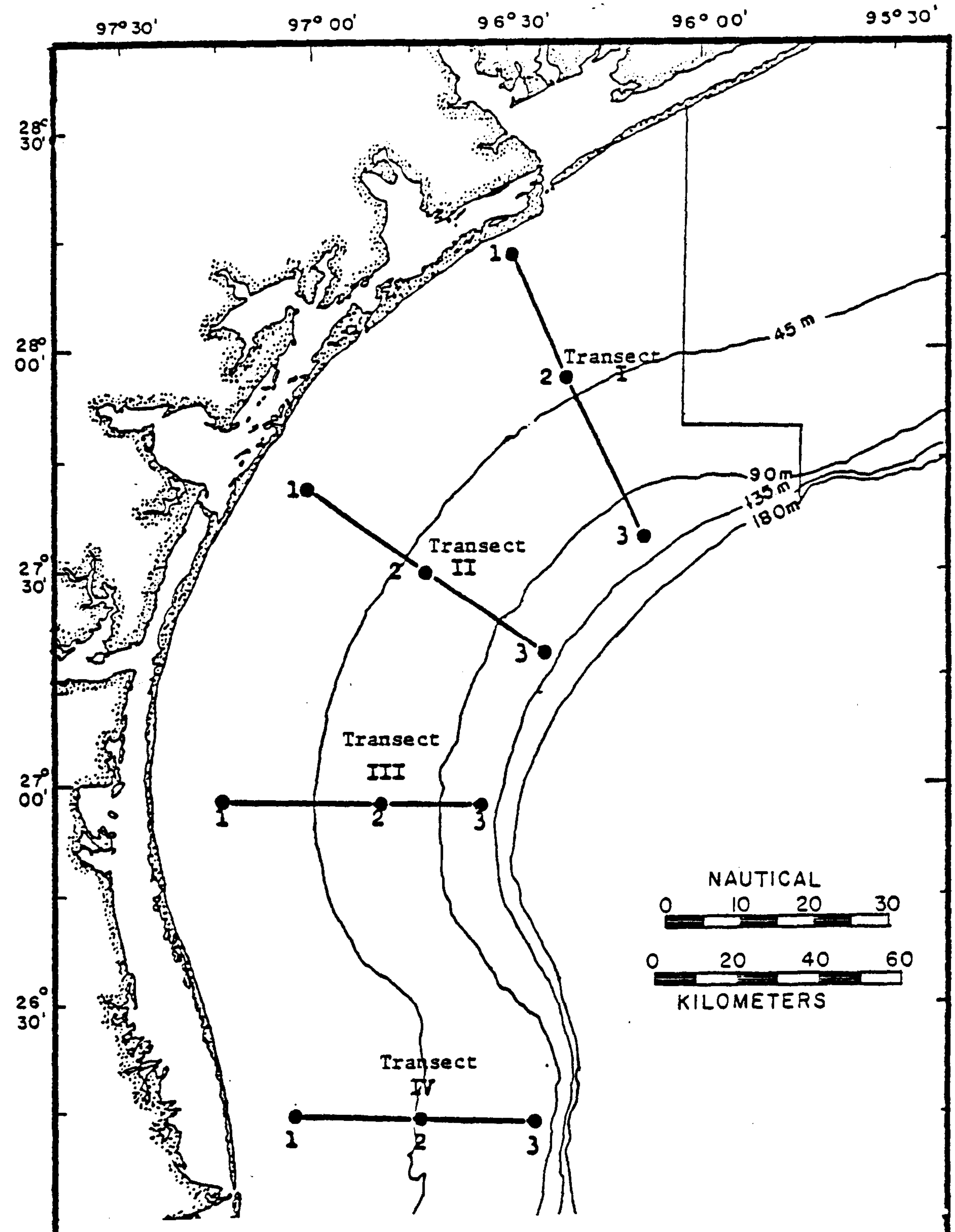


Figure 2. Station Locations for the 1975 South Texas Outer Continental Shelf Study. Depth in Meters.

The information on the components outlined above suggested that a more intensified investigation should be conducted for a second year of research (1976). Therefore, at the initiation of field sampling in mid-January 1976, 13 additional transect stations were sampled besides the 12 studied in 1975 (Figure 3). This increased sampling effort was conducted to cover three areas of the STOCS not previously studied:

(a) the near-shore environment (about 15 m depth);

(b) a zone in the middle of the study area that appeared anomalous in its sediment characteristics, sediment trace metal content and distributions of certain biological populations; and,

(c) a zone of active gas seepage near the shelf-slope break.

Also, four stations on each of two submarine carbonate reefs, Hospital Rock and Southern Bank, were sampled. A total of 33 stations were sampled during 1976 (Figure 3). Table 1 gives the LORAN and LORAC coordinates, latitude and longitude and depths of the sample stations.

In addition to the three seasonal cruises (Winter, Jan-Feb.; Spring, May-June; and Fall, Sept-Oct), Transect II was sampled during the remaining six months of the year to obtain a better characterization of the temporal variability of the various study components. For each collection period the sampling effort was broken up into three types of cruises: water column, benthic and histopathology. A complete list of cruises by date and type is presented in Table 2 while Table 3 gives a breakdown of the different scientific elements by cruise type and sampling frequency.

In addition to continuing the study of spatial and temporal variability of the different shelf ecosystem components, a second objective of the 1976 study year was to begin assessing the impact of petroleum exploration and development. To meet this objective a study was initiated in September 1976 consisting of before, during and after drilling surveys, to examine

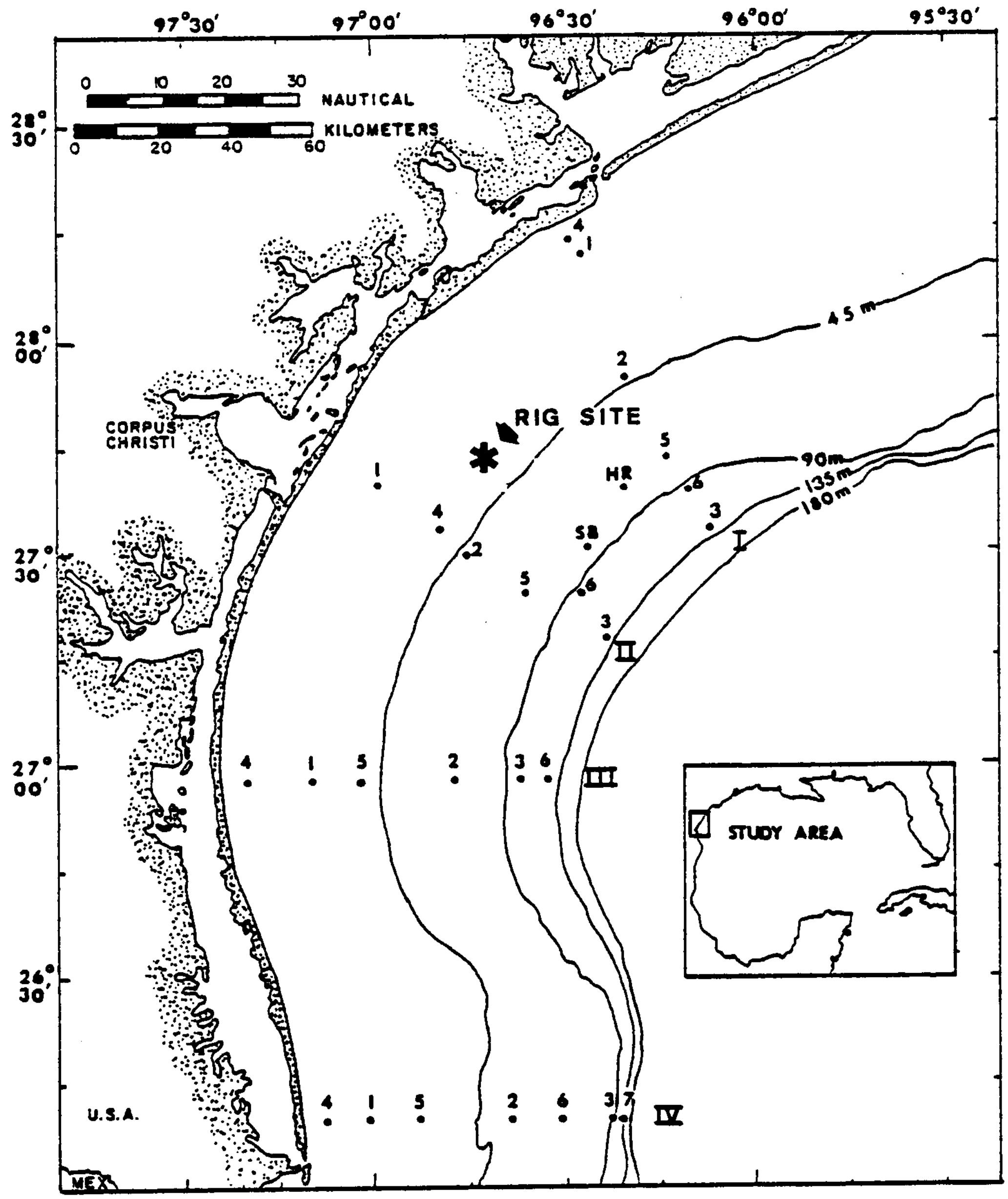


Figure 3. Station Locations for the 1976 South Texas Outer Continental Shelf Study. Depths in Meters.

TABLE 1

BLM STOCS/MONITORING STUDY 1976-STATION LOCATIONS

TRAN.	STA.	LORAN 3H3	LORAN 3H2	LORAC LG	LORAC LR	LATITUDE	LONGITUDE	DEPTH METERS	DEPTH FEET
I	1	2575	4003	1180.07	171.46	28°12'N	96°27'W	18	59
	2	2440	3950	961.49	275.71	27°55'N	96°20'W	42	138
	3	2300	3863	799.45	466.07	27°34'N	96°07'W	134	439
	4	2583	4015	1206.53	157.92	28°14'N	96°29'W	10	33
	5	2360	3910	861.09	369.08	27°44'N	96°14'W	82	269
	6	2330	3892	819.72	412.96	27°39'N	96°12'W	100	328
II	1	2078	3962	373.62	192.04	27°40'N	96°59'W	22	72
	2	2050	3918	454.46	382.00	27°30'N	96°45'W	49	161
	3	2040	3850	564.67	585.52	27°18'N	96°23'W	131	430
	4	2058	3936	431.26	310.30	27°34'N	96°50'W	36	112
	5	2032	3992	498.85	487.62	27°24'N	96°36'W	78	256
	6	2068	3878	560.54	506.34	27°24'N	96°29'W	98	322
	7	2045	3835			27°15'N	96°18.5'W	182	600
III	1	1585	3880	139.13	909.98	26°58'N	97°11'W	25	82
	2	1683	3841	286.38	855.91	26°58'N	96°48'W	65	213
	3	1775	3812	391.06	829.02	26°58'N	96°33'W	106	348
	4	1552	3885	95.64	928.13	26°58'N	97°20'W	15	49
	5	1623	3867	192.19	888.06	26°58'N	97°02'W	40	131
	6	1790	3808	411.48	824.57	26°58'N	96°30'W	125	410
IV	1	1130	3747	187.50	1423.50	26°10'N	97°01'W	27	88
	2	1300	3700	271.99	1310.61	26°10'N	96°39'W	47	154
	3	1425	3663	333.77	1241.34	26°10'N	96°24'W	91	298
	4	1073	3763	163.42	1456.90	26°10'N	97°08'W	15	49
	5	1170	3738	213.13	1387.45	26°10'N	96°54'W	37	121
	6	1355	3685	304.76	1272.48	26°10'N	96°31'W	65	213
	7	1448	3659	350.37	1224.51	26°10'N	96°20'W	130	426
HR	1	2159	3900	635.06	422.83	27°32'05"	96°28'19"	75	246
	2	2169	3902	644.54	416.95	27°32'46"	96°27'25"	72	237
	3	2163	3900	641.60	425.10	27°32'05"	96°27'35"	81	266
	4	2165	3905	638.40	411.18	27°33'02"	96°29'03"	76	250
SB	1	2086	3889	563.00	468.28	27°26'49"	96°31'18"	81	266
	2	2081	3889	560.95	475.80	27°26'14"	96°31'02"	82	269
	3	2074	3890	552.92	475.15	27°26'06"	96°31'47"	82	269
	4	2078	3890	551.12	472.73	27°26'14"	96°32'07"	82	269

TABLE 2

SCHEDULE OF 1976 CRUISES

Cruise No.	Date	Season	Type	Transect
16	1/13-16	W	Water Column	IV
17	1/30-2/4	W	Water Column	I - IV
18	2/8-10	W	Benthos	II
19	2/12-17	W	Benthos	I & II
20	2/19-23	W	Benthos	III & IV
21	2/26-29	W	Benthos	III & IV
22	3/9-12	W	Benthos	I, II & III
23	3/18-20	Mar.	Water Column	II
24	3/25-28	Mar.	Benthos	II
25	4/2-4	Apr.	Water Column	II
26	4/8-11	Apr.	Benthos	II
27	5/29-6/8	S	Water Column	I - IV
28	6/10-15	S	Benthos	I & II
29	6/18-22	S	Benthos	III & IV
30	6/24-29	S	Benthos	I - IV
31	7/10-12	July	Water Column	II
32	7/16-19	July	Benthos	II
33	7/22-23	July	Histopathology	II
34	8/4-7	Aug.	Benthos	II
35	8/9-11	Aug.	Water Column	II
36	8/12-13	Aug.	Histopathology	II
37	8/27-29	Aug.	Make-up	II
38	9/10-16	F	Water Column	I - IV
39	9/19-23	F	Benthos	III & IV
40	9/25-27	F	Pre-Drill Rig Monitoring	
41	10/1-2	Oct.	Histopathology	II
42	10/6-11	F	Benthos	I, II & Banks
43	11/2	Nov.	Water Column	II
44	11/5-6	Nov.	Histopathology	II
45	11/8-10	Nov.	Water Column	II
46	11/15-18	Nov.	Benthos	II
47	12/1-3	Dec.	Water Column	II
48	12/3-4	Dec.	Histopathology	II
49	12/8-10	Dec.	Benthos	II

TABLE 3

SAMPLING FREQUENCY AND STATIONS DURING THE 1976 STOCS STUDY

Monthly and Seasonally

Water Column Sampling	Stations
Meteorology	All Transects and Bank Stations
Hydrography	All Transects and Bank Stations
High-Molecular-Weight Hydrocarbons in Zooplankton and Water	Stations 1-3, All Transects
Low-Molecular-Weight Hydrocarbons, Nutrients, and Dissolved Oxygen	Stations 1-3, All Transects and Bank Stations
Phytoplankton and Phytoplankton Biomass	Stations 1-3, All Transects
Zooplankton	Stations 1-3, All Transects
Shelled Microplankton and General Microplankton	Stations 1-3, All Transects and Bank Stations
Benthic Sampling	
Macroinfauna	All Transects and Bank Stations
Meiofauna	All Transects and Bank Stations
Shelled Microzoobenthon	All Transects and Bank Stations
Sediment Textural Analysis	All Transects and Bank Stations
Macroepifauna (Day & Night)	All Transect Stations
Demersal Fishes (Day & Night)	All Transect Stations
Neuston (Day & Night)	All Transect Stations
High-Molecular-Weight Hydrocarbons in Macronekton	Stations 1-3, All Transects
Trace Metals in Macronekton	Stations 1-3, All Transects
Histopathology*	
Histopathology of Macroepifauna	Stations 1-3, Transect II
Histopathology of Demersal Fishes	Stations 1-3, Transect II
Histopathology: Gonadal Tissues of Macroepifauna and Demersal Fishes	Stations 1-3, Transect II

SEASONALLY ONLY

Water Column Sampling	
Trace Metals in Zooplankton	Stations 1-3, All Transects
Benthic Sampling	
High-Molecular-Weight Hydrocarbons in Sediment	Stations 1-3, All Transects
High-Molecular-Weight Hydrocarbons in Macroepifauna and Demersal Fishes	Stations 1-3, All Transects
Trace Metals in Macroepifauna and Demersal Fishes	Stations 1-3, All Transects

*Program not initiated until July 1976

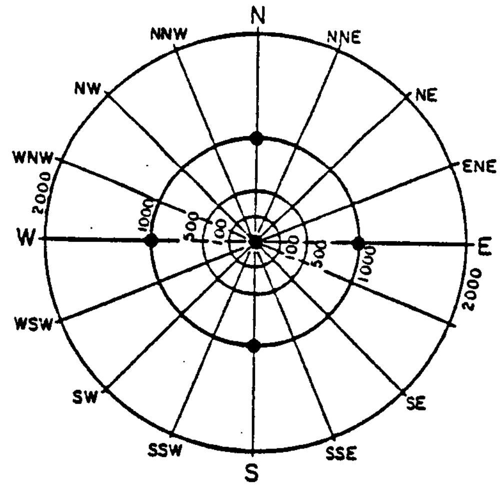
the geological, physical, chemical and biological components of an area in the vicinity of a typical exploratory drilling rig. The purpose of this study was to determine any spatial and temporal impacts on the immediate environment resulting from exploratory drilling activities.

The exploratory rig monitoring site was located between Transects I and II, 20 miles East - 10° South of Port Aransas, Texas in close proximity to the main Port Aransas shipping lane (Figure 3). The water depth at the site was approximately 33 m. The location of sampling stations and the specific components studied for pre-, during and post-drilling investigations are presented in Figures 4, 5 and 6.

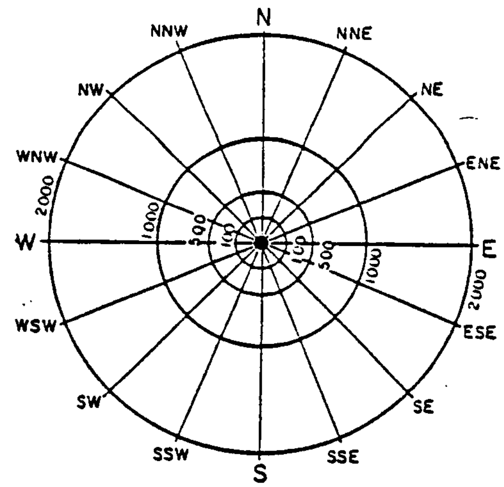
Several drilling muds and additives were used in the drilling process. These included bentonite (montmorillonite), barite (barium sulfate), lignosulfonate, caustic-sodium hydroxide, soda ash, aluminum stearate, sodium acid pyrophosphate, diatomaceous earth, walnut hulls, and ground-up polyethylene sheeting. These muds and additives were washed from the cuttings with fresh water and reused. The cuttings were then washed overboard with salt water. At the end of drilling operations approximately 500 barrels of drilling mud were dumped. The discharge from the drilling rig was approximately 50 ft above the sea surface.

The pre-drilling survey was accomplished September 25, 26 and 27, 1976. The rig was positioned December 1, 1976. Drilling began December 3, 1976 and continued to January 15, 1977. The during-drilling survey was conducted January 7-14, 1977. Post-drilling sampling was accomplished February 28, March 1 and 2, 1977.

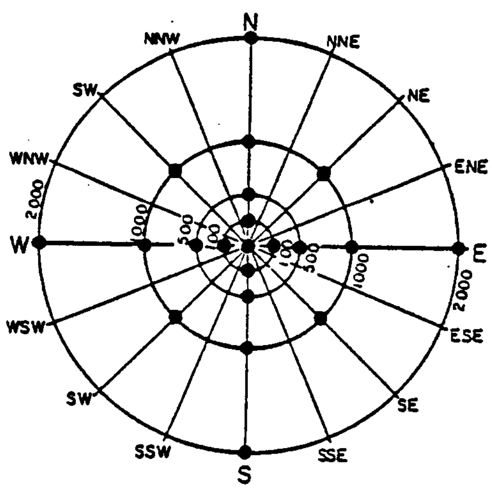
Sampling stations were established at the intersections of transects emanating from the drill site and concentric circles 100, 500, 1000 and 2000 m from the drill site (Figure 4). Two additional stations, 100 m from the rig in the sediment plume and 100 m from the rig opposite the



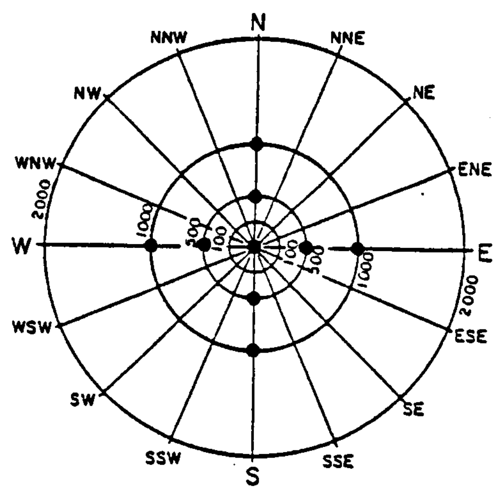
STD, Transmissometry, Sediment Trace Metal and Hydrocarbons, Sediment-Deposition and Low-Molecular-Weight Hydrocarbons



Particulate Trace Metals, Suspended Sediment Mineralogy, Macro-epifauna and Demersal Fishes Taxonomy, Hydrocarbon & Trace Metal

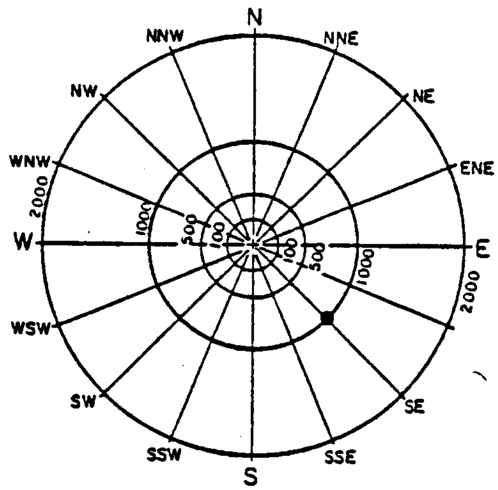


Macroinfauna, Sediment Texture

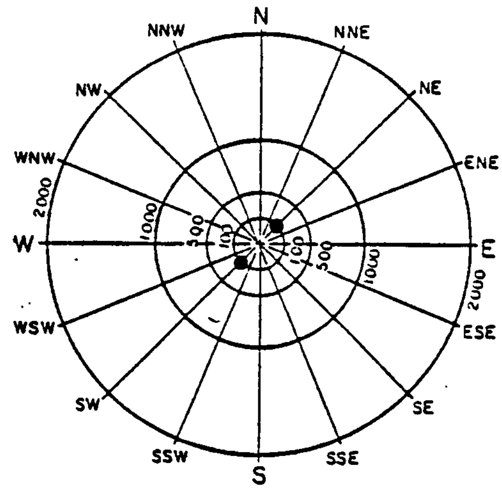


Meiofauna

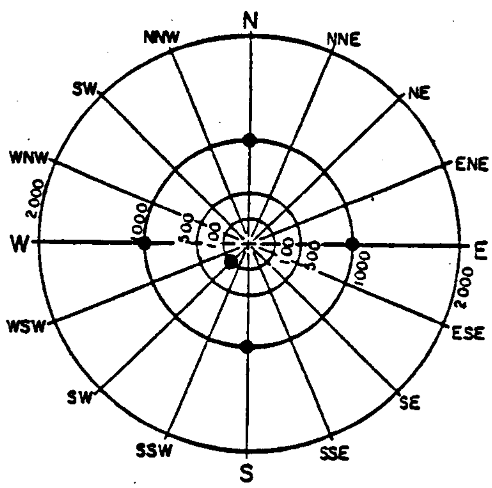
Figure 4. Pre-Drill Sampling Locations by Study Element.



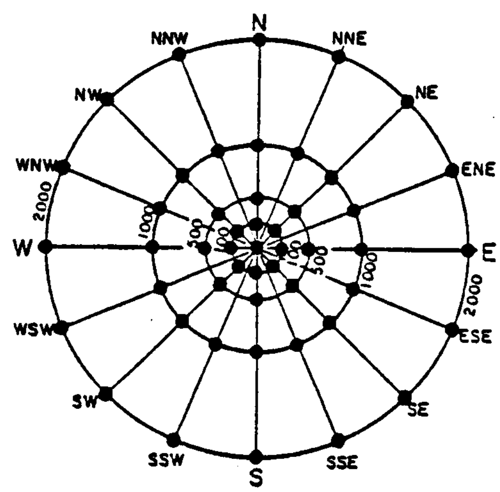
Currents



Suspended Sediment Mineralogy & Particulate-Trace Metals (In and Out of Sediment Plume)

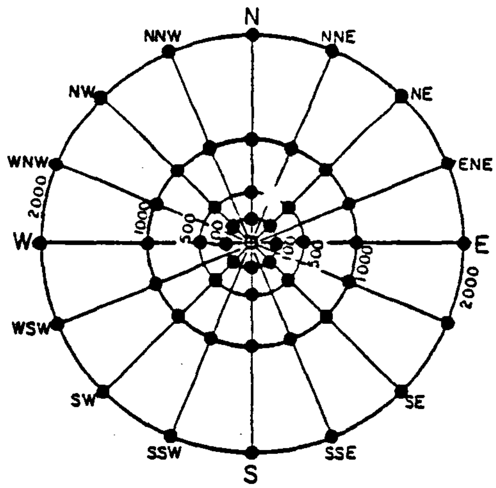


STD & Transmissometry

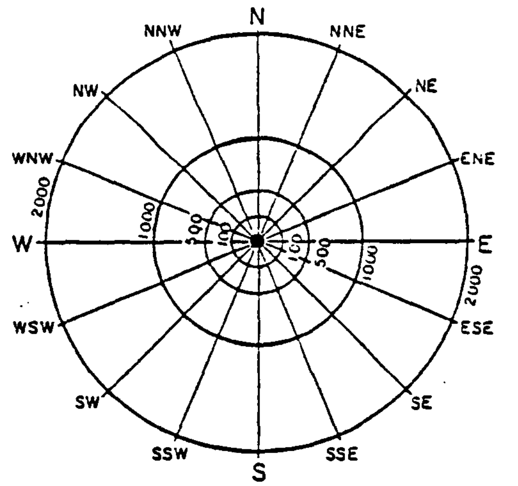


Low-Molecular-Weight Hydrocarbons

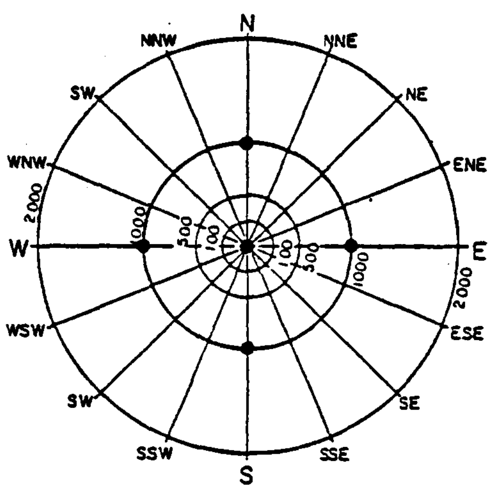
Figure 5. During-Drill Sampling Locations by Study Element.



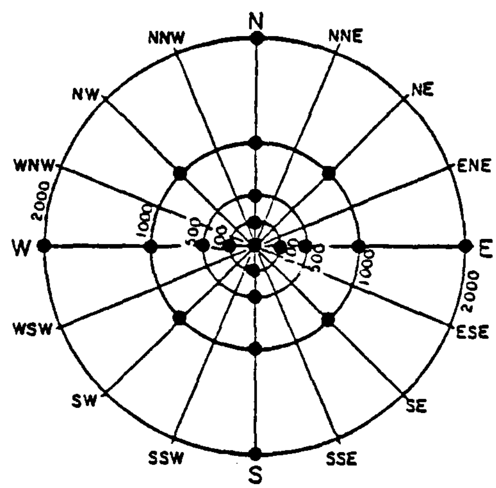
Low-Molecular-Weight Hydrocarbons



Particulate Trace Metals and Suspended Sediment Mineralogy

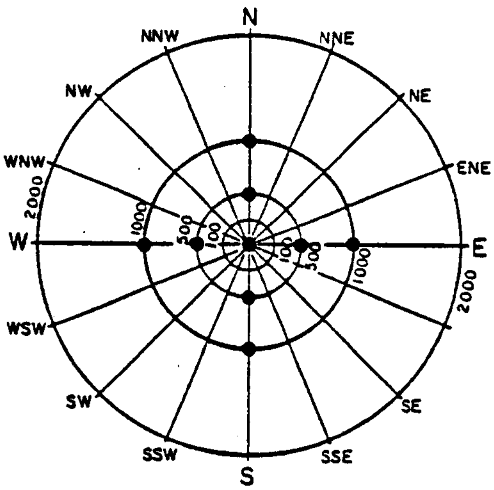


STD, Transmissometry and Sediment Hydrocarbon and Trace Metals

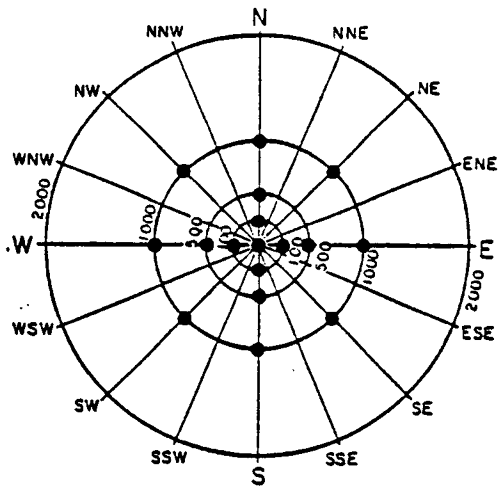


Macroinfauna and Sediment Texture

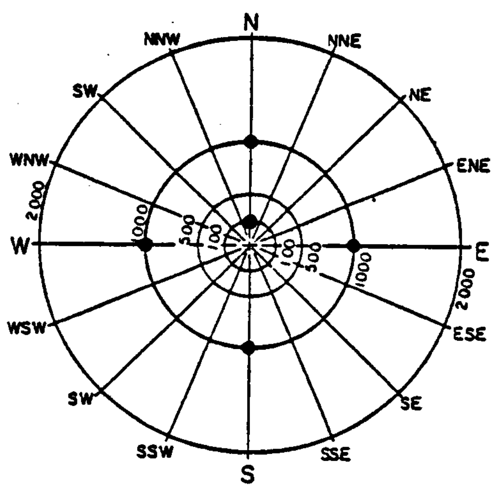
Figure 6. Post-Drill Sampling Locations by Study Element.



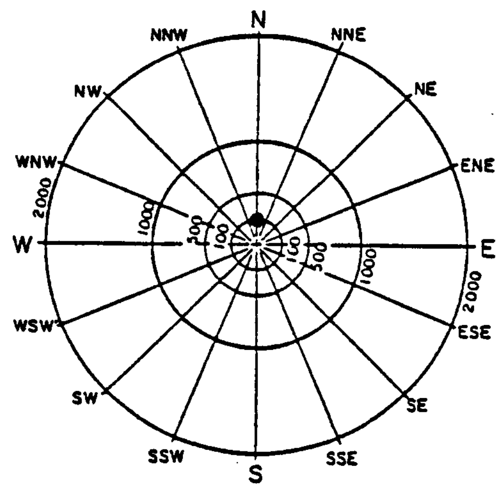
Meiofauna



Sediment Deposition



Macroepifauna and Demersal Fishes Taxonomy



Macroepifauna and Demersal Fishes Hydrocarbon & Trace Metal

Figure 6. Cont.'d

sediment plume, were added for the during-drilling survey. Navigation for all station location was by the LORAC navigational system.

A total of 22 principal investigators participated in the OCS characterization studies. Table 4 lists the principal investigators by institutions represented and scientific responsibility. Ship time was also provided for the NOAA/NMFS ichthyoplankton sampling. Supportive work was performed by the USGS (sediment texture and sediment trace metals) and the Topographic Features (sediment texture and transmissometry) components.

A total of 17 principal investigators participated in the rig monitoring study. These consisted of several scientists from the general characterization study as well as scientists from the United States Geological Survey's Corpus Christi, Texas Office of Marine Geology. Table 5 lists these P.I.'s by institution represented and scientific responsibility.

All sampling and measurements, except the placement and recovery of current meters, were taken aboard the University of Texas research vessel, the R/V LONGHORN. The R/V LONGHORN, designed and constructed as a coastal research vessel in 1971, is a steel-hulled 24.38 (80 ft.) by 7.42 m (24 ft.), 2.13 m (7 ft.) draft ship. She carries a crew of five and can accomodate a scientific party of ten. The R/V LONGHORN is equipped with a stern-mounted crane, a trawling winch, scan sonar, radar, LORAN-A and LORAC navigational systems, and dry and wet laboratory space.

The data derived from the 1976 study of the STOCS area are large and extensive. For convenience in presenting the extensive information, the remaining sections of this summary have been broken into climatology and hydrology, water column, sea floor and rig monitoring sections.

TABLE 4

STOCS BIOLOGICAL AND CHEMICAL COMPONENT PARTICIPANTS BY WORK ELEMENT AND INSTITUTION

Work Element	Participants
University of Texas Marine Science Institute-Port Aransas Marine Laboratory	
Hydrography	Ned P. Smith
High-Molecular-Weight Hydrocarbons in Zooplankton, Sediment and Water	Patrick L. Parker, Richard S. Scalan, J. Kenneth Winters
Phytoplankton and Phytoplankton Biomass	Chase Van Baalen, Daniel L. Kamykowski, Warren M. Pulich
Sediment Texture	E. William Behrens
Macroinfauna and Macroepifauna	J. Selmon Holland
Demersal Fishes	Donald E. Wohlschlag
Texas A & M University	
High-Molecular-Weight Hydrocarbons in Macroepifauna, Demersal Fishes and Macronekton	C. S. Giam, H. S. Chan
Trace Metals in Macroepifauna, Demersal Fishes, Macronekton and Plankton	Bobby Joe Presley, Paul N. Boothe
Low-Molecular-Weight Hydrocarbons, Nutrients and Dissolved Oxygen	William M. Sackett, James M. Brooks
Zooplankton	E. Taisoo Park
Neuston	John H. Wormuth, Linda H. Pequegnat
Meiofauna	Willis E. Pequegnat
Histopathology of Macroepifauna	Jerry M. Neff
Histopathology of Demersal Fishes	William E. Haensly
University of Texas at San Antonio	
Histopathology: Gonadal Tissues of Macroepifauna and Demersal Fishes	Samual A. Ramirez
Rice University	
Shelled Microplankton, General Microplankton and Shelled Microzoobenthos	Richard E. Casey

TABLE 5

RIG MONITORING STOCS BIOLOGICAL AND CHEMICAL COMPONENT PARTICIPANTS BY WORK ELEMENT AND INSTITUTION

University of Texas Marine Science Institute-Port Aransas Marine Laboratory

Work Element	Participants
Hydrography and Currents	Ned P. Smith
High-Molecular-Weight Hydrocarbons in Sediment	Patrick L. Parker, Richard S. Scalan, J. K. Winters
Sediment Texture and Deposition	E. William Behrens
Macroinfauna and Macroepifauna	J. Selmon Holland
Demersal Fishes	Donald E. Wohlschlag

Texas A&M University

Work Element	Participants
High-Molecular-Weight Hydrocarbons in Macroepifauna and Demersal Fishes	C. S. Giam, H. S. Chan
Trace Metals in Macroepifauna and Demersal Fishes	B. J. Presley, Paul N. Boothe
Low-Molecular-Weight Hydrocarbons	William M. Sackett, James M. Brooks
Meiofauna	Willis E. Pequegnat
Transmissometry	Richard Rezak

U. S. Geological Survey, Corpus Christi, Texas, Office

Work Element	Participants
Particulate-Trace Metals	Chuck Holmes
Suspended Sediment Mineralogy	Chuck Holmes
Trace Metals in Sediment	Chuck Holmes
Sediment Texture (Chemical Samples)	Gerald L. Shideler

CLIMATOLOGY AND HYDROLOGY

The climate of south Texas is subtropical and is characterized by short, mild winters and hot summers. Significant variations in this trend do occur from north to south along the coastline. The climate becomes progressively drier southward and most of the south Texas coastal area is classed as semi-arid. Compared to an average of 106.2 cm of rainfall at Galveston, Corpus Christi recieves an average of 71.9 cm and Brownsville 67.9 cm annually.

The general circulation of air near the surface over the south Texas coastal region follows the sweep of the western extension of the Bermuda high pressure system throughout the year. The Bermuda pressure system becomes dominant during the spring months, as the influence of northern anticyclones causing northerly fronts disappears. Mean barometric pressure falls as the operational trough migrates northward, allowing prevailing southwesterly winds to dominate, and the low pressure system over Mexico deepens. The minimum mean pressure of 1014 millibars (mb) occurs in summer.

Beginning in September, the equatorial trough migrates southward, the Mexican low pressure system fills, and the Bermuda high pressure system decreases in strength. Accompanying this trend, continental high pressure systems to the north intensify as winter approaches. As barriers weaken to the south, the high pressure systems moving from the north reach the lower latitudes and produce maximum mean pressures of 1020 mb in winter. The high pressure systems and their associated extratropical cyclones are responsible for the wide pressure ranges, observed in the winter.

Air temperature extremes for the south Texas area are temporal significantly by the combined effects of prevailing southeasterly winds and the large area of the Gulf waters. Low temperatures occur when strong northerly winds associated with cold fronts penetrate the area. Freezing temperatures normally occur in near-coast areas at least once each winter. The highest summer temperatures occur when there is a shift of wind direction from the prevailing southeasterlies to south and southwest.

As mentioned previously, the south Texas area is semi-arid. Peak precipitation months are May and September. Tropical cyclones may add large amounts to the monthly rainfall totals for the period of June to October and may cause normally higher saline bays to freshen drastically in a period of a few hours. The winter months have the least rainfall. Winter precipitation comes mainly from frontal activity and low stratus clouds. Because of the semi-arid conditions not only along the coast but landward for more than a hundred miles, no major stream flows to the Gulf of Mexico along the south Texas coast between Port Aransas and the Rio Grande, 135 miles to the south. This factor has a direct influence on the pattern of marine processes on the south Texas OCS.

Compared to the adjacent land area, offshore winter temperatures are higher and average wind velocities are greater. Offshore summer conditions are more similar to the onshore climate, but with some diurnal differences: the daily temperature range is smaller and the afternoon wind speed maximum is less pronounced offshore than at stations along the coast.

The offshore area, unlike the coastal area, does not exhibit a season of extensive rainfall. Rain is most frequent in December and January with a secondary maximum in August and September. Based on rain frequency, the driest season in the offshore area is March-June with an average of less than three percent of ship's weather observations reporting rain.

The physical oceanographic and hydrographic characteristics for the STOCS, as indicated by the data collected for 1976, were similar to other semi-tropical bodies of water.

dients in annual temperature ranges were directed generally downwards and in an offshore direction. Minimum temperature and salinity variations occurred at near bottom levels over the outer shelf. The greater temperature and salinity variability over the inner shelf reflected the more rapid responses to heating and cooling processes characteristic of a shorter water column, and the closer proximity of the inner shelf to freshwater run-off through estuaries.

The seasonal transition from stratified to unstratified conditions over the shelf is illustrated in Figure 7. The pattern that characterized the 1976 STOCS conditions was composed of two parts. An upper envelope, defined by the 25°C isopleth, represented the portion of the water column which became stratified as densities decreased from seasonal heating and/or freshwater runoff. This occurred in approximately the upper 75 m of water in 1976. The influence of spring runoff was clearly seen in the upper 80 m in May and early June. There was some indication of a slight convergence of the temperature isopleths during the summer months but with a few exceptions the stratification of Texas shelf waters did not appear to be particularly strong. The data suggested that the mid-summer density stratifications were strongly influenced by shorter-period, cross-shelf motion that also produced the observed large vertical migration of isothermal surfaces in 1976.

The data for salinity and temperature did indicate a dominant annual periodicity in the waters of the inner shelf. These observed periodicities and variations in the hydrographic variables were thought to be strongly influenced by the encroachment of offshore waters onto the shelf. If so, the effect that these motions have on the cross-shelf transport of suspended materials and planktonic forms of life makes this aspect of physical oceanography studies of prime importance for further study.

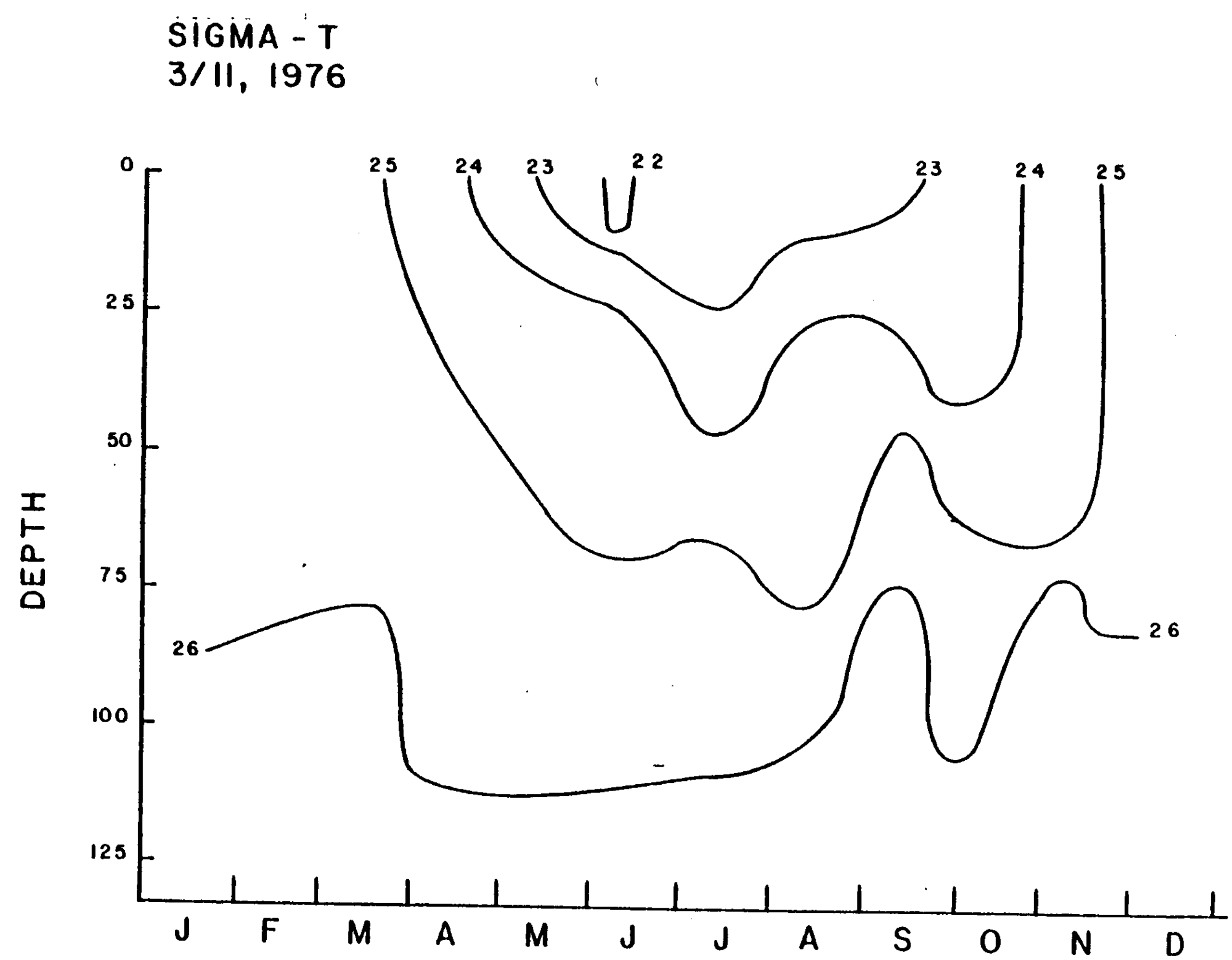

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Figure 7.

WATER COLUMN

The level of total dissolved and particulate organic matter generally found in the Gulf of Mexico aquatic ecosystem is in the range of 0.1 to 10 μg/ℓ. Less accurate hydrocarbon concentrations have been obtained in these same waters. Recent data collected from other systems (*i.e.*, McAullife, 1976; Koons, 1977) have indicated that generally the highest concentrations of hydrocarbons are located in the surface microlayer of the water column and that these concentrations decrease rapidly with the first 10 m of water depth.

Total particulate hydrocarbon data collected during 1976 appeared to show a trend of higher concentrations at the shallower stations of each transect with little spatial difference between stations on the outer shelf (Figure 8). The one exception to this pattern was observed for the winter data and may have been related to biological activity during this period of the year.

Monthly collections along Transect II indicated that highest values of particulate hydrocarbons were observed in March and July. In contrast, the lowest values were reported in the spring and December.

An interesting pattern of relatively constant concentrations of higher molecular weight hydrocarbons (C_{28}-C_{30}) was observed during 1976. Such a distribution could be explained by the production and introduction of these materials inshore with subsequent movement offshore. Preferential retention of heavy hydrocarbons during weathering would explain their more uniform concentration.

During the 1976 collection periods polycyclic aromatic compounds in the benzene eluates were observed for the first time. A petroleum origin for these aromatics was implicated. The concentrations of polycyclics appeared to be highest at the shallower sites and lower farther offshore.

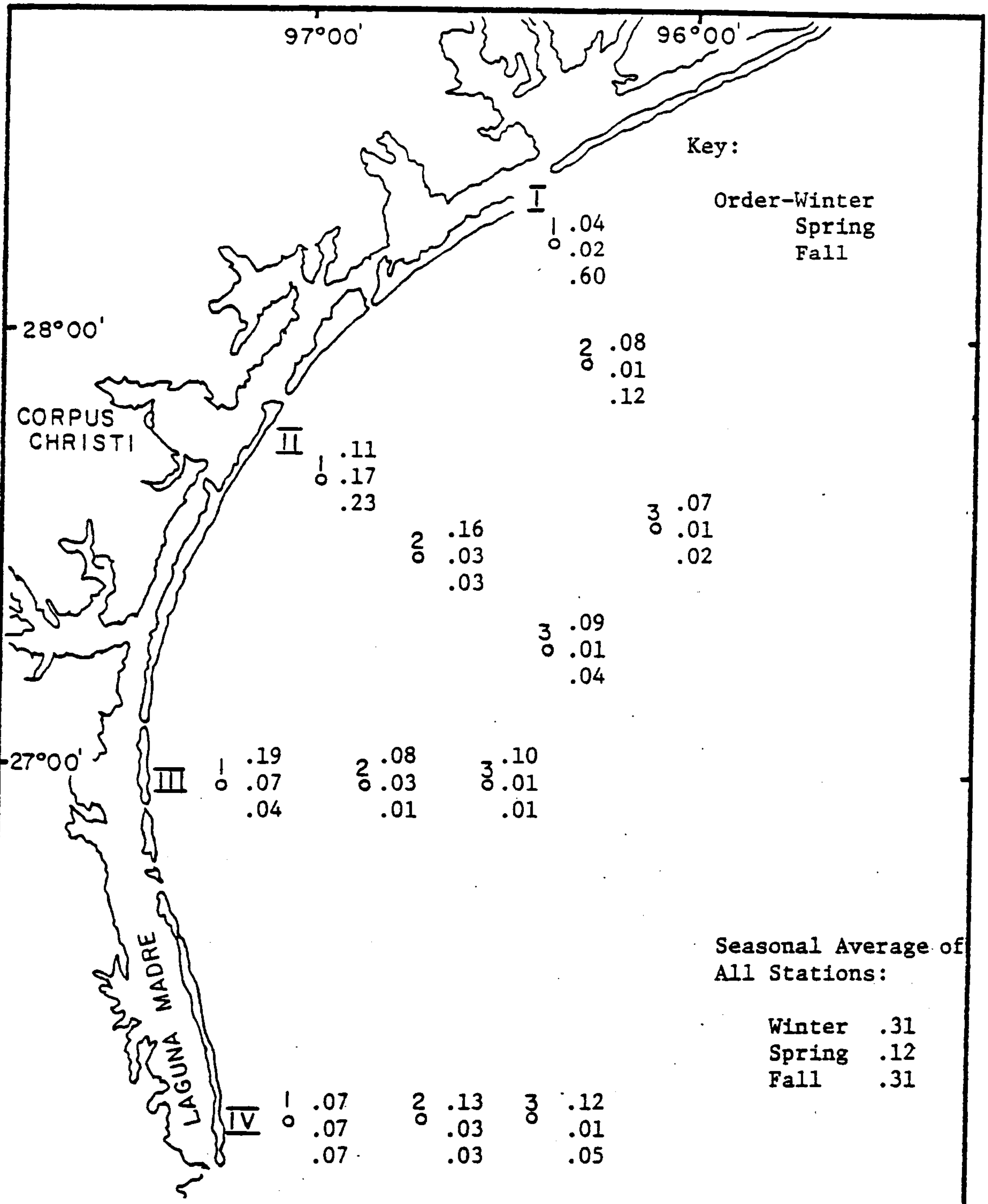

Figure 8. Order of values (μg/l) for particulate hydrocarbons (hexane eluate) at each station.

The actual geographic source of these higher values could not be identified from the collections taken.

The lower Texas shelf is relatively pristine in terms of low molecular weight hydrocarbons and those present are felt to be chiefly derived from natural sources. The major source of methane appeared to be from production within the water column and was seasonal in respect to the vertical distribution observed. In winter, the water column showed relatively uniform concentrations due to turbulent mixing. Summer and fall maximums in low molecular weight hydrocarbons were found associated with the development of the thermocline. These maximums were an order of magnitude above other vertical measurements and probably resulted from the accumulation of particulate matter in these water layers with subsequent reducing activities of bacteria.

Gas seepage also accounted for some input of low molecular weight hydrocarbons to the STOCS area. This was especially evident at the southern end of the study area in 1976. The observed gas was principally methane (> 99%) with only a small amount of ethane. The molecular composition along with the C^{13}/C^{12} ratios on the methane suggested a biogenic source.

The unsaturated hydrocarbons (*e.g.* ethene, propene) generally followed aquatic flora productivity patterns with low values in the winter and higher values observed for summer and fall. Ethene further showed a subsurface maximum in several collections that were associated with a primary productivity maximum. The general implications were that biological processes were also the source of these materials. The unsaturates dominated over their saturated analogs in the STOCS study area.

Oxygen concentrations in the upper 60 m of the 1976 study area varied seasonally, being generally highest at nearshore stations in the winter and lowest in the summer. Ratios of measured oxygen to equilibrium oxygen concentrations indicated that oxygen variations were primarily controlled by physical processes such as seasonal changes in seawater temperature and salinity rather than the expected cause of productivity fluctuations.

A mass of highly-oxygenated water could be traced by cross-sectional concentration contours as it formed nearshore in the winter and displaced by warming in the spring and summer. The intrusion of oxygen-depleted 200-300 m western Gulf Water was evident year-round below approximately 70 m in the STOCS region, and seasonal variations in stratification of the water column were seen by the extent of vertical mixing with this bottom water.

Nutrient concentrations in 1976 were representative of open Gulf surface water in most of the water above 60 m, but continental runoff influenced nearshore concentrations, especially in the spring. Nitrate was the limiting nutrient to productivity, and disappeared after the spring phytoplankton blooms through the summer and early fall. Phosphate and silicate were affected by the high spring productivity but were not completely removed. These nutrients were gradually replenished during the summer and fall to moderately high values by December. The intrusion of the nutrient-rich 200-300 m western Gulf Water was again clearly seen below 70 m as was indicated by nutrient concentration contours across cross-sectional diagrams of Transect II as illustrated by Figure 9.

The data collected for the floral communities within the water column of the STOCS during 1976 indicated that there was a general offshore decline in phytoplankton biomass and also a decrease in these primary producers from north to south within the study area. The larger species of phytoplankton occurred in detectable concentrations only at the inshore stations.

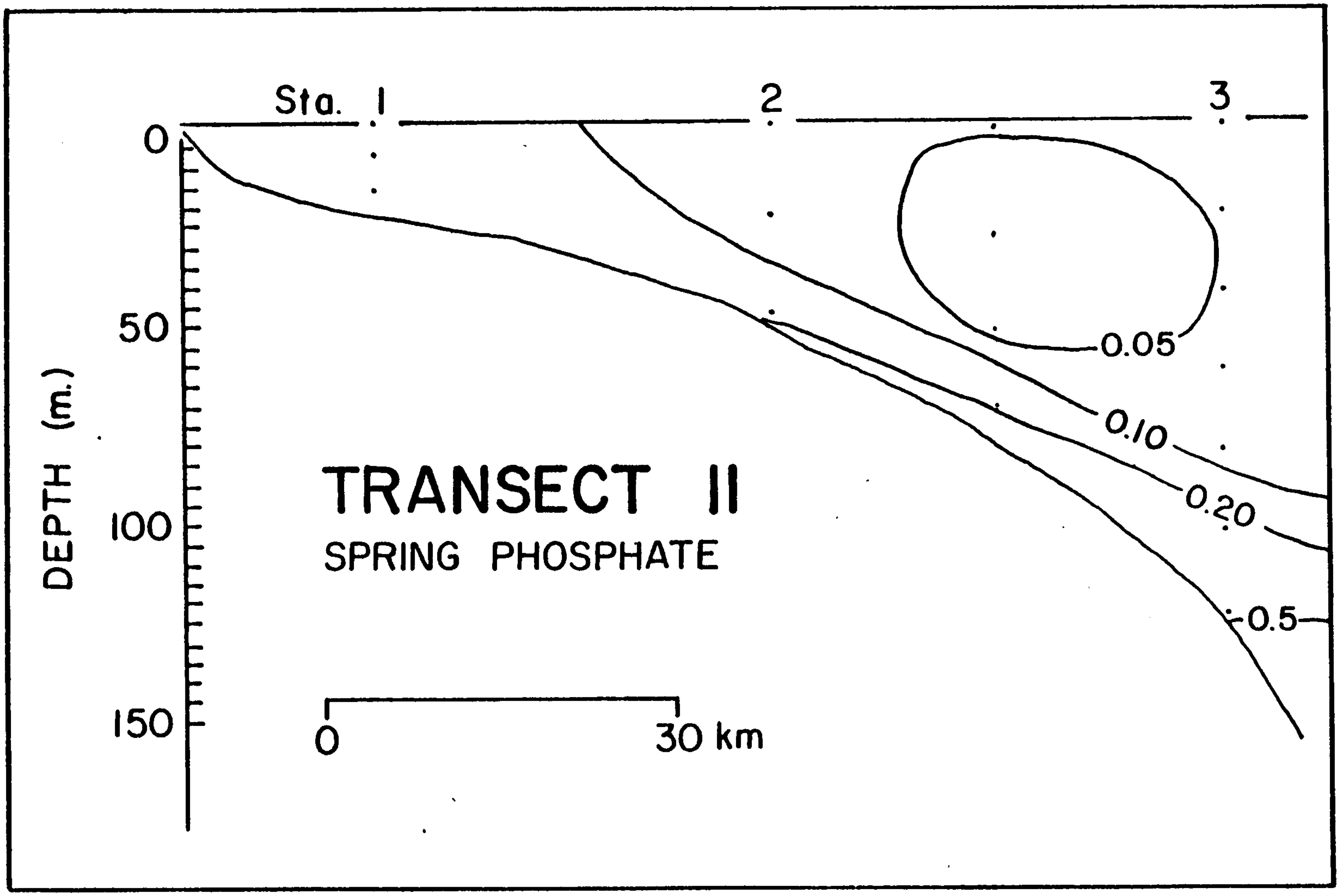

Figure 9. Phosphate (μM) Cross-sectional Contours Along Transect II During the Spring Seasonal Sampling (1976).

Chlorophyll a concentrations, which represented a biomass measure for the primary producers, often showed subsurface maxima for all size ranges of phytoplankton. Monthly collections illustrated that in the shallow water there was a characteristic bimodal cycle of production during the year. This pattern was represented by a peak in April and another minor rise in biomass between September and December. In contrast, the mid-depth stations showed a single maximum in the deeper waters that appeared to lag behind the peak in surface primary productivity with a broad rise that lasted through July. Peak production for the extreme offshore collections was observed in the latter half of the year.

In terms of species composition of the phytoplankters there appeared to be a gross division into two groups at the shallower stations. Temporally the first group was observed between December and April while the second assemblage persisted from May to November. The deeper stations exhibited less seasonality in species composition with a few species being abundant throughout the year. Throughout the shallower waters there were occasions when blooms by a single species resulted in a very low diversity within the floral community.

Light penetration of the water column as indicated by secchi depth of the water column, along with both phytoplankton abundances and biomass, were directly related during 1976. ATP concentrations were related during 1976. ATP concentrations were related to chlorophyll a more so during the spring than during late summer and fall. The inverse relationship between salinity and biomass of the phytoplankters (Figure 10) suggested that freshwater runoff was a significant nutrient source for primary production in the STOCS study area.

Neuston samples collected during 1976 showed variations in biomass, species diversity, numerical abundance of taxonomic components, and dry

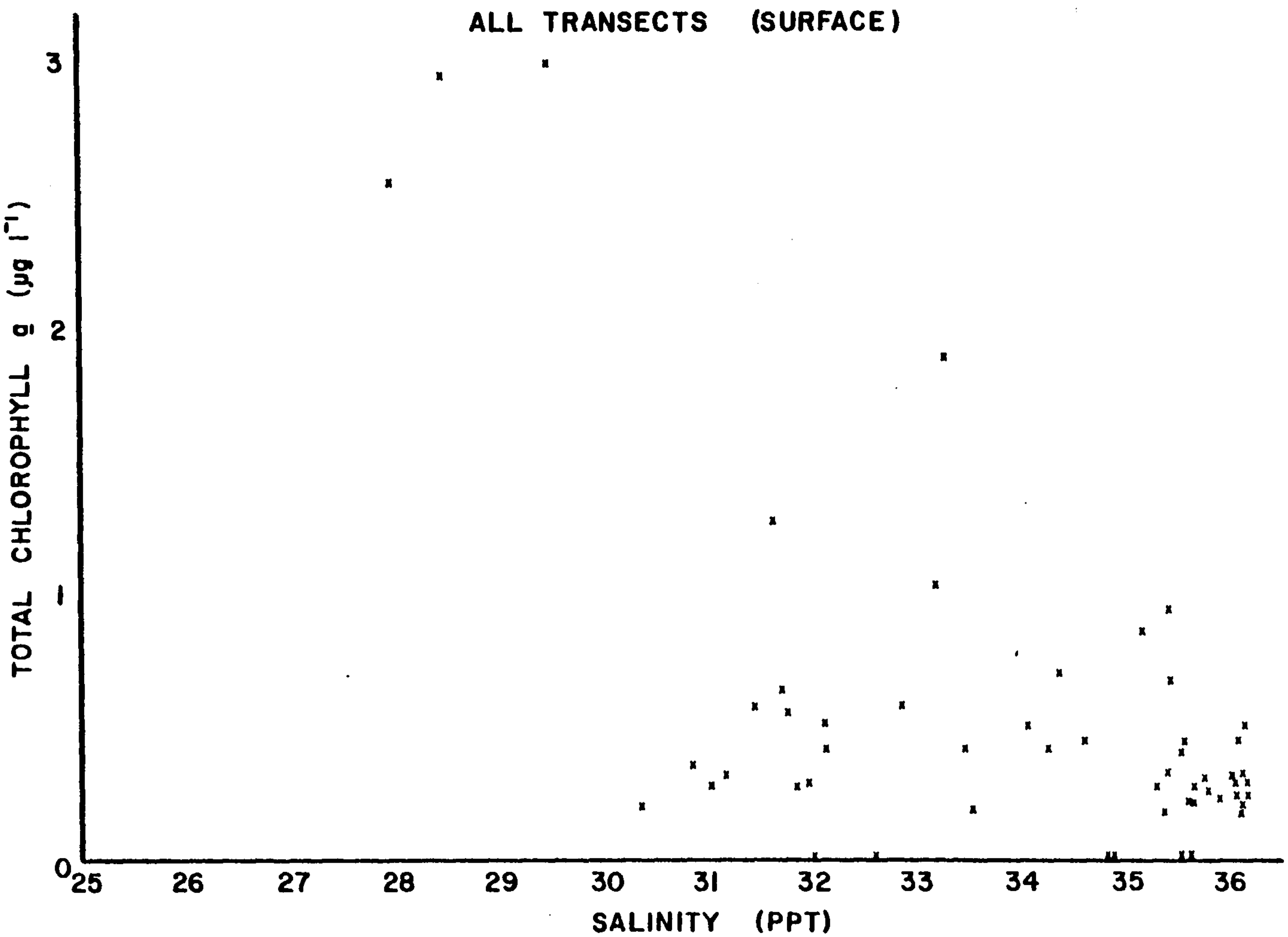

Figure 10. Relationship Between Salinity (ppt) and Total Chlorophyll a ($\mu g\ l^{-1}$) at the Surface.

weights of tar. These variations were related to diel, seasonal and geographical considerations as well as distance from shore. For example, certain taxa were more abundant in the surface waters at night than during the day as a result of nocturnal migrations known to occur in many of the species observed. In addition, June collections showed the highest average biomass and highest abundance while August displayed the highest species diversity. The highest concentrations of tar occurred in April.

Geographic variations in the neuston were numerous and generally suggested a very patchy character for this faunal group. More taxa were absent from or showed least abundant distributions on Transect IV than any other transect. Transect IV was also lowest in species diversity, average biomass, numerical abundance of total organisms and dry weight of tar. Transect III had the highest average biomass, while Transect II had the highest average species diversity and the highest dry weight of tar. There appeared to be few physical or chemical factors that showed any influence on the distribution of the neuston faunal component from the variables measured in 1976.

The general distributions and densities of microzooplankton indicated that there was a decrease in this biotic component of the water column offshore and in a southerly direction within the STOCS study area. These general patterns correlated well with phytoplankton biomasses. The microzooplankton data from 1976 were also contrasted with hydrological variables during this period. These comparisons using indicator species were quite valuable in describing the general movement of waters over the outer shelf. They revealed: 1) ponds of offshore water moving onto the shelf during winter and early spring; 2) strong upwelling occurring and bringing deep offshore water onto the shelf in the spring and early summer; 3) a movement of water offshore in the fall which was overriding a wedge of estuarine derived water; and 4) an incursion of a proposed anticyclonic gyre that detached from the Gulf Loop Current onto the shelf in the late summer and early fall. With the aid of numerical analysis and contrast with other data several of these fauna were able to be grouped and designated as biological indicators of specific water masses on the shelf. The general biological indicators were as follows: inshore waters = absence 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. It was generally concluded from these results that small scale seasonal trends in physical oceanographic conditions could be detected from samples collected by Nansen bottle tows alone and evaluating the biological specimens.

Evaluation of protozoan species living within the water column of the STOCS study area indicated that oligotrichs, as a group, were widely distributed in time and space. The data indicated that this group may serve as an indicator of water quality. On the other hand, the tintinnids as a group were more restricted in temporal and spatial distribution. For example, the hyaline and sculptured-loricate forms tended to inhabit more offshore regions while the arenaceous-loricate forms occurred at inshore sampling sites. Population alterations in individual species of tintinnids, therefore, suggested that they may serve as very sensitive and immediate (short-term) indicators of water quality at specific times or specific areas in the Gulf.

In general, protozoan biomass averaged eight percent of the macrozooplankton biomass during 1976. This appeared to be well below observations for other aquatic systems. There is increasing evidence that stressed ecosystems tend to go from a macrozooplankton-net phytoplankton community to a microzooplankton-nannoflagellate community. If this is the case the protozoans may serve as valid "fingerprints" to monitor the health of the ecosystem.

The trends in the macrozooplankton densities and distributions for 1976 were very similar to many other biotic patterns already described. These plankters decreased significantly on a seaward gradient (Table 6) and to a lesser extent on a north to south gradient (Table 7). Biomasses of zooplankton were greatest inshore in the spring and offshore in the winter. As illustrated, these patterns were similar to 1975 results.

The most abundant classification of organisms within the zooplankton were the copepods, which are small crustaceans distantly related to the shrimp. Averaged over the annual cycle, copepods made up about 60% of the zooplankton in 1976. Copepod densities declined seaward in all seasons, but the number of species identified increased seaward. Seasonally, copepod densities increased from winter to spring, but relative abundances decreased which indicated that other forms of zooplankton were increasing faster in the spring. Immature copepods appeared in fairly uniform abundances relative to the total copepod population which indicated a constant production throughout the year.

Several other zooplankton classifications were significant for their numbers. Some of these, such as mollusc larvae (immature marine snails and clams), barnacle larvae, ostracods and Cladocera, were very abundant at the nearshore and intermediate stations, particularly in the spring.

TABLE 6

AVERAGE SEASONAL NUMERICAL ABUNDANCE OF ZOOPLANKTON PER m^3
FOR EACH STATION
MEAN OF FOUR TRANSECTS FOR EACH STATION

Year	Station	Winter	Spring	Summer	Mean
1975	1	2115.3	3931.9	2224.5	2757.2
	2	1371.1	1547.8	1756.6	1558.5
	3	828.7	591.6	858.5	759.6
Mean		1438.4	2023.8	1613.2	1691.8
1976	1	2020.4	2103.7	3525.4	2549.8
	2	1261.3	2996.2	1116.8	1791.4
	3	825.5	725.5	1124.0	891.7
Mean		1369.1	1941.8	1922.1	1744.3
1975 & 1976	1	2067.8	3017.8	2874.9	2653.5
	2	1316.2	2272.0	1436.7	1675.0
	3	827.1	658.5	991.2	825.6
Mean		1403.7	1982.8	1767.6	1718.0

TABLE 7

AVERAGE SEASONAL NUMERICAL ABUNDANCE OF ZOOPLANKTON PER m^3
FOR EACH TRANSECT
MEAN OF THREE STATIONS FOR EACH TRANSECT

Year	Transect	Winter	Spring	Summer	Mean
1975	I	877.9	3320.9	1590.0	1929.6
	II	1797.5	2259.3	1370.0	1808.9
	III	1529.3	1169.5	1538.4	1412.4
	IV	1548.9	1345.4	1954.2	1616.2
Mean		1438.4	2023.8	1613.1	1691.8
1976	I	1020.9	2560.6	1211.3	1597.6
	II	1426.2	2015.9	1678.8	1707.0
	III	994.6	1987.1	3842.7	2274.8
	IV	2034.8	1203.6	955.4	1397.9
Mean		1369.1	1941.8	1922.0	1744.3
1975 & 1976	I	949.4	2940.7	1400.6	1763.6
	II	1611.8	2137.6	1524.4	1757.9
	III	1261.9	1578.3	2690.5	1843.6
	IV	1791.8	1274.5	1454.8	1507.0
Mean		1403.7	1982.8	1767.6	1718.0

Others, including small jellyfish, arrow worms and tunicates, were regularly occurring constituents which appeared in fairly constant numbers throughout the study area.

Selected zooplankton data were compared with concurrently collected physical and biological data from other BLM-STOCS studies. Zooplankton abundances were found to be greatest when salinities were lowest and temperatures were in the middle of their annual range. When correlated directly to temperature, salinity and primary production (chlorophyll a), the zooplankton correlated best with primary production. Correlations for monthly data were generally better than for seasonal data. This suggested that increased sampling frequency reduced the effect of natural time lags on relationships known to exist between the zooplankton and other biological and physical phenomena.

Water column biota do not generally contain large quantities of hydrocarbons relative to amino acids, fatty acids, etc. Two hydrocarbons, pristane and n-heptadecane, are generally dominant in marine zooplankton, but branched chain and polyunsaturated hydrocarbons also occur. It is thought that these biota accumulate hydrocarbons in lipid tissues by assimilation through their diet.

The zooplankton samples examined during this study showed considerable petroleum contamination. The 1976 zooplankton samples generally showed more contamination with petroleum-like hydrocarbons than were observed in 1975. Twenty-six samples (31%) showed contamination. This was due to the presumed presence of microscopic "tar balls" in the samples. The origin of this material was not discernible from the data collected. Pristane and n-heptadecane were still the most dominant hydrocarbons, even in many samples that showed petroleum-like contamination.

It was felt that these data suggested zooplankton as an excellent indicator of petroleum pollution. The high levels of C_{17} and pristane observed in these biota were also seen in biota of higher trophic levels in this study suggesting a transfer of these materials through the food chains.

SEA FLOOR

The primary topographic features of the South Texas Outer Continental Shelf are the deltaic bulge seaward of the Rio Grande, the comparable outline of an ancestral delta near the shelf edge seaward of Matagorda Bay and the broad ramp-like indentation on the outer shelf between the two deltaic bulges. Second order topographic features are the north-to-northeastward trending low ridges, terraces and low scarps over the ancestral Rio Grande delta, the series of small enclosures associated with a band of irregular topography along the ramp between water depths of 64 to 91 m and the terrace-like area along the outer shelf beginning at the 91 m isobath.

In general, the remainder of the sea floor is characterized by sand-sized sediments on the inner shelf which decrease in abundance seaward. The surficial and near-surface bottom sediments are typically relatively soft and not suitable for bearing heavy structures at shallow depths. Some slumping of the sea floor sediments has been indicated along the periphery of the ancestral Rio Grande delta. Where firm relict sand and soft mud are locally adjacent, sea floor stability is highly variable over short distances. Rapid rates of local sediment deposition or scour have not been observed for this area.

The results of 1976 collections for sediment texture characterization of the STOCS study area showed that the variability of sediment textural parameters on the scale of station relocation for each cruise followed approximately the uniformity or sorting of the texture itself as measured by grain size deviation about the mean. A large amount of patchiness of textures existed in much of the study area. This patchiness was believed to be related to a number of factors which may have included small scale variation from mottles of sand or clay in an otherwise uniform sediment, and larger scale features such as sand waves and biologically affected microenvironments.

Although seasonal changes in sediment structure were expectedly subtle, the windier spring period seemed to correlate with winnowing of some of the finest clays from the outer most shelf, removal of sands from the shallow waters, and coarsening of sediment texture on the mid-shelf. The data further suggested, although not as strong as above, that this trend was reversed between spring and fall.

The seasonal variation, that was apparent, in terms of sand/mud ratios of the sediments, was greatest along the inner shelf where water depths were shallowest. Causes for this subtle seasonal variability probably included the fact that the inner shelf was subjected to a wide range of energy from the moving water.

Many of the trace metals of the sediments were found to be directly related to the percentage of clay content which was expected. Seasonal variations in some of these metals, such as cadmium, were indicated and directly related to the small scale variations, or patchiness, observed in the sediment texture. The reasons for the variations, which were often significant, were not clearly established. The suspected cause, however, was the variation in the magnitude of infaunal activity from one season to another. Considering the high degree of bioturbation documented for the STOCS, considerable modification of the sediment and accompanying trace metals content in the near surface zone by infaunal activity would logically be expected.

Hydrocarbons constitute a small but ubiquitous fraction of the organic matter of sediment. By combining several approaches to studying the hydrocarbon geochemistry of the sea floor sediments, a conceptual model useful for environmental quality considerations can be stated. The essential elements of the model are: 1) organic matter including hydrocarbons is being continuously supplied to recent sediment from the biota of the water column; 2) bacteria and infauna synthesize new hydrocarbons, thus adding to the complexity of hydrocarbon pattern; 3) other sources of hydrocarbons for nearshore sediments include higher plants, sea grasses and benthic algae; and 4) petroleum must also be recognized as a potential source of sedimentary hydrocarbons.

With this background information to work from, the 1976 experimental design for sediment hydrocarbon chemistry identified several parameters that might allow a decision as to whether or not a sediment sample or group of samples were petroleum contaminated. The results indicated that the level of n-paraffins ranged between 0.001 and 6.0 ppm but most samples fell between 0.1 and 2.0 ppm. These data were similar to values reported for the northeastern Gulf shelf sediments (3-12 ppm), but not as high as reported for California basin sediments (100-200 ppm).

The paraffin patterns in all samples collected were complex but most showed strong odd carbon numbers dominant in the C_{-25} and C_{-33} region. This may be taken as evidence that petroleum derived material of the sediments was extremely low.

The hydrocarbons patterns of the sediment allowed the cautious formulation of the following interpretations: 1) the paraffins showed little if any petroleum contribution; 2) the observed hydrocarbon patterns required multiple sources such as plankton, bacteria and infauna; 3) pristane and phytane were low confirming a low petroleum input, but leaving unexplained the fate of the high levels of zooplankton pristane which must reach the sediment; 4) the sediment was indicated as a final, but active, sink for marine hydrocarbons, which contributes new hydrocarbons to the deposit.

The meiofauna exhibited seasonally related population peaks in March, July and November. The maxima in these peaks occurred in July. The 1976 collections demonstrated that both physical and biological factors exerted strong controls on the meiofaunal populations of the STOCS. Nematode distributions were strongly correlated with sediment characteristics, particularly when the sediment contained greater than 60% sand. Harpacticoid copepod distributions, on the other hand, showed no relationship to the sediment texture but showed relationships to sediment organic chemistry variables. It was felt that because of these two facts the harpacticoid/nematode ratio may serve as an indicator of environmental disturbance where the sediment organic chemistry and texture are changed.

Studies of living benthic foraminiferans of the sediments revealed that an average standing crop of 27.64 individuals/10 m^2 persisted in the STOCS study area. In addition, several species appeared to be indicative of overlying water masses. For example, perhaps one of the best indicator species of the benthonic foraminiferans was the most abundant species *Brizalina lowmani*. This species appeared to be meroplanktonic and present in the water column throughout the year, but it only appeared to settle out in shallow waters, or in deep waters when the waters became isothermal such as in winter. Therefore, the presence of this species in deeper waters may have indicated a water column mixing. *B. lowmani* densities and dominance in benthon samples appeared to be useful as a tracer for bottom currents on a robust scale (months).

Another possible good indicator was *Ammonia beccarii*, a species that is common in the lagoons and estuaries and may illustrate outflow periods.

A. beccarii appeared to be an infaunal component and most of the other species appeared to be epifaunal (such as *B. lowmani*). This difference showed up in numerical classification and may be useful in determining the amount of perturbations (in the water column and sediment) of oil spills, etc. Lastly, the bank stations appeared to be unique and perhaps very susceptible to perturbations due to their complex and diverse fauna in an obvious area for oil drilling.

Zonation of infaunal assemblages showed a very typical pattern of distribution by depth, modified by the influence of sandy sediments. There were three habitat types indicated by the data for STOCS infauna as illustrated by Figure 11. These included shallow muddy sand, mid-depth silty-clay and deep sediments represented by better than 60% clay. The shallow infaunal assemblages were rich in number of species and individuals but numerical dominance by some species resulted in low evenness between populations. The deepest assemblages inhabiting the clay sediments were characterized by high diversity and evenness of population densities with fewer species than the shallower stations.

Superimposed upon this structuring of the infaunal communities by sediment structure was the influence the variability of the bottom water exerted. As the annual variability of the bottom water environment decreased with depth, the stability of the infaunal assemblages appeared to increase and there were fewer occurrences of dominance within the community by one or two species.

In an attempt to delineate faunal assemblages by feeding mode it was found that on the STOCS, sedentary deposit feeders comprised the bulk of polychaete populations inshore, but were generally replaced by actively burrowing detrital feeders at mid-depths. Species which actively burrowed through sediments in search of food also dominated the deepest communities.

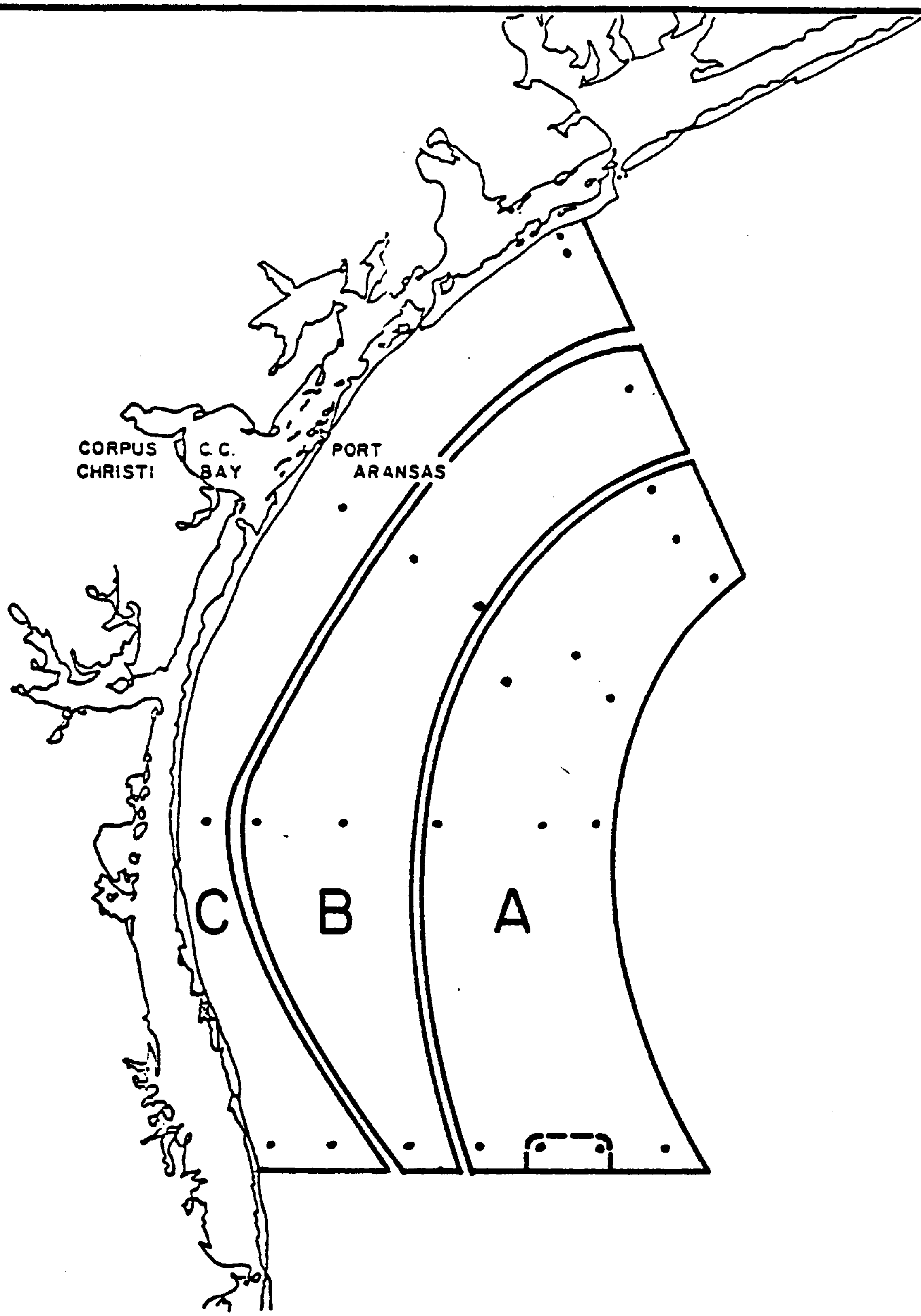

Figure 11. Location of Station-Group (A-C) from Cluster Analysis of Winter Infaunal Data.

The biomass of infauna, indicating the standing crops of these organisms, was very low and decreased in an offshore direction. Fourteen (14) species contributed at least 75% of the biomass of the infaunal communities. The low biomass measures obtained for infaunal communities suggested continued reproduction in these species which would result in high rates of turnover. This would appear to be the case for the STOCS area since infauna represent a source of nutrition to other fauna of the bottom waters, one of which are the epifauna.

As with the infauna, the epifauna showed a very distinct separation of species assemblages with increasing water depth (Figure 12). The inner-shelf, including both the very shallow and shallow-intermediate stations, had large numbers of individuals and low equitability and species diversity. Many of the species had their widest distribution in winter, occurred in large numbers in spring (May-June), and by fall (September-October), were limited to only a few stations. Many of the species most characteristic of the shallow shelf were motile decapods found in inlets, bays and shoal areas in summer and early fall. Seasonal changes in population may have been related to the annual temperature (14-29°C in 1976) and salinity (31-36 ppt in 1976) extremes at inner-shelf stations.

Large numbers of species with low abundance characterized the outer-shelf assemblage. Number of species and evenness of their distribution in this area reflected the relatively stable environmental conditions characteristic of the area.

Biomass totals for epifauna showed differences between seasons and transects, but due to the very great variability within a given treatment (season or transect), the one-way ANOVA tests were unable to detect differences between transects (season or sample). Spring samples for epifauna showed the highest biomass of the seasons sampled. The winter and

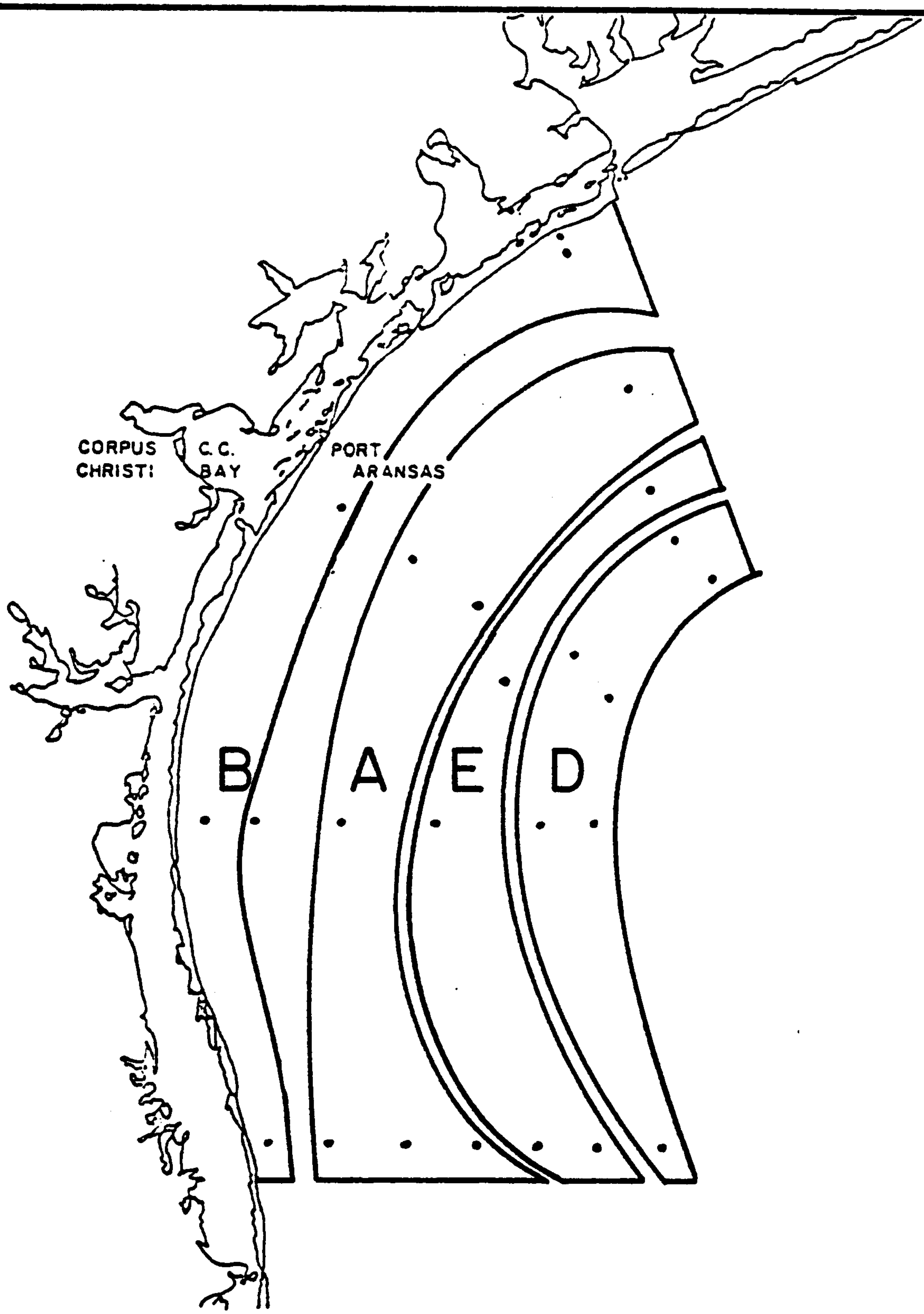

Figure 12. Location of Station-Groups (A-E) from Cluster Analysis of Seasonal Epifaunal Data.

spring epifaunal samples had similar numbers of individuals but the spring samples were much heavier. This may indicate growth of prevalent species between Winter (February) and Spring (May) sampling periods. Fall samples were similar in biomass to the winter samples but far fewer in numbers of individuals, indicating larger individuals preparing for reproduction in the winter-spring.

An important aspect of this study was the potential for understanding the distribution of organisms in relationship to their total environment. An explanation of how such a system works depends on understanding the behavior of the individual organisms. For this purpose, multi-variate analysis was undertaken and preliminary results of the analysis on three species of epifauna showed interesting results. Linear correlations of species abundance with independent variables were not significant in most cases. The distribution of many organisms followed a curve with optimal conditions grading off on one or both ends to sub-optimal conditions and finally to zero abundance. Non-linear functions were better able to fit this type of distribution. The multi-variate aspect allowed combinations of independent variables which were based on conditions closely resembling those that constitute the animal's environment.

As an example of this innovative technique the shrimp *Penaeus aztecus* was examined in terms of environmental temperature. The variation in abundance of this organism was best explained by seasonality, time of day and temperature as shown in Figure 13.

The above technique in conjunction with more popular means of evaluating data provided the following conclusions concerning the STOCS epifaunal pattern: 1) temporal and spatial patterns of abundance were generally due to recruitment of young age classes; 2) large variations in abundance

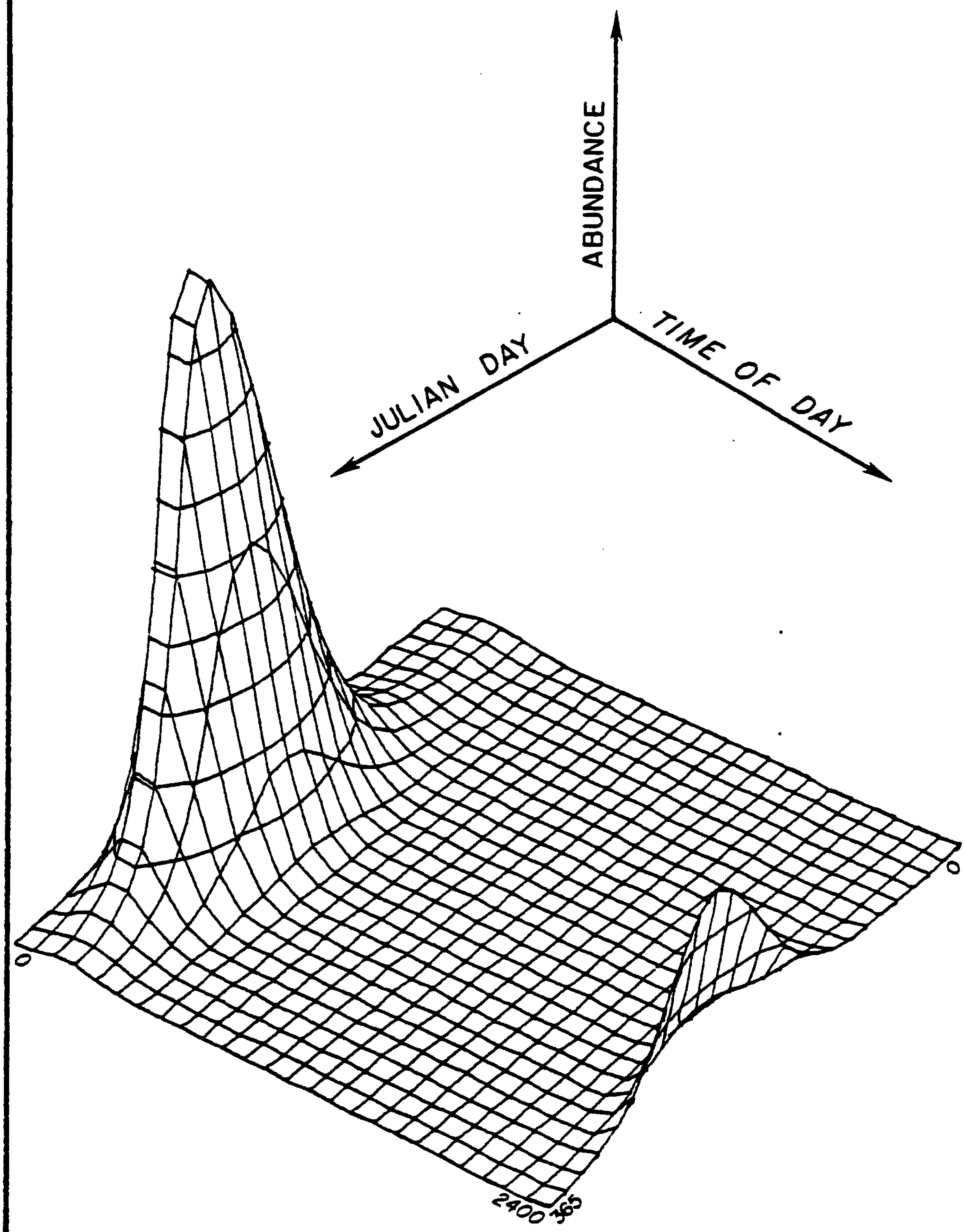

Figure 13. Abundance of *Penaeus aztecus* as a Function of Julian Day and Time of Day at a Constant Temperature of 25°C.

were confined to species with shallow shelf or estuarine associations; 3) there was a general tendency for young to be found in shallower water and for adults to move offshore.

The diversity of demersal fishes was low at shallow stations and increased with depth to about 85 m. As with the epifauna, seasonal changes in fish populations appeared to be related to depth, temperature, and movements into and out of the estuaries.

In terms of day vs. night collections of demersal fishes, parameters such as biomasses, numbers of species and individuals as well as measures of diversity differed between the day and night throughout the year. Fish taken predominantly during day collections were commonly schooling species while predominantly nocturnal species were solitary in nature. There was a pronounced tendency for both diurnal and nocturnal species to be at a minimal abundance in autumn with a slow rise to maximal abundance in the spring.

From numerical analyses of the demersal fish data the following general conclusions were apparent: 1) Zonation appeared to be depth related, with temperature and seasonal migration patterns influencing the species associations; 2) There was no direct evidence that zonation was related to salinity or sediment type; 3) The shallow-shelf turbulent zone had a low species diversity throughout the year, with especially high numbers of individuals in winter and spring; 4) The nearshore faunal associations dissipated during the late summer or autumn when shallow water temperatures were highest; 5) Mid- and deep-water associations were somewhat more stable throughout the year with the mid-shelf groups of species having the highest diversity; 6) North-south gradients were minimal except during autumn when weak species associations developed to show that the northern two transects were slightly different from the southern two transects; and, 7) All faunal zones had evidence of considerable species "shuffling" during the year, which suggested that Petersen-type, species-dominated communities did not persist in the shelf areas that were studied.

An evaluation of trace metal content of various fauna including zooplankton, macroepifauna and demersal fishes in the study area was done in 1976. Adequate data were obtained on eight metals, including cadmium, chromium, copper, iron, nickel, lead, vanadium and zinc.

There was considerable variability in the trace metals data; however, it was probably an accurate reflection of the natural variability within each species since an effort was made to control potential sources of additional variability (contamination, metal loss, erratic dissection procedures, etc.) during sample preparation. Large ($\geq$ 100%) changes in organismal trace metals levels which occurred over significant portions of the STOCS study area could be detected with this data. Similar annual averages for groups of related organisms had generally more variability than the species averages and could detect only larger changes.

Far too few samples were collected in 1976 to completely define the natural variability of the trace metal content of fauna. Several considerations should be made in selecting species for further examination. These include the point that species selected should be widely distributed and available during all seasons of the year.

The major component of hydrocarbons within the muscle tissues of most species studied was C_{15} and C_{17} alkanes (Tables 8 and 9). Pristane was also apparent in many of the muscle samples. These occurrences of hydrocarbons were probably due to the diets of the test organisms, as pristane is the major hydrocarbon of zooplankton and the C_{15} and C_{17} alkanes are the dominant hydrocarbons in unpolluted algae. Phytane was observed

TABLE 8

PERCENTAGES OF C_{15} AND C_{17} IN TOTAL n-ALKANES OF MACRONEKTON FROM THE STOCS 1976

Species	Percentages ($C_{15} + C_{17}$)
Red Snapper	
muscle (15)	95 ± 4
liver (15)	92 ± 8
gill (13)	90 ± 8
Vermilion Snapper	
muscle (19)	92 ± 10
liver (10)	91 ± 11
gill (11)	91 ± 11

TABLE 9

PERCENTAGES OF C_{15} AND C_{17} IN TOTAL n-ALKANES OF MUSCLES OF SPECIES OF MACROEPIFAUNA FROM SOUTH TEXAS OCS (1975-1976)

Species	Percentages ($C_{15} + C_{17}$)
Wenchman (27)	87 ± 13
Lizard fish (10)	86 ± 10
Atlantic bumper (7)	86 ± 6
Butterfish (6)	84 ± 3
Rough scad (17)	84 ± 13
Dwarf goatfish (16)	79 ± 19
Squid (32)	68 ± 26
Longspine porgy (17)	40 ± 31
Shoal flounder (15)	27 ± 35

in a few of the samples and tended to occur at some stations more frequently than others, especially the southern section on the study area. As phytane is generally considered to be derived from petroleum rather than from biogenic origin, these findings suggested that there could be sources of petroleum pollution in the STOCS area. However, other indicators of petroleum such as aromatic hydrocarbons were absent and the levels of phytane were very low implying the presence of very low levels of petroleum. Thus, if petroleum was present in the South Texas OCS study area, it was probably at very low levels.

There was also an absence of correlation of the pristane/phytane, pristane/C_{17} and phytane/C_{18} ratios between and within stations. 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. In any case, the lack of correlation of the ratios further implied the absence of significant petroleum sources in the Texas OCS. The above results generally indicated that heavy hydrocarbons of anthropogenic origins were not indicated during 1976.

Symbionts, particularly parasitic ones, apparently caused the most damage to marine invertebrates collected in the histopathology study. Many parasites of the animals used in this study could not be identified without special culturing methods and some may be entirely new to science.

The histopathological study of demersal fishes demonstrated that parasitism was the major cause of lesions observed. Lesions that may be related to other etiologic agents were not observed. Parasitism caused varying degrees of necrosis, especially in the liver and stomach. The measure of natural occurrence in these conditions provided a "fingerprint" of conditions to look for in future monitoring of the environment. Therefore, the following conclusions were drawn from the histopathological study of fishes: 1) About one-third of the organs collected demonstrated pathologic conditions, most of which were parasitic lesions; 2) Among the 10 species of fish examined, the rock sea bass had the smallest percentage of lesions and the vermilion snapper the largest; 3) The vermilion snapper also demonstrated the largest percentage of cardiac lesions; 4) There was a tendency for kidney and muscle lesions to be more numerous in the sand seatrout; 5) There was a tendency for kidney, muscle and liver lesions to be more numerous in specimens collected during the last three cruises, October, November and December, than during the first two cruises, July and August; 6) The stomach and liver tissues were more frequently involved with parasitism than the muscle, kidney and heart. This was apparently unrelated to species, station or monthly cruise; 7)The overall percentage of lesions was larger in fish obtained from the Southern Bank than at other stations, while the smallest percentage of lesions occurred in fish obtained from Station 2. These observations were due to the vermilion snapper sampled at the Southern Bank and the rock sea bass sampled at Station 2; 8) In general, all stations showed a tendency for the percentages of lesions in fish to increase over the last three monthly cruises, October, November and December.

In addition to establishing conditions inherent in the natural environment, histopathologies of demersal fishes exposed to crude oil were also evaluated for significant findings. Most of the organ samples obtained from fish exposed to varying concentrations of water soluble fractions of South Louisiana crude oil did not show lesions that could be attributed to the oil. Gill epithelium and liver, and possibly the subcutaneous areas did show a response to the crude oil. The fact that some organs did not demonstrate a response and that others showed a minimal response suggests that the lengths of exposure, the concentrations used, or both exposure and concentrations, were too low to permit severe lesions to occur.

Epithelial tissue has high regenerative capacity. It is expected that gill epithelium would continually be replaced while under constant irritation from petroleum elements. After prolonged exposure to a foreign substance, however, replacement of gill epithelium may not be able to keep pace with cell loss, and erosion of the epithelium would begin to take place. This erosion of epithelium was beginning to take place between 14 and 21 days of exposure to crude oil as demonstrated in this study. It is expected that with exposures greater than 21 days there would be ulceration followed by sloughing of gill lamina. The latter lesions would cause severe respiratory depression.

It has been stated that the gill membranes are one major pathway by which exogenous hydrocarbons enter the body of aquatic animals. Such hydrocarbons would be transported to the liver for metabolism. In the present study an increase in hepatic vacuoles occurred with increase in time of exposure, an apparent response to crude oil uptake. The exact nature of the hepatocyte vacuolation cannot be determined without employing histochemical procedures. It is believed, however, that these vacuoles probably are lipid concentrations. Longer exposures to crude oil could lead to irreversible degenerative processes, primarily in the liver and secondarily in other organs, especially the heart and kidney.

The lack of subcutaneous adipose tissue in the fish exposed to the crude oil suggested that lipids may be depleted through the skin. This would be an important aspect of hydrocarbon pollution, especially for use in a monitoring system. The observations presented here, however, are not conclusive since skin was not collected routinely as part of this study.

In histological-histopathological survey of gonadal tissue, one must first establish criteria for normal tissue. Once the normal conditions have been established, the effects of different pollutants can be assayed.

No conclusion was possible in the study of the reproductive cycles of vertebrates and invertebrates, because sampling was not done for an entire reproductive season. A change was noticed however, in the gonadal tissue of the vermilion snapper, *Rhomboplites aurorubens*. In August, 1976, both male and female were maturing and were almost ready for spawning. A collection was not made in September. In October, when *R. aurorubens* was again collected, the gonadal tissues of both males and females were back at the early stages of the reproductive cycles. One might conclude that the fish had indeed spawned.

RIG MONITORING STUDY

The monitoring of an exploratory drilling operation on the STOCS to determine impacts from this activity on the marine ecosystem commenced in September 1976 with a pre-drilling sampling period. A during-drilling collection cruise occurred in January 1977 and a post-drilling sampling was conducted in early March 1977.

Thirty-nine days of current data were obtained from recording current meters at four levels in the water column just prior to initiation of drilling and through the entire drilling operations. The current data at all locations indicated longshore motion predominantly to the south, but with three distinct current reversals during the study period. Harmonic analysis of current component time series indicated that the tidal component of the current was an insignificant fraction of the total observed water motion. Consequently, in terms of any far-reaching impacts from drilling, if they did occur, one would expect them to occur primarily to the south of the drill site.

No significant changes in low-molecular-weight hydrocarbon concentrations were observed at the drill site when pre, during and post-drilling collections were contrasted. Since the drilling at the rig monitoring site was only an exploratory well, no additions of light hydrocarbons were expected.

The trace metal content of suspended sediments fell within the range established during the environmental phase of the STOCS study for 1976 with the exception of cadmium and zinc. It was suspected that the high and variable values obtained for these metals were a result of sampling or procedural contamination. Three clay minerals were detected from during-drilling and post-drilling samples. One of these, montmorillonite, found during the drilling phase of monitoring may have resulted from the drill fluid sinking to the sea floor. This was suspected because previous work in the area has shown that early spring waters are almost devoid of montmorillonite.

As illustrated in Table 10, chromium, copper, manganese, and nickel levels in the sediment showed no apparent change as a result of drilling. Levels of iron and vanadium, covariant elements, were somewhat lower, while lead showed a two-fold increase after the drilling operation (Table 10).

TABLE 10

TRACE METALS - BENTHIC SEDIMENTS (PPM)

Pre-Drilling

Site	Ba	Cd	Cr	Cu	Fe	Mn	Ni	Pb	V	Zn	Code
DS	110.8	0.07	23.8	5.9	20200	312	14.3	7.6	17.7	64.7	TAK
N-1000	112.2	0.07	25.3	6.5	20500	320	17.7	7.1	17.6	69.4	TCX
E-1000	107.0	0.06	19.6	4.9	18200	279	17.0	6.0	17.3	61.0	TGB
S-1000	95.1	0.08	31.4	6.8	22100	275	16.5	6.3	20.3	71.0	TJB
W-TMB	89.0	0.08	40.9	5.4	19000	292	13.6	6.1	15.9	66.1	TMB
TQT	94.8	0.07	29.7	6.0	21000	293	15.6	6.4	18.2	69.6	TQT
TQZ	104.4	0.08	29.1	5.9	21400	252	14.6	7.4	15.9	69.5	TQZ

Post-Drilling

Site	Ba	Cd	Cr	Cu	Fe	Mn	Ni	Pb	V	Zn	Code
DS-1	470.7	0.61	21.5	6.7	16400	279	12.3	20.5	9.2	168.6	BDSM
-2	512.7	0.49	16.9	5.0	14200	260	9.0	18.3	8.4	219.6	BDSU
-3	77.8	0.22	23.3	6.3	18700	308	12.7	15.8	11.9	68.6	BDEW
N-1000	50.0	0.11	19.5	6.8	19000	313	14.1	12.1	12.4	62.2	BDHQ
E-1000	46.5	0.03	21.9	5.9	17400	280	14.7	11.8	12.3	58.1	BDTR
S-1000	52.6	0.04	20.6	6.7	18300	291	12.6	12.9	13.7	62.7	BDWB
W-1000	59.2	0.04	21.6	6.8	19300	319	14.5	14.5	11.7	63.8	BDHL

Zinc, barium and cadmium were directly tied to the drilling activity as these elements showed a marked increase at the drill site following drilling operations. These variations in sediment trace metals were observed only at the drill site.

Saturated and non-saturated high-molecular-weight hydrocarbons were measured in samples from five pre- and five post-drilling stations. The pre-drill samples indicated no evidence of oil pollution. One of the seven post-drilling samples was apparently contaminated with petroleum hydrocarbons. This sample was one of three samples taken at the drill site. Whether this contamination resulted directly from drilling operations, oil from another source, or just drill cuttings from ancient shales could not be determined.

Comparisons of bottom sediment textural variability between composite pre-drilling and post-drilling sample suites were made. The results illustrated that statistically significant differences occurred between the two collection periods for the following textural parameters: grain size skewness, percentages of silt and clay, the silt/clay ratio, and grain size mean diameter (Table 11). No meaningful inferences could be formulated regarding causative factors because the observed sea-floor textural changes could potentially have resulted from a number of sources including modified sampling procedures, analytical variability, natural seasonal variability and drilling rig operations.

Examination of the deposition of sediment at numerous distances from the drill site indicated an addition of coarse (sandy) materials 100 m south and west of the center drill site. Additionally, traces of these coarser materials were observed as far as 1000 m south of drilling. Farther from the drill site and in the opposite direction (northeast) there

TABLE 11

ANALYSIS OF VARIANCE FOR PRE-DRILLING
AND POST-DRILLING SUITE COMPARISONS

Hypothesis: Ho: $U_1 = U_2$
Statistic: F
Risk of Type 1 Error: α = 5%
Critical Region: $F > F_{5\%}$ (1,36 d.f.); $F_{5\%} = 4.12$

Parameter	F-value
Sand % ($\bar{x}_1$ = 4.67, $\bar{x}_2$ = 6.08)+	1.58
Silt % ($\bar{x}_1$ = 45.47, $\bar{x}_2$ = 55.09	14.97*
Clay % ($\bar{x}_1$ = 49.82, x_2 = 38.82)	22.93*
Sand/Mud ratio ($\bar{x}_1$ = 0.049, $\bar{x}_2$ = 0.068)	1.87
Silt/Clay ratio ($\bar{x}_1$= 0.931, $\bar{x}_2$ = 1.556)	17.98*
Mean Diameter ($\bar{x}_1$ = 7.72, $\bar{x}_2$ = 7.13)	24.25*
Standard Deviation ($\bar{x}_1$ = 2.04, x_2 = 2.15)	3.80
Skewness ($\bar{x}_1$ = -0.157, $\bar{x}_2$ = -0.008	7.41*
Kurtosis ($\bar{x}_1$ = -0.947, $\bar{x}_2$ = -0.822	0.70

+ $\bar{x}_1$ = pre-drilling mean, $\bar{x}_2$ = post-drilling mean

* = significant difference

was a suggestion of clay transport and deposition.

There were no significant differences noted for the abundances of true benthic meiofauna between any of the rig montioring sites for either pre- or post-drilling collections (Table 12). Two stations that could have been affected by drilling operations when the characteristic longshore current underwent reversals produced lower than expected meiofaunal populations and markedly higher harpacticoid/nematode ratios.

Analysis of benthic macrofaunal populations showed a high degree of similarity among pre-drill samples as illustrated by station group C in Figure 14. Post-drill samples although slightly separated along a north-east to south-west line through the study area (groups A1 and A2), with the exception of the actual drill site (B) also showed a high degree of similarity (Figure 14).

Differences between pre-drill and post-drill infaunal samples were attributed to drilling operations and seasonality. Benthic populations were definitely diminished at the drill site, presumably due to direct impact from drilling operations. All other post-drill stations were fairly distinct from pre-drill stations due to several groups of organisms that appeared to have some members that are seasonal.

Analysis of individual species distribution patterns indicated that many species were apparently distributed on a small scale relative to the size of the study area.

Analysis of pre- and post-drilling demersal fish trawl data revealed numerical and biomass declines, up to a radius of 1 km around the drill site in relation to the general trends observed for these fauna on the STOCS during the 1976 study period. The data however, were not statistically definitive. There were also post-drilling declines in diversity,

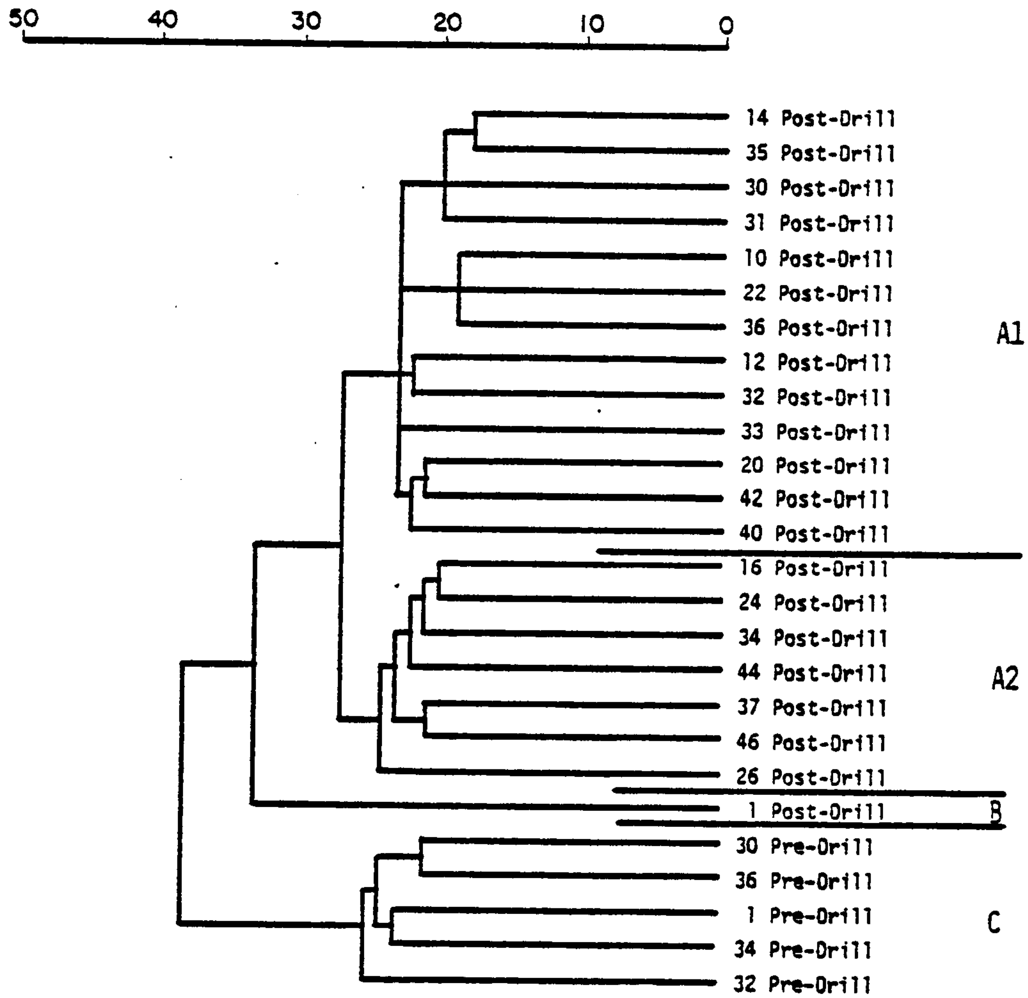

Figure 14. Normal Dendrogram from Cluster Analysis of Pre- and Post-Drill Data. Numbers Refer to Stations. Letters Designate Station Groups.

TABLE 12

COMPARISON OF MEAN NUMBERS OF TRUE MEIOFAUNA AT THE NINE RIG MONITORING STATIONS IN SEPTEMBER 1976 AND MARCH 1977. THE PAIRED t TEST SHOWED NO SIGNIFICANT DIFFERENCE. ($t = 1.39$, 8 d.f., $p - 0.20$)

Station	Pre-Drill September 1976	Post-Drill March 1977
DS	36.5	50.5
N-500	25.5	102.0
N-1000	16.0	136.0
E-500	65.0	110.5
E-1000	83.5	35.0
S-500	45.0	90.0
S-1000	24.0	165.0
W-500	133.5	30.0
W-1000	37.5	64.5
	$\bar{x} =$ 52.3	$\bar{x} =$ 87.5

and evenness of the demersal fish species in the vicinity of drilling.

The three pre-drilling specimens sampled, squid, rough scad and Atlantic croaker, contained no evidence of petroleum hydrocarbons. The n-alkane distributions in three post-drilling samples, butterfish, shoal flounder, and shrimp, were petroleum-like, most notably in the shrimp. Also, the shrimp sample had a hydrocarbon content 150% higher than the range for this species in the surrounding areas. No aromatic compounds were detected in any of these samples. Thus, there may be an indication of a low level petroleum contamination of post-drilling samples but more analyses are needed to verify this observation and the sources of contamination.

The trace metals data set did not permit a realistic assessment of the possible impact of drilling operations on the levels of trace metals in organisms inhabiting the immediate vicinity. Not enough samples were collected and only one species occurred in both pre- and post-drilling sample groups. The species collected were all very mobile and their period of exposure to the ambient environment of the rig was probably variable and very limited.

As would be expected for an exploratory drilling operation, there were biological, chemical and physical effects within the immediate area of the drill site. The spatial extent of these effects could not be precisely determined from the data. In general, however, it appeared that the effects were isolated in an area less than 100 m from the drill site. The temporal effects of this operation could not be assessed because there was only one post-drilling sampling made which was shortly after the drilling was completed.

[illegible]

As can be seen by reading this document, large amounts of data were obtained during the 1976 BLM STOCS program. Only broad generalized conclusions have been drawn and presented in this report. More definitive statements about the STOCS ecosystem and interrelationships of the results of the various study elements await further analysis of the data. Integration of the data produced by the 1975-1977 BLM-STOCS studies is to be carried out during the upcoming year. The results of this integration will be presented in a report to be completed by mid-1979.

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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.